NFPA Technical Committee on Wildland and Rural Fire Protection

NFPA 1141, 1142 & NFPA 1144
Kick-Off Conference Call
Minutes
February 27th, 2019

11:00 AM – 1:00 PM (ET)

Attendees:

Swan, Rick	Chair	International Association of Fire Fighters
Bartlett, Gregory	Principal	Brandon University, Rural Policy Learning
Bradley, Randall	Principal	Tracy Fire Department/South County Fire
Christiansen, Erik	Principal	Exponent, Inc.
Doudy, David	Principal	City of Farmington Fire Department
Gogolski, James	Principal	Hoover Treated Wood Products
Gollner, Michael	Principal	University of Maryland
Green, Dustin	Principal	Citrus County Sheriffs Office
Johnston, Kelly	Principal	Wildland Professional Solutions
Jones, Justice	Principal	Austin Fire Department
Keller, Jeremy	Principal	Macochee Joint Ambulance District
Keller, Wesley	Principal	Pennsylvania Bureau of Forestry
Kowalski, Robert	Principal	Nationwide Insurance Companies
Novak, Mark	Principal	International Association of Fire Chiefs
Oaks, Don	Principal	California Fire Chief's Association
Pine, James	Principal	San Diego County Fire Authority
Quarles, Stephen	Principal	Insurance Institute for Business & Home
Shaner, Deborah	Principal	Shaner Life Safety
Watters, William	Principal	Verisk Analytics/Insurance Services Office,
Biteau, Hubert	Alternate	Exponent, Inc.
Holland, Joseph	Alternate	Hoover Treated Wood Products
Oaks, Steve	Alternate	Santa Barbara County Fire Department
Wixted, Michael	Staff Liaison	National Fire Protection Association

Guests:

Sreeni Ranganathan	Fire Protection Research Foundation
Victoria Hutchison	Fire Protection Research Foundation

I. Chair Rick Swan called meeting to order on February 27th, 2019 at 11:00 AM (ET).

II. Welcome and opening remarks provided.

III. Introduction of attendees.

IV. NFPA process presentation provided.

V. Motion to approve the minutes from the NFPA 1144 SD Meeting - September 29, 2016 – Carried.

VI. The committee reviewed purpose of meeting and document schedules.

VII. Old business:

- An update from the existing Task Group on the Table for Water Requirements was provided.
    - The Fire Protection Research Foundation (FPRF) will provide a report in relation to the project that was engaged (Attachment A). The Task Group will be maintained and continue to work on changes for the edition of the 2022 editions of NFPA 1141 & NFPA 1142, and 2023 edition of NFPA 1144.

VIII. New business:

- The committee identified the following topics Task Groups for the 2022 editions of NFPA 1141 & NFPA 1142, and 2023 edition of NFPA 1144:
    - NFPA 1142 50 year Drought Water Source. The committee identified the need for the Task Group to explore the following:
        - Increase and/or refine requirements
        - Update annexes
        - Definition for a 50 year drought,
        - Availability of water
        - Sprinklers and home spacing recommendations, use of sprinklers, use of sprinklers in attic spaces, exterior sprinklers (i.e. spacing and effectiveness, amount of varying unknowns)
        - Home spacing, relationship of fire size to home losses (large fires with minor home losses vs. small fires with huge home losses)

        - Industrial considerations
        - Other protection systems
        - Occupancy classifications

    - Hazard Mitigation Plans and Risk Analysis. The committee identified the need for the Task Group to explore the following:
        - Requires more detail
        - Potential for a workshop to feed suggestions into the standards (NFPA Staff to provide workshop update when available)

    - Evacuation. The committee identified the need for the Task Group to explore the following:
        - Wildland Urban Interface (WUI) information
        - Recent CA evacuation experiences
        - Elements of NFPA 1616 (NFPA Staff will bring to the attention of the NFPA 1616 Technical Committee)
        - Evacuation modeling
        - Road sizing
        - Ingress and egress,
        - Evacuation rates and life safety code information
        - Evacuation planning
        - Inability to evacuate,
        - Land use planning concepts (safe zones, temporary refuge etc.)
        - Built environment considerations
        - Modeling portion
        - Human factors

    - Industrial Urban Interface. The committee identified the need for the Task Group to explore the following:
        - Fort McMurray experiences

        - Nampak disasters
        - Economy and job related losses
        - Loss of employment and impact on the successful re-integration of the community
        - Community impact in general
        - Industrial aspect
        - Commercial aspect in NFPA 1144
        - Global concepts/issues
        - Infrastructure
        - Other types of facilities (i.e. storage, education, hospitals, agricultural)
        - Ignition prevention,
        - Hazards in relation to ignition sources
    - See Attachment B for a copy of the Task Group roster (as of 4/9/2019).
    - Staff identified Task Group Reports should be submitted by the Public Input Closing Dates (NFPA 1141 & NFPA 1142 6/26/2019, NFPA 1144 6/30/2020) *Note, due to Emergency Response and Responder Safety Consolidation Plan, this timeline has changed. Staff will provide a separate email outlining the new timeline.*
    - The committee chair provided other updates.

IX. Committee training was provided.

X. Date and location of next meeting:
    - November 4th - 15th, 2019.
    - Suggested locations include San Diego, CA, Denver, CO, Northern California, Santa Rosa, CA and Sacramento, CA.
      Note, although dates and locations where provided, these will be impacted by action taken at the April, 2019 Standards Council meeting. Staff will provide a separate email outlining the impact to the committee meeting.

XI. The meeting was adjourned at 1:51 pm (ET) on February 27th, 2019.

ATTACHMENT A

History of NFPA 1142 Table 4.6.1 “Minimum Capability of Fire Departments to Deliver Water”

Activity Summary Prepared by:

Muhammad Siddiq, Research Associate, Fire Protection Research Foundation
Lana Benny, Intern, Fire Protection Research Foundation
Anthony Capuano, Intern, National Fire Protection Association

Last Updated: 03/12/2019

Submitted to NFPA 1142 Task Group on Table for Water Requirements

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Summary

This document summarizes the history of NFPA 1142 Table 4.6.1 "Minimum Capability of Fire Departments to Deliver Water". This activity stemmed from a project statement form submitted by the NFPA 1142 Technical Committee. The original objective of this project request was to determine the validity of Table 4.6.1 in NFPA 1142. While providing an interim update to the task group (Nov 2017), the objective was modified to include historical information of the water supply rate equation.

This document references NFPA 25, *Water Systems for Rural Fire Protection*, NFPA 1231, *Suburban and Rural Fire Fighting*, NFPA 1142, *Standard on Water Supplies for Suburban and Rural Fire Fighting, and NFPA 1720 Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations and Special Operations to the Public by Volunteer Fire Departments*.

This document provides an overview of the evolution of this table throughout these documents. NFPA 1142 originated in 1968, however the code has had a series of identification number changes— it was first named NFPA 25, it was then renamed to NFPA 1231, and finally to NFPA 1142.

This document aims to provide a review of the table in question, its history and changes from the first edition of NFPA 25 to the current edition of NFPA 1142. This effort was initiated to evaluate the extent of scientific basis behind the delivery of water and water delivery rate for rural areas. The structure of this document is intended to provide a summary of the collected information, so that the reader is able to refer to the original documents to obtain further details.

This document also provides Appendix 1 – a presentation provided as an interim update to the task group, and Appendix 2 – a summary of this interim update meeting.

There was no substantive technical justification identified for the history of NFPA 1142 Table 4.6.1 during this review. Future research, in the form of experimental field testing, may be required to further justify the values currently provided in this table.

NFPA 25 1968 Edition

The 1968 edition of NFPA 25 was the original document *tentative recommendations* for water supply systems for rural fire protection.

Section II of NFPA 25 states the context for the need for water supplies in rural areas (page 25-4). The section states that water supplies in rural areas should be consistent with the anticipated Fire Load of the area. The section notes that fire loads in rural areas can be exceedingly variable. Though a specific quantity is not provided, the codes states, "…Provide the largest available volume of water discharge that can be afforded, at pressures necessary for the type of hose stream to be used…"

In Section III of NFPA 25, Water Supplies in Rural Areas were estimated using the following references:

- *Manual of Individual Water Supply Systems*[1]
- *Planning Water Systems*[2]

These documents were suggested to be referred when designing individual water supply systems.

Section 1(b) under Section III provides information about piping and system layout. The code states that hose connection should run around the perimeter of each building every 50 ft. In regards to pipe size for these should be adequate to permit a minimum of 2 ½ gallons per minute flow from the hose nozzle.

Figure 1 and Figure 3, on pages 25-8 and 25-9 respectively, should block and elevation diagrams of water system with intermediate storage. These are reproduced below:

[1] Manual of Individual Water Supply Systems— U.S. Public Health Service Water System and Treatment Handbook— Water Systems Council, Chicago, IL. (This is now an EPA document)
[2] Planning Water Systems— American Assn. of Agr. Eng & Vo. Ag., Athens, GA

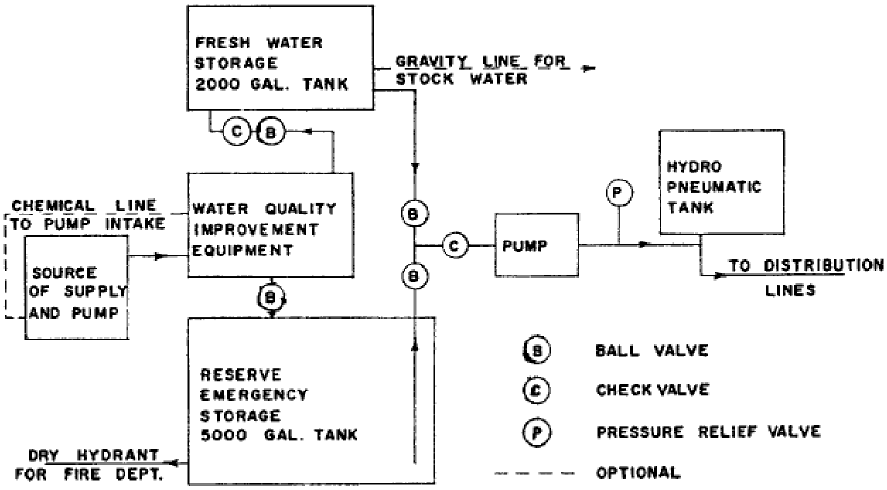

Fig. 1. Block diagram of water system with intermediate storage (see Fig. 3 for elevation sketch).

Figure 1 Figure Reproduced from Fig 1 (NFPA 25 1968) Block diagram of water system with intermediate storage

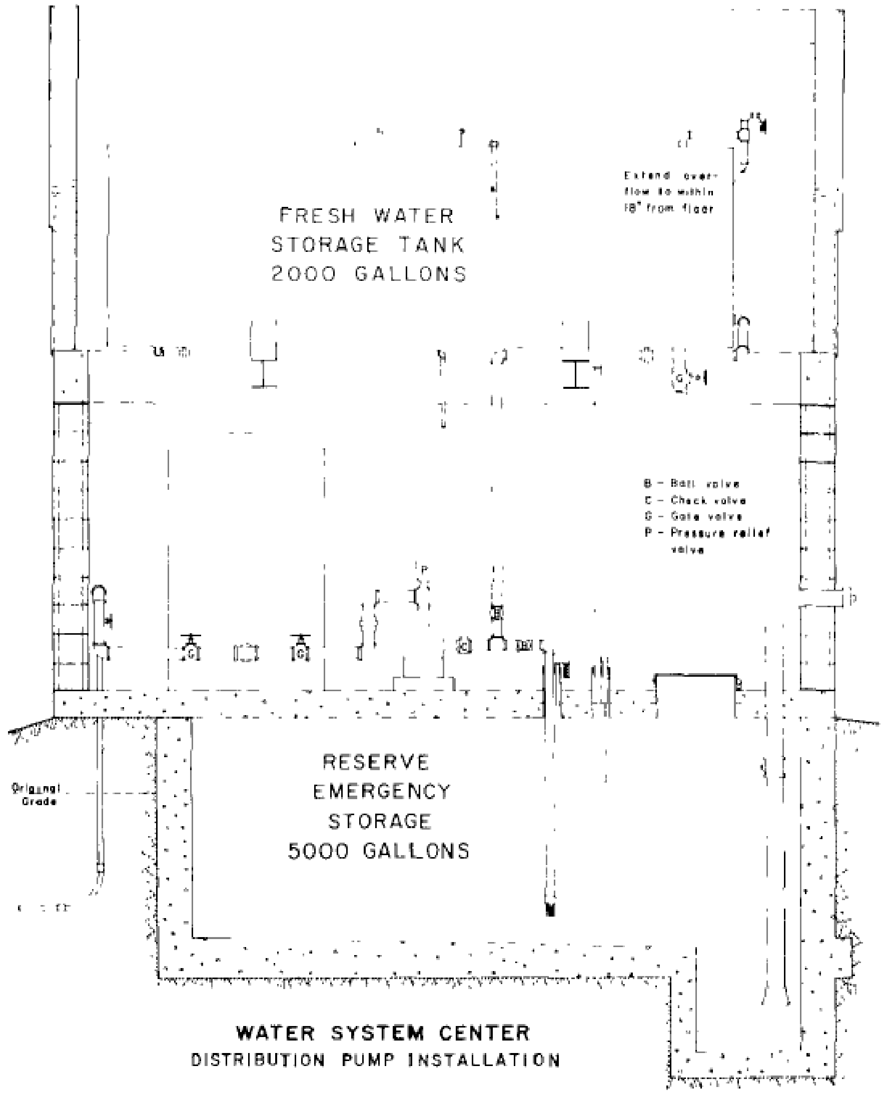

Fig. 3.

NOTE: Consult local fire department for dry fire hydrant thread.

Figure 2 Taken from NFPA 25 1968 – Reserve Emergency Storage

In these diagrams, the "Fresh Water Storage is a 2,000 gallon tank. The "Reserve Emergency Storage" is a 5000 gallon tank.

Section 1(c) under Section III provides information on Intermediate Water Storage[3]. The codes notes that, "Domestic, farm, or industrial use of water is not uniform throughout the 24-hour day." It is also acknowledged that the yield of storage capacity of wells are not sufficient to meet the demands of rural use. Keeping this in mind, the code has incorporated the concept of intermediate storage— defined as "atmospheric storage, with the free water surface at atmospheric pressure, located between the source

[3] Elmer Jones, Intermediate Water Supply Systems. U.S.D.A. Mimeo.

of supply and the distribution pump, and carefully planned and constructed to preserve water quality. Intermediate storage is in effect the source of supply for the distribution system." The conditions for how this may benefit firefighting in rural areas is provided on Page 25-11.

For the case of farmstead water systems design criteria is laid out on page 25-12. The section states that two storage tanks should be provided, one for fresh water storage, the other for reserve emergency storage. It is stated in the code that the fresh water storage tank should be able to operate at maximum capacity for 80 minutes. A mathematical relation is descried:

Storage volume (V_s) should be greater than the quantity multiplied by 80. The quantity is defined as the distribution pump capacity (Q_d) minus source pump capacity (Q_s). The reasoning provided for this is that this should allow replacing the distribution pump with a larger pump in the future, without having to replace the storage tank. The storage tank should have a service life of 3 or 4 times that of a pump. The recommendation for the minimum size of the tank is 2,000 gallons.

For the case of the reserve emergency storage, it should be equipped with a fire hydrant for use by the local fire department. The reserve emergency storage tank should hold enough water sufficient for two days' normal needs or 5,000 gallons of water for fire protection, whichever is larger. The code states that many farms should have more than this recommended minimum amount of water for fire protection.

Section 2 provides information on Water Supplies for Community Pumpers. Section (b) in Section 2 provides information on Water Source. Three sources are identified: flowing streams, ponds, and cisterns. For a stream, a flow rate of 250 gallons per minute or over at all times. If the capacity is less, then a bypass pond fed from the stream is preferable.

Section (d) provides information on Hydrant and Water-Pipe Supply Line. This section tabulated the Gallons Per Minute Flow at 20 Feet of Head in Table 1, reproduced below:

Table 1 Taken from NFPA 25 1968 Table 1 Gallons Per Minute Flow at 20 Feet of Head

Table 1. Gallons Per Minute Flow at 20 Feet of Head*

Length	*Steel Pipe (c = 120)*		*Cast Iron (c = 110)*		*Asbestos Cement (c = 130)*		*Bitum. Fiber (c = 120)*	
	4 in. dia.	*6 in. dia.*	*4 in. dia.*	*6 in. dia.*	*4 in. dia.*	*6 in. dia.*	*4 in. dia.*	*6 in. dia.*
25′	1100	3400	1040	3060	1240	3650	1100	3400
50′	790	2300	720	2100	850	2500	790	2300
100′	540	1600	500	1475	590	1700	540	1600
500′	225	660	200	615	250	720	225	660
1000′	150	460	145	425	170	495	150	460

*Based upon the Hazen-Williams formula with estimated values of C. Courtesy of Dr. Gilbert Levine.

The table may be used to determine pipe size of a given line basing the flow upon 10 psi or 20 feet of head. The values from this table are based upon the Hazen-Williams formula with estimated values of C.

Section III provides information on Emergency Wells (for Fighting Forest Fires). Section (b) Slip-on Tanker provides recommendations for slip-on tanker for moderate to heavy use from the rural-wildland stand point. The following specifications are listed

- 36 inches wide and 72 inches long
- 250 to 300 gallon capacity
- Pumper should be designed to be engine drive with a minimum capacity of 35 gallons per minute at 250 psi or higher; dry weight of pumper to be under 325 pounds; starter recommended.

It is suggested that smaller- or medium-sized slip-on tankers may be more appropriate in rough, steep terrain, and on low-standard roads. For these cases, capacity may range from 50 to 200 gallons, with a pump capacity to be 10-15 gallons per minute at 150 psi. The code further proceeds to state that portable pumpers may be excellent for fighting rural and wildland fires. For these pumpers, the range of output referenced is: 10 gallons per minute at 100 psi to 80 gallons per minute at 100 psi for these pumpers, the power of these engines is stated to be 3 to 18 horsepower at 3,400 revolutions per minute with an overall weight from 40 to 300 pounds. It is stated that these pumpers belong in the “Brush, Grass, Forest”- type of fire equipment which has been used successfully by forest protection agencies throughout the United States.

Sub-section (c) provides information on Tank Trucks, this section discusses motorized fire apparatus with tank capacity of 300 to 500 gallons. The pumping equipment provides a minimum of 500 gallons per minute. It is stated that this combination of vehicle is the backbone of the department’s firefighting ability. This section also states that departments are beginning to use a “mother” tanker (truck or semi-trailer) which has a capacity of 1,000 to 3,000 gallons to supply the pumper truck. It is noted that the 1,500 capacity for tankers should not be exceeded, the reasons for this limit are the weather and road conditions.

Additional information is provided in Section V Civil Defense Needs. In the sub-section (c) Water Supply and Requirements, the codes provides information in the case of National Emergency. Applicable to the project may be table: Water Requirements— Gallons per Animal Day, reproduced below:

Table 2 Taken from NFPA 25 1968 Water Requirements – Gallons Per Animal Day

Water Requirements — Gallons Per Animal Day

Animal	*Ample Supply Gal/Day*	*Limited Supply Gal/Day*
Cattle	17	7
Hogs	2.4	1.2
Poultry — layers and broilers	0.06	0.05
turkeys	0.30	0.12
Sheep	1.4	1.0

[From Proposed ASAE Standard Nuclear Radiation Protection Committee (FS-38)]

The table above represents the water requirement taken from Proposed ASAE Standard Nuclear Radiation Protection Committee (FS-38). No further elaboration on this table is provided.

Three Appendixes are provided in Section VII. Appendix B offers information on Proposed Standards for Water Supplies for Rural Fire Protection. Criteria is put forth as proposed values.

Class A is proposed as being equivalent to Municipal Hydrant. For water sources, a stream is suggested to maintain 500 gallons per minute at all times. For a pond or cistern, a minimum total capacity of 100,000 gallons is suggested, at a minimum depth of eight feet. For the pump cite, the capacity of hydrant and main is suggested to be 500 gallons per minute (keeping in mind that calculations assume not over 10 pounds vacuum.

Class B is proposed to be Intermediate between Class A and No Water. For water sources, a stream is suggested to maintain 250 gallons per minute at all times (3,750 gallons in 15 minutes). For a pond or cistern, a minimum total capacity of 3,000 gallons, or ½ gallon per dollar of property value.

Further, Appendix C County of Los Angeles Department of Forester and Fire Warden provides instructions for obtaining a Certificate of Availability for Fire Protection from the County of Los Angeles Department of Forester. This section provides information to fill out in an application to obtain a certificate of availability for fire protection. As part of this, the water utility has to meet Storage requirements for the amount of water storage to be reserved for fire protection. These values are tabulated in the Appendix, this table is reproduced below:

Table 3 Taken from NFPA 25 (1968) Storage Requirements for Certificate of Availability of Water for Fire Protection

Storage Requirements*
for
Certificate of Availability
of
Water for Fire Protection

One-Story Single Family Dwellings

Building Square Feet	*Amount of Water Storage to be Reserved for Fire Protection*
Up to 500	1,000 gallons
501 to 1,000	1,500 gallons
1,001 to 1,500	2,000 gallons
1,501 to 2,000	2,500 gallons
2,001 to 2,500	3,000 gallons
2,501 to 3,000	3,500 gallons
3,001 to 3,500	4,000 gallons
3,501 to 4,000	4,500 gallons
4,001 to 4,500	5,000 gallons

Include square footage in additional floor levels, attached garages, sheds, etc.

If water is to be hauled due to lack of well, add 500 gallons to total fire storage.

Water storage for other than single family dwellings will be determined on each individual request. Consideration to be given zoning, and actual use of buildings. (Commercial — Industrial — etc.)

*County of Los Angeles, California
Requirement for Building Permit if water not available from a utility.

It should be noted that these values are for One-Story Single Family Dwellings.

NFPA 25 1969 edition:

The 1969 edition of NFPA 25 was the first officially adopted code for Water Systems for Rural Fire Protection. This document is based on the 1968 tentative recommendations. The 1969 adopted code varies slightly from the tentative recommendations set forth in 1968. In general, the 1969 adoption does not vary much from the 1968 recommendations. This text provides a basic overview of water systems for rural fire protection and does not provide many calculations for water supply.

NFPA 1231 1975 edition:

At this point in history the code experienced a numbering change, changing from NFPA 25 to NFPA 1231. This action was under the committee reorganization, and is the official second edition of the Standard. In addition to renumbering, the title of the code changed from *Water Supply Systems for Rural Fire Protection* to *Water Supplies for Suburban and Rural Fire Fighting*. There are more equations relating to water supply, yet there is no table about the minimum capability of fire department to deliver water. There is no Technical Committee Documentation or Report about the transition from NFPA 25 to NFPA 1231.

As a note in Chapter 1, the Administration Section of the code, the code aims to identify the minimum requirements for water supplies for firefighting purposes in rural and suburban areas, especially in which adequate and reliable water supply systems for firefighting purposes do not exist. In the General section, it is stated that the requirements set forth in the standard are "…performance oriented and allow the authority having jurisdiction the option of how to make these water supplies available…" These requirements should be appropriated with consideration given to local conditions.

The code introduces the concept of Occupancy Hazard Classification Number. Per Appendix A-3.2, the Occupancy Hazard Classification Number is a mathematical factor to be used in calculating water supplies. No basis is provided for these numbers, which range from 3 to 7. No technical basis had been provided for this Occupancy Hazard Classification Number except for examples of which occupancies may this be applied towards.

Chapter 4, Determining Total Water Supplies provides information on water supply and calculations relating to water supply.

Section 4-2 outlines requirements for Single- and Two-family dwellings that are 1,200 square feet and under. The total water supply shall not be less than 2,000 gallons (4-2.1). For the rate of the supply, the available rate shall not be less than 500 gallons per minute (GPM) (4-2.2).

Section 4-3 outlines requirements for all types of structures, except dwellings specific in Section 4-2.2. The code states that the total water supply shall be in line with the total cubic footage of the structure, including any attached structures. Section 4-3.1 references an example calculation provided in Appendix A-4-3.1 Example of Calculating Total Water Supply, reproduced below are the equations:

Area = Length x Breadth [m^2]
Total height = Height of each story + Height from attic floor + Consider pitch roof (½ the distance from attic floor to ridge pole) [m]
Volume of structure = Area x Total Height [m^3]
Identify Occupational Hazard Number from section 3-2

$$\text{Total water supply [gallons]} = \frac{Volume\ of\ structure\ [m^3]}{Occupancy\ Hazard\ Classification}$$

The factors used in this equation are the Occupancy Hazard Classification Number, the total Area, and Height. Per Appendix A-2-1.1, the following is required to compute the total water supplies to be collected during the building survey:

a) Area of all floors, including attics, basements and crawl spaces
b) Height between floors or crawl spaces and in the attics from floor to ridge pole
c) Construction materials used in each building, including walls floors, roofs, ceilings, interior partitions, stairs, etc.
d) Occupancy (occupancies) of buildings
e) Occupancy (occupancies of buildings
f) Exposures to building and yard storage and distances between them
g) Fire protection systems – automatic and manual protection systems, hydrants, yard mains, and other protection facilities
h) On-premises water supplies including natural and man-made sources of water

Examples of calculations for Residential, Industrial and Assembly occupancies are provided. The total water supply required cannot be less than 2,000 gallons (4-3.2). Cases for which the total water supply is from 2,000 gallons through 19,999 gallons, determined from the equation in 4-3.1, cannot be provided at a rate less than 500 GPM. For cases where the total calculated water supply is 20,000 or greater, the rate cannot be less than 1,000 GPM (4-3.4). The code states that for special cases, the water supply shall be determined with consideration given to the number of fire streams required, and by multiplying the estimated total application rate in GPM by "… a liberal estimate of time in minutes..," of 60 minutes or more.

Section 4-4 provides information on Structures with Exposure Hazards. For Single- and Two-family Dwellings, 1,200 square feet and under, the total water supply shall not be less than 3,000 gallons (4-4.1). The total water supply shall also meet the requirements specified in 4-2.2. For the case of all structures, except dwellings, the total water supply is calculated similar to that in Section 4-3, except that the quotient is multiplied by 1.5. The total water supply cannot be less than 3,000. Example of Calculating Total Water Supply [with exposure hazards], is reproduced below:

Area = Length x Breadth [m^2]
Total height = Height of each story + Height from attic floor + Consider pitch roof (½ the distance from attic floor to ridge pole) [m]
Volume of structure = Area x Total Height [m^3]
Identify Occupational Hazard Number from section 3-2

$$\text{Total water supply [gallons]} = \frac{Volume\ of\ structure\ [m^3]}{Occupancy\ Hazard\ Classification} \times 1.5$$

Chapter 5 Water Supply, provides brief guidelines on water supply. The code states that water may be supplied from a wide range of sources including, rivers, streams, irrigation canals, lakes, ponds, cisterns, livestock watering tanks, etc. The section states that this may require pumping operations. In general, Chapter 5 refers to sections 4-2.2, 4-3.2, 4-3.4. 4-4.1.2, and 4-4.2.4.

NFPA 1231 1984 edition:

NFPA 1231 1984 Edition is the third official edition of the standard. On the topic of Delivery of Water, this edition provides Table 5-5.1(a) Pre-calculated Minimum Water Supplies by Occupancy Hazard and Construction Classification. Table 5-5.1(b) Minimum Water Requirements (Examples) and Table 5-5.1(c) Minimum Capability of Fire department to Transport and to Use Water were created and Appendix A from Appendix A from NFPA 1232 1975 Edition was removed. Table 5-5.1(a) is reproduced below in its entirety:

Table 4 Taken from Table 5.5.1(a) Pre-calculated Minimum Water Supplies by Occupancy Hazard and Construction Classification

Table 5-5.1(a) Precalculated Minimum Water Supplies by Occupancy Hazard and Construction Classification.
(no exposures)

Occupancy Hazard Class.	3				4				5				6				7			
Construction Class.	.5	.75	1.0	1.5	.5	.75	1.0	1.5	.5	.75	1.0	1.5	.5	.75	1.0	1.5	.5	.75	1.0	1.5
Cubic Feet	*Gallons*				*Gallons*				*Gallons*				*Gallons*				*Gallons*			
8,000		2,000	2,667	4,000			2,000	3,000				2,400				2,000				
12,000	2,000	3,000	4,000	6,000		2,250	3,000	4,500			2,400	3,600			2,000	3,000				2,571
16,000	2,667	4,000	5,333	8,000	2,000	3,000	4,000	6,000		2,400	3,200	4,800		2,000	2,667	4,000			2,286	3,429
20,000	3,333	5,000	6,667	10,000	2,500	3,750	5,000	7,500	2,000	3,000	4,000	6,000		2,500	3,333	5,000		2,143	2,857	4,286
24,000	4,000	6,000	8,000	12,000	3,000	4,500	6,000	9,000	2,400	3,600	4,800	7,200	2,000	3,000	4,000	6,000		2,571	3,429	5,143
28,000	4,667	7,000	9,333	14,000	3,500	5,250	7,000	10,500	2,800	4,200	5,600	8,400	2,333	3,500	4,667	7,000	2,000	3,000	4,000	6,000
32,000	5,333	8,000	10,667	16,000	4,000	6,000	8,000	12,000	3,200	4,800	6,400	9,600	2,667	4,000	5,333	8,000	2,286	3,429	4,571	6,857
36,000	6,000	9,000	12,000	18,000	4,500	6,750	9,000	13,500	3,600	5,400	7,200	10,800	3,000	4,500	6,000	9,000	2,572	3,857	5,143	7,714
40,000	6,667	10,000	13,333	20,000	5,000	7,500	10,000	15,000	4,000	6,000	8,000	12,000	3,333	5,000	6,667	10,000	2,857	4,286	5,714	8,571
44,000	7,333	11,000	14,667	22,000	5,500	8,250	11,000	16,500	4,400	6,600	8,800	13,200	3,667	5,500	7,333	11,000	3,143	4,714	6,286	9,429
48,000	8,000	12,000	16,000	24,000	6,000	9,000	12,000	18,000	4,800	7,200	9,600	14,400	4,000	6,000	8,000	12,000	3,429	5,143	6,857	10,286
52,000	8,667	13,000	17,333	26,000	6,500	9,750	13,000	19,500	5,200	7,800	10,400	15,600	4,333	6,500	8,667	13,000	3,715	5,571	7,429	11,143
56,000	9,333	14,000	18,667	28,000	7,000	10,500	14,000	21,000	5,600	8,400	11,200	16,800	4,667	7,000	9,333	14,000	4,000	6,000	8,000	12,000
60,000	10,000	15,000	20,000	30,000	7,500	11,250	15,000	22,500	6,000	9,000	12,000	18,000	5,000	7,500	10,000	15,000	4,286	6,429	8,571	12,857
64,000	10,667	16,000	21,333	32,000	8,000	12,000	16,000	24,000	6,400	9,600	12,800	19,200	5,333	8,000	10,667	16,000	4,572	6,857	9,143	13,714
68,000	11,333	17,000	22,667	34,000	8,500	12,750	17,000	25,500	6,800	10,200	13,600	20,400	5,667	8,500	11,333	17,000	4,857	7,286	9,714	14,571
72,000	12,000	18,000	24,000	36,000	9,000	13,500	18,000	27,000	7,200	10,800	14,400	21,600	6,000	9,000	12,000	18,000	5,143	7,714	10,286	15,429
76,000	12,667	19,000	25,333	38,000	9,500	14,250	19,000	28,500	7,600	11,400	15,200	22,800	6,333	9,500	12,667	19,000	5,429	8,143	10,857	16,286
80,000	13,333	20,000	26,667	40,000	10,000	15,000	20,000	30,000	8,000	12,000	16,000	24,000	6,667	10,000	13,333	20,000	5,715	8,571	11,429	17,143
84,000	14,000	21,000	28,000	42,000	10,500	15,750	21,000	31,500	8,400	12,600	16,800	25,200	7,000	10,500	14,000	21,000	6,000	9,000	12,000	18,000
88,000	14,667	22,000	29,333	44,000	11,000	16,500	22,000	33,000	8,800	13,200	17,600	26,400	7,333	11,000	14,667	22,000	6,286	9,429	12,571	18,857
92,000	15,333	23,000	30,667	46,000	11,500	17,250	23,000	34,500	9,200	13,800	18,400	27,600	7,667	11,500	15,333	23,000	6,572	9,857	13,143	19,714
96,000	16,000	24,000	32,000	48,000	12,000	18,000	24,000	36,000	9,600	14,400	19,200	28,800	8,000	12,000	16,000	24,000	6,857	10,286	13,714	20,571
100,000	16,667	25,000	33,333	50,000	12,500	18,750	25,000	37,500	10,000	15,000	20,000	30,000	8,333	12,500	16,667	25,000	7,143	10,714	14,286	21,429
104,000	17,333	26,000	34,667	52,000	13,000	19,500	26,000	39,000	10,400	15,600	20,800	31,200	8,667	13,000	17,333	26,000	7,429	11,143	14,857	22,286
108,000	18,000	27,000	36,000	54,000	13,500	20,250	27,000	40,500	10,800	16,200	21,600	32,400	9,000	13,500	18,000	27,000	7,715	11,571	15,429	23,143
112,000	18,667	28,000	37,333	56,000	14,000	21,000	28,000	42,000	11,200	16,800	22,400	33,600	9,333	14,000	18,667	28,000	8,000	12,000	16,000	24,000
116,000	19,333	29,000	38,667	58,000	14,500	21,750	29,000	43,500	11,600	17,400	23,200	34,800	9,667	14,500	19,333	29,000	8,286	12,429	16,571	24,857
120,000	20,000	30,000	40,000	60,000	15,000	22,500	30,000	45,000	12,000	18,000	24,000	36,000	10,000	15,000	20,000	30,000	8,572	12,857	17,143	25,714
124,000	20,667	31,000	41,333	62,000	15,500	23,250	31,000	46,500	12,400	18,600	24,800	37,200	10,333	15,500	20,667	31,000	8,857	13,286	17,714	26,571
128,000	21,333	32,000	42,667	64,000	16,000	24,000	32,000	48,000	12,800	19,200	25,600	38,400	10,667	16,000	21,333	32,000	9,143	13,714	18,286	27,429
132,000	22,000	33,000	44,000	66,000	16,500	24,750	33,000	49,500	13,200	19,800	26,400	39,600	11,000	16,500	22,000	33,000	9,429	14,143	18,857	28,286
136,000	22,667	34,000	45,333	68,000	17,000	25,500	34,000	51,000	13,600	20,400	27,200	40,800	11,333	17,000	22,667	34,000	9,715	14,571	19,429	29,143
140,000	23,333	35,000	46,667	70,000	17,500	26,250	35,000	52,500	14,000	21,000	28,000	42,000	11,667	17,500	23,333	35,000	10,000	15,000	20,000	30,000
144,000	24,000	36,000	48,000	72,000	18,000	27,000	36,000	54,000	14,400	21,600	28,800	43,200	12,000	18,000	24,000	36,000	10,286	15,429	20,571	30,857
148,000	24,667	37,000	49,333	74,000	18,500	27,750	37,000	55,500	14,800	22,200	29,600	44,400	12,333	18,500	24,667	37,000	10,572	15,857	21,143	31,714
152,000	25,333	38,000	50,667	76,000	19,000	28,500	38,000	57,000	15,200	22,800	30,400	45,600	12,667	19,000	25,333	38,000	10,857	16,286	21,714	32,571
156,000	26,000	39,000	52,000	78,000	19,500	29,250	39,000	58,500	15,600	23,400	31,200	46,800	13,000	19,500	26,000	39,000	11,143	16,714	22,286	33,429
160,000	26,667	40,000	53,333	80,000	20,000	30,000	40,000	60,000	16,000	24,000	32,000	48,000	13,333	20,000	26,667	40,000	11,429	17,143	22,857	34,286

Note: For structures with exposures, multiply results by 1.5 for water supply requirements.

SI units: 1 gal = 3.785 L; 1 cu ft = 0.0283 m³

Table 5-5.1(a) Continued.

Occupancy*	3				4				5				6				7			
Construction**	.5	.75	1.0	1.5	.5	.75	1.0	1.5	.5	.75	1.0	1.5	.5	.75	1.0	1.5	.5	.75	1.0	1.5
Cubic Feet	*Gallons*				*Gallons*				*Gallons*				*Gallons*				*Gallons*			
175,000	29,167	43,750	58,333	87,500	21,875	32,813	43,750	65,625	17,500	26,250	35,000	52,500	14,583	21,875	29,167	43,750	12,500	18,750	25,000	37,500
200,000	33,333	50,000	66,667	100,000	25,000	37,500	50,000	75,000	20,000	30,000	40,000	60,000	16,667	25,000	33,333	50,000	14,286	21,429	28,571	42,857
225,000	37,500	56,250	75,000	112,500	28,125	42,188	56,250	84,375	22,500	33,750	45,000	67,500	18,750	28,125	37,500	56,250	16,071	24,107	32,143	48,214
250,000	41,667	62,500	83,333	125,000	31,250	46,875	62,500	93,750	25,000	37,500	50,000	75,000	20,833	31,250	41,667	62,500	17,857	26,786	35,714	53,571
275,000	45,833	68,750	91,667	137,500	34,375	51,563	68,750	103,125	27,500	41,250	55,000	82,500	22,917	34,375	45,833	68,750	19,643	29,464	39,286	58,929
300,000	50,000	75,000	100,000	150,000	37,500	56,250	75,000	112,500	30,000	45,000	60,000	90,000	25,000	37,500	50,000	75,000	21,429	32,143	42,857	64,286
325,000	54,167	81,250	108,333	162,500	40,625	60,938	81,250	121,875	32,500	48,750	65,000	97,500	27,083	40,625	54,167	81,250	23,214	34,821	46,429	69,643
350,000	58,333	87,500	116,667	175,000	43,750	65,625	87,500	131,250	35,000	52,500	70,000	105,000	29,167	43,750	58,333	87,500	25,000	37,500	50,000	75,000
375,000	62,500	93,750	125,000	187,500	46,875	70,313	93,750	140,625	37,500	56,250	75,000	112,500	31,250	46,875	62,500	93,750	26,786	40,179	53,571	80,357
400,000	66,667	100,000	133,333	200,000	50,000	75,000	100,000	150,000	40,000	60,000	80,000	120,000	33,333	50,000	66,667	100,000	28,571	42,857	57,143	85,714
425,000	70,833	106,250	141,667	212,500	53,125	79,688	106,250	159,375	42,500	63,750	85,000	127,500	35,417	53,125	70,833	106,250	30,357	45,536	60,714	91,071
450,000	75,000	112,500	150,000	225,000	56,250	84,376	112,500	168,750	45,000	67,500	90,000	135,000	37,500	56,250	75,000	112,500	32,143	48,214	64,286	96,429
475,000	79,167	118,750	158,333	237,500	59,375	89,063	118,750	178,125	47,500	71,250	95,000	142,500	39,583	59,375	79,167	118,750	33,929	50,893	67,857	101,786
500,000	83,333	125,000	166,667	250,000	62,500	93,751	125,000	187,500	50,000	75,000	100,000	150,000	41,667	62,500	83,333	125,000	35,714	53,571	71,429	107,143
525,000	87,500	131,250	175,000	262,500	65,625	98,438	131,250	196,875	52,500	78,750	105,000	157,500	43,750	65,625	87,500	131,250	37,500	56,250	75,000	112,500
550,000	91,667	137,500	183,333	275,000	68,750	103,126	137,500	206,250	55,000	82,500	110,000	165,000	45,833	68,750	91,667	137,500	39,286	58,929	78,571	117,857
575,000	95,833	143,750	191,667	287,500	71,875	107,813	143,750	215,625	57,500	86,250	115,000	172,500	47,917	71,875	95,833	143,750	41,071	61,607	82,143	123,214
600,000	100,000	150,000	200,000	300,000	75,000	112,501	150,000	225,000	60,000	90,000	120,000	180,000	50,000	75,000	100,000	150,000	42,857	64,286	85,714	128,571
625,000	104,167	156,250	208,333	312,500	78,125	117,188	156,250	234,375	62,500	93,750	125,000	187,500	52,083	78,125	104,167	156,250	44,643	66,964	89,286	133,929
650,000	108,333	162,500	216,667	325,000	81,250	121,876	162,500	243,750	65,000	97,500	130,000	195,000	54,167	81,250	108,333	162,500	46,429	69,643	92,857	139,286
675,000	112,500	168,750	225,000	337,500	84,375	126,563	168,750	253,125	67,500	101,250	135,000	202,500	56,250	84,375	112,500	168,750	48,214	72,321	96,429	144,643
700,000	116,667	175,000	233,333	350,000	87,500	131,251	175,000	262,500	70,000	105,000	140,000	210,000	58,333	87,500	116,667	175,000	50,000	75,000	100,000	150,000
725,000	120,833	181,250	241,667	362,500	90,625	135,938	181,250	271,875	72,500	108,750	145,000	217,500	60,417	90,625	120,833	181,250	51,786	77,679	103,571	155,357
750,000	125,000	187,500	250,000	375,000	93,750	140,626	187,500	281,250	75,000	112,500	150,000	225,000	62,500	93,750	125,000	187,500	53,571	80,357	107,143	160,714
775,000	129,167	193,750	258,333	387,500	96,875	145,313	193,750	290,625	77,500	116,250	155,000	232,500	64,583	96,875	129,167	193,750	55,357	83,036	110,714	166,071
800,000	133,333	200,000	266,667	400,000	100,000	150,001	200,000	300,000	80,000	120,000	160,000	240,000	66,667	100,000	133,333	200,000	57,143	85,714	114,286	171,429
825,000	137,500	206,250	275,000	412,500	103,125	154,688	206,250	309,375	82,500	123,750	165,000	247,500	68,750	103,125	137,500	206,250	58,929	88,393	117,857	176,786
850,000	141,667	212,500	283,333	425,000	106,250	159,376	212,500	318,750	85,000	127,500	170,000	255,000	70,833	106,250	141,667	212,500	60,714	91,071	121,429	182,143
875,000	145,833	218,750	291,667	437,500	109,375	164,064	218,750	328,125	87,500	131,250	175,000	262,500	72,917	109,375	145,833	218,750	62,500	93,750	125,000	187,500
900,000	150,000	225,000	300,000	450,000	112,500	168,751	225,000	337,500	90,000	135,000	180,000	270,000	75,000	112,500	150,000	225,000	64,286	96,429	128,571	192,857
925,000	154,167	231,250	308,333	462,500	115,265	173,439	231,250	346,875	92,500	138,750	185,000	277,500	77,083	115,625	154,167	231,250	66,071	99,107	132,143	198,214
950,000	158,333	237,500	316,667	475,000	118,750	178,126	237,500	356,250	95,000	142,500	190,000	285,000	79,167	118,750	158,333	237,500	67,857	101,786	135,714	203,571
975,000	162,500	243,750	325,000	487,500	121,875	182,814	243,750	365,625	97,500	146,250	195,000	292,500	81,250	121,875	162,500	243,750	69,643	104,464	139,286	208,929
1,000,000	166,667	250,000	333,333	500,000	125,000	187,501	250,000	375,000	100,000	150,000	200,000	300,000	83,333	125,000	166,667	250,000	71,429	107,143	142,857	214,286

*Occupancy Hazard Classification

**Construction Classification

Note: For structures with exposures, multiply results by 1.5 for water supply requirements.

SI units: 1 gal = 3.785 L; 1 cu ft = 0.0283 m^3

Table 5 Taken from Table 5-5.1(c) Minimum Capability of Fire Department to Transport and to Use Water

Table 5-5.1(c)

Minimum Capability of Fire Department to Transport and to Use Water

Total Water Supply Required (Gallons)	Rate Water Is Available to Fireground and Fire Department's Capability for Using Water (GPM)
up to 2,499 (up to 9459 L)	250 (946 L/min)
2,500 to 9,999 (9460 L to 37 849 L)	500 (1893 L/min)
10,000 to 19,999 (37 850 L to 75 699 L)	750 (2839 L/min)
20,000 or more (75 700 L)	1000 (3785 L/min)

It is noted that the table is nearly identical to Table 4.6.1 in NFPA 1142 2012 Edition. From the years 1975 to 1984 there were no comments regarding this table in the Technical Committee Documentation- Fall or Technical Committee Report- Fall.

Chapter 5, Determining Total Water Supplies provides information on water supply and calculations relating to water supply. This section introduces more equations than the previous editions of this code.

Section 5-2 addresses Structurers without Exposure Hazards, maintaining the same requirements as the previous edition. The equation provided to calculate the minimum water supply (5-2.1.1) is below:

Equation:

$$\text{Minimum water supply} = \frac{Total\ Cu\ Ft.of\ structure}{Occupancy\ Hazard\ Classification} * Construction\ Classification\ No.$$

The concept of Construction Classification Number is a new addition to the equations. It is stated that the authority having jurisdiction should assign the particular building a construction classification number. The construction classification number is referenced from NFPA 220, Standard on Types of Building Construction. This number is significant as it is used to find the appropriate values in Table 5-5.1(a).

The total water supply for these dwellings cannot be less than 2,000 gallons. The total water supply calculations use Table 5-5.1(b) Minimum Water Requirements (Examples). The following table should be used to determine the water supply that may be required on the fireground (5-2.1.3).

Table 6 Taken from NFPA 1231 (1984) Table 5-5.1(b) Minimum Water Requirements

Table 5-5.1(b)
Minimum Water Requirements
(Examples)

Structure Without Exposures

Paragraph	Type of Occupancy	Min. Gal. Water
5-2.1.2	1 & 2 Family Dwellings 1200 sq ft (111.8 m^2) or less	2,000 (7570 L)
5-2.2.2	All structures, except dwellings	2,000 (7570 L)

Structure With Exposures

Paragraph	Type of Occupancy	Min. Gal. Water
5-3.1.2	1 & 2 Family Dwellings 1200 sq ft (111.8 m^2) or less	3,000 (11 355 L)
5-3.2.2	All structures, except dwellings	3,000 (11 355 L)

Multiple Structures - Single Water Point

Paragraph	Type of Occupancy	Min. Gal. Water
5-4.4	All Structures, with or without exposures	3,000 (11 355 L)

For all structurers except dwellings, without exposure hazards, the following equation is provided (5-2.2.1):

$$\text{Minimum water supply } = \frac{Total\ Cu\ Ft.of\ structure}{Occupancy\ Hazard\ Classification} * Construction\ Classification\ No.$$

The minimum water supply required cannot be less than 2,000 gallons (5-2.2.2). The minimum water supply calculations use Table 5-5.1(c).

Section 5-3 addresses Structures with Exposure Hazards. For Single- and two-family dwellings, 1,200 square feet or under, the following equation is used (5-3.1.1):

$$\text{Minimum water supply } = \frac{Total\ Cu\ Ft.of\ structure}{Occupancy\ Hazard\ Classification} * Construction\ Classification\ No. * 1.5$$

For structures with exposure hazards, it is required that there be no less than 3,000 gallons (5-3.1.2). The minimum water supply calculations use Table 5-5.1(c).

For all structures except dwellings, without exposure hazards, section 5-3.2.1 provides the following equation:

$$\text{Minimum water supply } = \frac{Total\ Cu\ Ft.of\ structure}{Occupancy\ Hazard\ Classification} * Construction\ Classification\ No. * 1.5$$

The total water supply required cannot be less than 3,000 gallons (5-3.2.2). The minimum water supply calculations use Table 5-5.1(c) (5-3.2.3).

Section 5-4 addresses Multiple Structures— Single water Point. This section is for structurers that are close enough together that they may be served from a single water point. Water supply computed from structure with largest total water supply requirement. The following equation is provided (5-4.2):

$$\text{Minimum water supply } = \frac{Total\ Cu\ Ft.of\ structure}{Occupancy\ Hazard\ Classification} * Construction\ Classification\ No.$$

For structures with unattached structural exposure hazards closer than 50 feet to any portion of the structure larger than 100 square feet, the following equation should be used (5-2.2):

$$\text{Minimum water supply } = \frac{Total\ Cu\ Ft.of\ structure}{Occupancy\ Hazard\ Classification} * Construction\ Classification\ No. * 1.5$$

The total water supply must not be less than 3,000 gallons (5-4.4). The minimum water supply calculations use Table 5-5.1(c).

Section 5-5 addresses Special Fire Protection Problems. The authority having jurisdiction may waive any requirement for additional water supply required by the standard (5-6.1). For structurers with an automatic sprinkler system that does not meet the requirements of NFPA 13, the total water supply may be reduced by the authority having jurisdiction to that of Section 5-2, 5-3, or 5-4, as applicable.

Section 5-7 addresses Structures with Other Automatic Fire Suppression System. The code states that fully or partially automatic fire suppression protected structures the fire department having jurisdiction shall determine the total water supply required for firefighting purpose.

In Chapter 6 Water Supply, the code suggests that sources of water may be either natural or man-made, the same list of sources are provided as in Chapter 5 of the previous edition. Transferring of water from the water source can be done by a number of methods, such as tanker shutters, pumper relays, etc. Additional information is provided in Appendices C, D, and E. Appendix C provides detailed information on Water Hauling methods, Appendix D provides detailed information on using Large Diameter Hose, and Appendix E provides detailed information on Portable Pumps. The total water supply must meet the requirements set forth in Chapter 5 of the code (6-3).

NFPA 1231 1989 edition:

This code is the fourth official revision to NFPA 1231. There were no comments in the 1989 Technical Committee Documentation- Annual about the Table 5-9.1(c).

One of the main change in this standard is the changing of sections of the previous tables. Table 5-9.1(a) Pre-calculated Minimum Water Supplies by Occupancy Hazard and Construction Classification , Table 5-9.1(b) Minimum Water Requirements (Examples) , and Table 5-9.1(a) Minimum Capability of Fire Department to Transport and to Use Water have changed sections from the previous edition; previously these tables were in section 5-5.1 (a), (b), and (c), respectively. Of these tables, Table 5-9.1(b) has experienced changes— there has been a change in Type of Occupancy and Minimum Gallons of water.

The changes in Type of Occupancy include changing the 1 & 2 family dwellings to single structures (with and without exposures). It may be important to note that this change is only in the name of the classification as in the respective appendix sections, single structures have been referred to as one and two-family dwellings.

The equations for determining minimum water supplies have not been changed in any way. The following equation is used for *single structures without exposure hazards* (5-2.1):

$$\text{Minimum water supply } = \frac{Total\ Cu\ Ft.of\ structure}{Occupancy\ Hazard\ Classification} * Construction\ Classification\ No.$$

The total water supply is required to be no less than 2,000 gallons, referencing Table 5-9.1(a) (5-2.1.1). Minimum water supply calculation should use Table 5-9.1(c).

For the case of single structures with exposure hazards, the following equation is used (5-3.1):

$$\text{Minimum water supply } = \frac{Total\ Cu\ Ft.of\ structure}{Occupancy\ Hazard\ Classification} * Construction\ Classification\ No. * 1.5$$

The total water supply is required to be no less than 3,000 gallons (5-3.1.1). Minimum water supply calculation should use Table 5-9.1(c) (5-3.1.2).

For Multiple Structures that may be served from a single water point, without exposure hazards, Section 5-4.1.2 gives the following equation:

$$\text{Minimum water supply } = \frac{Total\ Cu\ Ft.of\ structure}{Occupancy\ Hazard\ Classification} * Construction\ Classification\ No.$$

The total water supply may not be less than 3,000 gallons (5-4.1.1). The minimum water supply calculation uses T rate specified in 5-9.1(c).

For multiple structures that may be served from a single water point, with exposure hazards, Section 5-5.1 gives the following equation:

$$\text{Minimum water supply} = \frac{Total\ Cu\ Ft.of\ structure}{Occupancy\ Hazard\ Classification} * Construction\ Classification\ No. * 1.5$$

The total water supply required cannot be less than 3,000 gallons (5-5.1.1). The minimum water supply calculation should refer to Table 5-9.1(c).

Section 5-6 addresses Special Fire Protection Problems. This section topic has changed from the previous edition by stating that the code does not intend to provide details for calculating water for special fire problems.

For structures with an automatic sprinkler system that does not meet the requirements of NFPA 13, the total water supply may be reduced by the authority having jurisdiction to that of Section 5-2, 5-3, or 5-4, as applicable (Section 5-7).

Section 5-8 addresses Structures with Other Automatic Fire Suppression System. The code states that fully or partially automatic fire suppression protected structures the fire department having jurisdiction shall determine the total water supply required for firefighting purpose.

In Chapter 6 Water Supply, the code suggests that sources of water may be either natural or man-made, the same list of sources are provided as in Chapter 5 of the previous edition. Transferring of water from the water source can be done by a number of methods, such as tanker shutters, pumper relays, etc. Additional information is provided in Appendices C, D, and E. Appendix C provides detailed information on Water Hauling methods, Appendix D provides detailed information on using Large Diameter Hose, and Appendix E provides detailed information on Portable Pumps. The total water supply must meet the requirements set forth in Chapter 5 of the code (6-3).

NFPA 1231 1993 edition:

This is the fifth official edition of NFPA 1231. Overall there have been slight changes in numbering and the total water supply and delivery rates have not changed much. In previous editions, the mathematical relationships were presented using "Total Cu Ft of Structure." In the 1993 edition, the mathematical relationships are also presented using "m^3" notation.

The major change in this edition is the organization of the tables. The three tables were in section 5-9.1 in the previous edition, but the 1993, subsection 5-9.1 has been merged as part of 5-9 altogether. Of the three tables to note, Table 5-9(c) Minimum Capability of Fire Department to Transport and to Use Water has been cleaned up. This table is reproduced below:

Table 7 Taken from NFPA 1231 (1993) Table 5-9(C) Minimum Capability of Fire Department to Transport and Use Water

Table 5-9(c) Minimum Capability of Fire Department to Transport and to Use Water

Total Water Supply Required (gallons)	Rate Water Is Available to Fireground and Fire Department's Capability for Using Water (gal/m)
up to 2499 (9459 L)	250 (946 L/min)
2500 to 9999 (9460 L to 37 849 L)	500 (1893 L/min)
10,000 to 19,999 (37 850 L to 75 699 L)	750 (2839 L/min)
20,000 or more (75 700 L)	1000 (3785 L/min)

The equations for determining minimum water supplies have not been changed in any way. The following equation is used for *single structures without exposure hazards* (5-2.1):

$$\text{Minimum water supply } = \frac{Total\ ft^3(m^3)\ of\ structure}{Occupancy\ Hazard\ Classification} * Construction\ Classification\ No.$$

The total water supply is required to be no less than 2,000 gallons, referencing Table 5-9 (a) (5-2.1.1). Total water supply calculation should use Table 5-9(c).

For the case of single structures with exposure hazards, the following equation is used (5-3.1):

$$\text{Minimum water supply } = \frac{Total\ ft^3(m^3)\ of\ structure}{Occupancy\ Hazard\ Classification} * Construction\ Classification\ No. * 1.5$$

The total water supply is required to be no less than 3,000 gallons (5-3.1.1). Minimum water supply calculation should use Table 5-9.1(c) (5-3.1.2).

For Multiple Structures that may be served from a single water point, without exposure hazards, Section 5-4.1 gives the following equation:

$$\text{Minimum water supply } = \frac{Total\, ft^3(m^3)\ \ of\ structure}{Occupancy\ Hazard\ Classification} * Construction\ Classification\ No.$$

The total water supply may not be less than 3,000 gallons (5-4.1.1). The minimum water supply calculation uses the rate specified in 5-9.1(c).

For multiple structures that may be served from a single water point, with exposure hazards, Section 5-5.1 gives the following equation:

$$\text{Minimum water supply } = \frac{Total\ Cu\ Ft. of\ structure}{Occupancy\ Hazard\ Classification} * Construction\ Classification\ No. * 1.5$$

The total water supply required cannot be less than 3,000 gallons (5-5.1.1). The minimum water supply calculation should refer to Table 5-9 (c) (5-5.1.2).

Section 5-6 addresses Special Fire Protection Problems. This section topic has changed from the previous edition by stating that the code does not intend to provide details for calculating water for special fire problems.

For structurers with an automatic sprinkler system that does not meet the requirements of NFPA 13, the total water supply may be reduced by the fire department having jurisdiction to that of Section 5-2, 5-3, or 5-4, as applicable (Section 5-7).

Section 5-8 addresses Structures with Other Automatic Fire Suppression System. The code states that fully or partially automatic fire suppression protected structures the fire department having jurisdiction shall determine the total water supply required for firefighting purpose.

In Chapter 6 Water Supply, the code suggests that sources of water may be either natural or man-made, the same list of sources are provided as in Chapter 5 of the previous edition. Transferring of water from the water source can be done by a number of methods, such as tanker shutters, pumper relays, etc. Additional information is provided in Appendices C, D, and E. Appendix C provides detailed information on Water Hauling methods, Appendix D provides detailed information on using Large Diameter Hose, and Appendix E provides detailed information on Portable Pumps. The total water supply must meet the requirements set forth in Chapter 5 of the code (6-3).

NFPA 1142 1999 edition:

The 1999 edition was renumbered to NFPA 1142 from NFPA 1231. There are a number of additions to the document overall, this includes a Table 4-2.2 Fire Resistance Rating (in Hours) for Type I through Type V Construction. The table that was previously in section 5-9(a) Pre-calculated Minimum Water Supplies by Occupancy Hazard & Construction Classification, has been moved to Annex A, Table A-5-2 Pre-calculated Minimum Water Supplies by Occupancy Hazard and Construction Classification (no exposures). The other tables in the previous edition, titled Minimum Water Requirements (Examples), and Minimum Capability of Fire Department to Transport and to Use Water, have been removed from the document altogether. There are no comments about the removal of the tables in TCDA or TCRA preceding the 1999 edition.

The equation have experienced another organizational change, where the quotient is now referred to as “total volume of structure.”

The mathematical relationships for determining minimum water supplies have not been changed in any way. The following equation is used for *single structures without exposure hazards* (5-2):

$$\text{Minimum water supply} = \frac{total\ volume\ of\ structure}{Occupancy\ Hazard\ Classification} * Construction\ Classification\ No.$$

The total water supply is required to be no less than 2,000 gallons, referencing Table 5-9.1(a) (5-2.1). Total water supply calculation should use Table A-5-2.

For the case of single structures with exposure hazards, the following equation is used (5-3.1):

$$\text{Minimum water supply} = \frac{total\ volume\ of\ structure}{Occupancy\ Hazard\ Classification} * Construction\ Classification\ No. * 1.5$$

The total water supply is required to be no less than 3,000 gallons. Total water supply calculation should use Table A-5-2 (5-3.2)).

Section 5-4, which was previously about multiple structures that may be served from a single water point, is about *Structures with Automatic Sprinkler Protection*. An example to calculate water supply is provided in Section A-5-2 for multiple structures that may be served from a single water point; this has been moved from being a section by itself in previous editions to being incorporated as part of structures with/without exposure hazards.

For structures with an automatic sprinkler system that does not meet the requirements of NFPA 13, the total water supply may be reduced by the authority having jurisdiction (Section 5-4).

Section 5-5 addresses *Structures with Other Automatic Fire Suppression System*. The code states that fully or partially automatic fire suppression protected structures the fire department having jurisdiction shall determine the total water supply required for firefighting purpose.

In Chapter 6 Water Supply, the code states that any water source used to meet the requirement of the standard shall be approved by the authority having jurisdiction. Regarding access to water sources, NFPA 299, *Standard for Protection of Life and Property from Wildfire*, and NFPA 1141, *Standard for Fire Protection in Planned Building Groups*.

NFPA 1142 2001 edition:

It is noted that the 2001 edition is a partial revision, and it incorporates much of the information about the design of dry hydrants, which was formerly in the appendices, into the requirements of the standard. The section that was attributed to Calculating Minimum Water Supplies was changed from being Chapter 5 to Chapter 7. Although the equations and the conditions of use for those equations have not changed, much of the previous information that was present within the section, the 2001 has moved to Annex H. This action includes the table on *Pre-calculated Minimum Water Supplies by Occupancy Hazard & Construction Classification*, now labeled Table H.1.4(a). The formatting changes made, sort the information in the tables into two tables— Table H.1.4 (a) tabulates values for Occupancy Hazard Classification numbers 3 and 4, and Table H.1.4(b) tabulates Occupancy Hazard Classification numbers 5 through 7. The other two tables, Minimum Water Requirements (Examples) and Minimum Capability of Fire Department to Transport and to Use Water, have been removed altogether from the code.

In Annex H, the code states, “This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.” Though this statement excludes the information from being a part of the code, much of the information contained in this section is what a part of the code in previous editions was. The annex includes many examples of water supply calculations, many of these examples are similar to ones presented in previous editions.

The equations have had formatting changes. The following equation is used for structures without exposure hazards (7.2):

$$\text{Minimum water supply} = \frac{(total\ volume\ of\ structure)}{(Occupancy\ Hazard\ Classification)} * Construction\ Classification\ No.$$

The minimum water supply cannot be less than 2,000 gallons, and reference to Table H.1.4(b) is made (7.2.1).

For structures with exposure hazards, the following equation is used (7.3.1):

$$\text{Minimum water supply} = \frac{(total\ volume\ of\ structure)}{(Occupancy\ Hazard\ Classification)} * Construction\ Classification\ No. * 1.5$$

The minimum water supply cannot be less than 3,000 gallons, reference to Table H1.4(b) is made (7.3.2).

Section 7.4 addresses structures with automatic sprinkler protection. For structures with an automatic sprinkler system that do not meet the requirements of NFPA 13, the total water supply may be reduced by the authority having jurisdiction (Section 7.4).

Section 7.5 addresses Structures with Other Automatic Fire Suppression System. The code states that fully or partially automatic fire suppression protected structures the authority having jurisdiction shall determine the total water supply required for firefighting purpose.

In Chapter 8 Water Supply, the code states that any water source used to meet the requirement of the standard shall be approved by the authority having jurisdiction. Regarding access to water sources, NFPA 299, *Standard for Protection of Life and Property from Wildfire*, and NFPA 1141, *Standard for Fire Protection in Planned Building Groups*.

NFPA 1142 2007 edition:

It is noted that the 2007 edition is a complete revision to better organize the requirements in the standard and to better differentiate between alternate water supplies for firefighting and municipal-type water systems.

This edition has available documentation that provides insight on the codes history of changes and proposals. One change that has been made in this edition is moving the Calculating Minimum Water Supplies section— in the last edition this was in Chapter 7, but this edition includes it in Chapter 4. A Report on Proposals accepted this move. The definition and requirements of "exposure" and how they affected the required water supplies were moved, from what was Chapter 5 in the previous edition to Chapter 4. From the Report on Proposals, under Log #8, a change is accepted for a new definition for water delivery rate. The table that had been included in the first few editions, the table for Minimum Capability of Fire Department to Deliver Water, is put back into the code, this time, it is Table 4.6.1 minimum Capability of Fire Department to Deliver Water. In the Report on Comments, Log #11 notes that Eddie Phillips, Southern Regional Fire Code Development Committee wanted to replace the language of Table 4.6.1 however the action was rejected by NFPA. Table 4.6.1 Minimum Capability of Fire Department to Deliver Water is reproduced from the code below:

Table 8 Taken from NFPA 1142 (2007) Table 4.6.1 Minimum Capability of Fire Department to Deliver Water

Table 4.6.1 Minimum Capability of Fire Department to Deliver Water

Total Water Supply Required		Rate Water Is Available at the Incident	
gal	L	gpm	L/min
<2,500	9,459	250	950
2,500–9,999	9,460–37,849	500	1,900
10,000–19,999	37,850–75,699	750	2,850
≥20,000	≥75,700	1,000	3,800

Annex H Calculating Minimum Water Supplies still has similar information as in the previous edition, however there are additional calculations, more examples relating to different occupancies and so on.

The equations presented in Chapter 4 Calculating Minimum Water Supplies do not vary greatly from previous editions of the code. There have been formatting changes of the equations. An addition in this code is conversion factors are provided if they are required.

For Structures without exposure hazards, the following equation is provided (4.2.1):

$$WS_{min} = \frac{VS_{total}}{OHC}(CC)$$

where:

$$WS_{min} = minimum\ water\ supply\ in\ gal\ (For\ results\ in\ L, multiply\ by\ 3.785)$$

$$VS_{tot} = total\ volume\ of\ structure\ in\ ft^3\ (if\ volume\ is\ measured\ in\ m^3, multiply\ by\ 35.3.)$$
$$OHC = occupancy\ hazard\ classification\ number$$
$$CC = construction\ classification\ number$$

The minimum water supply required for any structure without exposure hazards shall not be less than 2,000 gallons (4.2.2).

For structures with exposure hazards, the following equation is provided (4.3.1):

$$WS_{min} = \frac{VS_{total}}{OHC}(CC) * 1.5$$

where:

$$WS_{min} = minimum\ water\ supply\ in\ gal\ (For\ results\ in\ L, multiply\ by\ 3.785)$$
$$VS_{tot} = total\ volume\ of\ structure\ in\ ft^3\ (if\ volume\ is\ measured\ in\ m^3, multiply\ by\ 35.3.)$$
$$OHC = occupancy\ hazard\ classification\ number$$
$$CC = construction\ classification\ number$$

The minimum water supply required for any structure with exposure hazards shall not be less than 3,000 gallons (4.3.2).

Section 4.4 addresses structures with automatic sprinkler protection. For structures with an automatic sprinkler system that do not meet the requirements of NFPA 13, the total water supply may be reduced by the authority having jurisdiction (Section 4.4).

Section 4.5 addresses *Structures with Other Automatic Fire Suppression System*. The code states that fully or partially automatic fire suppression protected structures the authority having jurisdiction shall determine the total water supply required for firefighting purpose.

In Chapter 7 Water Supply, the code states that any water source used to meet the requirement of the standard shall be approved by the authority having jurisdiction.

NFPA 1142 2012 edition:

It is noted that the 2012 edition of NFPA 1142 includes multiple updates to definitions in order to be consistent with the NFPA *Glossary of Terms*. Table 4.6.1 Minimum Capability of Fire Department to Deliver Water remains unchanged in this edition of the code. However it may be important to note that in Report on Proposals A2011, Log # 6 and Log #7 discuss changing the layout of the table, but there is no mention of addressing the content of the table. Table 4.6.1 is reproduced from the 2012 edition of the code.

Table 9 Taken from NFPA 1142 (2012) Table 4.6.1 Minimum Capability of Fire Department to Deliver Water

Table 4.6.1 Minimum Capability of Fire Department to Deliver Water

Total Water Supply Required		Rate Water Is Available at the Incident	
gal	L	gpm	L/min
<2,500	9,459	250	950
2,500–9,999	9,460–37,849	500	1,900
10,000–19,999	37,850–75,699	750	2,850
≥20,000	≥75,700	1,000	3,800

It is noted that water should be available at the rate shown in Table 4.6.1 within 5 minutes of firefighters arriving at the incident (4.6.2).

The equations presented in Chapter 4 Calculating Minimum Water Supplies do not vary from the equation in the last edition.

For structures without exposure hazards, the following equation is provided (4.2.1):

$$WS_{min} = \frac{VS_{total}}{OHC}(CC)$$

where:

$$WS_{min} = minimum\ water\ supply\ in\ gal\ (For\ results\ in\ L, multiply\ by\ 3.785)$$
$$VS_{tot} = total\ volume\ of\ structure\ in\ ft^3\ (if\ volume\ is\ measured\ in\ m^3, multiply\ by\ 35.3.)$$
$$OHC = occupancy\ hazard\ classification\ number$$
$$CC = construction\ classification\ number$$

The minimum water supply required for any structure without exposure hazards shall not be less than 2,000 gallons (4.2.2).

For structures with exposure hazards, the following equation is provided (4.3.1):

$$WS_{min} = \frac{VS_{total}}{OHC}(CC) * 1.5$$

where:

$$WS_{min} = minimum\ water\ supply\ in\ gal\ (For\ results\ in\ L, multiply\ by\ 3.785)$$

$$VS_{tot} = total\ volume\ of\ structure\ in\ ft^3\ (if\ volume\ is\ measured\ in\ m^3, multiply\ by\ 35.3.)$$
$$OHC = occupancy\ hazard\ classification\ number$$
$$CC = construction\ classification\ number$$

The minimum water supply required for any structure with exposure hazards shall not be less than 3,000 gallons (4.3.2).

Section 4.4 addresses structures with automatic sprinkler protection. For structures with an automatic sprinkler system that do not meet the requirements of NFPA 13, the total water supply may be reduced by the authority having jurisdiction (Section 4.4).

Section 4.5 addresses Structures with Other Automatic Fire Suppression System. The code states that fully or partially automatic fire suppression protected structures the authority having jurisdiction shall determine the total water supply required for firefighting purpose.

In Chapter 7 Water Supply, the code states that any water source used to meet the requirement of the standard shall be approved by the authority having jurisdiction.

NFPA 1142 2017 edition:

It is noted that this edition develops new text for alternative methods, modifications to the standard, and unit and formula consistency.

The concerned table, Table 4.6.1, experienced a title change to "Water Delivery Rate" in this edition, compared with the previous edition where it was titled Table 4.6.1 Minimum Capability of Fire Department to Deliver Water. The table is reproduced from the code below:

Table 10 Taken from NFPA 1142 (2017) Table 4.6.1 Water Delivery Rate

Table 4.6.1 Water Delivery Rate

Total Water Supply Required		Water Delivery Rate	
gal	L	gpm	L/min
<2,500	9,459	250	950
2,500–9,999	9,460–37,849	500	1,900
10,000—19,999	37,850–75,699	750	2,850
≥20,000	≥75,700	1,000	3,800

There is an additional section in Chapter 4.6 *Water Delivery Rate to the Fire Scene* section, Section 4.6.3 states that the minimum water delivery rate shall not be less than 250 gallons per minute. There is no further explanatory material on this particular section.

The equations presented in Chapter 4 *Calculating Minimum Water Supplies* does not vary from the equation in the last edition (4.2.1).

$$WS_{min} = \frac{VS_{total}}{OHC}(CC)$$

where:

$$WS_{min} = minimum\ water\ supply\ in\ gal\ (For\ results\ in\ L, multiply\ by\ 3.785)$$
$$VS_{tot} = total\ volume\ of\ structure\ in\ ft^3\ (if\ volume\ is\ measured\ in\ m^3, multiply\ by\ 35.3.)$$
$$OHC = occupancy\ hazard\ classification\ number$$
$$CC = construction\ classification\ number$$

The minimum water supply required for any structure without exposure hazards shall not be less than 2,000 gallons (4.2.2).

For structures with exposure hazards, the following equation is provided (4.3.1):

$$WS_{min} = \frac{VS_{total}}{OHC}(CC) * 1.5$$

where:

$$WS_{min} = minimum\ water\ supply\ in\ gal\ (For\ results\ in\ L, multiply\ by\ 3.785)$$
$$VS_{tot} = total\ volume\ of\ structure\ in\ ft^3\ (if\ volume\ is\ measured\ in\ m^3, multiply\ by\ 35.3.)$$
$$OHC = occupancy\ hazard\ classification\ number$$

$$CC = construction\ classification\ number$$

The minimum water supply required for any structure with exposure hazards shall not be less than 3,000 gallons (4.3.2).

Section 4.4 addresses structures with automatic sprinkler protection. For structures with an automatic sprinkler system that do not meet the requirements of NFPA 13, the total water supply may be reduced by the authority having jurisdiction (Section 4.4).

Section 4.5 addresses Structures with Other Automatic Fire Suppression System. The code states that fully or partially automatic fire suppression protected structures the authority having jurisdiction shall determine the total water supply required for firefighting purpose.

In Chapter 7 Water Supply, the code states that any water source used to meet the requirement of the standard shall be approved by the authority having jurisdiction.

NFPA 1720 – Table 4.3.2

During the meeting held on November 9, 2017, one of the questions raised was about Table 4.3.2 Staffing and Response Time in NFPA 1720, *Standard for the Organization and Deployment of Fire Suppression Operations, Emergency Medical Operations, and Special Operations to the Public by Volunteer Fire Departments*. The last edition for this code was in the year 2014. Attendees at the meeting inquired about the connection between NFPA 1720 (2014 edition) Table 4.3.2 and the table in NFPA 1142 (2017 edition) Table 4.6.1 Water Delivery Rate— to see if there was some scientific link between the two tables.

NFPA 1720, Table 4.3.2 was first established in the 2004 edition of the code. In the 2010 edition, the table experienced a format change for this edition. The 2014 edition states that the changes made in 2010 to the table included "...the requirement that the fire department have the capability to initiate and attack within two minutes of having necessary resources at the scene in remote areas was moved from the footnotes to a new paragraph and made applicable to all operations." Furthermore the introductory material for the table was changed to indicate that the requirements apply to a structural fire in a typical 2,000 ft^2, two-story single family dwelling without basement and with no exposures. The annex of this section indicates that the 2010 edition of the code added text to aid in calculating the percentage of times they meet the objective. The tables provided below are from the 2004 and 2010 editions of the code— to provide background of the changes that took place.

From the 2004 edition of NFPA 1720:

Table 11 Taken from NFPA 1720 (2004) Table 4.3.2 Staffing and Response Time

Table 4.3.2 Staffing and Response Time

Demand Zone	Demographics	Staffing and Response Time	Percentage
Special risks	AHJ	AHJ	90
Urban	>1000 people/mi.^{2}	15/9	90
Suburban	500–1000 people/mi.^{2}	10/10	80
Rural	< 500 people/mi.^{2}	6/14	80
Remote*	Travel dist ≥ 8 mi.	4	90

*Upon assembling the necessary resources at the emergency scene, the fire department should have the capability to safely commence an initial attack within 2 minutes 90 percent of the time.

From the 2010 edition of NFPA 1720:

Table 12 Taken from NFPA 1720 (2010) Table 4.3.2 Staffing and Response Time

Table 4.3.2 Staffing and Response Time

Demand Zone[a]	Demographics	Minimum Staff to Respond[b]	Response Time (minutes)[c]	Meets Objective (%)
Urban area	>1000 people/mi^2	15	9	90
Suburban area	500–1000 people/mi^2	10	10	80
Rural area	<500 people/mi^2	6	14	80
Remote area	Travel distance ≥ 8 mi	4	Directly dependent on travel distance	90
Special risks	Determined by AHJ	Determined by AHJ based on risk	Determined by AHJ	90

[a] A jurisdiction can have more than one demand zone.
[b] Minimum staffing includes members responding from the AHJs department and automatic aid
[c] Response time begins upon completion of the dispatch notification and ends at the time interval shown in the table.

From the 2014 edition of NFPA 1720:

Table 13 Taken from NFPA 1720 (2014) Table 4.3.2 Staffing and Response Time

Table 4.3.2 Staffing and Response Time

Demand Zone[a]	Demographics	Minimum Staff to Respond[b]	Response Time (minutes)[c]	Meets Objective (%)
Urban area	>1000 people/mi^2	15	9	90
Suburban area	500–1000 people/mi^2	10	10	80
Rural area	<500 people/mi^2	6	14	80
Remote area	Travel distance ≥ 8 mi	4	Directly dependent on travel distance	90
Special risks	Determined by AHJ	Determined by AHJ based on risk	Determined by AHJ	90

[a]A jurisdiction can have more than one demand zone.
[b]Minimum staffing includes members responding from the AHJs department and automatic aid
[c]Response time begins upon completion of the dispatch notification and ends at the time interval shown in the table.

These tables are provided to be used by the authority having jurisdiction to "…to determine staffing and response time objectives for structural fire fighting."

In regards to the original query, there is no explicit statement in either codes, NFPA 1142 (all editions) and NFPA 1720 (2014 edition) indicating that there is a link between the two respective tables. Annex A.4.3.2 does reference a number of texts that may provide a level of scientific technical foundation for Table A.4.3.2. However, the references made in this particular section are different to any reference made in the editions of NFPA 1142. From a preliminary review, it may be concluded that these two tables are not related.

A comprehensive annex section is provided in NFPA 1720; the annex section A.4.3.2 from the 2014 edition of NFPA 1720 is reproduced below:

A.4.3.2 Table 4.3.2 outlines demographic areas, as defined by the U.S. Census Bureau, staffing and deployment requirements and fractal measurements. The suburban area is based on the requirements provided in the report by the Ontario Fire Marshal's Office, *Shaping the Future of Fire Ground Staffing and Delivery Systems within a Comprehensive Fire Safety Effectiveness Model*, a report referenced in NFPA 1710, as well. This requirement must be met 80 percent of the time. Rural areas have a lower population density and require six people (two in/two out plus the incident commander and pump operator), a requirement that is derived from the country-UK standards of fire cover and must be met 80 percent of the time. The remote areas reference the OSHA "two in/two out" requirement and the assembly of four persons 90 percent of the time. Travel distances are varied and can be computed utilizing the ISO travel formula. This travel formula is as follow:

1.7 x distance + 0.65 = travel time

For evaluation of response time objectives based on Table 4.3.2, the fire department needs to record the number of members on the scene at the end of the response time given in the table for each incident. For example, in an urban area, the fire department would record the number of members on scene 9 minutes after the completion of the dispatch notification. They would then determine how many times they had at least 15 members on scene within that 9-minute time interval and calculate a percentage based on the total calls in urban areas. To meet the objective defined in this standard for an urban area, they would need to assemble at least 15 members within 9 minutes for 90 percent of the incidents.

Appendix I

On November 9, 2017 a Research Needs & Project Planning Meeting was held to discuss Project Statement on Rural Water Supply. The following is a presentation that was given at this meeting by FPRF. The need for the first phase of this project— information collection— was iterated during this meeting.

Project Statement Form

- Submitted December 2015
- Problem: Lack of scientific basis for water supply & delivery rate requirements in NFPA 1142
- Questions
  - Technical basis for water delivery rates (table 4.6.1)
  - Minimum water supply for single building with modern construction
  - Water supply for non-single building (e.g. WUI incident)
  - Water delivery rate vs. fire flow

Terminology

Minimum Water Supply, the quantity of water required for fire control and extinguishment [NFPA 1142-2017]

Water Delivery Rate, the minimum amount of water per minute (in gpm or L/min), required… to be delivered to a fire scene via mobile water supply apparatus, hose lines, or a combination of both [NFPA 1142-2017]

Fire flow, the rate of water flow, at a residual pressure of 20 psi and for a specified duration necessary to control a major fire in a specific structure [NFPA Fire Protection Handbook]

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Minimum Water Supply

- Calculated based on: [1142-2017, section 4.1.1]
  - Occupancy hazard
  - Type of construction
  - Structure dimensions (length, width, and height)
  - Exposures, if any
- "water supply necessary for <u>structural fire-fighting</u> purposes" [1142-2017, section 4.1.2]
- Consider local conditions [1142-2017, section 4.1.3]

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Water Delivery Rate to Fire Scene

- Delivery Rate based on total water supply required (table 4.6.1)
- Minimum water deliver rate, 250 gpm
- Water supplies permitted to be used for fighting fires other than structures or for other emergencies

Table 4.6.1 Water Delivery Rate

Total Water Supply Required		Water Delivery Rate	
gal	L	gpm	L/min
<2,500	9,459	250	950
2,500–9,999	9,460–37,849	500	1,900
10,000–19,999	37,850–75,699	750	2,850
≥20,000	≥75,700	1,000	3,800

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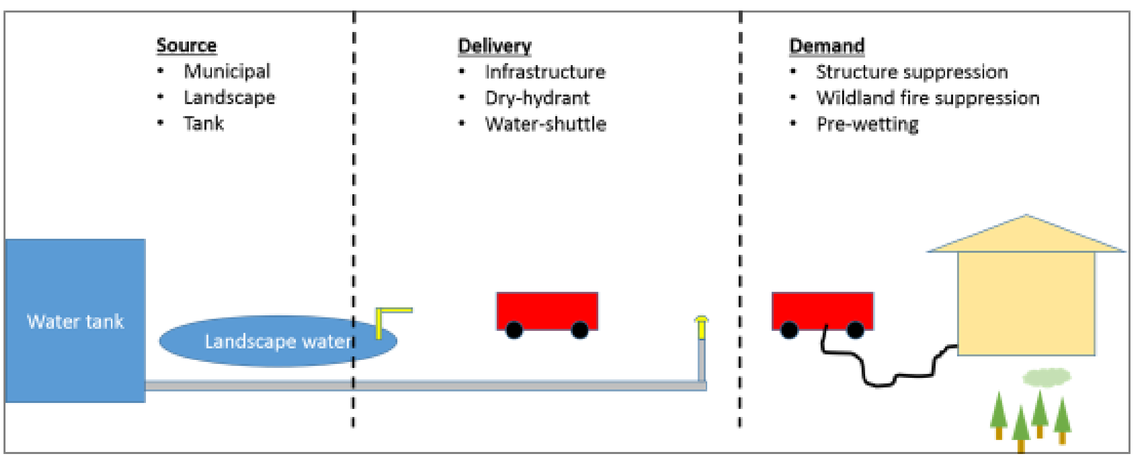
History of Table 4.6.1

Summary of write-up produced by Anthony Capuano, NFPA intern

- 1984 edition (NFPA 1231) – Table 5-5.1(c) "Minimum Capability of Fire Department to Transport and to Use Water"
- 1999 edition (NFPA 1142) – No table containing information on water delivery rate
- 2007 edition (NFPA 1142) – Table 4.6.1 "Minimum Capability of Fire Department to Deliver Water"
- 2017 edition (NFPA 1142) – Table 4.6.1 "Water Delivery Rate"

Rural & suburban water supply



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Evaluation of Fire Flow Methodologies (2014)

- Review of 19 existing fire flow calculation methods (US and globally)
  - Water flow rates for sprinklered & non-sprinklered buildings
  - Generally derived using data from actual fires
- Building planning & on-scene methods

Related research

- UL Firefighter Safety Research Institute, *Study of the Impact of Fire Attack Utilizing Interior and Exterior Streams on Firefighter Safety and Occupant Survival*
  - *Nozzle air entrainment effects on fire behavior*
  - *Water mapping within structure based on application*
  - *Amount of water (total volume and application rate) to extinguish enclosure fire*
- Rahn (2010), *Initial Attack Effectiveness: Wildfire Staffing Study: Final report*
  - Wildland firefighter hose lay efficiency

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Rural Water Supply for Firefighting

Research Planning Meeting
Thursday 09 November 2017; 11:00am – 12:00pm EST
Conference Call

MEETING SUMMARY

Attendance:

David Doudy, City of Farmington Fire Department
Michael Gollner, University of Maryland
Daniel Gorham, Fire Protection Research Foundation
Jeremy Keller, Macochee Joint Ambulance District
Bob Kowalski, Nationwide Insurance Companies
Steve Quarles, Insurance Institute for Business & Home Safety
Deborah Shaner, Shaner Life Safety
Rick Swan, International Association of Fire Fighters
Bill Watters, Verisk Analytics/Insurance Services Office, Inc.

Purpose: The purpose of this meeting was to review the original project statement form and initial work conducted by FPRF staff and clarify the research needs of the technical committee related to rural water supply.

Documents: Dan Gorham provided a brief presentation on the original project statement form related to this topic [**Attachment A**] submitted in December 2017. Slides from this presentation are provided with this meeting summary [**Attachment B**]. The full document produced by Anthony Capuano on the history of NFPA 1142 Table 4.6.1 is included with this meeting summary [**Attachment C**].

Discussion:

1. Background on NFPA 1142 table 4.6.1
    a. Originally intended to be a tool for rural fire chiefs with limited staffing and a long response time to a building with no municipal water supply.
    b. Give the fire departments the opportunity for life preservations (rescue) and property preservation (exposures).
    c. Some people use NFPA 1142 to circumvent the need for a municipal water system.
    d. The document has changed over time – there is currently a gap between municipal water supply and completely rural.

    e. Rural fire departments recognize if they get to a scene quick enough and the water initially on scene can be enough to contain the fire.

2. Current applications of NFPA 1142 Table 4.6.1
    a. Fire protection engineers use this table to design water supplies for rural and suburban buildings. The water deliver rate is calculated and the water deliver rate is specified by table 4.6.1. Based on the water application rate (from the amount of water available on scene to the fire) and the water delivery rate it is possible that a fire department would only have water supply for a short period of time (10 minutes) when "best practice" is to have water supply for at least 30 minutes.
    b. Example: A mining claim in the middle of wilderness (only have forest access road) has an approximately 2,500 square foot residential cabin. Based on water supply calculations is was determined that 5,000 gallons of water were needed on scene for firefighting operations and that based on firefighting operations this water supply would last approximately 12 minutes. This raises the question: what is the correct number for minimum amount of time with water on scene?
3. Fire department considerations
    a. Many rural fire departments are not capable (equipment and/or staffing) to apply 500 gpm of water on the fire upon fire arrival unless using deck guns.
    b. Rural water supply if for "room and contents" or protecting exposures.
    c. Delivery rate requirements in table 4.6.1 may be too high and unrealistic for many rural fire department operations.
    d. A typical hand line flows 250 gpm and for interior firefighting operations NFPA requires a backup line with at least as much flow capabilities – that's 500 gpm fire flow to start with for interior operations.
    e. ISO rating 8B requires a fire flow of 200 gpm for 20 minutes (4000 gallons).
    f. Fire flow water demands are different depending on the fire stage (growth, decay, and overhaul).
    g. Some rural municipal water supplies are only capable of 650 gpm water delivery due to the size of mains; 1000 gpm water delivery rate requirements are potentially unachievable.
    h. Rural fire departments typically protect single-family dwellings.
4. What research questions need to be answered to address concerns?
    a. Should there be a minimum fire flow duration requirement in addition to the minimum water supply and water delivery rate requirements for structures expected in the rural/suburban environment?
        i. There may be instances where the water supply (volume) at an expected fire flow (rate) is insufficient for the expected flow time (duration).
        ii. Need to consider fire departments ability to deliver water to the scene (staffing and equipment capabilities).
        iii. Fire department response time – is there an assumed level of fire involvement based on response time? Longer response time usually mean more fire involvement and in rural areas may mean lower staffing levels.
    b. What are the water requirements in a wildland-urban fire incident for structure protection (exterior) versus interior fire fighting?
        i. The level of preparedness for a building (e.g. defensible space, resistance to ignition) would affect the amount of fire involvement.
        ii. Any building has interior fuels (e.g. furniture) that are part of the fire hazards. If that building is placed in the wildland that is another fire hazard.

        iii. Survey of fire department water usage during these fire scenarios
            1. How many hose lines operating and at what flow rates?
            2. Recent (2017) wildland-urban fire incidents may provide valuable data points
    c. An ISO recognized water supply source is 30,000 gallons – would a higher deliver rate and minimum flow duration cause this to become a limiting factor?
5. Should there be a coordination between NFPA 1142 Table 4.6.1 based on the NFPA 1720 Table 4.3.2 requirements based on demand zone?
    a. Water delivery rate table based on staffing and response time of rural fire departments.
    b. What percentage of fire involvement within a structure would water application be effective? Should there be different delivery rates for different levels of involvement?
6. What are the water supply requirements for non-structure fires (e.g. fine wildland fires)?
    a. Typical tactics for fine fuel (vegetation) fires is to use rolling attack on engines which require resupply of apparatus water tanks.
    b. Fire behavior modeling (e.g. rate of spread) can be analyzed and compared to apparatus water tank capacities.
    c. These types of fire are not currently within the scope of NFPA 1142 which is specifically for "structure fires" – could possibly be added as an Annex or to support a revision of the document scope.

(Prepared by Daniel Gorham, 09 November 2017)

Attachments

Attachment	Description	No. of Pages
A	Project Statement Form "Scientific basis for water supply table"	14
B	SLIDES – Rural Water Supply, Research Planning	2
C	History of NFPA 1142 Table 4.6.1	2

Project Statement Form

1608

Return to research@nfpa.org

Fire Protection Research Foundation, One Batterymarch Park, Quincy, MA 02169-7471

1) **Proposed Project Title:**

Establish scientific basis for NFPA 1142 water supply table 4.6.1.

2) **Problem Statement (One or two sentences addressing "What is the research or data need?"):**

SME's believe there is no science behind this table.

3) **Research Objective (One or two sentences addressing "What is needed to solve the problem?" Examples include: Develop guidance for a specific issue, Determine effectiveness of current code/standard requirement):**

Determine if Table 4.6.1 in NFPA 1142 is still valid.

4) **Project Description (One or two paragraphs on study design & expected tasks. Project tasks can include literature reviews, data collection, loss summaries, field usage surveys, code comparisons, statistical analysis, computer modeling, hazard analysis, risk assessments, fire testing, recommendation development, and gap identification.):**

- Clarify fire flow formula. Is it still relevant?
- Address multiple structures such as what could occur in a WUI event. Although some codes stipulate that hydrant systems must flow 1000 gpm minimum, rates could be lower for a single, fully-involved structure, or small neighborhoods, but larger neighborhoods could warrant higher flows.
- Address equipment limitations, current rates for individual structures, and flow rates for firefighting operations.

5) **Data Collection (If data collection is part of the project scope, does data exist? If data exists, is it available to be used in the study? Please identify potential data sources.)**

That is part of the issue with this table, SME's unsure if there is data to support its continued use.

6) **Relevant NFPA Document(s), Technical Groups, or Foundation strategic research agenda item & How Project Will Impact:**

This research could have a large impact on rural water supply requirements that are used on a daily to establish the amount of water needed. In certain areas of the country this could mean costs of thousands of dollars to obtain the water required based on the current information contained in Table 4.6.1.

7) **Organizations That Could Possibly Fund (Examples: government grants, industry consortia, stakeholders):**

ISO-Verisk, Builder/Developer Associations

8) **<u>When Do You Need Project Deliverables</u> (when is information needed to coordinate with document revision cycles, sense of urgency):**

This research would need to be finished before the document comes up again for the 2019 Annual Revision Cycle so we could include the new material.

9) <u>Submitted By (Staff Liaison/TC Chair/etc) and Date Submitted:</u>

Rick Swan, NFPA 1142 Chair
18-December-2015

The Problem:

Table 4.6.1 (Minimum Capability of Fire Department to Deliver Water) is a key element of the NFPA 1142 standard, and has been since its inception as NFPA 1231 in the 70s. As someone actively engaged in planning water shuttle and relay pumping operations, I can tell you that this table is absolutely essential, as it is the only universally recognized set of delivery rates available. Having a GPM delivery rate to work with drives the whole water supply planning process, from mutual aid arrangements to apparatus specifications to development of water supply sources.

When the original NFPA 1231 was developed, Table 4.6.1 was developed from the experience and professional judgement of the committee rather than any experimental basis. The water delivery rates in the table have remained unchanged since the original document, and are due for an update based on current research methods.

Rate of Flow vs. Water Delivery Rate:

It is important to distinguish between Rate of Flow (ROF) and Water Delivery Rate (WDR). While both are measured in gallons per minute (GPM), and are often conflated, they serve different purposes. I have included an extract from the late Larry Davis' classic *Rural Firefighting Operations, Volume 2* for the committee's reference. Published by the ISFSI in 1986, and long since out of print, this book lays out the differences between ROF and WDR by someone who was around for the development of the original table in NFPA 1231.

Briefly, ROF is a figure for initial attack planning, intended to achieve knock-down of a fire through application over a 30-second period. ROF would represent the flow immediately available for initial attack, such as for the water carried on the first due apparatus. ROF is calculated using either the Iowa State (Royer/Nelson) or National Fire Academy methods, each yielding slightly different results. Notably, either method of determining ROF is intended to calculate the flows for only the involved part of the structure, not necessarily the entire volume of the structure. I'm also attaching a copy of a *Fire Engineering* article by Keith Royer (one of the developers of the Iowa formula) that explains this pretty well, for the committee's reference.

Water delivery rate, as laid out in NFPA 1142, represents flows to be delivered over an extended period. This is flow to support operations beyond initial attack, either for overhaul, or exposure protection for failed suppression action. Because of the different method used to determine WDR, it normally differs substantially from the Iowa or NFA ROF figures for the same structure. The longer time periods reflect the lead time necessary to set up the water shuttles or relays that will supply this flow.

Limitations of the NFPA 1142 Standard:

The water delivery rates in NFPA 1142 have some significant limitations in application. While it is never directly stated in the standard, it is normally understood that these rates are for a single involved structure, which makes sense given the original intent of NFPA 1231. This limits the standard's utility when planning for responses other than a conventional structure fire, however.

This committee itself has identified a need for planning figures for water supply on wildland-urban interface fires. And of course, NFPA 1142 is not strictly a WUI document. Dominic Colletti, in *The Rural Firefighting Handbook* (2nd edition, 2012), further identifies the standard's limitations when planning for other common needs, such as hazardous materials incidents or fires in piled materials. I would further add that the standard is silent on recommended flows for strictly wildland fires, when it seems like estimates for this would be relatively straightforward to develop.

Recommendations for Research:

The committee owes it to the fire service to fully overhaul NFPA 1142 for the next edition in 2022, starting with the water deliver rates in Table 4.6.1, which are the heart of the standard. To support this, I recommend the following research tasks be completed as soon as possible, using modern methods of experimentation and modeling:

1. Revise recommended water deliver rates for fires in single structures, as always provided in NFPA 1142 and its predecessor documents. This is still a key planning figure for all fire departments serving rural and suburban areas.
2. Develop recommended water delivery rates for wildland-urban interface operations. The only existing recommendation is a blanket rate of 1000 GPM for new developments, as laid out in the 2012 edition of the ICC International Wildland-Urban Interface Code (IWUIC), but this is intended for municipal-type hydrant systems, not the alternative water supply systems supported by NFPA 1142. Recommended rates are needed for protection of multiple exposures, with or without ignited structures, under a range of operational resource, housing density, fuel, weather and topography scenarios.
3. Develop recommended water delivery rates for fires occurring in strictly wildland fuels (traditional wildfires). What are appropriate delivery rates to support suppression operations against a fire occurring in 40 acres of pine forest? Or 160 acres of standing corn? Provide the figures in terms of a rural fire department operating on the ground with engines, but also in terms of supporting more exotic resources such as SEATs or helicopters. As with the WUI rates, provide estimates for a range of fuel, weather and topographic conditions.
4. Develop recommended water delivery rates to support common hazardous materials incidents faced by the rural fire service. What delivery rate is appropriate to prevent an impinged propane tank from escalating to BLEVE? Or to support a train derailment involving crude oil? These incidents require water supply, too.
5. Just as NFPA 1142 provides guidance on reducing needed water supply for sprinkler systems, similar guidance should be provided for use of Class A Foam, particularly when developing the WUI and wildland fuels water supply rates.

NFPA 1231, 1975 EDITION

NFPA 1231 requires firefighters to gather information by conducting surveys of structures within their community. The purpose in gathering this information is to determine (1) a total water supply (TWS) in gallons and (2) a delivery rate (DR) in gallons per minute (gpm) for each and every structure within the community.

The total water supply is the minimum amount of water that should be available to combat a fire in a given structure, while the delivery rate is the rate at which the water must be available on the fireground. This means that the total water supply must be delivered at the delivery rate from the source to the attack apparatus on the fireground and then from the attack apparatus onto the fire.

The information required to determine the total water supply is the structure's length, width, and average height, including basements, attics, and other concealed spaces; the occupancy of the structure; the distance to exposures; the area of the exposures; and the availability of automatic sprinklers or other fixed fire protection systems.

Water Supply Survey Forms

Figures 2-8 and 2-9 are sample survey forms that can be used to gather the information needed to calculate the water supply for any structure. The form shown in Figure 2-8 can be printed on 5-inch x 7-inch cards, while that shown in Figure 2-9 can be printed on standard paper for placement in a loose-leaf binder.

Location Owner/Occupant ________ Date ________
Address ________

Building Name ________ Occupancy ________
Length ____ ft. Width ____ ft. OHCN ____
Height: Basement ____ ft. No. stories ____ Each story ____ ft. Attic ____ ft.
Average height ____ ft. Concealed spaces? ________

Exposures Distance to closest ____ ft. Area ____ sq. ft.
Occupancy ________ OHCN ____

Total water supply
No exposure $TWS = \frac{L \times W \times H}{OHCN} =$ ____ gallons
With exposure $TWS = \frac{L \times W \times H}{OHCN} \times 1.5 =$ ____ gallons

Fixed protection

	Yes	No
Automatic sprinklers		
Provided	☐	☐
Meet NFPA 13	☐	☐
Supervised	☐	☐
Alarm to fire department or central station	☐	☐
Fire department connection	☐	☐
Private water supplies ( ) gallons	☐	☐
Sub-standard sprinklers	☐	☐
Explain ________		
Other fixed protection	☐	☐
Explain ________		

% Credit for fixed protection ____ %

Water requirements
Total water supply ____ gallons
Delivery rate ____ gpm
Rate-of-flow ____ gpm

Figure 2-8. Water Supply Survey Card (NFPA 1231-1975) tobacco barns

OHCN 6 (low hazard)

- bakeries
- canneries
- churches
- dairy products manufacturing and processing
- electric generating stations
- glass and glass products manufacturing
- laundries
- slaughterhouses
- theaters

OHCN 7 (light hazard)

- apartments
- colleges and universities
- dormitories
- dwellings
- hospitals
- hotels and motels
- libraries (except large stock room areas)
- nursing and convalescent homes
- offices
- prisons
- schools

Not all occupancies can be listed, nor can all occupancies easily be grouped into one of the classifications above as easily as it may seem. Those doing the survey should remember that they are the authority having jurisdiction and if they feel that a particular occupancy is more hazardous than the OHCN for that occupancy indicates, they may use a more severe classification as long as they can justify their actions. As long as the occupancy is not placed in a less severe class than that identified by the Standard, there is no problem.

General Rules

In using the total water supply formula, the following general rules apply:

- round all mea foot
- consider atta structure
- include the basement, attic, cockloft, and other concealed spaces in height of the structure
- use the average height for a building with a gable, sloping or other-than-flat roof design
- survey each building when calculating water supplies for buildings with exposures, because a smaller, higher-hazard exposure may require more water than the building it exposes
- for multiple occupancies within one building, use the OHCN of the highest hazard occupancy
- for groups of buildings, calculate the total water supply for each to determine which requires the greatest total water supply and the higher delivery rate
- if in doubt as to which OHCN to use, use the smaller one for the higher hazard

The Impact of Fixed Systems

In cases where automatic sprinkler protection or other fixed fire suppression systems — such as foam, dry chemical, carbon dioxide, or Halon 1301 — have been installed, the authority having jurisdiction can reduce the water supply requirements as it sees fit, as long as the reduction is in accordance with the minimum set forth in NFPA 1231.

If the sprinkler protection meets all of the Standard's criteria, no additional water supply is required. If the sprinklers do not meet the criteria, water supply requirements can be reduced by 50 percent, if the authority having jurisdiction so desires. It should be reemphasized that this Standard specifies only minimum requirements, which can be exceeded by the authority having jurisdiction.

Delivery Rate Versus Rate-of-Flow

When calculating the total water supply and delivery rate for a structure, it is also advisable to calculate the rate-of-flow required for knockdown. Since no correlation is intended between the delivery rate and the rate-of-flow, they may be the same or different, according to the individual situation. Each is a valuable tool for planning water supplies.

The rate-of-flow takes into consideration only those factors required to eliminate flaming combustion, and is based on a 30-second application. The delivery rate is based on the flow required to eliminate smoldering as well as flaming combustion.

Examples

For practice in determining water supplies based on the 1975 edition of NFPA 1231, calculate the total water supplies, delivery rates, and rates-of-flow for the following examples:

EXAMPLE 2-5:

An unsprinklered dwelling measuring 25 feet by 40 feet, the structure has an 8-foot-high basement, one 8-foot-high story, and an attic which is 8 feet high at the ridgepole (peak). There is no exposure.

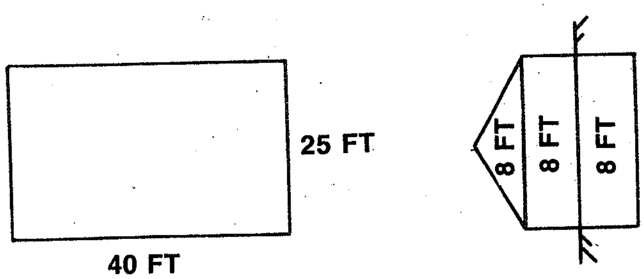


Figure 2-12.

- Total area = 25 ft. x 40 ft. = 1,000 sq. ft.
- Average height = 8 ft. + 8 ft. + 4 ft. = 20 ft.
- Total volume = 1,000 sq. ft. x 20 ft. = 20,000 cu. ft.
- OHCN = 7
- TWS = 2,000 gallons
- DR = 500 gpm
- Rate-of-Flow = $\frac{40 \times 25 \times 20}{100}$ = 200 gpm

By first determining the total area of the structure which is less than 1,200 square feet, the TWS required is 2,000 gallons and need not be calculated. The DR is 500 gpm. To determine the rate-of-flow, however, the average height must be calculated. The rate-of-flow required for knockdown is 200 gpm.

At this point, some comment should be made on the results. First, the total water supply of 2,000 gallons should be available from a hydrant, a swimming pool, a natural body of water, or some other static source from which water could be relayed or tanked to the fire. NFPA 1231 does not state where the water should come from; that is up to the fire department.

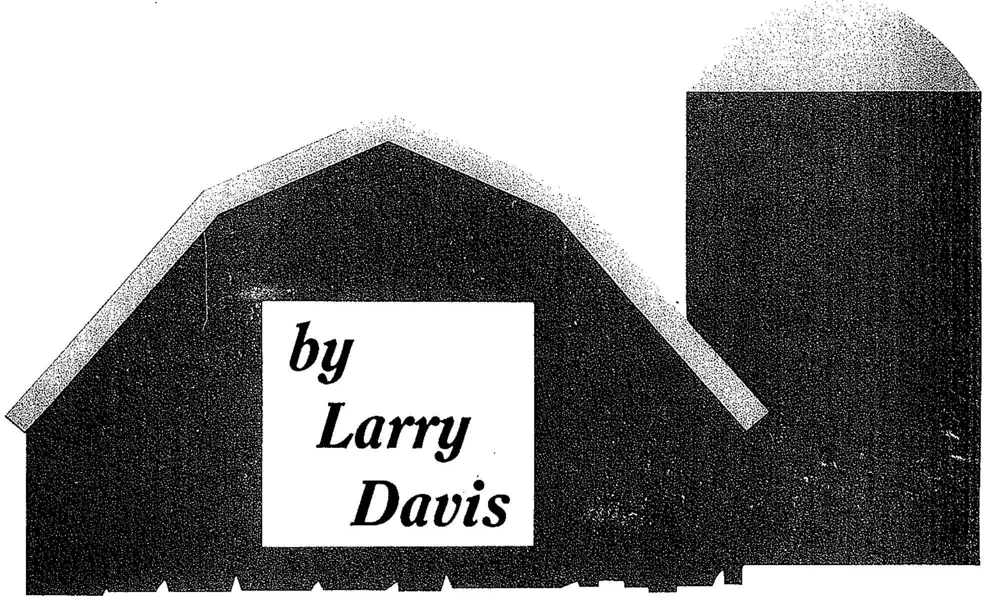
If a dwelling owner has a suitably sized swimming pool, which is full at all times and is accessible to pumpers or portable pumps, it could satisfy the requirement.

No matter where the water comes from, if the fire department has 2,000 gallons of available water and can deliver it to the scene at a rate of 500 gpm, the department meets the requirements of the Standard. Naturally, at a rate of 500 gpm, the 2,000 gallons of water will last only four minutes. To some, this may seem a short-duration water supply. However, when the size of the structure is considered, if a delivery rate of 500 gpm does not control the fire in four minutes, chances are that the fire would never be controlled anyway.

One other point should be made: The entire 500 gpm delivery rate may not be needed even if the structure is fully involved. In this case, the rate-of-flow required is only 200 gpm. Thus a 200 gpm rate-of-flow should control the fire within 30-60 seconds. If the department is set up to deliver 500 gpm, the delivery of 200 gpm is a snap. Again, it should be noted that the delivery rate and the rate-of-flow are not the same. In some cases, they are relatively close; in others they are not.

EXAMPLE 2-6:

An unsprinklered dwelling measuring 30 feet by 60 feet, the structure has a 10-foot-high



Rural Firefighting Operations

Book Two—The first encyclopedia of water supplies and water delivery techniques

Fire Engineering

Close

IOWA RATE OF FLOW FORMULA FOR FIRE CONTROL

IOWA RATE OF FLOW FORMULA FOR FIRE CONTROL

BY KEITH ROYER

It has been brought to my attention that the Royer/Nelson Rate of Flow Formula for fire control is being misunderstood and misused and that attempts have been made to alter it. I have read some of the interpretations and applications of the formula and believe that many do not understand the physical and chemical laws and principles on which the formula is based.

The research and experiments from which the formula evolved were conducted in the `50s and `60s. We did not set out to find a formula; it evolved from the research we were doing related to uncontrolled fire behavior in structures.

When faced with a fire problem, one of the things we need to do first is identify the problem and its cause. Otherwise, our efforts to overcome the problem will be nothing more than trial-and-error methods until, of course, we come to a method that works (eliminates or controls the fire). If we do not, the fire will burn itself out.

FORMAL EVOLUTION

The formula evolved from research done in the `50s by Iowa State University. The objectives were to identify and define what happens in uncontrolled fires in structures and why fire behaves the way it does in these environments. Hence, the term "fire behavior in uncontrolled environments" came into being.

This was not the first research in this area. This type of work had been going on for many years in several other countries and institutions. When questions arose during our research, we found many of the answers in chemistry and physics books as well as in research papers prepared by many others before us.

After we gained a better understanding of what was happening in structure fires, and why they were happening, we started research on the application of water early in 1952. We closely coordinated with research groups in other countries. The British Fire Research Station was very helpful, as were researchers in Canada, Germany, Japan, and Australia.

In early 1953, a pattern of water used in all of Iowa State`s fire experiments began to evolve. By 1955, it was clear we had found a way to estimate water needs. From 1955 to 1959, hundreds of experiments were conducted to test the method for determining water needs for controlling fires in all sizes of structures. The results of the research conducted at Iowa State University from 1952 to 1959 first were published in Fire Engineering (August 1959) and, in that same year, in Iowa State University Bulletin #18, "Water for Fire Fighting--Rate of Flow Formula."

THE FORMULA

The Iowa Rate of Flow Formula is

Cubic Feet = GPM

100

This formula spells out the rate of flow needed to knock down (control) a fire in a single open area when that area is fully involved. (Note: Control is not extinguishment. It means you have control of the fire instead of the fire`s having control of you.)

This formula states that the cubic feet involved, divided by 100, equals the gallons per minute necessary to knock down a fire in an area if that flow is properly distributed over the entire area.

Points of access for distribution should be established before the fact. Doing this enables you to conduct a size-up and develop plans for using a direct, indirect, or combination attack to achieve the best distribution of water using fog or straight streams.

Note: This formula is designed for use for the largest single open area in a given building. It does not take into account any water that is to be flowed at the same time in other rooms in the building or water that might be used for exposures. It spells out only the amount of water necessary to knock down the fire in the largest single open area.

The formula is based on and supported by the following:

the heat absorption capability of water,

the heat production based on the volume of air in a given open area, and

the steam generated and the amount required to displace air in a given area.

MISAPPLICATIONS OF THE FORMULA

Fuel loading of structures. Two natural laws apply and control this:

1. The only way to increase the heat-absorbing capability of any heat-absorbing material is to increase its surface area. Almost all fuels--solid or nonvolatile liquid--must be heated to their vaporization point before fuel in a state of readiness is available to burn and release its energy (heat). Some fuels will absorb heat very quickly and readily volatize; others will be slower.

2. It has been determined that most burning fuels, regardless of their calorific value, will release 535 Btus of heat when combined with one cubic foot of pure oxygen. It is also a proven fact that flame production stops when the oxygen falls to 14 percent. Normal air has 21 percent oxygen. In normal air, seven percent oxygen is available for heat release regardless of how much or what type of fuel is involved. This means approximately 37 Btus of heat would be released for each cubic foot of normal air.

The result of this, then, is that we need to know and keep in mind: Oxygen (normal air) is what governs the rate of heat release, not the fuel load.

Many times, you will see heated, oxygen-starved fuel vapors traveling in the thermal column until they encounter an air supply, upon which they burst into flame (heat release), far removed from the main body of fire.

The formula has been misapplied in that rates of flow have been changed for different fuel loads. The formula should not be altered regardless of the fuel load or type. This does not apply to the application stage. There is a difference between planning and application. Planning tells you the rate of flow; application tell you the volume, which is governed by time. Example: With a 100-gpm rate-of-flow requirement, if control is achieved in 30 seconds, the volume used would be 50 gallons; if it took one minute, 100 gallons would be used.

Control of the main body of fire is your objective. The environment the fire is in many times controls the time the flow is needed. If everything were perfect or close, a 30-second application would achieve control. When the fire blacks out, shut the nozzle down. Overapplication can be damaging.

I realize application is getting into tactics, but this can be very important. Floyd "Bill" Nelson in Qualitative Fire Behavior put it so aptly:

"If a combination attack is made and the nozzle is not advanced to the proper location and properly manipulated, the fire will not black out. When the fire does black out and the nozzle is not shut down within a reasonable time, the area will be overcooled, and overhaul will be difficult. In multistoried situations, late shutdown may even lead to the loss of the building."

During 30 years of leading, directing, or backing up nozzlemen, the author has often issued the following advice: ___ ___ ___, SHUT IT OFF (the publisher would not allow the foregoing blanks to be filled with the proper words. Needless to say, they are not terms of endearment).

Using the cubic volume of the total structure. This is another common misapplication of the formula. Only the largest single open area of the structure should be used. As stated before, this does not take into account other water that may be needed for other parts of the structure or for exposures. The old axiom applies, "The best exposure protection is control of the main body of fire."

We were trying to fill the area with steam and smother the fire. This is a misunderstanding of the formula`s use in a tactical sense. This method can work if we fought fires only in closed compartments. The Navy and Coast Guard did a lot of work and experiments on this approach during World War II. That is where Lloyd Layman`s "Little Drops of Water" came from.

Do not underestimate the role of steam. The reference material illustrates that when water is applied in partially enclosed areas where temperatures are 1,000 degrees or above at atmospheric pressures, water converting to steam will expand more than two times the normal expansion ratio at 212°F (that is, will expand more than 2 ¥ 1,700 times its original volume). This steam can play a large role in cooling remote areas or multistoried buildings.

A VALUABLE TOOL

Once it was accepted as a valid tool, the formula has proved to be useful in many ways, including the following:

In the middle 1950s when the formula evolved, it became apparent a constant-flow nozzle was needed. Akron Brass designed this nozzle and introduced it to the fire service.

When we applied the formula to larger structures (bowling alleys, supermarkets, and the like), the need for a large-volume highly mobile water delivery system was created. Akron Brass came up with the remote-control ladder nozzle. Snorkel Fire Equipment started work on an elevated platform large water delivery system and, ultimately, the Squirt.

The formula provides for a systems approach to resource determination. When applied to a structure (before the fire), we could determine resource requirements (water, hoselines, and nozzles; manpower; pumps; and so on). If the resources available did not come close to matching the resources needed, there was "trouble in River City."

Note: Time is a negative factor. If the resource needs cannot be met and applied within 10 minutes after ignition, the fire can reach its maximum potential or the peak of its damage curve.

The formula provides for a systems approach to determining loss probability, based on the rate of flow formula and the assumption that a fire has started in this environment.

In analyzing the largest single open area of this structure--and based on all of the natural laws applied, which was the foundation of our knowledge of fire behavior--we looked at and evaluated the building fire potential, the contents fire potential, and the reduction factors (factors that either enhance or reduce your chances of being able to manage the situation).

Using this system and the system for determining resources can tell us whether fire control in this structure is manageable or unmanageable.

If it is unmanageable, the only option is loss of the building.

These structures or conditions are not designed, built, or put together by fire departments; but when the fire occurs, the fire department--regardless of its size, its knowledge base, or resources--is called on to cope with the fire problem.

At times, it may be necessary for a fire department to use the formula (tool) to assess the relative probability of loss of a structure to a fire and communicate that probability factor to others. Such information may be important for the following:

an insurance engineer evaluating a risk,

a fire chief wishing to assess target hazards,

a training officer seeking to identify important buildings requiring prefire planning, an industrial fire protection specialist communicating recommendations to management,

a fire marshal reviewing fire protection needs for specific buildings, or

an architect assessing the value of various fire protection features.

Note: Many insurance engineers were taught to use the systems approaches to determining resources and loss probability in the `60s and `70s, which they used to assess risks for their underwriters when determining insurability. Most companies would not insure bowling alleys, supermarkets, and other structures with large open areas unless they were sprinklered.

* * *

I am not attempting to cover all the values of the Rate of Flow Formula. It is only an attempt to show that it is a valid tool that can be applied to many fire problems. A good analogy here might be the clock. We do not need to understand all of the natural laws, mechanical principles, and everything that goes into it to make it do what it does. We have come to rely on it as a valued tool to give us the time of day or night. Think of all the things you plan or do based on your reliance on this valid tool.

Remember also: "When you ignore or violate a natural law or proven principle, it will always give you a negative result." n

Suggested Reading

Books:

1. "Water for Firefighting," Fire Engineering, Aug. 1959.

2. "Water for Firefighting--Rate of Flow Formula," Iowa State University Bulletin #18, 1959.

3. Nelson, Floyd W. Qualitative Fire Behavior, International Society of Fire Service Instructors, Ashland, Mass., 1991, Isbn 0-929662-10-5.

Films:

1. The Nozzleman, Iowa State University (ISU), 1959.

2. Coordinated Fire Attack, ISU, 1961.

3. Closed Containers and Fire, ISU, 1976.

All should be available from the Fire Service Institute, Iowa State University, Ames, Iowa 50011; (515) 294-6817.

KEITH ROYER began his distinguished 43-year fire service career as a firefighter with the Wichita (KS) Fire Department in 1946. Three years later, he was one of the founding members of a statewide firefighter training program offered through the University of Kansas. In 1951, he joined the faculty of Iowa State University, where he was to become director of fire service education, college of engineering. It was there that Royer accomplished his most important work in firefighter education and fire science development. He retired from Iowa State University in 1988.

To access this Article, go to:
http://www.fireengineering.com//content/fe/en/articles/print/volume-148/issue-9/features/iowa-rate-of-flow-formula-for-fire-control.html

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NFPA 1142 Rural Water Supply

Research Needs & Project Planning Meeting

09 November 2017 | Daniel Gorham, Fire Protection Research Foundation

Project Statement Form

- Submitted December 2015
- Problem: Lack of scientific basis for water supply & delivery rate requirements in NFPA 1142
- Questions
  - Technical basis for water delivery rates (table 4.6.1)
  - Minimum water supply for single building with modern construction
  - Water supply for non-single building (e.g. WUI incident)
  - Water delivery rate vs. fire flow

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Terminology

Minimum Water Supply, the quantity of water required for fire control and extinguishment [NFPA 1142-2017]

Water Delivery Rate, the minimum amount of water per minute (in gpm or L/min), required… to be delivered to a fire scene via mobile water supply apparatus, hose lines, or a combination of both [NFPA 1142-2017]

Fire flow, the rate of water flow, at a residual pressure of 20 psi and for a specified duration necessary to control a major fire in a specific structure [NFPA Fire Protection Handbook]

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Minimum Water Supply

- Calculated based on: [1142-2017, section 4.1.1]
  - Occupancy hazard
  - Type of construction
  - Structure dimensions (length, width, and height)
  - Exposures, if any
- “water supply necessary for structural fire-fighting purposes” [1142-2017, section 4.1.2]
- Consider local conditions [1142-2017, section 4.1.3]

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Water Delivery Rate to Fire Scene

- Delivery Rate based on total water supply required (table 4.6.1)
- Minimum water deliver rate, 250 gpm
- Water supplies permitted to be used for fighting fires other than structures or for other emergencies

Table 4.6.1 Water Delivery Rate

Total Water Supply Required		Water Delivery Rate	
gal	L	gpm	L/min
<2,500	9,459	250	950
2,500–9,999	9,460–37,849	500	1,900
10,000–19,999	37,850–75,699	750	2,850
≥20,000	≥75,700	1,000	3,800

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History of Table 4.6.1

Summary of write-up produced by Anthony Capuano, NFPA intern

- 1984 edition (NFPA 1231) – Table 5-5.1(c) “Minimum Capability of Fire Department to Transport and to Use Water”
- 1999 edition (NFPA 1142) – No table containing information on water delivery rate
- 2007 edition (NFPA 1142) – Table 4.6.1 “Minimum Capability of Fire Department to Deliver Water”
- 2017 edition (NFPA 1142) – Table 4.6.1 “Water Delivery Rate”

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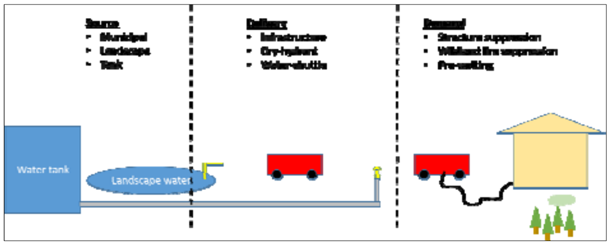
Rural & suburban water supply



Evaluation of Fire Flow Methodologies (2014)

- Review of 19 existing fire flow calculation methods (US and globally)
  - Water flow rates for sprinklered & non-sprinklered buildings
  - Generally derived using data from actual fires
- Building planning & on-scene methods


Evaluation of Fire Flow Methodologies

Final Report

THE FIRE PROTECTION RESEARCH FOUNDATION

FIRE RESEARCH

Related research

- UL Firefighter Safety Research Institute, *Study of the Impact of Fire Attack Utilizing Interior and Exterior Streams on Firefighter Safety and Occupant Survival*
  - *Nozzle air entrainment effects on fire behavior*
  - *Water mapping within structure based on application*
  - *Amount of water (total volume and application rate) to extinguish enclosure fire*
- Rahn (2010), *Initial Attack Effectiveness: Wildfire Staffing Study: Final report*
  - Wildland firefighter hose lay efficiency

Open Discussion

History of NFPA 1142 Table 4.6.1 “Minimum Capability of Fire Departments to Deliver Water”

Prepared by: Anthony Capuano, NFPA Intern

NFPA 25 1969 edition:
The first edition of this document. Does not mention anything about the minimum capability of Fire Department to Deliver Water. This document is a very basic overview of water systems for rural fire protection and does not provide many calculations for water supply.

NFPA 25 transitions to NFPA 1231

NFPA 1231 1975 edition:
NFPA 25 was renumbered to NFPA 1231, which become the second edition of the document. This document begins to focus on water supply to various regions with given equations. There are more equations related to water supply, yet does not obtain the table concerning the minimum capability of fire department to deliver water. There are no TCDF or TCRF reports about the transition from NFPA 25 to NFPA 1231.

NFPA 1231 1984 edition:
This document is the third edition of the standard and includes a complete revision. Table 5-5.1(c) Minimum Capability of Fire Department to Transport and to Use Water is nearly identical to table 4.6.1 from 1142(2012). From 1975 to 1984 there were no comments regarding the implementation of Table 5-5.1(c) in the TCDF or TCRF.

NFPA 1231 1989 edition:
This document contains the same table from the previous edition, yet the table was renumbered to Table 5-9.1(c) Minimum Capability of Fire Department to Transport and to Use Water. No comments in the 1989 TCDA concerning the table.

NFPA 1231 1993 edition:
Document contains the same table with a slight variation. Table 5-9(c) Minimum Capability of Fire Department to Transport and to Use Water

NFPA 1231 transitions to NFPA 1142

NFPA 1142 1999 edition:
Chapter 5 references calculating minimum water supplies. No Annex to explain calculations of minimum water supplies. There is no table containing information from the previous edition. NFPA 1231 (1993) has table and the NFPA 1142 (1999) does not have table. There are no comments about the removal of the table in TCDA or TCRA preceding the 1999 edition.

NFPA 1142 2001 edition:

Moved from Chapter 5 to Chapter 7 Calculating Minimum Water Supplies. Equations for minimum water supply introduced for both structures with and without exposure hazards. Section references Annex H Table H.1.4. Annex H is stated *not a part of the requirements of this NFPA document but is inclined for informational purposes only*. In Annex H there are example calculations for minimum water supply. There is no table for Minimum Capability of Fire Department to Deliver Water.

NFPA 1142 2007 edition:
Report on Proposals accepted that materials were moved from Chapter 7 to Chapter 4 from the previous edition. Requirements related to what constitutes an exposure and how they affect needed water supplies were moved from Chapter 5 to Chapter 4. Water delivery rates that were in previous editions were put back into the document. In the Report on Proposals, Log #8, accepted a new definition for water delivery rate. Table 4.6.1 Minimum Capability of Fire Department to Deliver Water is put into the standard. More detailed calculations are located in Annex H. Report on Comments submitted by Eddie Phillips, Southern Regional Fire Code Development Committee wanted to replace the language of Table 4.6.1, the action was rejected by the NFPA (Log #11).

NFPA 1142 2012 edition:
Table 4.6.1 Minimum Capability of Fire Department to Deliver Water is the same layout from the previous edition 2007. Report on Proposals A2011 - log #7 & #6 discuss changing the layout of the table, but do not mention the content behind the table.

ATTACHMENT B

Task Groups for the 2022 editions of NFPA 1141 & NFPA 1142, and 2023 edition of NFPA 1144

(As of 4/9/2019, subject to change and updates)

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