NFPA 1142

Standard on Water Supplies for Suburban and Rural Fire Fighting

2001 Edition

NFPA, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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NFPA 1142

Standard on

Water Supplies for Suburban and Rural Fire Fighting

2001 Edition

This edition of NFPA 1142, *Standard on Water Supplies for Suburban and Rural Fire Fighting*, was prepared by the Technical Committee on Forest and Rural Fire Protection and acted on by NFPA at its May Association Technical Meeting held May 13–17, 2001, in Anaheim, CA. It was issued by the Standards Council on July 13, 2001, with an effective date of August 2, 2001, and supersedes all previous editions.

This edition of NFPA 1142 was approved as an American National Standard on August 2, 2001.

Origin and Development of NFPA 1142

This text originally was NFPA 25, *Recommended Practices for Water Supply Systems for Rural Fire Protection*, as developed by the Subcommittee on Water Supply Systems for Rural Fire Protection of the Committee on Rural Fire Protection and Prevention. It received tentative adoption in 1969 and was further amended and adopted in May 1969 as NFPA 25. The 1975 edition represented a complete revision of the previous document, included a title change to *Water Supplies for Suburban and Rural Fire Fighting*, and was renumbered NFPA 1231.

The 1984, 1989, and 1993 editions again represented complete revisions to both mandatory and advisory material. The 1999 edition was again a complete revision with some significant changes and additions and was renumbered NFPA 1142, in keeping with the Committee's plan to group all its documents within a number range.

The 2001 edition is a partial revision and incorporates much of the information about the design of dry hydrants, formerly found in the appendices, into the requirements of the standard to encourage improved design and performance.

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

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

Contents

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

Changes other than editorial are indicated by a vertical rule in the margin of the pages on which they appear. These lines are included as an aid to the user in identifying changes from the previous edition. Where one or more complete paragraphs have been deleted, the deletion is indicated by a bullet between the paragraphs that remain.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. The complete title and edition of the document the material is extracted from is found in Annex I. Editorial changes to extracted material consist of revising references to an appropriate division in this document or the inclusion of the document number with the division number when the reference is to the original document. Requests for interpretations or revisions of extracted text shall be sent to the appropriate technical committee

Information on referenced publications can be found in Chapter 2 and Annex I.

Chapter 1 Administration

1.1 Scope. This standard shall identify minimum requirements for water supplies for structural fire-fighting purposes in rural and suburban areas where adequate and reliable water supply systems for fire-fighting purposes, as determined by the authority having jurisdiction, do not otherwise exist. The minimum requirements identified in this standard shall be subject to increase by the authority having jurisdiction to meet particular conditions such as the following:

(1) Limited fire department resources
(2) Extended fire department response time
(3) Delayed alarms
(4) Limited access
(5) Hazardous vegetation
(6) Structural attachments, such as decks and porches
(7) Unusual terrain
(8) Special uses

1.2* Purpose. The water supply requirements developed by this standard shall be performance oriented, and the authority having jurisdiction shall specify how these water supplies are made available.

1.2.1 This standard shall not set forth fireground operational parameters.

1.2.2 This standard shall not provide details for calculating an adequate amount of water for large special fire protection problems, such as bulk flammable liquid storage, bulk flammable gas storage, large varnish and paint factories, some plastics manufacturing and storage, aircraft hangars, distilleries, refineries, lumberyards, grain elevators, large chemical plants, coal mines, tunnels, subterranean structures, and warehouses using high rack storage for flammables or pressurized aerosols.

1.2.3 This standard shall not exclude the use of this water for other fire-fighting or emergency activities.

1.2.4 This standard shall not be an installation standard.

1.2.5 This standard shall not be used to calculate water supply for structures that are fully protected by an automatic fire sprinkler system installed in compliance with NFPA 13, *Standard for the Installation of Sprinkler Systems*; NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*; or NFPA 13R, *Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height.*

1.3 General.

1.3.1 The requirements of Chapters 4 through 7 shall be used for determining the minimum amount of water required for fire suppression. Chapter 9 on dry hydrant construction is performance oriented and shall allow the authority having jurisdiction latitude in specifying the method by which water supplies are provided, considering local conditions and needs.

1.3.2* The water requirements developed by this standard are performance oriented and shall be considered minimum in scope. The required water determined by the water supply officer shall be delivered to the fire scene. *(See Annexes A and B.)* The authority having jurisdiction shall be permitted to determine that additional water supplies are warranted. Annex G contains water supply recommendations that can be useful where the authority having jurisdiction determines additional water supplies are necessary.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, P.O. Box 9101, Quincy, MA 02269-9101.

NFPA 13, *Standard for the Installation of Sprinkler Systems,* 1999 edition.

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes,* 1999 edition.

NFPA 13R, *Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height,* 1999 edition.

NFPA 220, *Standard on Types of Building Construction,* 1999 edition.

NFPA 285, *Standard Method of Test for the Evaluation of Flammability Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components Using the Intermediate-Scale, Multistory Test Apparatus,* 1998 edition.

NFPA 299, *Standard for Protection of Life and Property from Wildfire,* 1997 edition.

NFPA 1141, *Standard for Fire Protection in Planned Building Groups,* 1998 edition.

NFPA 1963, *Standard for Fire Hose Connections,* 1998 edition.

2.1.2 Other Publications. (Reserved)

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not included, common usage of the terms shall apply.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction. The organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure.

3.2.3 Shall. Indicates a mandatory requirement.

3.2.4 Should. Indicates a recommendation or that which is advised but not required.

3.2.5 Standard. A document, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and which is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions shall be located in an appendix, footnote, or fine-print note and are not to be considered a part of the requirements of a standard.

3.3 General Definitions.

3.3.1 Adequate and Reliable Water Supply. See Water Supply.

3.3.2 Automatic Aid. A plan developed between two or more fire departments for immediate joint response on first alarms.

3.3.3 Building. Any structure used or intended for supporting any occupancy.

3.3.4 Classification Number.

3.3.4.1 Construction Classification Number. A series of numbers from 0.5 through 1.5 that are mathematical factors used in a formula to determine the total water supply requirements.

3.3.4.2 Occupancy Hazard Classification Number. A series of numbers from 3 through 7 that are mathematical factors used in a formula to determine total water supply requirements.

3.3.5 Dry Hydrant. An arrangement of pipe permanently connected to a water source other than a piped, pressurized water supply system that provides a ready means of water supply for fire-fighting purposes and that utilizes the drafting (suction) capability of fire department pumpers. [**299:**2.1]

3.3.6* Exposure Hazard. A structure within 50 ft (15.24 m) of another building and 100 ft^2 (9.3 m^2) or larger in area.

3.3.7* Fire Department. An organization providing rescue, fire suppression, and related activities. [**1001:**1.4]

3.3.8* Large Diameter Hose. A hose of 3½ in. (90 mm) size or larger. [**1961:**1.3]

3.3.9 Minimum Water Supply. See Water Supply.

3.3.10 Mobile Water Supply Apparatus (Tanker, Tender). A vehicle designed primarily for transporting (pickup, transporting, and delivering) water to fire emergency scenes to be applied by other vehicles or pumping equipment.

3.3.11 Municipal-Type Water System. A system having water pipes serving hydrants and designed to furnish, over and above domestic consumption, a minimum flow of 250 gpm (946 L/min) at 20 psi (139 kPa) residual pressure for a 2-hour duration. [**1141:**2.1]

3.3.12* Mutual Aid Plan. A plan developed between two or more agencies to render assistance to the parties of the agreement. [**1600:**1.3]

3.3.13 Occupancy Hazard Classification Number. See Classification Number.

3.3.14 Secondary (Design) Water Supply. See Water Supply.

3.3.15 Structure. That which is built or constructed; an edifice or building of any kind.

3.3.16 Water Supply.

3.3.16.1 Adequate and Reliable Water Supply. A water supply that is sufficient every day of the year to control and extinguish anticipated fires in the municipality, particular building, or building group served by the water supply.

3.3.16.2 Minimum Water Supply. The quantity of water required for fire control.

3.3.16.3 Secondary (Design) Water Supply. The estimated rate of flow [expressed in gpm (L/min) for a prescribed time period] that is necessary to control a major fire in a building or structure.

3.3.17* Water Supply Officer (WSO). The fire department officer responsible for providing water for fire-fighting purposes.

Chapter 4 Structure Surveys

4.1 General.

4.1.1* The minimum water supply required under this standard shall be determined by obtaining the following information:

(1) Classification of occupancy hazard
(2) Classification of construction
(3) Structure dimensions
(4) Exposures, if any

4.1.2* A record of water supplies shall be prepared and periodically updated. Required water supplies shall be of suitable quality as approved by the authority having jurisdiction, and be maintained and accessible on a year-round basis.

4.1.3 The minimum fire-fighting water supply shall be determined (per Chapter 7) from the information collected in 4.1.1 and 4.1.2.

Chapter 5 Classification of Occupancy Hazard

5.1 General.

5.1.1* The authority having jurisdiction, in conjunction with the fire department, upon obtaining the information specified in 4.1.1, shall determine the occupancy hazard classification number according to this chapter. These classification numbers shall range from 3 through 7.

5.1.2 Where more than one occupancy is present in a structure, the occupancy hazard classification number for the most hazardous occupancy shall be used for the entire structure.

5.2* Occupancy Hazard Classification Number.

5.2.1* Occupancy Hazard Classification 3.

5.2.1.1* Occupancy Hazard Classification 3 shall be used for severe hazard occupancies.

5.2.1.2 When an exposing structure is of occupancy hazard classification 3, it shall be considered an exposure hazard if within 50 ft (15.24 m), regardless of size.

5.2.1.3 This classification shall include occupancies with operations or functions similar to the following:

(1) Cereal or flour mills
(2) Combustible hydraulics
(3) Cotton picker and opening operations
(4) Die casting
(5) Explosives and pyrotechnics manufacturing and storage
(6) Feed and gristmills
(7) Flammable liquid spraying
(8) Flow coating/dipping
(9) Linseed oil mills
(10) Manufactured homes/modular building assembly
(11) Metal extruding
(12) Plastic processing
(13) Plywood and particle board manufacturing
(14) Printing using flammable inks
(15) Rubber reclaiming
(16) Sawmills
(17) Solvent extracting
(18) Straw or hay in bales
(19) Textile picking
(20) Upholstering with plastic foams

5.2.2* Occupancy Hazard Classification 4.

5.2.2.1* Occupancy Hazard Classification 4 shall be used for high hazard occupancies.

5.2.2.2 When an exposing structure is of occupancy hazard classification 4, it shall be considered an exposure hazard if within 50 ft (15.24 m), regardless of size.

5.2.2.3 This classification shall include occupancies having conditions similar to the following:

(1) Barns and stables (commercial)
(2) Building materials supply storage
(3) Department stores
(4) Exhibition halls, auditoriums, and theaters
(5) Feed stores (without processing)
(6) Freight terminals
(7) Mercantiles
(8) Paper and pulp mills
(9) Paper processing plants
(10) Piers and wharves
(11) Repair garages
(12) Rubber products manufacturing and storage
(13) Warehouses, such as those used for furniture, general storage, paint, paper, and woodworking industries

5.2.3* Occupancy Hazard Classification 5.

5.2.3.1 Occupancy Hazard Classification 5 shall be used for moderate hazard occupancies, in which the quantity or combustibility of contents is expected to develop moderate rates of spread and heat release. The storage of combustibles shall not exceed 12 ft (3.66 m) in height.

5.2.3.2 This classification shall include occupancy locations similar to the following:

(1) Amusement occupancies
(2) Clothing manufacturing plants
(3) Cold storage warehouses
(4) Confectionery product warehouses
(5) Farm storage buildings, such as corn cribs, dairy barns, equipment sheds, and hatcheries
(6) Laundries
(7) Leather goods manufacturing plants
(8) Libraries (with large stockroom areas)
(9) Lithography shops
(10) Machine shops
(11) Metalworking shops
(12) Nurseries (plant)
(13) Pharmaceutical manufacturing plants
(14) Printing and publishing plants
(15) Restaurants
(16) Rope and twine manufacturing plants
(17) Sugar refineries
(18) Tanneries
(19) Textile manufacturing plants
(20) Tobacco barns
(21) Unoccupied buildings

5.2.4* Occupancy Hazard Classification 6.

5.2.4.1 Occupancy Hazard Classification 6 shall be used for low hazard occupancies, in which the quantity or combustibility of contents is expected to develop relatively low rates of spread and heat release.

5.2.4.2 This classification shall include occupancy locations similar to the following:

(1) Armories
(2) Automobile parking garages
(3) Bakeries
(4) Barber or beauty shops
(5) Beverage manufacturing plants/breweries
(6) Boiler houses
(7) Brick, tile, and clay product manufacturing plants
(8) Canneries
(9) Cement plants
(10) Churches and similar religious structures
(11) Dairy products manufacturing and processing plants
(12) Doctors' offices
(13) Electronics plants
(14) Foundries
(15) Fur processing plants
(16) Gasoline service stations
(17) Glass and glass products manufacturing plants
(18) Horse stables
(19) Mortuaries
(20) Municipal buildings
(21) Post offices
(22) Slaughterhouses
(23) Telephone exchanges
(24) Tobacco manufacturing plants
(25) Watch and jewelry manufacturing plants
(26) Wineries

5.2.5* Occupancy Hazard Classification 7.

5.2.5.1 Occupancy Hazard Classification 7 shall be used for light hazard occupancies, in which the quantity or combustibility of contents is expected to develop relatively light rates of spread and heat release.

5.2.5.2 This classification shall include occupancy locations similar to the following:

(1) Apartments
(2) Colleges and universities
(3) Clubs

(4) Dormitories
(5) Dwellings
(6) Fire stations
(7) Fraternity or sorority houses
(8) Hospitals
(9) Hotels and motels
(10) Libraries (except large stockroom areas)
(11) Museums
(12) Nursing and convalescent homes
(13) Offices (including data processing)
(14) Police stations
(15) Prisons
(16) Schools
(17) Theaters without stages

Chapter 6 Classification of Construction

6.1 General.

6.1.1 The authority having jurisdiction shall obtain the information specified in 4.1.1 and shall determine the classification number according to this chapter.

6.1.2 For purposes of this standard, structures shall be classified by type of construction and shall be assigned a construction classification number.

6.1.3 Where more than one type of construction is present in a structure, the higher construction classification number shall be used for the entire structure.

6.2* Construction Classification Number.

6.2.1* Guide to Classification of Types of Building Construction. Classification of types of building construction shall be in accordance with NFPA 220, *Standard on Types of Building Construction.*

6.2.2 Type I (443 or 332) Construction [Construction Classification Number 0.5]. Type I construction shall be that type in which the structural members, including walls, columns, beams, girders, trusses, arches, floors, and roofs, are of approved noncombustible or limited-combustible materials and shall have fire resistance ratings not less than those specified in Table 6.2.2 (Table 3.1 in NFPA 220).

Table 6.2.2 Fire Resistance Ratings (in hours) for Type I through Type V Construction

	Type I		Type II			Type III		Type IV	Type V	
	443	332	222	111	000	211	200	2HH	111	000
Exterior Bearing Walls										
Supporting more than one floor, columns, or other bearing walls	4	3	2	1	0[1]	2	2	2	1	0[1]
Supporting one floor only	4	3	2	1	0[1]	2	2	2	1	0[1]
Supporting a roof only	4	3	1	1	0[1]	2	2	2	1	0[1]
Interior Bearing Walls										
Supporting more than one floor, columns, or other bearing walls	4	3	2	1	0	1	0	2	1	0
Supporting one floor only	3	2	2	1	0	1	0	1	1	0
Supporting roofs only	3	2	1	1	0	1	0	1	1	0
Columns										
Supporting more than one floor, columns, or other bearing walls	4	3	2	1	0	1	0	H[2]	1	0
Supporting one floor only	3	2	2	1	0	1	0	H[2]	1	0
Supporting roofs only	3	2	1	1	0	1	0	H[2]	1	0
Beams, Girders, Trusses, and Arches										
Supporting more than one floor, columns, or other bearing walls	4	3	2	1	0	1	0	H[2]	1	0
Supporting one floor only	3	2	2	1	0	1	0	H[2]	1	0
Supporting roofs only	3	2	1	1	0	1	0	H[2]	1	0
Floor Construction	3	2	2	1	0	1	0	H[2]	1	0
Roof Construction	2	1½	1	1	0	1	0	H[2]	1	0
Exterior Nonbearing Walls[3]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]	0[1]

[Shaded box] Those members that shall be permitted to be of approved combustible material.

[1]See NFPA 220, A.3.1 (Table).
[2]"H" indicates heavy timber members; see NFPA 220 for requirements.
[3]Exterior nonbearing walls meeting the conditions of acceptance of NFPA 285, *Standard Method of Test for the Evaluation of Flammability Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components Using the Intermediate-Scale, Multistory Test Apparatus*, shall be permitted to be used.

6.2.3 Type II (222, 111, or 000) Construction [Construction Classification Number 0.75]. Type II construction shall be that type not qualifying as Type I construction in which the structural members, including walls, columns, beams, girders, trusses, arches, floors, and roofs, are of approved noncombustible or limited-combustible materials and shall have fire resistance ratings not less than those specified in Table 6.2.2. [**220:**3.2]

6.2.4* Type III (211 or 200) Construction [Construction Classification Number 1.0]. Type III construction shall be that type in which exterior walls and structural members that are portions of exterior walls are of approved noncombustible or limited-combustible materials, and interior structural members, including walls, columns, beams, girders, trusses, arches, floors, and roofs, are entirely or partially of wood of smaller dimensions than required for Type IV construction or of approved noncombustible, limited-combustible, or other approved combustible materials. In addition, structural members shall have fire resistance ratings not less than those specified in Table 6.2.2. [**220:**3.3]

6.2.5 Type IV (2HH) Construction [Construction Classification Number 0.75]. Type IV construction shall be that type in which exterior and interior walls and structural members that are portions of such walls are of approved noncombustible or limited-combustible materials. Other interior structural members, including columns, beams, girders, trusses, arches, floors, and roofs, shall be of solid or laminated wood without concealed spaces and shall comply with the provisions of 6.2.5.1 through 6.2.5.5. In addition, structural members shall have fire resistance ratings not less than those specified in Table 6.2.2.

Exception No. 1: Interior columns, arches, beams, girders, and trusses of approved materials other than wood shall be permitted, provided they are protected to provide a fire resistance rating of not less than 1 hour.

Exception No. 2: Certain concealed spaces shall be permitted by the exception to 6.2.5.3. [**220:**3.4.1]

6.2.5.1 Wood columns supporting floor loads shall be not less than 8 in. (203 mm) in any dimension; wood columns supporting roof loads only shall be not less than 6 in. (152 mm) in the smallest dimension and not less than 8 in. (203 mm) in depth. [**220:**3.4.2]

6.2.5.2 Wood beams and girders supporting floor loads shall be not less than 6 in. (152 mm) in width and not less than 10 in. (254 mm) in depth; wood beams and girders and other roof framing, supporting roof loads only, shall be not less than 4 in. (102 mm) in width and not less than 6 in. (152 mm) in depth. [**220:**3.4.3]

6.2.5.3 Framed or glued laminated arches that spring from grade or the floor line and timber trusses that support floor loads shall be not less than 8 in. (203 mm) in width or depth. Framed or glued laminated arches for roof construction that spring from grade or the floor line and do not support floor loads shall have members not less than 6 in. (152 mm) in width and not less than 8 in. (203 mm) in depth for the lower half of the member height and not less than 6 in. (152 mm) in depth for the upper half of the member height. Framed or glued laminated arches for roof construction that spring from the top of walls or wall abutments and timber trusses that do not support floor loads shall have members not less than 4 in. (102 mm) in width and not less than 6 in. (152 mm) in depth.

Exception: Spaced members shall be permitted to be composed of two or more pieces not less than 3 in. (76 mm) in thickness where blocked solidly throughout their intervening spaces or where such spaces are tightly closed by a continuous wood cover plate not less than 2 in. (51 mm) in thickness, secured to the underside of the members. [**220:**3.4.4]

6.2.5.3.1 Splice plates shall be not less than 3 in. (76 mm) in thickness. [**220:**3.4.4]

6.2.5.4 Floors shall be constructed of splined or tongue-and-groove plank not less than 3 in. (76 mm) in thickness that is covered with 1-in. (25-mm) tongue-and-groove flooring, laid crosswise or diagonally to the plank, or with ½-in. (12.7-mm) plywood; or they shall be constructed of laminated planks not less than 4 in. (102 mm) in width, set close together on edge, spiked at intervals of 18 in. (457 mm), and covered with 1-in. (25-mm) tongue-and-groove flooring, laid crosswise or diagonally to the plank, or with ½-in. (12.7-mm) plywood. [**220:**3.4.5]

6.2.5.5 Roof decks shall be constructed of splined or tongue-and-groove plank not less than 2 in. (51 mm) in thickness; or of laminated planks not less than 3 in. (76 mm) in width, set close together on edge, and laid as required for floors; or of 1⅛-in. (28.6-mm) thick interior plywood (exterior glue); or of approved noncombustible or limited-combustible materials of equivalent fire durability. [**220:**3.4.6]

6.2.6 Type V (111 or 000) Construction [Construction Classification No. 1.5]. Type V construction shall be that type in which exterior walls, bearing walls, columns, beams, girders, trusses, arches, floors, and roofs are entirely or partially of wood or other approved combustible material smaller than material required for Type IV construction. In addition, structural members shall have fire resistance ratings not less than those specified in Table 6.2.2. [**220:**3.5]

Chapter 7 Calculating Minimum Water Supplies

7.1 General.

7.1.1 After completing the structure survey and determining the construction classification number and the occupancy hazard classification number, the authority having jurisdiction shall compute the required minimum water supply.

7.1.2 A structure shall be considered an exposure hazard if it is 100 ft^2 (9.29 m^2) or larger in area and is within 50 ft (15.24 m) of another structure. However, if a structure, regardless of size, is of occupancy hazard classification number 3 or 4, it shall be considered an exposure hazard if within 50 ft (15.24 m) of another structure.

7.2 Structures Without Exposure Hazards. For structures with no exposure hazards, the minimum water supply, in gallons, shall be determined by the total cubic footage of the structure, including any attached structures, divided by the occupancy hazard classification number as determined from Chapter 5, and multiplied by the construction classification number as determined from Chapter 6. *(See Annex H for sample calculations for structures without exposure hazards.)*

$$\text{minimum water supply} = \frac{\left(\text{total volume of structure}\right)}{\left(\text{occupancy hazard classification number}\right)} \times \text{construction classification number}$$

7.2.1 The minimum water supply required for any structure without exposure hazards shall not be less than 2000 gal (7570 L). *[See Table H.1.4(b).]*

7.2.2 The minimum water supply, as determined for any structure that is specified in Section 7.2 and 7.2.1, shall be provided for emergency operations.

7.3 Structures with Exposure Hazards.

7.3.1 For structures with unattached structural exposure hazards, the minimum water supply, in gallons, shall be determined by the cubic footage of the structure, divided by the occupancy hazard classification number as determined from Chapter 5, multiplied from the construction classification number as determined from Chapter 6, and multiplied by 1.5. *(See Annex H for sample calculations for structures with exposure hazards.)*

$$\text{minimum water supply} = \frac{\left(\text{total volume of structure}\right)}{\left(\text{occupancy hazard classification number}\right)} \times \text{construction classification number} \times 1.5$$

7.3.2 The minimum water supply required for structure with exposure hazards specified in 7.3.1 shall not be less than 3000 gal (11,355 L). *[See Table H.1.4(b).]*

7.4 Structures with Automatic Sprinkler Protection.

7.4.1 The authority having jurisdiction shall be permitted to waive the water supply required by this standard when a structure is protected by an automatic sprinkler system that fully meets the requirements of NFPA 13, *Standard for the Installation of Sprinkler Systems*; NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*; or NFPA 13R, *Standard for the Installation of Sprinkler Systems in Residential Occupancies up to and Including Four Stories in Height. (See Annex F.)*

7.4.2 If a sprinkler system protecting a building does not fully meet the requirements of NFPA 13, NFPA 13D, or NFPA 13R, a water supply shall be provided in accordance with this standard.

7.5 Structures with Other Automatic Fire Suppression Systems. For any structure fully or partially protected by an automatic fire suppression system other than as specified in Section 7.4, the authority having jurisdiction shall determine the minimum water supply required for fire-fighting purposes.

Chapter 8 Water Supply

8.1 Water Source Approval. Any water source used to meet the requirement of this standard shall be of suitable quality as approved by the authority having jurisdiction and be maintained and accessible on a year-round basis.

8.2 In locations where adequate municipal water systems are not provided and additional fire protection is needed, minimum water supplies shall be established in, or transportable to, the designated area. Water sources provided or developed to supply dry hydrant systems shall continually meet all minimum capacity and delivery requirements, as determined by approved engineering practices.

8.3 Water Use Agreements. The authority having jurisdiction shall enter into water use agreements when a private source of water is used to meet the requirements of this standard.

8.4 Identifying Water Sources. A water source indicator approved by the authority having jurisdiction shall be erected at each water point identifying the site for fire department emergency use.

8.5 Fire Department Connections. Any connection provided at a water source required by this standard shall be approved by the authority having jurisdiction and shall conform to NFPA 1963, *Standard for Fire Hose Connections*.

8.6 Access to Water Sources. Means of access to any required water supply shall be constructed and maintained according to NFPA 299, *Standard for Protection of Life and Property from Wildfire;* NFPA 1141, *Standard for Fire Protection in Planned Building Groups;* and local regulations.

Chapter 9 Dry Hydrants

9.1* General. The authority having jurisdiction shall ensure that generally accepted design practices are employed during the following:

(1) Dry hydrant planning
(2) The permit process
(3) Design criteria
(4) Construction

9.2* Planning and Permits. The planning, permitting, and design processes shall be completed before the actual construction begins.

9.2.1 Planning. Planning shall involve all affected agencies and private concerns so that a coordinated effort is undertaken.

9.2.2 Permits. Required permits to install a dry hydrant shall be obtained from the authorities having jurisdiction prior to installation.

9.3* Dry Hydrant Design and Location.

9.3.1* Design Criteria. To ensure safety of design, functionality, installation, maintenance, and proper appropriation of financial resources, the authority having jurisdiction shall approve all aspects of construction design, type of materials, pipe, and system fittings.

9.3.2* The authority having jurisdiction shall determine which materials are best suited to meet fire flow needs and installation conditions. In no case shall less than Schedule 40 pipe and component fittings be used.

9.3.3* All dry hydrant systems shall be designed and constructed to provide a minimum flow of 1000 gpm (3785 L/min) at draft.

9.3.4* Dry hydrant systems shall be designed and constructed so that slope and piping configuration does not impede drafting capability.

9.3.5* All exposed surfaces and all underground metal surfaces shall be protected to prevent deterioration.

9.3.6* Subject to alternative engineering practices, no more than the equivalent of two 90-degree elbows shall be used in the total system.

9.3.7 Dry hydrant(s) shall be designed and constructed to include a suitable protective cap. Steamer connection(s) shall be compatible with the fire department's hard suction hose size and shall conform to NFPA 1963, *Standard for Fire Hose Connections*.

9.3.8* An acceptable system design formula shall be developed that reflects the various requirements outlined in this standard and the adequacy of the water source to be used to supply the dry hydrant.

9.3.8.1 Available site pressure shall be determined using the following formula: Available site pressure *(ASP)* is equal to the adjusted atmospheric pressure above sea level *(AAP)* minus the pressure changes associated with static lift *(SL)*, minus vapor pressure *(VP)*, minus minimum pump pressure, which is expressed as the following equation:

$$ASP = AAP - SL - VP - 5$$

where:
ASP = available site pressure (psi)
AAP = adjusted atmospheric pressure (psi)
SL = static lift (psi)
VP = vapor pressure (psi)

9.3.9* Dry hydrant system piping shall be supported and/or stabilized using approved engineering design practices. Thrust blocks, or equivalent protection, shall be employed at elbows and other system stress points.

9.3.10 In addition to strength of materials and structural support criteria, design shall address appropriate aggregates and soil materials to be used to backfill/cover piping during installation.

9.3.11* All connections shall be clean and the appropriate sealing materials shall be used according to manufacturer's specifications so as to ensure that all joints are airtight.

9.3.12* System strainers shall be constructed to permit required fire flow, in accordance with approved engineering practices.

9.4* Access to Water Sources and Dry Hydrant Locations.

9.4.1 Locations for, and the immediate area around, dry hydrants shall provide for fire fighter safety.

9.4.2* Dry hydrants shall be located to be accessible under all weather conditions.

9.4.3 System and site accessibility criteria shall ensure that hydrant can be reached with one or two 10 ft (3.05 m) lengths of hard suction.

9.4.4 Dry hydrants shall have a minimum clearance of 20 ft (6.6 m) on each side and be located a minimum of 100 ft (30 m) from any structure. Highway or road traffic shall not be impaired during the use of the dry hydrant.

9.4.5* Dry hydrants shall be protected from damage by vehicular and other perils, including freezing and damage from ice and other objects.

9.4.6* Dry hydrant locations shall be made visible from the main roadway during emergencies by reflective marking and signage approved by the authority having jurisdiction. All identification signs shall be approved by the highway authority prior to installation if they are to be located on the right-of-way or are subject to state laws.

9.4.7* Vehicle access shall be designed and constructed to support the heaviest vehicle.

9.5* Depth of Water Sources. Consideration shall be given to the measurement of water supply capacities when designing and installing dry hydrant systems. There shall be not less than 2 ft (0.6 m) of water above the strainer and 1 ft (0.3 m) to 18 in. (0.45 m) below the strainer depending on bottom condition of the body of water.

9.6* Installation Procedure for Dry Hydrant System. The authority having jurisdiction shall ensure the installation meets all design criteria and the process is conducted in a safe manner.

9.6.1 A safety officer shall be designated to monitor the installation of the dry hydrant(s).

9.6.2* The proximity of any underground and overhead utilities to the selected site(s) shall be identified and appropriate measures shall be taken to ensure the safety of personnel prior to installation.

9.6.3 During installation, no one shall be allowed into or close to the trench without adequate safety measures.

9.7* Maintenance of Dry Hydrant. Dry hydrants shall require checking and maintenance at least quarterly. Thorough surveys shall be conducted, to reveal any deterioration in the water supply situation in ponds, streams, or cisterns.

9.7.1 Grass, brush, and other vegetation shall be kept trimmed and neat. Vegetation shall be cleared for a minimum 3 ft (0.9 m) radius from around hydrants.

9.7.2 The hydrant shall be painted as needed, with reflective material to maintain visibility during emergencies, in accordance with 9.4.5.

9.7.3* Maintenance Records for Dry Hydrants. The authority having jurisdiction shall maintain in a safe location, maps and records of dry hydrant system installation, tests, inspections, maintenance and repairs.

9.7.4* The hydrants shall be tested at least annually with a fire department pumper.

9.8* Maps and Location/Detail Drawings. An official record shall be kept of all pertinent information recommended for each dry hydrant area.

Chapter 10 Reports and Records

10.1 Plans for Proposed Construction.

10.1.1 Where the authority having jurisdiction requires plans to be submitted for review before construction is started, the plans shall be submitted to the fire department for review in accordance with 4.1.1.

10.1.2 Where plans are not required by the authority having jurisdiction, the fire department shall request the property owner(s) to submit plans for proposed construction for the purpose of determining the minimum water supply requirements.

10.2 Reporting Requirements.

10.2.1 The authority having jurisdiction shall make the results available to the owner(s) of surveyed structures.

10.2.2 If the authority having jurisdiction is not the fire department, the results of the structure survey shall be made available to the fire department.

10.3 Resurveying Property. In other than residential occupancies, changes made in the structural design, occupancy, or contents that affect the occupancy hazard classification number as specified in Chapter 5 shall require that the structure be resurveyed.

10.4 Changes on Automatic Fire Suppression Systems. The property owner(s) shall notify the authority having jurisdiction in writing of any changes, including temporary impairment, that are made in any automatic fire suppression system that would affect the protection afforded.

10.5 Retention of Reports. The authority having jurisdiction shall retain copies of plans, reports, and surveys specified in this standard for a minimum of 3 years.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.2 In some areas, water supply systems have been installed for domestic water purposes only. These systems can be equipped with hydrants that might not be standard fire hydrants, with available volume, pressure, and duration of flow being less than needed for adequate fire-fighting purposes. Where such conditions exist, this standard and annex should be applied in water supply matters.

A.1.3.2 Fire apparatus and associated equipment are important components of the water transport process. *(See Annexes B, C, D, and E; NFPA 1901, Standard for Automotive Fire Apparatus; and other applicable standards.)*

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction. The phrase "authority having jurisdiction" is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.3.6 Exposure Hazard. If a structure is a Class 3 or Class 4 occupancy hazard, it is an exposure hazard if within 50 ft (15.24 m) of another building, regardless of size.

A.3.3.7 Fire Department. The authority having jurisdiction and the fire department having jurisdiction can be the same agency. The term *fire department* includes any public, governmental, private, industrial, or military organization engaging in this type of activity.

A.3.3.8 Large Diameter Hose. Supply hose is designed to be used at operating pressures not exceeding 185 psi (1275 kPa). Attack hose is designed for use at operating pressures up to at least 275 psi (1895 kPa).

A.3.3.12 Mutual Aid Plan. Often the request for such aid to be rendered comes only after an initial response has been made and the emergency incident status has been determined.

A.3.3.17 Water Supply Officer (WSO). Many progressive rural fire departments depend on a Water Supply Officer (WSO). The WSO is the individual who implements the water supply pre-fire planning. The work of a properly trained and equipped WSO makes it possible for the officer supervising the actual fire attack to operate on the basis of reliable water supply information, to coordinate the attack with the available water supplies, and to help prevent the confusion inherent in fighting a major fire when the chief officer at the scene has to divert too much personal attention from the attack to the logistics of backing it up.

The duties of the WSO are as follows.

The WSO's overall responsibilities are to determine water requirements of the targeted structures, to plan availability of and access to water sources, and to ensure sufficient water is provided at each fire site. The WSO should maintain and have available a complete set of files, including locations of water points and lists of automatic and mutual aid mobile water supply apparatus available. Modern technology in computers makes it feasible for even a relatively low-budget department to reduce this data to electronic files that can be maintained at the fire alarm communication center and provided at the scene of every fire.

The WSO participates in the pre-fire planning and in calculating the fire flow requirements for the various buildings in the area under the department's jurisdiction. To satisfy these water requirements, the WSO should survey the district and the surrounding areas for available water for fire-fighting purposes. Water supplies might exist on the property to be protected or might need to be transported. The WSO should develop preplans and see that the fire department is kept aware of all the water supplies available to the entire area. The WSO maintains close coordination with the fire department training officer and provides assistance in joint water supply training sessions with neighboring fire departments. The WSO should make periodic inspections of all water supplies and structural changes in the department's jurisdiction.

A list of all apparatus, equipment, and personnel available to the officer's department should be developed. Arrangements should be developed for specific apparatus and personnel to respond under an automatic aid agreement (first alarm response) or a mutual aid agreement (called as needed). Needs will be dictated by the nature of the structure(s) involved and the quantity of water required.

At the fire scene, the WSO's duty is to maintain continuous fire streams by establishing several water hauling facilities, assembling water-carrying equipment of automatic and mutual aid departments, and calculating estimated arrival times of mobile water supply apparatus, through a thorough knowledge of available water supplies throughout a wide area of fire department jurisdiction.

To develop and sustain large fire flow requires the use of several water sources as well as several drop tanks where water can be dumped. Therefore, reliable and effective communication is necessary in directing mobile water supplies so that time is not lost at the fill and the dump points. To obtain water supply efficiency, a radio frequency separate from that used for the fire ground operations needs to be assigned to the WSO and the water supply site and the mobile water supply apparatus. The WSO will also require efficient communication with the incident commander.

The WSO (or designee) meets with property owners and others to secure their permission to use the water supply, to develop an all-weather road to the supply, and to install dry hydrants (see Chapter 9). The installation of roads to or dry hydrants in navigable water or wetlands might require a permit from appropriate local, state, or national agencies. The WSO should also consult with the owner in the design of a water source on a property to be protected.

A.4.1.1 Information needed to compute the minimum water supplies that should be collected during building surveys includes the following:

(1) Area of all floors, including attics, basements, and crawl spaces
(2) Height between floors or crawl spaces and in the attics from floor to ridgepole
(3) Construction materials used in each building, including walls, floors, roofs, ceilings, interior partitions, stairs, etc.
(4) Occupancy (occupancies) of buildings
(5) Occupancy (occupancies) of yard areas
(6) Exposures to buildings and yard storage and distances between them
(7) Fire protection systems — automatic and manual protection systems, hydrants, yard mains, and other protection facilities
(8) On-premises water supplies, including natural and constructed sources of water

A.4.1.2 In determining suitable water quality, the authorities having jurisdiction should consider potential environmental contaminates or particulate matter in the proposed source.

A.5.1.1 In addition to the storage of products that are potentially hazardous from the standpoint of increased fire load, farm properties present certain inherent dangers to the rural fire fighter that are not contemplated by the urban fire fighter. Storage of products that are potentially hazardous to fire fighters from the standpoint of increased fire volume, explosion, and toxicity exists at most rural fire locations. These hazards include the following:

(1) Bulk storage of petroleum fuels, more frequently fuel oil, but often gasoline and propane, can be hazardous. While some tanks are underground, many are aboveground and often located within 50 ft (15.24 m) of farm buildings.
(2) Many farmers use and store blasting agents, such as dynamite, that are often extended with ammonium nitrate (the latter having greater explosive impact per unit weight).
(3) Nearly all farms use and store different pesticides. Some of these chemical compounds give off very toxic fumes while burning. Two compounds that are safe where used independently of each other can be very hazardous to the fire fighter where mixed together in a fire situation.
(4) Localized problems also exist in corn growing areas; for example, anhydrous ammonia is stored and used in large amounts during the early growing season.

The rural fire department needs to work with the farmer to reduce the fire and potential hazard to life of these products by storing them safely. However, fire fighters of the rural fire departments should know the potential hazards presented by the products and the appropriate fire-fighting precautions to be taken. The department membership should be aware of the hazards listed in (1) through (4) by means of the survey of the farm by the Water Supply Officer or other inspector, and appropriate measures should be taken to protect the membership of the department from potential hazards.

A.5.2 The occupancy hazard classification number is a mathematical factor to be used in calculating minimum water supplies. The lowest occupancy hazard classification number is 3, and 4 is assigned to the highest hazard group. The highest occupancy hazard classification number is 7, and it is assigned to the lowest hazard group.

A.5.2.1 When using SI metric unit calculations, divide the total volume of the structure in cubic meters by the SI metric unit conversion factor for the occupancy classification 3, which is 0.0224. See Table A.5.2.1.

Table A.5.2.1 SI Metric Unit Conversion Factors for Occupancy Classifications

Occupancy Classification Number	SI Metric Unit Conversion Factor
3	0.0224
4	0.0299
5	0.0373
6	0.0448
7	0.0523

A.5.2.1.1 In severe hazard occupancies, the quantity or combustibility of contents is expected to develop very high rates of spread and heat release.

A.5.2.2 When using SI metric unit calculations, divide the total volume of the structure in cubic meters by the SI metric unit conversion factor for the occupancy classification 4, which is 0.0299. See Table A.5.2.1.

A.5.2.2.1 In high hazard occupancies, the quantity or combustibility of contents is expected to develop high rates of spread and heat release.

A.5.2.3 When using SI metric unit calculations, divide the total volume of the structure in cubic meters by the SI metric unit conversion factor for the occupancy classification 5, which is 0.0373. See Table A.5.2.1.

A.5.2.4 When using SI metric unit calculations, divide the total volume of the structure in cubic meters by the SI metric unit conversion factor for the occupancy classification 6, which is 0.0448. See Table A.5.2.1.

A.5.2.5 When using SI metric unit calculations, divide the total volume of the structure in cubic meters by the SI metric unit conversion factor for the occupancy classification 7, which is 0.0523. See Table A.5.2.1.

A.6.2 The construction classification number is a mathematical factor to be used in calculating minimum water supplies. The slowest burning or lowest hazard type of construction, fire-resistive, is construction classification 0.5. The fastest burning or highest hazard type of construction, wood frame, is construction classification 1.5. All dwellings should be assigned a construction classification number of 1.0 or lower where construction is noncombustible or fire resistive.

A.6.2.1 The types of construction include five basic types designated by roman numerals as Type I, Type II, Type III, Type IV, and Type V. This system of designating types of construction also includes a specific breakdown of the types of construction through the use of arabic numbers. These numbers follow the roman numeral notation where identifying a type of construction (e.g., Type I-443, Type II-111, Type III-200). [**220:**1.3]

The arabic numbers following each basic type of construction (e.g., Type I, Type II) indicate the fire resistance rating requirements for certain structural elements as follows:

(1) First arabic number: Exterior bearing walls
(2) Second arabic number: Columns, beams, girders, trusses and arches, supporting bearing walls, columns, or loads from more than one floor
(3) Third arabic number: Floor construction [**220:**A.1.3]

Specific fire resistance ratings are found in Table 6.2.2 of this standard, and additional information is found in NFPA 220, *Standard on Types of Building Construction.*

A.6.2.4 Due to cost savings, many Type III (ordinary) and Type V (wood frame) constructed buildings can have wood trusses as a lightweight pre-engineered framing system used in the roof and floors. As long as the integrity of all members of the unit is intact, the unit is a stable building item. However, this might not be the case if one of the outer members is destroyed or damaged. If this happens during a fire, the roof or floor supported by the unit can be weakened to the point where it will be unsafe to support fire fighters.

Another weak point found in the lightweight pre-engineered trusses during a fire is the joint formed by metal gussets. The use of metal gussets has reduced the cost and increased production of wood trusses; however, the metal gussets might not retain their strength and integrity where exposed to heat or fire.

Therefore, during the survey of the buildings for water requirements, fire prevention, or pre-fire planning purposes, the fire department should be aware of such structural fire fighting hazards, take appropriate steps to make all fire fighters aware of the conditions, and plan alternate fire tactics.

A.9.1 Factors to consider in determining the need and locations for a dry hydrant system should include, but not be limited to, the following:

(1) Current and future population and building trends
(2) Property values protected
(3) Potential for loss
(4) Proximity to structures (e.g., not closer than 100 ft from a structure it is designed to protect)
(5) Fire history of the area protected
(6) Current water supply systems
(7) Potential water supply sources and reliability (i.e., constructed or natural)
(8) Cost of project
(9) Other factors of local concern

A.9.2 Planning should involve all affected agencies and private concerns so a coordinated effort can be undertaken. Permits to install a dry hydrant should be obtained from the authorities having jurisdiction, which can include local, state, and federal agencies, such as zoning, water authority, environmental protection, resource departments, agriculture and conservation districts, among others.

In addition to permits, a water usage agreement is often required for using water sources on private lands. The WSO should make arrangements with the owner of water supplies before a fire develops. Such agreements should be made in writing in close cooperation with the municipal, town, or county attorney. Also, it is highly desirable that the agreement be reviewed by a representative of the highway or the county road department or other persons who will build, service, and maintain the access road to the supply, including such functions as snow plowing in certain areas of the country. The property owner also should have a copy of the agreement that has been used by several fire departments with the approval of their county or town attorney. See sample water usage agreement, Figure A.9.2.

Water Usage Agreement

I/We, the undersigned owner(s) of a lake or pond located at __________ do hearby grant the Anytown Fire Department permission to erect and maintain, at its expense, a dry hydrant and access roadway to said lake or pond to be utilized for emergency fire suppression purposes.

All other uses of said pond or lake shall be after notification and permission of the owners. The Anytown Fire Department shall be responsible for any and all damages to property resulting from fire department exercises.

This contract can be cancelled at any time by written notice thirty days in advance to the Anytown Fire Department located at Scott and College Road, Anytown, U.S.A.

Owner ______________________________ Date ________________

President ___________________________ Date ________________
Anytown Fire Department

Secretary ___________________________ Date ________________
Anytown Fire Department

Chief _______________________________ Date ________________
Anytown Fire Department

FIGURE A.9.2 Sample water usage agreement.

A.9.3 The design of dry hydrant installations should be carefully planned to incorporate the several desirable advantages that tend to bring the installation of dry hydrants within the resources of rural fire departments and property owners.

A.9.3.1 Local topography, climatic conditions, and access to materials will, among other factors, determine the design characteristics of each installation. Distance to the water combined with the difference in elevation between the hydrant head and the water source, and the desired gpm (L/min) flow, will affect the pipe size that needs to be used.

Local preferences and experience, along with access to materials, will determine the type of pipe and fittings best suited for the job. In some parts of the country, brass and bronze caps and steamer connections, along with iron, steel, and bituminous cement pipe and fittings are being used for hydrant materials.

A.9.3.2 In many parts of the country, schedule 40 or 80 PVC pipe, fittings, and connections are becoming more common.

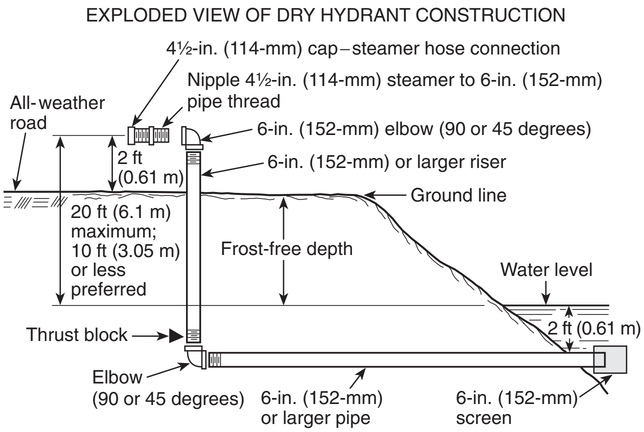


FIGURE A.9.3.2(a) Dry hydrant construction using iron, steel, or PVC pipe.

Many fire service manufacturers are now offering pre-made and pre-assembled PVC suction screens, hydrant heads, and supports that come ready to attach to the pipe.

Figures A.9.3.2(a) and A.9.3.2(b) are examples of dry hydrant design and are provided here for guidance.

A.9.3.3 System design requirements should consider required fire flow, atmospheric pressure, static lift, vapor pressure, length of required pipe run, coefficient of materials, piping configuration, and other design factors approved engineering practices would necessitate. Standard requirements of 1000 gpm (3785 L/min) are computed at sea level.

The following are some factors to consider in designing the dry hydrant:

(1) Static lift should not exceed 10 ft to 12 ft (3.1 m to 3.7 m), if possible. This is dead lift and cannot be overcome by enlarging the pipe size. Keep the static lift as low as possible.
(2) Total head loss should not exceed 20 ft (6.1 m), or the pump might not supply its rated gpm (L/min). If the fire department will be using portable pumps on the dry hydrant, keep total head loss as low as possible.

A.9.3.4 The worksheet shown in Figure A.9.3.4 and Table A.9.3.4(a), Table A.9.3.4(b), Table A.9.3.4(c), and Table A.9.3.4(d) can be used to assist in the design of a dry hydrant installation. The tables will help determine the size of pipe and fittings that will be needed to flow the capacity of the pumps being used at the hydrant site and allow for flow calculations and conversions between various pipe material.

The following steps describe how to use the worksheet.

Add the total length of straight pipe to be used at the site (screen + lateral run + riser = total length of pipe). Write this down on the design worksheet at step 1.

Using Figure A.9.3.4, add up the number of feet of straight pipe equivalent for all fittings used to make up the hydrant (elbows + hydrant adapter + any reducers = straight pipe equivalent for fittings). Write this down on the design worksheet at step 2.

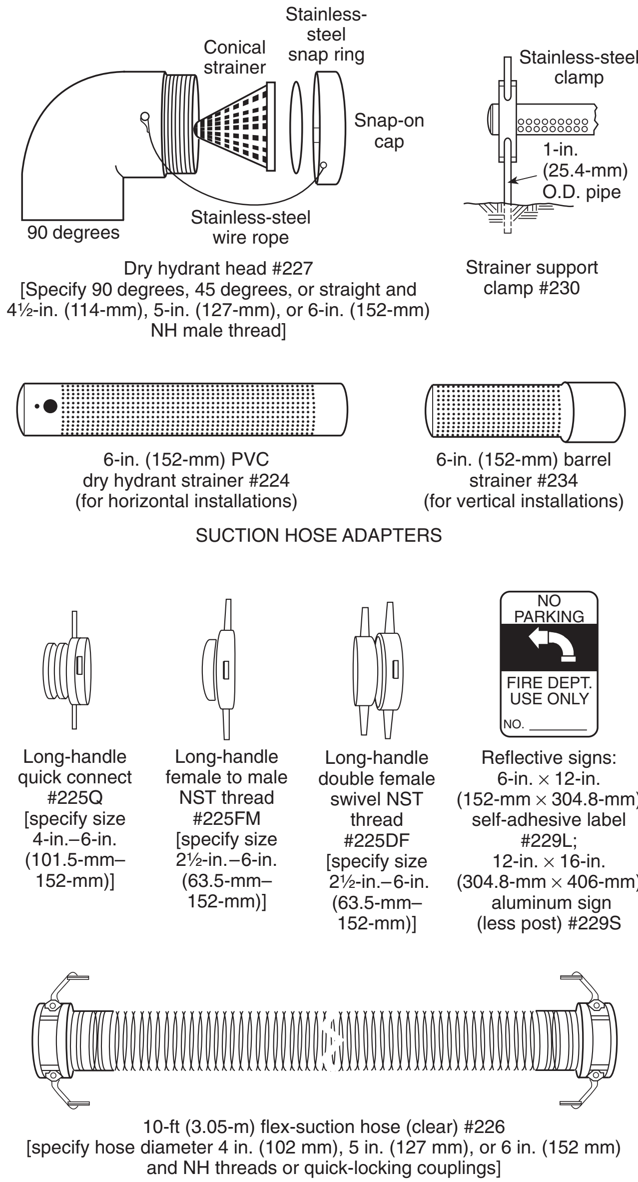


FIGURE A.9.3.2(b) Commercially available dry hydrant components. (Courtesy of Wisconsin Department of Natural Resources)

Add the numbers from step 1 and step 2 together to obtain the total straight pipe equivalent of the hydrant. Write this total down on the design worksheet at step 3.

Determine the desired maximum gpm (L/min) hydrant flow. Usually this would be the pumping capacity of the pump or pumper used at this hydrant. Write this figure down on the design worksheet at step 4.

Using Table A.9.3.4(a), determine the head loss due to friction per 100 ft (30.5 m) of pipe (number from step 3) based on the gpm (L/min) from step 4. If there is over or under 100 ft (30.5 m) of pipe equivalent (from step 3), adjust head loss from the table. For example, if the total straight pipe

Design Worksheet

FIRE DEPARTMENT ____________________________________

DRY HYDRANT LOCATION ________________________________

Step 1

Screen length ________________________________

Lateral run length ____________________________

Riser height _________________________________

Straight pipe = ______________________________

Step 2

Use Table A.9.3.4(c) to fill in the following values:

Hydrant adapter _____________ Reducer ________________

Elbow ____________________ Elbow ___________________

Elbow ____________________ Elbow ___________________

Straight pipe equivalent for fittings = __________________

Step 3

Straight pipe + Straight pipe equivalent for fittings =

_________ + _________ = _________ (Total straight pipe equivalent)

Step 4

Desired gpm flow = ___________ (Rated pump capacity)

Step 5

Using answers from Steps 3 and 4, use Table A.9.3.4(a) to determine head loss for pipe and fittings.

Head loss for pipe and fittings = ___________________________

Step 6

Using Table A.9.3.4(e), determine suction hose head loss for length of suction hose used to connect the pump to the hydrant.

Suction hose head loss = _________________________________

Step 7

Static lift = _______________________

Step 8

Add the answers from Steps 5, 6, and 7 together to get total head loss.

#5 _________ + #6 _________ + #7 _________ = Total head loss

If total head loss is greater than 20 ft to 25 ft (6.1 m to 7.6 m), the pump might not be able to flow its rated gpm.

FIGURE A.9.3.4 Design worksheet.

equivalent is 75 ft (22.9 m) and the desired volume is 1950 gpm (7441 L/min) then the head loss from the table is 20 ft/100 ft (6.1 m/30.5 m) of pipe. For this run, there would be a head loss of 15 ft (4.6 m) [20 ft (6.1 m) × 75 ft/100 ft (22.9 m/30.5 m) = 15 ft (4.6 m)]. Write this figure down as head loss for pipe and fittings on the design worksheet at step 5.

From Table A.9.3.4(e), figure the head loss due to friction in the suction hose to be used on the hydrant. Write this down on the design worksheet as suction hose head loss at step 6.

Next, determine static lift. This is the vertical distance from the water's surface in the hydrant pipe (use the lowest water level as it will represent the maximum lift needed) and the pump or pumper intake. Write this figure down on the design worksheet as static lift at step 7. Try not to exceed 8 ft to 10 ft (2.4 m to 3.1 m) if possible. Remember that this is a vertical measurement and represents dead lift.

Add the answers from steps 5, 6, and 7 together on the design worksheet at step 8. This is the total head loss. Do not exceed 20 ft to 25 ft (6.1 m to 7.6 m) of total head loss at the pump intake; otherwise, all the pump capacity will be used for suction (or lift), and the pump might not flow its rated capacity.

The tables are for PVC schedule 40 pipe. Other types of pipe material have similar tables that should be consulted when other pipe is used.

Table A.9.3.4(a) Friction Loss in Pipe

lb/in.² per 100 ft of Pipe Hazen-Williams C = 100*											
	Actual Diameter of Pipe ½ in. through 3½ in. (Nominal Diameter of Pipe for 4 in. through 30 in.)										
gpm	**½**	**¾**	**1**	**1¼**	**1½**	**2**	**2½**	**3**	**3½**	**4**	**gpm**
5	17.9	4.55	1.40	0.369	0.174	0.052					5
10	64.5	16.4	5.06	1.33	0.629	0.186	0.078	0.030			10
15		34.7	10.7	2.82	1.33	0.394	0.166	0.064	0.028		15
20	5	59.1	18.2	4.89	2.27	0.671	0.282	0.109	0.048	0.027	20
30	0.019	6	38.6	10.2	4.80	1.42	0.598	0.231	0.102	0.057	30
40	0.033	—	65.8	17.3	8.17	2.42	1.02	0.393	0.174	0.097	40
50	0.050	0.020	8	26.2	12.3	3.66	1.54	0.593	0.263	0.147	50
60	0.069	0.029	—	36.6	17.3	5.12	2.16	0.831	0.369	0.206	60
70	0.092	0.038	—	48.7	23.0	6.81	2.87	1.11	0.490	0.274	70
80	0.118	0.049	—	62.4	29.4	8.72	3.67	1.41	0.628	0.350	80
90	0.147	0.060	—	77.6	36.6	10.8	4.56	1.76	0.781	0.435	90
100	0.178	0.074	—	10	44.5	13.1	5.55	2.14	0.949	0.529	100
120	0.250	0.103	—	—	62.3	18.5	7.77	3.00	1.33	0.741	120
140	0.333	0.137	0.034	—	82.9	24.6	10.3	3.98	1.77	0.986	140
160	0.426	0.175	0.043	—	106.0	31.4	13.2	5.10	2.26	1.26	160
180	0.529	0.218	0.054	0.018	12	39.1	16.5	6.34	2.81	1.57	180
200	0.643	0.265	0.065	0.022	—	47.5	20.0	7.71	3.42	1.91	200
220	0.768	0.316	0.078	0.026	—	56.7	23.9	9.19	4.08	2.28	220
240	0.902	0.371	0.091	0.031	0.013	14	28.0	10.8	4.79	2.67	240
260	1.05	0.430	0.106	0.036	0.015	—	32.5	12.5	5.56	3.10	260
280	1.20	0.493	0.122	0.041	0.017	—	37.3	14.4	6.37	3.55	280
300	1.36	0.562	0.138	0.047	0.019	—	42.3	16.3	7.24	4.04	300
350	1.81	0.746	0.184	0.062	0.026	0.012	16	21.7	9.63	5.37	350
400	2.32	0.955	0.235	0.079	0.033	0.015	—	27.8	12.3	6.88	400
450	2.88	1.19	0.292	0.099	0.041	0.019	—	34.6	15.3	8.55	450
500	3.51	1.44	0.353	0.120	0.049	0.023	0.012	42.0	18.6	10.4	500
550	4.18	1.72	0.424	0.143	0.059	0.028	0.015	50.1	22.2	12.4	550
600	4.91	2.02	0.498	0.168	0.069	0.033	0.017	58.8	26.1	14.6	600
650	5.70	2.34	0.577	0.195	0.080	0.038	0.020	68.2	30.3	16.9	650
700	6.53	2.69	0.662	0.223	0.092	0.043	0.023	18	34.7	19.4	700
750	7.42	3.05	0.752	0.254	0.104	0.049	0.026	—	39.4	22.0	750
800	8.36	3.44	0.848	0.286	0.118	0.056	0.029	—	44.5	24.8	800
850	9.35	3.85	0.948	0.320	0.132	0.062	0.032	—	49.7	27.7	850
900	10.4	4.28	1.05	0.356	0.146	0.069	0.036	—	20	30.8	900
950	11.5	4.73	1.17	0.393	0.162	0.076	0.040	—	—	34.1	950
1,000	12.6	5.20	1.28	0.432	0.178	0.084	0.044	—	—	37.5	1,000
1,250	19.1	7.85	1.94	0.653	0.269	0.127	0.066	—	—	24	1,250
1,500	30	11.0	2.71(18.7)	0.914	0.376	0.178	0.093	—	—	—	1,500
1,750	—	—	3.61	1.22	0.501	0.236	0.123	—	—	—	1,750
2,000	0.007	—	4.62	1.56	0.641	0.303	0.158	0.089	0.053	0.022	2,000
2,250	0.009	—	—	1.94	0.797	0.376	0.196	0.111	0.066	0.027	2,250
2,500	0.011	—	—	2.35	0.969	0.457	0.239	0.134	0.081	0.033	2,500
2,750	0.013	—	—	2.81	1.16	0.545	0.285	0.160	0.096	0.040	2,750
3,000	0.016	—	—	3.30	1.36	0.641	0.334	0.188	0.113	0.046	3,000
4,000	0.027	—	—	—	2.31	1.09	0.569	0.321	0.192	0.079	4,000
5,000	0.040	—	—	—	3.49	1.65	0.860	0.485	0.290	0.119	5,000

* To convert friction loss at C = 100 or other values of C, see Table A.9.3.4(b).

Notes:

(1) Schedule 40 pipe sizes ½ in. through 3½ in. steel pipe.

(2) SI units: 1 psi = 6.895 kPa; 1 gpm = 3.785 L/min; 1 in. = 25.4 mm.

(3) Actual inside diameter for sizes ½ in. through 3½ in. is given for greater accuracy as these sizes include sprinkler branch lines and the smaller sizes of cross mains. For sizes 4 in. and greater, the nominal diameters were used as a fairly safe average for the diameters of various types of underground pipes as follows: cast-iron unlined and Enameline, greater than nominal; cast iron cement lines and Class 200 asbestos cement, less than nominal; Class 150 asbestos-cement sizes 6 and 8 in. less than nominal, and other sizes even nominal. (A 0.10 variation is true for Class 150 cement lined only — see ASHD FT-9 through 45 for actual IDs.)

This table will be useful in approximating friction loss in flow through existing underground piping where the type, inside diameter, and condition are frequently unknown. However, in such cases, a flow test is recommended.

When the type, inside diameter, and condition are known, and in designing new systems for all sizes and types of pipes, the friction loss tables should be used. Friction tables based on Hazen-Williams formula are published in "Automatic Sprinkler Hydraulic Data" by Automatic Sprinkler Corporation of America, and tables based on Darcy-Weisbach formula are published in Standards of the Hydraulic Institute.

Table A.9.3.4(b) Conversion Factors for Friction Loss in Pipe for Values of Coefficient Other than 100

C	Factor	C	Factor	C	Factor
150	0.472	110	0.838	70	1.93
145	0.503	105	0.914	65	2.22
140	0.537	100	1.00	60	2.57
135	0.574	95	1.10	55	3.02
130	0.615	90	1.22	50	3.61
125	0.662	85	1.35	45	4.38
120	0.714	80	1.51	40	5.48
115	0.772	75	1.70	35	6.97

Table A.9.3.4(c) Equivalent Pipe Length Chart (Straight Pipe Equivalents for Fittings in Feet and Meters)

	Fittings and Valves Expressed in Equivalent ft (m) of Pipe						
	¾ in.	**1 in.**	**1¼ in.**	**1½ in.**	**2 in.**	**2½ in.**	**3 in.**
45-degree elbow	1(0.3)	1(0.3)	1(0.3)	2(0.6)	2(0.6)	3(0.9)	3(0.9)
90-degree standard elbow	2(0.6)	2(0.6)	3(0.9)	4(1.2)	5(1.5)	6(1.8)	7(2.1)
90-degree long-turn elbow	1(0.3)	2(0.6)	2(0.6)	2(0.6)	3(0.9)	4(1.2)	5(1.5)
Tee or cross (flow turned 90 degrees)	4(1.2)	5(1.5)	6(1.8)	8(2.4)	10(3.1)	12(3.7)	15(4.6)
Gate valve					1(0.3)	1(0.3)	1(0.3)
Butterfly valve					6(1.8)	7(2.1)	10(3.1)
Swing check*	4(1.2)	5(1.5)	7(2.1)	9(2.7)	11(3.4)	14(4.3)	16(4.9)
	Fittings and Valves Expressed in Equivalent ft (m) of Pipe						
	3½ in.	**4 in.**	**5 in.**	**6 in.**	**8 in.**	**10 in.**	**12 in.**
45-degree elbow	3(0.9)	4(1.2)	5(1.5)	7(2.1)	9(2.7)	11(3.4)	13(4.0)
90-degree standard elbow	8(2.4)	10(3.1)	12(3.7)	14(4.3)	18(5.5)	22(6.7)	27(8.2)
90-degree long-turn elbow	5(1.5)	6(1.8)	8(2.4)	9(2.7)	13(4.0)	16(4.9)	18(5.5)
Tee or cross (flow turned 90 degrees)	17(5.2)	20(6.1)	25(7.6)	30(9.2)	35(10.7)	50(15.3)	60(18.3)
Gate valve	1(0.3)	2(0.6)	2(0.6)	3(0.9)	4(1.2)	5(1.5)	6(1.8)
Butterfly valve		12(3.7)	9(2.7)	10(3.1)	12(3.7)	19(5.8)	21(6.4)
Swing check*	19(5.8)	22(6.7)	27(8.2)	32(9.8)	45(13.7)	55(16.8)	65(19.8)

*Use with Hazen-Williams C = 120 only. For other values of C, the figures in this table should be multiplied by the factors in Table A.9.3.4(b) and Table A.9.3.4(d).

Table A.9.3.4(d) Guide for Estimating Hazen-Williams C

Kind of Pipe	Value of C 1*	2†	3‡
Cast iron, unlined:			
10 years old	110	90	75
15 years old	100	75	65
20 years old	90	65	55
30 years old	80	55	45
50 years old	70	50	40
Cast iron, unlined, new		120	
Cast iron, cement-lined		140	
Cast iron, bitumastic enamel-lined		140	
Average steel, new		140	
Riveted steel, new		110	
Asbestos-cement		140	
Reinforced concrete		140	
Plastic		150	

* Water mildly corrosive. Use same values for fire protection mains.
†Water moderately corrosive.
‡Water severely corrosive.
Note: C values chosen for design or piping systems should be based on applicable NFPA standards or the Authority Having Jurisdiction.

Table A.9.3.4(e) Head Loss (Feet per 100 ft of Hard Rubber Suction Hose)

GPM	Hose Size 1½ in.	2½ in.	4 in.	4½ in.	5 in.	6 in.
100	84.1	7.0	0.7	0.4	0.2	0.1
200	303.6	25.3	2.6	1.4	0.9	0.4
250	459.0	38.2	3.9	2.2	1.3	0.5
300	643.3	53.6	5.4	3.1	1.8	0.8
350	855.9	71.3	7.2	4.1	2.4	1.0
400	1096.0	91.3	9.3	5.2	3.1	1.3
500	1656.9	138.0	14.0	7.9	4.7	1.9
600	2322.4	193.4	19.7	11.1	6.6	2.7
700	3089.7	257.3	26.1	14.7	8.8	3.6
800	3956.6	329.5	33.5	18.9	11.3	4.7
900	4921.0	409.9	41.6	23.5	14.1	5.8
1000	5981.4	498.2	50.6	28.5	17.1	7.0
1100	7136.1	594.4	60.4	34.0	20.4	8.4
1200	8383.8	698.3	71.0	40.0	24.0	9.9
1300	9723.5	809.9	82.3	46.4	27.8	11.4
1400	11153.9	929.0	94.4	53.2	31.9	13.1
1500	12674.2	1055.6	107.2	60.5	36.2	14.9
1600	14283.3	1189.6	120.9	68.1	40.9	16.8
1700	15980.5	1331.0	135.2	76.2	45.7	18.8
1800	17765.0	1479.6	150.3	84.7	50.8	20.9
1900	19635.9	1635.5	166.2	93.7	56.1	23.1
2000	21592.7	1798.5	182.7	103.0	61.7	25.4
2100	23634.7	1968.5	200.0	112.8	67.5	27.8
2200	25761.2	2145.7	218.0	122.9	73.6	30.3
2300	27971.7	2329.8	236.7	133.4	80.0	32.9
2400	30265.7	2520.8	256.1	144.4	86.5	35.6
2500	32642.5	2718.8	276.2	155.7	93.3	38.4
2600	35101.9	2923.7	297.0	167.5	100.3	41.3
2700	37643.1	3135.3	318.5	179.6	107.6	44.3
2800	40265.8	3353.8	340.7	192.1	115.0	47.4
2900	42969.6	3579.0	363.6	205.0	122.8	50.6
3000	45753.9	3810.9	387.1	218.3	130.7	53.8

For SI units, 1 gpm = 0.0631 L/sec

A.9.3.5 Metal piping and surfaces should be primed and painted to prevent deterioration of the material.

A.9.3.6 Preferably no more than two 90-degree elbows should be used. It might be desirable to have a wide-sweep elbow [using two 45-degree elbows and a 2 ft (0.6 m) length of pipe] installed at the bottom of the riser where the lateral run connects. In the event of a broken-off hydrant connection, this could permit sections of 2 ½ in. (64 mm) suction hose to be inserted down the 6 in. (15.2 cm) pipe to the water and would permit drafting to continue, although at a much reduced rate of flow.

A.9.3.8 For a supply flowing from a stream, the quantity to be considered available is the minimum rate of flow during a drought with an average 50-year frequency as determined by a registered/licensed professional engineer, hydrologist, or other similarly qualified person. The maximum rate of flow is determined by testing using the pumper(s), hose arrangement, and dry hydrant normally used at this site.

Historical Stream Flow data are available for most streams from the United States Geological Survey (USGS) Water Resources Information. These data can also be accessed from their Internet World Wide Web site: http/www.usgs.gov. The USGS does not establish flow rates but provides historical data to assist with assessment. Additional assistance is available from individual state and organization contacts at the National Drought Mitigation Center (NDMC). The National Drought Mitigation Center Directory of Drought Contacts can be accessed from their home page at: http://enso.unl.edu/ndmc/index.html.

Examples of two shallow stream installations are shown in Figure A.9.3.8(a) and Figure A.9.3.8(b).

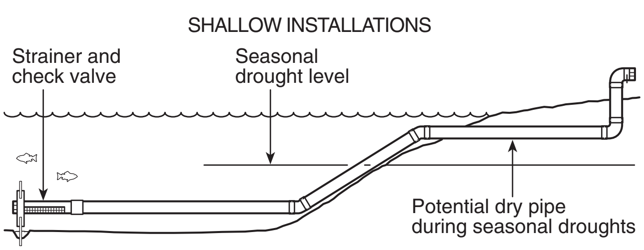


FIGURE A.9.3.8(a) Shallow stream installation based on seasonal droughts.

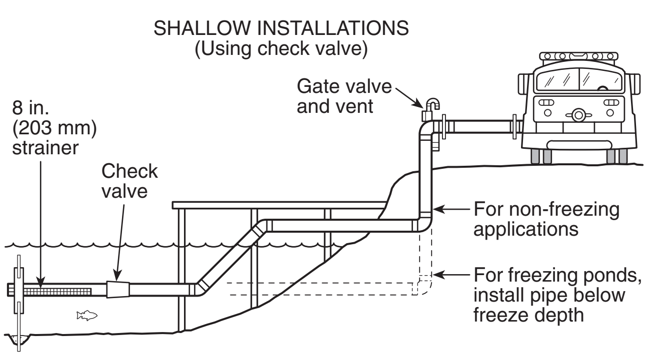


FIGURE A.9.3.8(b) Shallow stream installation based on seasonal drought and freezing conditions.

A.9.3.9 Thrust blocks should be considered at the elbow joint both to resist hydraulic forces and to steady the installation in unstable soils.

A.9.3.11 All connections should be clean and the appropriate sealing materials used according to manufacturer's specifications so as to ensure all joints are airtight.

A.9.3.12 Strainers or screens can be handmade by drilling 1000, 5⁄16 in. (8 mm) holes in length of pipe and capping the end with a removable or hinged cover. Remember to leave a solid strip of pipe approximately 4 in. to 5 in. (10.2 cm to 12.7 cm) wide along one side to act as a baffle to prevent whirlpooling during periods of low water.

A.9.4 The fact that an adequate water supply is in sight of the main road does not ensure that the water can be used for fire-fighting purposes. Many times, it is necessary that a suitable approach be provided to reach within 10 ft (3.1 m) of the water supply. This should be done and the department trained in the use and limitations of the water supply before a fire occurs. A suitable approach might call for a roadway. However, at some sites and in some areas of the country, it might not be necessary that a roadway be constructed, due to soil conditions. Other sites might already have roadways provided or pavement installed, with the construction of an entranceway or a gate necessary to provide access to the water supply. Other sites can be reached by foot only and can necessitate that a path be constructed and maintained so that portable pumps can be carried to the site.

Dry hydrant installations can be adapted to as many situations as a fire department faces, such as the following:

(1) Industrial fire protection as shown in Figure A.9.4(a)
(2) Design to overcome roadways that prevent the direct hauling of water as shown in Figure A.9.4(b)
(3) Unusually heavy silt and mud in the water source as shown in Figure A.9.4(c)
(4) Underground obstructions like rocks as shown in Figure A.9.4.7(c)

Each site should be evaluated by the WSO to determine the best way, within the fire department's means, for using the water supply. Additional information on several optional water sources can be found in Annex B.

For an impounded supply, cistern, tank, or storage facility, the quantity of water to be considered available is the minimum available [at not over 15 ft (4.6 m) lift] during a drought with an average 50-year frequency (certified by a registered or licensed professional engineer). The maximum rate of flow is determined by testing, using the pumper(s), hose arrangement, and dry hydrant normally used at the site.

Natural Water Sources: Streams. Streams, including rivers, bays, creeks, and irrigation canals, can represent a continuously flowing source of substantial capacity. Where considering water from flowing streams as potential water sources, the fire department should consider the following factor.

(1) Flowing Capacity. The stream should deliver water in capacities compatible with those outlined in the water requirements of this standard. *(See Chapter 7.)*
(2) Climatic Characteristics. Streams that deliver water throughout the year and are not susceptible to drought are desirable for fire protection. However, where such streams are not available, a combination of supplies might be necessary. In many sections of the country, streams cannot be relied on during drought seasons. If the stream is subject to flooding or freezing, special evolutions might

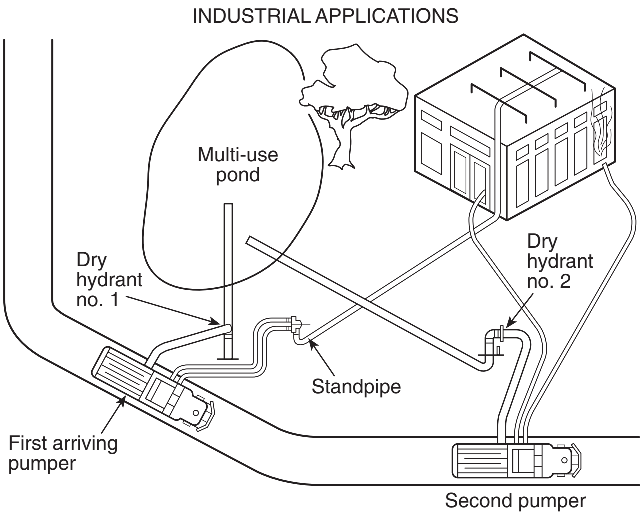


FIGURE A.9.4(a) Locating multiple water supply points for industrial occupancies.

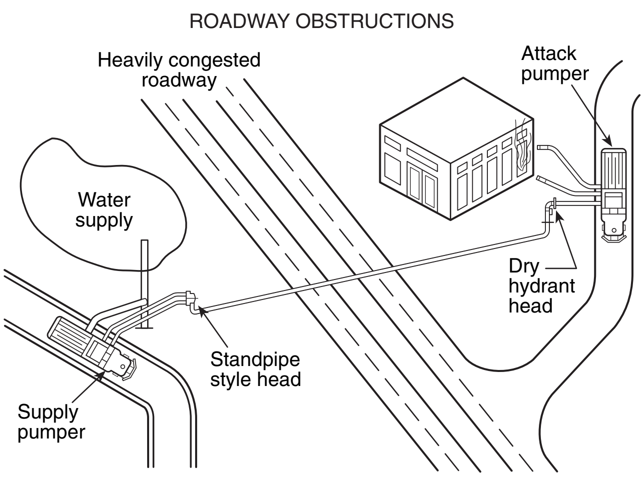


FIGURE A.9.4(b) Locating water supplies to overcome roadway obstructions.

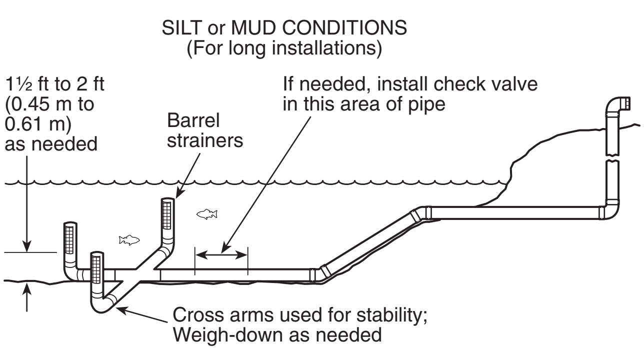


FIGURE A.9.4(c) Installation for silt and mud conditions.

be necessary to make the stream usable under such conditions. Similar circumstances might exist during wet periods or when the ground is covered with snow.

(3) Accessibility. A river or other source of water might not be accessible to the fire department for use during a fire. Distance and terrain from the all-weather road to the source should be such as to make the water readily available. In some cases, special equipment should be used to obtain the water. *(See Annexes B and E.)* Where roadways are provided to the water supply, they should be constructed in accordance with 9.4.7.
(4) Calculating Flow of a Stream. A simple method for estimating the flow of water in a creek is to measure the width and depth of the creek. Drop a cork or any light floating object into the water, and determine the time it takes the cork to travel 10 ft (3.1 m). To obtain complete accuracy, the sides of the creek should be perpendicular, the bottom flat, and the floating object should not be affected by the wind. Where the sides and bottom of the stream are not uniform, the width and depth can be averaged.

Take for example a creek that is 4 ft (1.2 m) wide and 6 in. (15.2 cm) deep. The flow of water is such that it takes 45 seconds for a cork to travel 10 ft (3.1 m), therefore the following formula should be used:

$$W \times D \times TD = \text{ft}^3\ (\text{m}^3) \text{ of water}$$

where:

W = width of 4 ft (1.2 m)
D = depth of 6 in. (15.2 cm) [½ ft (0.15 m)]
TD = travel distance of 10 ft (3.1 m)

Calculate the flow of water as follows:

4 ft (1.2 m) × ½ ft (0.15 m) × 10 ft (3.1 m) = 20 ft^3 (0.57 m^3)

The cork takes 45 seconds to flow the 10 ft (3.1 m) distance. Divide the volume by the time as follows:

20 ft^3 (0.57 m^3)/45 sec = 0.44 ft^3/sec (0.0125 m^3/sec)

Convert the flow from seconds to minutes:

0.444 ft^3/sec (0.0125 m^3/sec) × 60 sec = 26.64 ft^3/min (0.75 m^3/min)

Using conversion factors [1 cubic foot = 7.48 gallons (28.31 liters); and 1 gallon = 3.785 liters], convert these values to gal (L)/min:

26.64 ft^3/min × 7.48 = 199.27 gal (754 L)/min

For assistance in more accurately determining stream flow, contact the state Department of Natural Resources, Soil Conservation Service, or county agents.

Natural Water Sources: Ponds. Ponds can include lakes or farm ponds used for watering livestock, irrigation, fish culture, recreation, or other purposes while serving a secondary function for fire protection. Valuable information concerning the design of ponds can be obtained from county agricultural agents, cooperative extension offices, county engineers, etc. Most of the factors relative to streams are pertinent to ponds, with the following items to be considered:

(1) Minimum annual level should be adequate to meet water supply needs of the fire problem the pond serves.
(2) Freezing of a stationary water supply, contrasted with the flowing stream, presents a greater problem.
(3) Silt and debris can accumulate in a pond or lake, reducing its actual capacity, while its surface area and level remain constant. This can provide a deceptive impression of

capacity and calls for at least seasonal inspections. See Figure A.9.4(c) for an example of protective measures for silt and mud conditions.

(4) Accessibility should always be considered. Many recreational lakes are provided with access by roads, driveways, and boat launching ramps and are available for fire department use. Some large lakes, formed by a dam on a river, might have been constructed for such purposes as to generate power, for flood control, or to regulate the flow of a river. During certain periods of the year (droughts, drawdowns, etc.), such bodies of water can have very low water levels. The water under such conditions might not be accessible to the fire department for drafting by the fire department pumping unit, even where a paved road, for boat launching, has been provided and extended into the water at normal water levels for several feet or meters. Under such conditions, other provisions should be made to make the water supply fully accessible to the fire department.

Figures A.9.4(d) and A.9.4.(e) provide examples of access to ponds that are above grade in both freezing and nonfreezing areas.

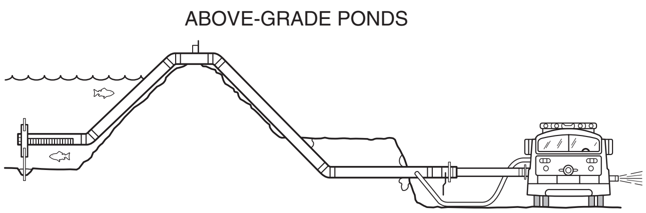


FIGURE A.9.4(d) Example of access to a pond that is above grade in freezing areas.

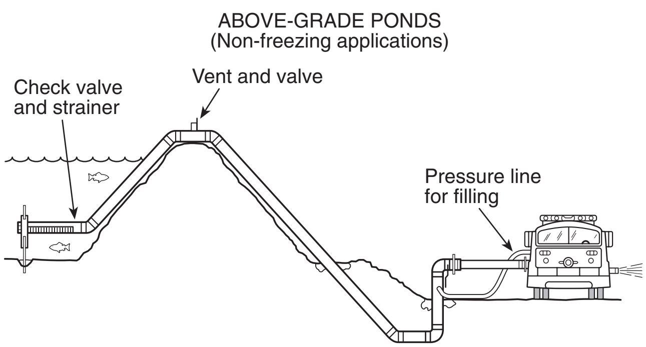


FIGURE A.9.4(e) Example of access to a pond that is above grade in non-freezing areas.

Other natural sources might include springs and artesian wells. Individual springs and occasional artesian water supplies exist in some areas and, again, while generally of more limited capacity, can be useful for water supply, subject to reasonable application of the factors listed for ponds and streams. In many cases, it might be necessary to form a temporary natural pool or form a pond with a salvage cover, for example, to collect water for the use of the fire department where using a spring or an artesian well.

Developed sources of water supplies adapted for fire fighting are limited only to the innovative nature of the fire department. They range from cisterns, swimming pools, quarries, mines, automatic sprinkler system supplies, stationary tanks, driven wells, and dry hydrants, to situations where fire fighters have drafted water out of the basement of a burning building into which it was pumped only minutes before to fight the fire. More information on using cisterns for water supplies can be found in Section B.3.

Some fire departments are using reclaimed underground storage tanks that have purged and cleaned. These are fitted with piping and placed strategically around the community. Figure A.9.4(f) and Figure A.9.4(g) are examples of construction of water cisterns using underground tanks.

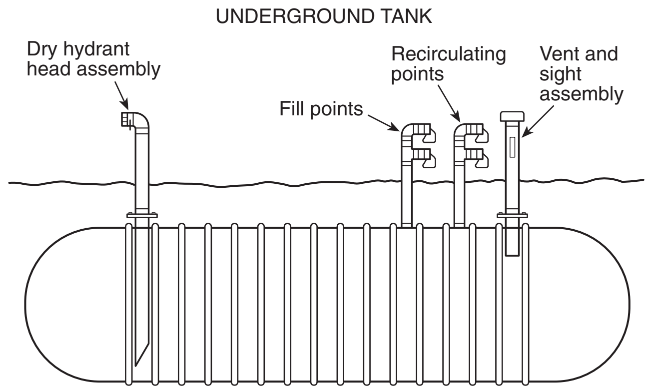


FIGURE A.9.4(f) Example of construction of water cisterns using an underground storage tank.

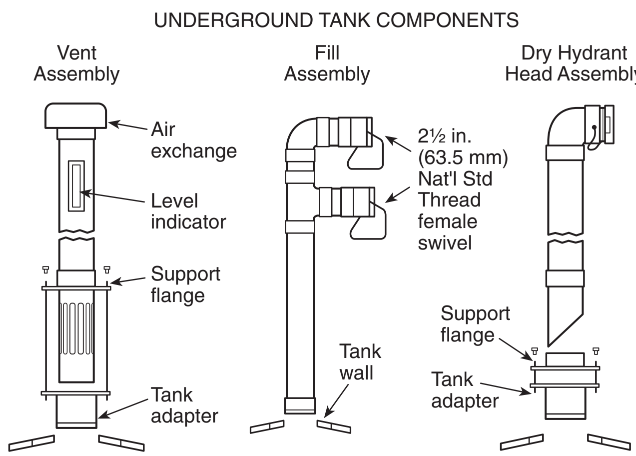


FIGURE A.9.4(g) Examples of fill and vent assemblies for water cisterns using underground tanks.

Other types of existing water tanks can also be adapted for use with dry hydrants, as illustrated in Figure A.9.4(h). A drafting procedure for elevated tanks is shown in Figure A.9.4(i).

A.9.4.2 It is the responsibility of the WSO to make inspections of all water sources available as often as conditions warrant and to note any changes in the facilities. This is particularly true during adverse weather conditions, such as droughts, very wet periods, heavy freezing, and following snowstorms.

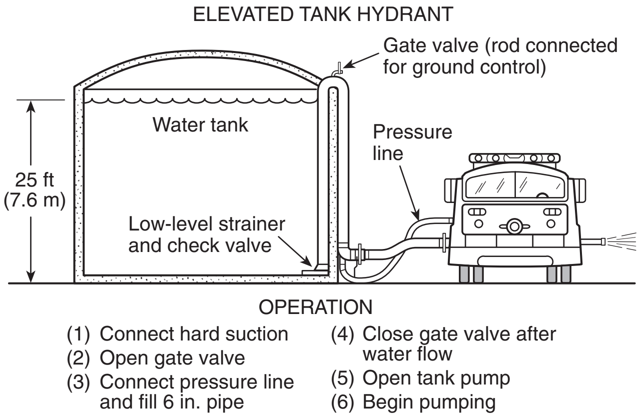


FIGURE A.9.4(h) Example of an elevated hydrant from a water tank.

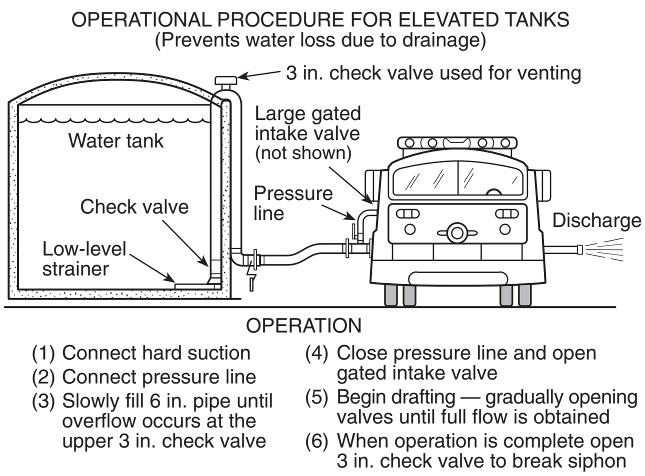


FIGURE A.9.4(i) Drafting procedure for elevated tanks.

A.9.4.5 In areas where frost is a problem, the design should ensure that no frost will reach the water in the pipe. There are two ways to accomplish this: (1) bury the pipe below the frost line and mound up the soil over the pipe and around the rise; or (2) place an insulating barrier, such as Styrofoam, between the pipe and the surface to prevent the frost from reaching the water in the pipe. Placement of the suction screen in the body of water should be deep enough to ensure that ice will not reach the screen. In such cases, divers might be needed to assist in proper screen placement.

If a dry hydrant is not installed in a cistern, then, depending on local conditions, a heavy pipe or a pike pole can be adequate to break an ice formation. In fact, the weight of the suction hose itself can be sufficient, provided there is no danger of damaging the strainer, the hose, or hose threads.

There are several methods of providing an ice-free surface area in a cistern or other water source. These include floating a log or a bale of hay or straw on the surface of the water or placing a partly filled, floating barrel on the surface of the water.

Examples of freeze prevention methods are provided in Figure A.9.4.5(a), Figure A.9.4.5(b), and Figure A.9.4.5(c).

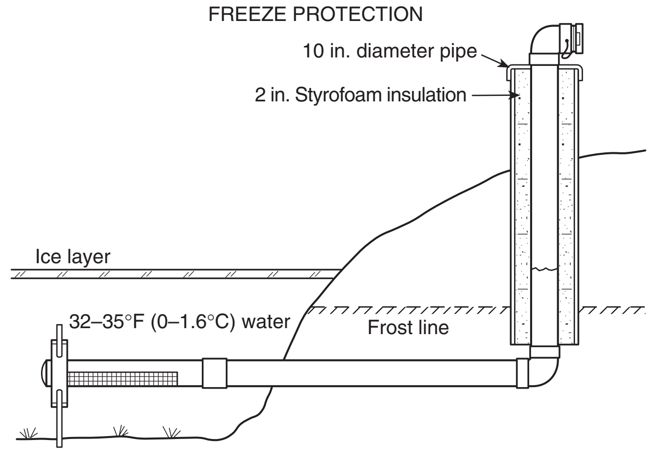


FIGURE A.9.4.5(a) Example of freeze protection for dry hydrant.

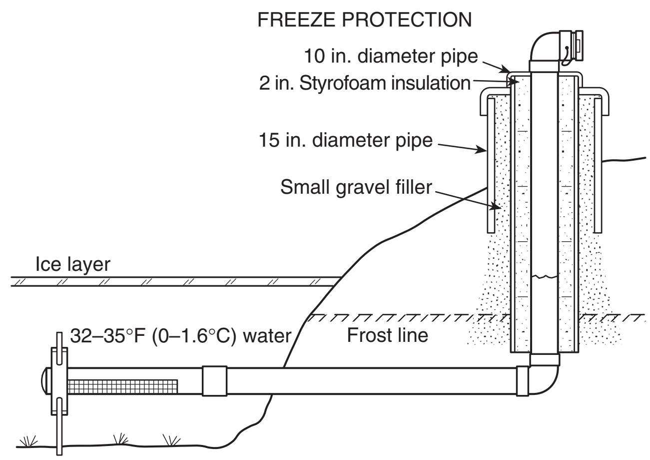


FIGURE A.9.4.5(b) Example of freeze protection for dry hydrant subject to severe freezing conditions.

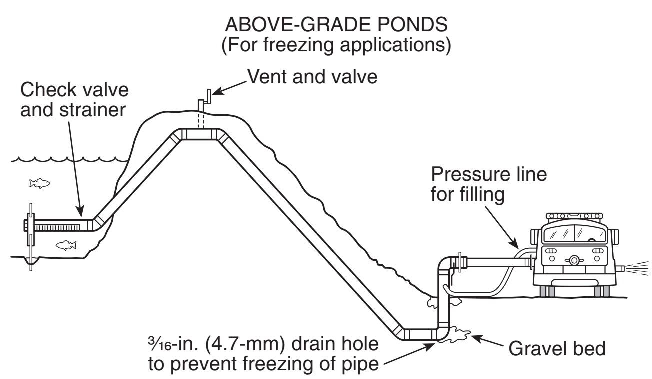


FIGURE A.9.4.5(c) Example of freeze protection for an above-grade pond used as a water source.

A.9.4.6 The WSO should ensure that an appropriate sign is erected at each water point identifying the site for fire department emergency use and including the name, or a number, for the water supply. Letters and numbers should be at least 3 in. (76 mm) high, with a ½ in. (13 mm) stroke and reflective, as allowed by state and local regulations.

A.9.4.7 Most artificial lakes are constructed with heavy earth moving equipment. In order for the property owner to construct a roadway for fire department use, the WSO should make the property owner aware of the needs of the fire department while the heavy equipment is still on the job. Table A.9.4.7 details considerations that should be kept in mind when planning access.

While the roadway to the water supply is being developed, consideration should be given to providing a 90 ft (27.4 m) diameter turnaround for the mobile water supply apparatus. Where conditions at the supply do not make a turnaround feasible, a large underground pipe transmission line can be laid from the water supply to the highway and the mobile water supply apparatus filled on the highway right-of-way. However, a turnaround or looped facility will still need to be provided at the fill point on the right-of-way.

Bridges Used as Water Points. In some states, a fire department cannot use a bridge to park a mobile water supply while it is being filled, thereby blocking traffic on a road. However, the fire department might be able to use the water source by moving the fill point off of the bridge to the right-of-way. Therefore, the department needs to check with the state Department of Transportation and abide by the appropriate laws governing the situation. Two optional dry hydrant configurations for constructing dry hydrants using bridges are shown in Figure A.9.4.7(a) and Figure A.9.4.7(b).

It is expected that the general condition of the bridges in most states is poor. A large number of these bridges are very old, and many that were built for farm-to-market-type use are now in urban areas with greatly increased traffic loads. During the last few years, a number of states have set up bridge inspection programs and the current safe tonnage is being posted. Over the entire country, a large number of bridges have been restricted to below the legal weight limit for which the road and bridge were originally designed. One state with over 15,000 bridges reports that 50 percent of all its bridges are now posted below the original maximum load limits, and 25 percent of these bridges are unsafe for use by a fully loaded school bus or normal fire department equipment.

While highway departments are doing what is possible with the money available to improve bridge safety, priority is given to bridge upkeep only on primary roads. Many bridges cannot be brought up to standard without complete rebuilding, and most states do not have money available for such an overhaul program. Some state highway departments have consulted with fire officials to identify bridges in order of their importance to the fire service response needs. The highway departments then attempt to upgrade these bridges on the basis of fire department priority.

The load capacities of bridges are a serious consideration when planning purchases of fire apparatus. Mobile water supply apparatus has to be restricted to volumes that will not cause overloading. Whether or not a fire department is held financially responsible for damage to a bridge depends on state law; however, a good policy for every rural fire department is to check the bridge load restrictions before purchasing a new piece of apparatus. The lighter the equipment, the more bridges the department can use. The fire department will need to make whatever special provision is indicated to protect an accessible area using an unsafe bridge. [See Figure A.9.4.7(c) for installing a dry hydrant with underground obstructions]

Table A.9.4.7 Recommendations for Roads to Water Supplies

Road Characteristic	Minimum Recommendations
Width	Roadbed: 12 ft (3.7 m) Tread: 8 ft (2.4 m) Shoulders: 2 ft (0.6 m)
Alignment	Radius centerline curvature: 50 ft (15.2 m)
Gradient	Maximum sustained grade: 8 percent
Side Slopes	All cut and fill slopes to be stable for the soil involved
Drainage	Bridges, culverts, or grade dips at all drainageway crossings; roadside ditches deep enough to provide drainage; special drainage facilities (tile, etc.) at all seep areas and high water-table areas
Surface	Treatment as required for year-round travel
Erosion control	Measures as needed to protect road ditches, cross drains, and cut and fill slopes
Turnaround	Turnaround designed to handle the equipment of the responding fire department with a minimum diameter of 90 ft (27.4 m)
Load carrying capacity	Adequate to carry maximum vehicle load expected
Condition	Suitable for all-weather use

A.9.5 The installation of dry hydrants calls for care in measuring water storage capacities. The useful depth of a lake with a dry hydrant installation, for instance, is from the minimum

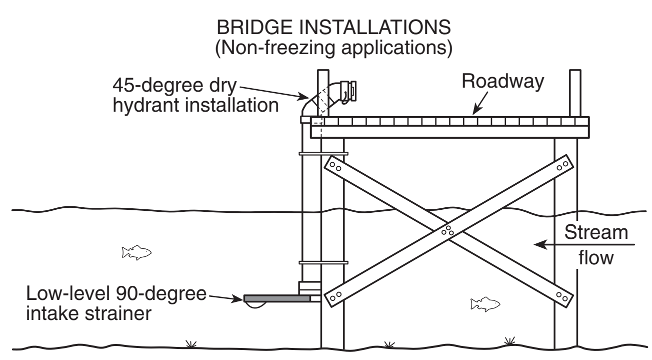


FIGURE A.9.4.7(a) Installation of a dry hydrant from a bridge.

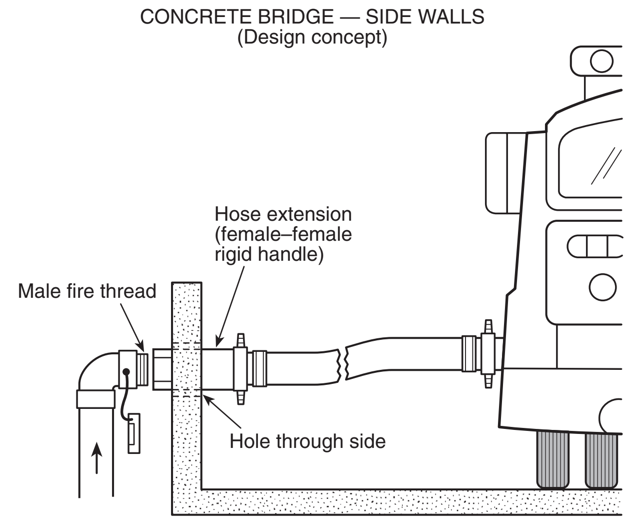


FIGURE A.9.4.7(b) Installation of a dry hydrant through the side wall of a concrete bridge.

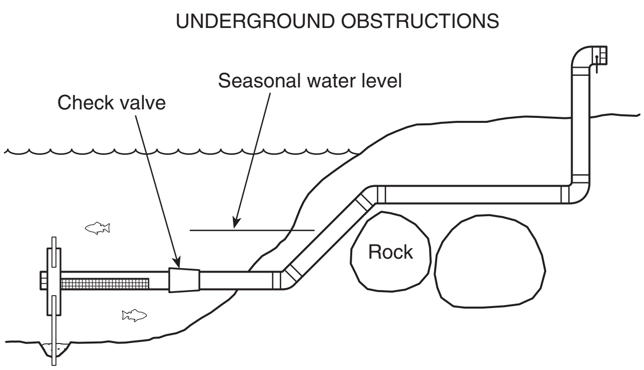


FIGURE A.9.4.7(c) Overcoming underground obstructions for installing a dry hydrant.

foreseeable low-water surface level to the top of the suction strainer, not to the bottom of the lake, and cannot be less than 2 ft (0.6 m) of water. This becomes a very important point where hydrants are installed on a body of water affected by tide or on a lake that is lowered to maintain the flow of a river during drought conditions, to generate power, or that freezes over. Pump suction requires submergence below the water surface of 2 ft (0.6 m) or more, depending on the rate of pumping, to prevent the formation of a vortex or whirlpool. Baffle and anti-swirl plates should be added to minimize vortex problems and allow additional water use. The vortex allows air to enter the pump, which can cause the loss of the pump prime. Therefore, pumping rates should be adjusted as the water level is lowered. This factor should be considered by the WSO when estimating the effective rate at which water can be drawn from all suction supplies.

A.9.6 A typical installation process includes the following steps:

(1) Check for any underground or overhead utilities before digging.
(2) Using a backhoe or excavator, dig in the trench starting at the point where the suction screen will be placed in the water.
(3) Maintain a uniform level trench cut all the way from the screen location to the point where the riser begins.
(4) Assemble the horizontal run and vertical riser portion of the hydrant (screen, lateral run, and riser) and place into the trench and water source as one piece.
(5) Sink the screen end and allow the assembly to sink into the bottom of the trench.
(6) When certain the suction screen is placed correctly, start backfilling the trench at the riser (keeping the riser pipe vertical) and backfill out into the water, being careful not to cover the suction screen.
(7) Mound and tamp the dirt slightly, as settling will occur over time. Mounding the dirt will also help to keep frost away from the water in the pipe.
(8) Place a cement block or use a commercial or manufactured strainer support under the suction screen to support the screen off the bottom. If the installation is in a fast moving waterway, several blocks or supports might have to be attached to the screen to prevent the current from moving the screen. The pipe and screen will also have to have special protection from any debris washing down the stream and hitting the pipe or screen.
(9) Cut off the vertical riser and attach the hydrant connection, making sure that the top of the hydrant connection is below the bottom of the pump intake. It is important that the pump intake remain slightly above the hydrant connection to prevent an air lock in the suction line.
(10) Set the guards and hose supports. Level, seed, and mulch the area to prevent erosion.
(11) Test pump the hydrant.

See Figure A.9.6 for an illustration of the installation.

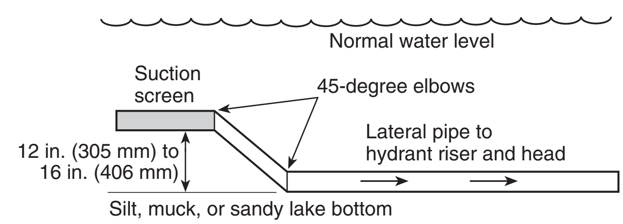


FIGURE A.9.6 Offset screen installation. *(Courtesy of Weyerhaeuser Volunteer Fire Department, WI)*

A.9.6.2 Contact the appropriate authorities (for example, water, power, telephone, cable, and gas).

A.9.7 These facilities require periodic checking, testing, and maintenance at least quarterly. There could need to be more frequent inspections due to freezing and droughts. Checking and testing by actual drafting should be a part of fire department training and drills. Thorough surveys should reveal any deterioration in the water supply situation in ponds, streams, or cisterns.

Particular attention should be given to streams and ponds. They need frequent removal of debris, dredging or excavation of silt, and protection from erosion. The hydrants should be tested at least annually with a pumper. Back flushing, followed by a test at a maximum designed flow rate, with records kept of each test, is highly desirable. Tests of this kind will not only verify proper condition but also keep the line and strainer clear of silt and the water supply available for any fire emergency.

The pond should be maintained as free of aquatic growth as possible. At times it might be necessary to drain the pond to control this growth. Helpful information is available from such sources as the county agricultural extension agent or the U.S. Department of Agriculture.

Inspections should verify safety procedures such as posted warning signs and the availability of life preservers, ropes, etc. Particular attention should be given to local authorities' regulations governing such water points.

It is important to consider appearance of this water point. Grass should be kept trimmed and neat. The hydrant should be freshly painted as needed. The cap can be painted a reflective material to improve visibility during emergencies. All identification signs should be approved by the Department of Transportation prior to installation if they are to be located on the right-of-way or are subject to state laws. Vegetation should be cleared for a minimum 3 ft (0.9 m) radius from around hydrants.

A.9.7.3 *Recordkeeping for Dry Hydrants—Water Source Cards.* A recommended practice is to prepare individual water source cards for each water point. This is a job that lends itself ideally to computers. There may be one or more water source applicable to a given potential fireground. In addition to the computer, the water sources should be noted on a master grid map of the area. Thus, the grid map will show the index location of water source cards on which pertinent data will be noted. This data should include type of source (stream, cistern, domestic system, etc.), point of access [100 ft (30.5 m) north of barn, etc.], gallons available [flows minimum 250 gpm (946 L/min), 10,000 gal (37,850 L) storage, etc.], and any particular problem such as weather condition or seasonal fluctuations that can make a source unusable. It is good practice to attach a photograph of the water point to the card. It is advisable to designate an alternate source.

These water source cards should be used as the basis of regular inspections to make sure the source continues to be available and to note any improvement or deterioration of its usefulness. A program to develop additional sources as needed, including water sources for new construction as it evolves, should be an ongoing program in an alert organization.

It is suggested that a record of inspection be maintained with a separate card on each dry hydrant. See Figure A.9.7.3(a).

An official record should be kept of all pertinent information recommended for each dry hydrant area. An example of one type is Figure A.9.7.3(b). The record will provide invaluable information whenever the need for such is required.

A.9.7.4 Checking and testing by actual drafting shall be a part of fire department training and drills.

A.9.8 *Map and Location/Detail Drawings — Water Map.* Each WSO should maintain a map showing the location and amount of water available at each water site. A copy of this map should be located in the fire alarm dispatcher's headquarters where such an alarm facility is available and should be carried on at least one pumper and the chief's car and by the WSO. Any problems that are encountered at the supply should be recorded.

Location and direction: ________________________________ Depth of water above intake: ______________

________________________________ Date: ______________

Date of Insp.	By	Depth of Water[1]	Amount of Water Available[2]	Condition of Water[3]	Erosion[4]	Dry Hydrant		Weed Control[7]	Road Condition[8]	Sign[9]	Remarks[10]
						Test[5]	Flow[6]				

[1] Record depth of water from the surface to the top of strainer.
[2] Record amount of water available calculated from surface to at least 2 ft (0.61 m) above top of strainer.
[3] Record a condition, the deterioration of which, over time, will reduce the water available. Special attention should be given to such items as silting, debris, and aquatic growth.
[4] Record erosion of the areas around the hydrant, access road, and bank of the water supply.
[5] Record by noting pumper used for the test, thereby indicating that the dry fire hydrant was back-flushed and that the end cap is in place, screen is clear of any stoppage, and supports or gravel, or both, is in place. Any problems corrected are recorded under "Remarks."
[6] Record of the actual test of the hydrant in gpm (L/min) following the department's standard operating procedure for testing dry fire hydrants. Care should be taken to use the same test procedures during each test.
[7] Record complete information on chemicals and process used, where applicable.
[8] Record condition of roadway, drainage, and so forth.
[9] Record information pertaining to accuracy and clarity of information on sign (e.g., repainted or replaced).
[10] Record general information about the dry fire hydrant as found at the time of inspection.

FIGURE A.9.7.3(a) Maintenance record for dry hydrant.

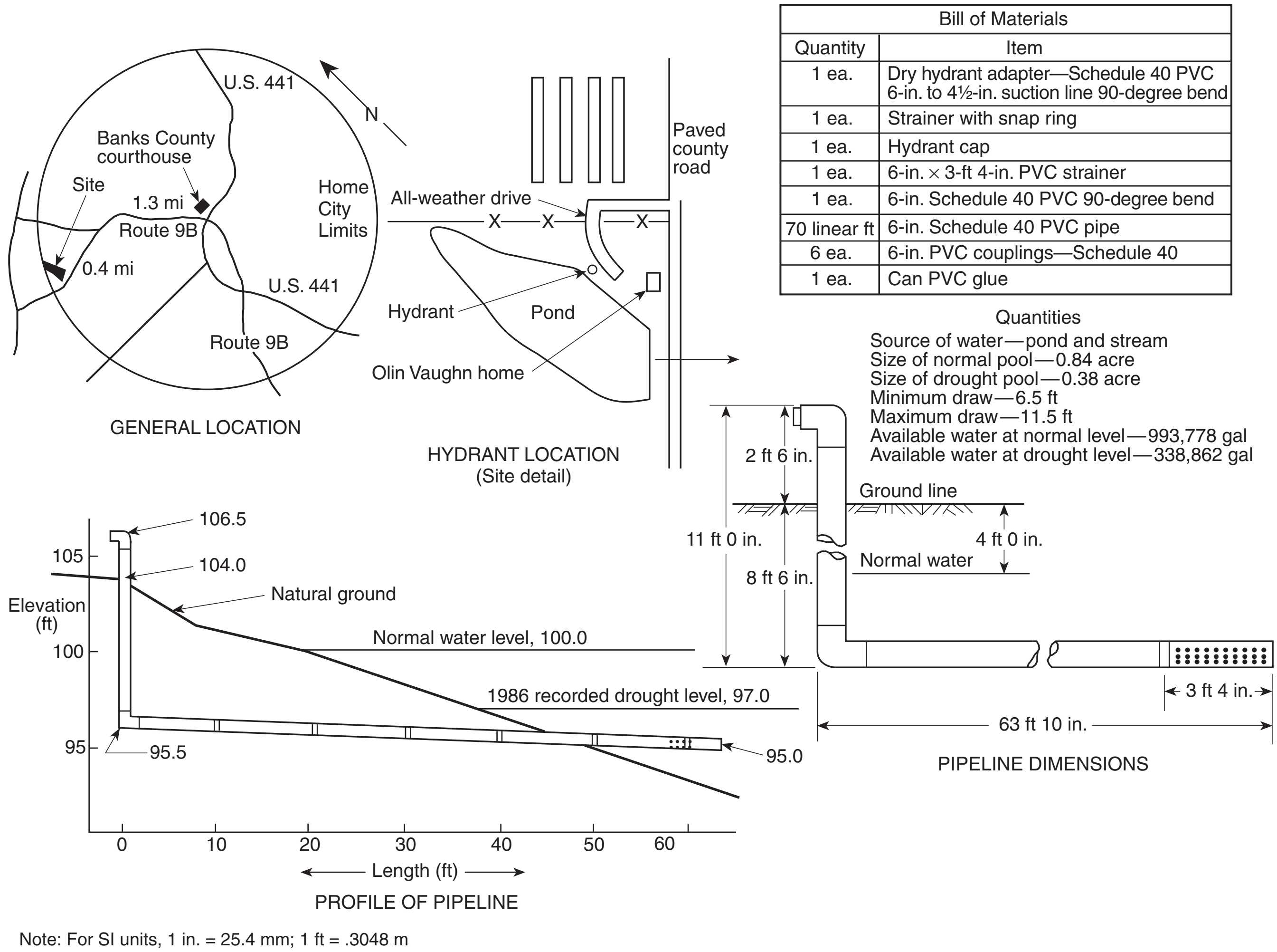


FIGURE A.9.7.3(b) Example map and location/detail drawing.

Annex B Water Supply

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 Water Supply.

B.1.1 General. The fire fighter operating without a water system with hydrants (or with a very limited number of hydrants) has two means of getting water: (1) from supplies on the fireground, which can be constructed or natural, or (2) from supplies transported to the scene. This annex discusses the variety and potential of these sources.

B.1.2 Water Operations. The WSO and the training officer, in conjunction with the fire chief, should develop standard operating procedures for hauling water to fires. The standard operating procedures should be put in motion for all structural fires; however, they can be discontinued after the officer in charge has evaluated the fire and determined that water hauling capabilities will not be needed.

B.2 First Aid Fire Protection Using On-Site Water Systems.

B.2.1 General. The individual domestic water supply system provided in many rural homes and business establishments, if properly equipped and maintained, is an effective first aid fire extinguisher. For large establishments, an elevated water storage tank or reservoir connected to hydrants and standpipes could provide substantial fire streams as well.

B.2.2 Domestic Water Systems. In order for domestic (farm) water systems to provide some degree of reliability in case of fire, the pump or pumps should be placed in a fire-resistive location. The electric power supply should have the maximum protection from de-energization by fire or other cause. In some cases, standby power and pumps can be justified.

B.2.3 Delivery of First Aid Fire Protection. For first aid fire protection to be effective, every portion of the dwelling and outlying buildings should be within reach of a hose stream. This might require some additional pipelines beyond those needed for other purposes. A garden hose long enough to reach any point in a structure is often valuable for fire fighting use. Care should be taken so that water is drained from hose or pipes that could be subject to freezing weather.

B.2.4 In-Depth Fire Protection. To provide for in-depth fire protection, one of the following three types of water supplies might be needed:

(1) First aid via the domestic water system. Alternative power supplies should be considered;
(2) A bulk water supply at the property, which can be a stream, pond, elevated tank, ground level tanks, or a cistern;
(3) An area system of static water supplies with drafting points and means for transporting the water to the fire site.

B.3 Cisterns.

B.3.1 General. Cisterns are one of the oldest sources of emergency water supply, both for fire fighting and drought storage. They are very important sources of water for fire fighting, domestic consumption, and drought storage in many rural and beach areas.

Cisterns should have a minimum usable volume as determined by the authority having jurisdiction, using the methods described in Chapter 7 of this standard, and there is no real limit to the maximum capacity. A cistern should be accessible to the fire apparatus or other pumping device but should be located far enough from the hazard that personnel and equipment are not endangered. *(See Figure B.3.1.)*

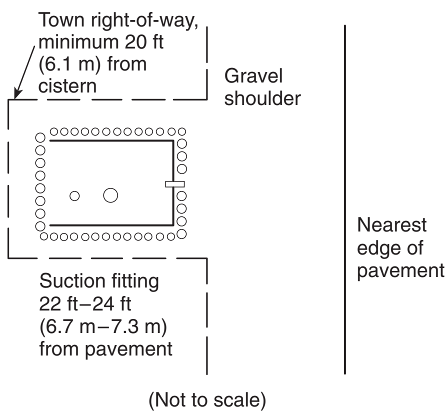


FIGURE B.3.1 Cistern site.

The water level of a cistern can be maintained by rainfall, water pumped from a well, water hauled by a mobile water supply, or by the seasonal high water of a stream or river. The cistern can present a freezing problem because its surface is often relatively inaccessible and the water is stagnant. One method for minimizing freezing is to use a dry hydrant protruding into the water at a point below the local frost line.

Cisterns should be capped for safety, but they should have openings to permit inspections and use of suction hose when needed. *(See B.3.4.)*

B.3.2 Construction of Cisterns. Construction of cisterns is governed by local conditions of soil and material availability. Practical information can be obtained from local governmental departments or agricultural agencies. Some engineering considerations to be used in designing cisterns include the following:

(1) Base, walls, and roof should be designed for the prevailing soil conditions and for the loads encountered where heavy vehicles are parked adjacent.
(2) If groundwater conditions are high, the cistern should not float when empty.
(3) Suction piping should be designed to minimize whirlpooling.
(4) Vent piping should be of sufficient size.

Maintenance factors to be considered by the fire department include the danger of silting, evaporation or other low water conditions, and the freezing problems previously discussed.

B.3.3 Cistern Specifications. Some governing bodies, where water systems are not available and water for water-hauling fire departments is inadequate, require developers to provide cisterns with all subdivisions that are constructed. As each cistern can provide fire protection for a number of buildings, the necessary capacity is rather large and represents a substantial investment. The following specifications for cistern design and construction are used by one governing body.

(1) Cisterns should be located no more than 2200 ft (671 m) truck travel distance from the nearest lot line of the furthermost lot.
(2) The design of a cistern should be trouble-free and last a lifetime.
(3) The cistern capacity should be 30,000 gal (113,560 L) minimum, available through the suction piping system.
(4) The suction piping system should be capable of delivering 1000 gpm (3785 L/min) for three quarters of the cistern capacity.
(5) The design of the cistern should be submitted to the authority having jurisdiction for approval prior to construction. All plans should be signed by a licensed/registered professional engineer. See Figure B.3.3(a).
(6) The entire cistern should be rated for highway loading, unless specifically exempted by the authority having jurisdiction.
(7) Each cistern should be sited to the particular location by a registered engineer and approved by the authority having jurisdiction.
(8) Cast-in-place concrete should achieve a 28-day strength of a gauge pressure of 3000 psi (20,700 kPa). It should be placed with a minimum of 4 in. (10.2 cm) slump and vibrated in a professional manner.
(9) The concrete should be mixed, placed, and cured without the use of calcium chloride. Winter placement and curing should follow the accepted American Concrete Institute (ACI) codes.
(10) All suction and fill piping should be American Society for Testing and Materials (ASTM) Schedule 40 steel. All vent piping should be ASTM Schedule 40 PVC with glued joints.
(11) All PVC piping should have glued joints.
(12) The 8 in. × 5 in. (20.3 cm × 12.7 cm) eccentric reducer is available from suppliers.
(13) The final suction connection should be a minimum of 4 ½ in. (11.4 cm). It should be capped.
(14) The filler pipe siamese should have 2½ in. (64 mm) National Standard female threads with plastic caps.
(15) The entire cistern should be completed and inspected before any backfilling is done.
(16) All backfill material should be screened gravel with no stones larger than 1½ in. (38 mm) and should be compacted to 95 percent ASTM 1557, *Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort [56,000 ft/lbf/ft^3 (2,700 kN-m/m^3)]*.
(17) Bedding for the cistern should consist of a minimum of 12 in. of ¾ in. to 1½ in. crushed, washed stone, compacted. No fill should be used under stone.

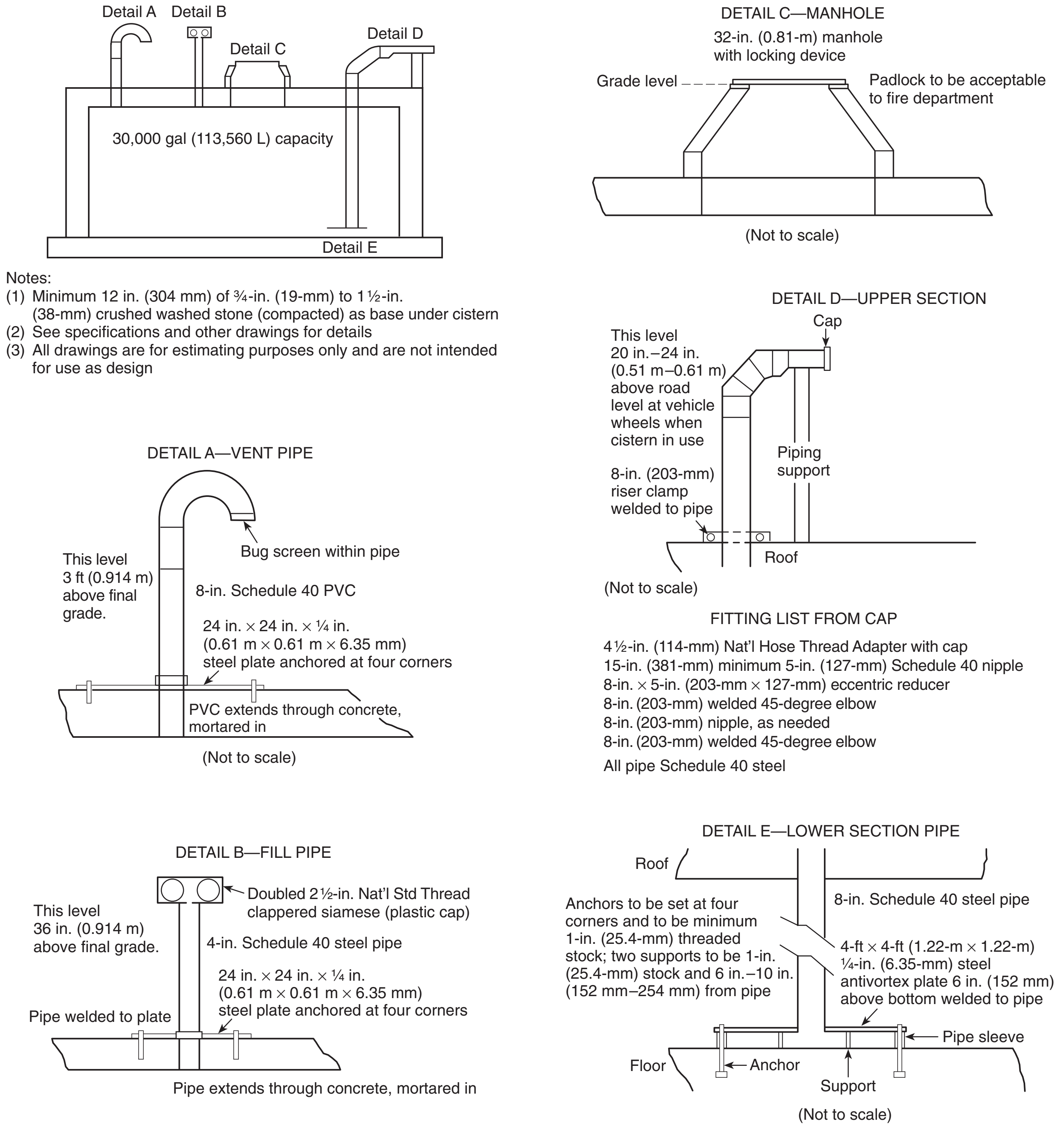


FIGURE B.3.3(a) Cistern and details.

(18) Filler pipe siamese should be 36 in. (91.4 cm) above final backfill grade.
(19) Suction pipe connection should be 20 in. to 24 in. (51 cm to 61 cm) above the level of the gravel where vehicle wheels will be located when cistern is in use.
(20) Suction pipe should be supported either to top of tank or to a level below frost.
(21) Base should be designed so that cistern will not float when empty.
(22) Perimeter of tank at floor/wall joint should be sealed with 8 in. (20.3 cm) PVC waterstop.
(23) After backfilling, tank should be protected by fencing or large stones.

(24) Backfill over the tank should be one of the following characteristics:
   (a) 4 ft (1.2 m) of fill.
   (b) The top and highest 2 ft (0.6 m) of sides of cistern should be insulated with vermin-resistant foam insulation, and 2 ft (0.6 m) of fill.
   (c) All backfill should extend 10 ft (3.1 m) beyond the edge of the cistern, and then have a maximum 3:1 slope, loamed and seeded.
(25) Bottom of suction pipe to pumper connection should not exceed 14 ft (4.25 m) vertical distance.
(26) Pitch of shoulder and vehicle pad from edge of pavement to pumper suction connection should be 1 to 6 percent downgrade.
(27) Shoulder and vehicle pad should be of sufficient length to permit convenient access to suction connection when pumper is set at 45 degrees to road.
(28) All construction, backfill, and grading material should be in accordance with proper construction practices and acceptable to the authority having jurisdiction.
(29) All horizontal suction piping should slope slightly uphill toward pumper connection.
(30) Installer is responsible for completely filling cistern until accepted by the authority having jurisdiction.

The specifications in (1) through (30) were furnished by the New Boston Fire Department, New Boston, NH. See Figure B.3.3(b) for an illustration of a typical well with a dry hydrant installed. Same design suitable for cistern if bottom of casing is not perforated. For usable water depth, see B.3.4 warning.

B.3.4 Guide to Circular Cistern Capacity. A ready guide to the capacity of cisterns with vertical sides is provided in Table B.3.4.

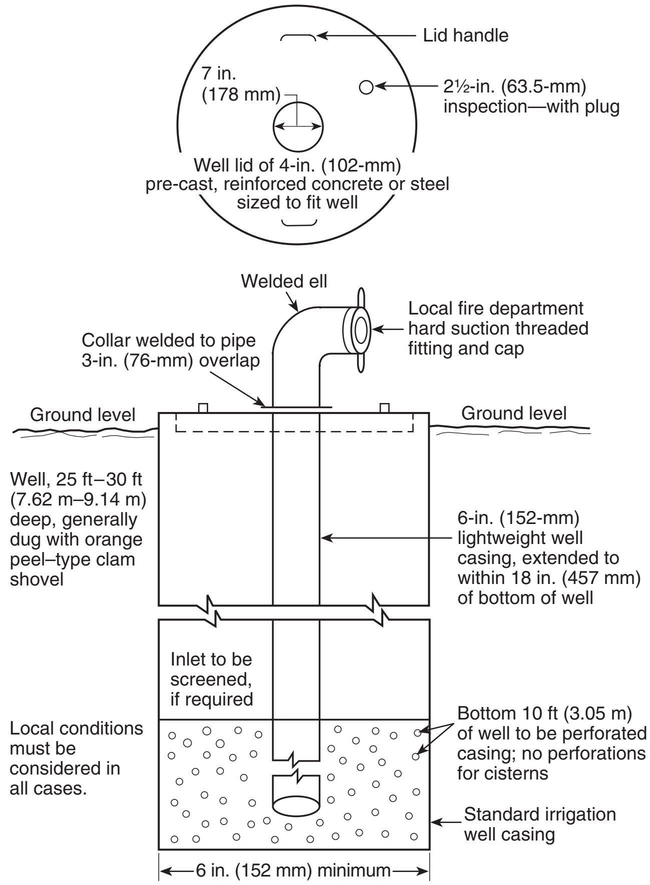


FIGURE B.3.3(b) Typical well (cistern) with dry hydrant installed.

Table B.3.4 Cistern Storage Capacity

Inside Diameter		Storage Capacity per Foot of Depth	
ft	**m**	**gal**	**L**
6	1.8	212	802
7	2.1	288	1090
8	2.4	376	1423
9	2.7	476	1801
10	3.0	588	2226

Notes:
(1) For SI units: 1 ft^3 = 7.48 gal of water; 1 ft^3 = 0.02832 m^3.
(2) A formula for calculating the storage capacity of a rectangular cistern is the same as the formula for pool capacity. *(See B.4.2.)*

WARNING: Reference is made to water depths in cisterns, swimming pools, streams, lakes, and other sources in a number of places in this annex. It should always be remembered that the depth with which the fire fighter is concerned is the usable depth. In a cistern, a bottom bed of gravel protecting a dry hydrant inlet, for instance, reduces the usable depth of the area above the gravel.

B.4 Swimming Pools. Swimming pools are an increasingly common source of water for fire protection. Even in some areas with normally adequate hydrant water supplies, they have been a factor in providing protection, such as in cases in which water demands have exceeded availability because of wildfire disasters, etc. They provide an advantage in that they are sources of clean water, but have major drawbacks due to the weight of fire department vehicles and poor accessibility for large apparatus. There are some areas of the country in which swimming pool distribution is better than hydrant distribution. If the WSO intends to use a swimming pool as a supply of water, it is a good practice to develop these water sources through working with property owners and preplanning.

B.4.1 Pool Accessibility. If fire department accessibility is considered with the design of the pool, a usable water supply should be available to the fire department for supplying direct hose lines or a source of water for mobile water supply filling. Most swimming pools are built in areas requiring security fencing or walls, and these can complicate accessibility. Fences and walls can be designed for fire department use or, depending on construction, can be entered forcibly. In most cases, a solution to the problems of accessibility can be achieved through preplanning and might call for long lengths of suction hose, portable pumps, dry hydrants, siphon ejectors, or properly spaced gates. Portable (or floating) pumps designed for large volume delivery at limited pressures deliver water to portable folding tanks or fire department pumpers and are frequently ideal where accessibility problems exist. *(See E.1.2.)*

A swimming pool located virtually under the eaves of a burning house can be a very poor location from which to pump if there are problems of fire exposure to the work area, etc. Pumping from a neighboring pool, if it is close enough, or setting the water-hauling program in motion is frequently preferable to pumping from the pool of the burning house. *(See Figure B.4.1.)*

FIGURE B.4.1 Where plans are made before a fire, it might not take elaborate preparation to use a swimming pool as a water supply.

B.4.2 Pool Capacity. The following formula is a short-form method of estimating pool capacity:

$$L \times W \times D\ 7.5\ \text{gal}\ (1000\ \text{L}) = \text{estimated capacity in gal (L)}$$

where:
L = length in feet (m)
W = width in feet (m)
D = estimated average depth in feet, from water line in feet (m)

Note that the dimensions used in the formula should be estimated or rounded off if pool is of stylized construction. For conversion purposes, 1 ft^3 water = 7.5 gal (1 m^3 = 1000 L).

Consideration should be given for providing more suction hose on fire apparatus responding in areas dependent on swimming pools. Fast rigging of such suction hose demands special training. Using long lengths of hose over walls and other obstacles typical of swimming pools demands techniques other than those used for drafting from ponds or streams. Adequate pre-fire planning requires knowledge of individual pools so that the method of obtaining water at the property is known. Lightweight or flexible-type suction hose can be advantageous for this purpose.

B.4.3 Care in Use of Pools. Care has to be exercised to be sure structural damage will not be done to a pool and the surrounding area if the water is used for fire fighting. Lightly built cement, Gunite®, or poured concrete pools can present danger of structural damage, cracking, or collapse when drained. If a pool is located in extremely wet soil, it will tend to float upwards when drained. In this case, refill the pool as soon as the fire is under control and mobile water supply apparatus can be released from fire duties.

Some pools are compacted earth covered by a plastic surfacing or light-gauge metal panels placed against such earth or a special fill. Such pools can collapse internally if emptied. It might be possible to use a limited portion of such water sources but not possible to use the entire depth apparently available. It might be prudent not to use these pools at all.

Another consideration is whether the ground surrounding a pool will support the weight of a fire department vehicle without collapsing. The WSO should study and know the various pool limitations within the area served by consulting with the builders and installers of these pools.

B.5 Livestock Watering Ponds and Tanks. Many farms have livestock water tanks and other similar facilities. If the owner is aware of the water needs for the farm's buildings for fire fighting purposes, such tanks and ponds should be so sized as to be adequate in volume for both farm and fire department use and so located as to be readily available to the fire department. Tanks should be placed on the edge of the barnyard and on a side accessible to the fire department, with the pumper or pump taking suction through a connection on the tank or by suction hose. These watering tanks and ponds are often filled and maintained full by a pump operated by a windmill or by an electric pump. Figure B.5(a) and Figure B.5(b) illustrate the components of a dry hydrant system for holding tanks and procedures for successfully using them as water sources.

Where a well fitted with an electric pump is used for irrigation or industrial use, the fuses can be pulled for periods of time when the farmer or plant does not need the water supply. Therefore, the fire department should carry fuses for all of the pumps in the district, and provisions should be made for an electrician or a power company employee or individual knowledgeable of pumps to respond on all alarms of fire.

B.6 Sprinkler Systems. In some rural areas, the only large water supply might be storage provided for use of a sprinklered building. The supply might be from an underground water distribution system, a pond or suction tank with pumps, an elevated tank, or a combination of these. In many cases, preplan arrangements can be made to use the water. This is particularly true if the property owner is contacted before installation of sprinkler protection, as it might be necessary to increase the capacity of the storage or to install a hydrant that is accessible to the fire department and connected to the private yard distribution system.

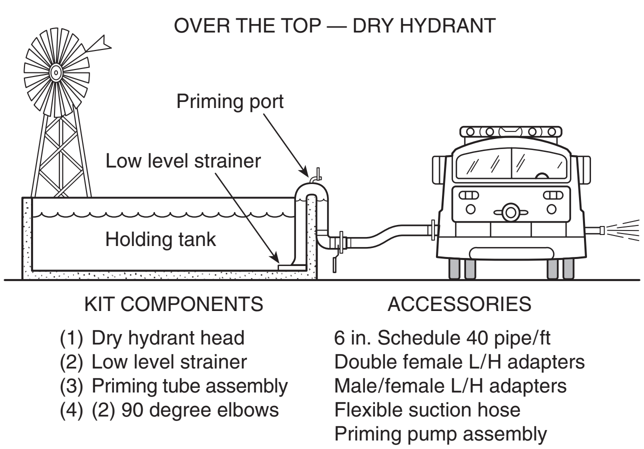


FIGURE B.5(a) Components of a dry hydrant system for farm holding tanks.

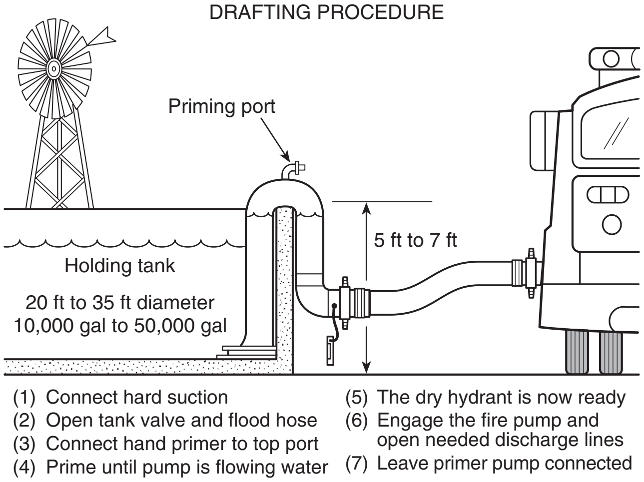


FIGURE B.5(b) Drafting procedure for farm holding tanks.

FIGURE B.8.1 Dry hydrant.

Extreme care should be exercised in the use of water supplies provided for sprinkler protection. A certain amount of water should be retained in these systems for minimum sprinkler protection. A careful study and pre-plan should be made to determine such use.

Some states and municipalities might have special ordinances requiring sprinkler protection for certain properties such as nursing homes. Frequently, the water supplies for these systems are minimal and are from pressure tanks of limited capacity. Where this is the case, it is suggested that the fire department not consider such supplies in their planning, as the rural fire department should take care that it does not disrupt the protection at such a property. *(See Annex F for additional information on sprinkler systems.)*

B.7 Driven Wells. Wells and well systems are becoming increasingly popular as water supplies for fire-fighting purposes at industrial properties, shopping centers, subdivisions, and farm houses located in rural areas beyond the reach of a municipal water distribution system.

In areas with suitable soil conditions, for instance those of a very sandy nature, it might be possible to use driven wells or water-jetted wells to obtain water for fire fighting. These wells are, in essence, pipes, usually with perforations about the base to permit entry of water, driven into the ground. From the threaded pipe head (or a fitting attached to the body of the pipe) a pump connection can be made to draft water much as from a well hydrant. A high water table is a prerequisite to using this method. Fire-fighting units in areas conducive to this technique should have the necessary equipment for such installations.

Some states and local governments have regulations or licensing requirements in order to construct a well. Such restriction will probably increase in the future.

B.8 Dry Hydrants.

B.8.1 General. As the installation of rural dry hydrants using constructed or natural water sources increases, an understanding of the planning, permitting, design criteria, and construction processes becomes evident. A strategically placed rural dry hydrant system, with all-weather road access, significantly reduces water point set-up time and turnaround time to the fireground, improves the life safety of the fire fighter, and can reduce insurance costs. *(See Figure B.8.1.)*

B.8.2 Pressurized Dry Hydrant Sources. There can be two types of pressurized dry hydrants: (1) those flowing through a dam (or dike) (2) those coming from an uphill water source emptying at a point downhill from the source. Although the water source uphill can be of extreme advantage when flowed to a downhill source, a major disadvantage could lie in the burying of the pipe below the frost level. For a pressure hydrant, the pipe should be sloped downhill to the hydrant riser and be fitted with a gate valve. Where the supply line passes through the dike of a pond, anti-seep collars should be attached to the pipe to prevent water from seeping and channeling beside the pipe.

B.8.3 Variations in Dry Hydrant Design. There are numerous adaptations to the basic design of a dry hydrant. These have been developed to overcome local or regional problems and can have applications over a large geographical area. Figures B.8.3(a) and B.8.3(b) illustrate a dry hydrant design that eliminates the top elbow on each hydrant. In Figure B.8.3(b), the driver maneuvers the truck as the fire fighter walks the suction end of the hose to the dry hydrant. An O-ring in the plastic "L" provides a right fit and allows the operator to draft. This is a quick and simple method to connect the pumper to a dry hydrant. It is critical that a good seal be obtained with the O-ring to prevent any air leakage, or the pump will fail to prime.

Dry hydrants can be installed in areas where the frost line would freeze the water in the hydrant pipe. This system was designed to inject air into the hydrant and displace the water to prevent freezing. With the water displaced below the frost line, the hydrant would be usable year-round for drafting purposes. Air is injected into the hydrant until it bubbles out of the suction screen, or the air pressure gauge no longer rises. This low-pressure air should not cause a safety problem, but all personnel should be advised to remove the hydrant cap slowly to prevent any possible injury. The air gauge should be checked periodically to be sure the water remains displaced in the hydrant. *[See Figure B.8.3(c).]*

In Figure B.8.3(d), an air pressure gauge and air chuck have been installed in the cap of the hydrant by drilling and

FIGURE B.8.3(a) A dry hydrant innovation has eliminated the top 90-degree or 45-degree elbow on each hydrant. *(Photo by Nahunta Volunteer Fire Department, NC)*

FIGURE B.8.3(b) Hard suction hose is connected to the pumper.

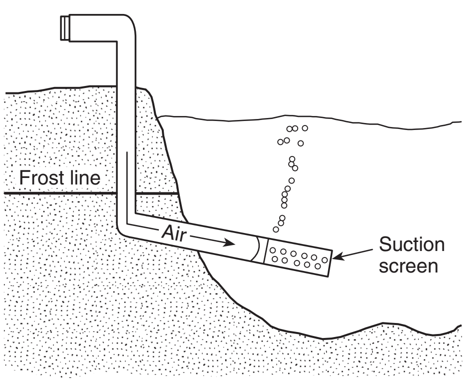


FIGURE B.8.3(c) Air injection frost-proofing system. *(Developed by Wascott Volunteer Fire Department, WI)*

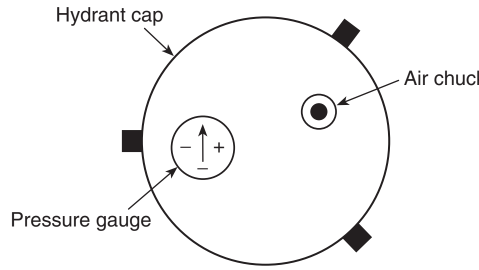


FIGURE B.8.3(d) Cap design for air injection system.

tapping into the metal. The chain for the hydrant cap has been removed. Teflon® tape has been applied to the threads of the gauge and chuck. This method has the advantage that if the chuck or gauge is damaged, it will not affect the airtight integrity of the hydrant while drafting, because the cap has been removed. *[See Figure B.8.3(d).]*

In water sources where heavy sediment and silt could present a problem of clogged suction screens, raise the intake screens above the bottom. *[See Figure B.8.3(e).]*

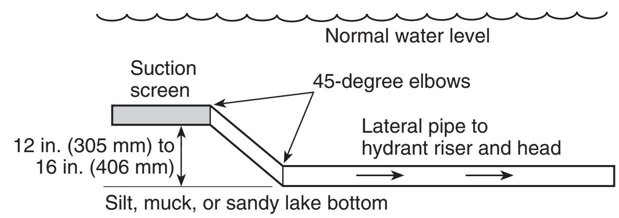


FIGURE B.8.3(e) Offset screen installation. *(Developed by Weyerhaeuser Volunteer Fire Department, WI)*

B.8.4 Dry Hydrant with Suction Line. In some cases, it can be desirable to install a dry hydrant with a suction line in lieu of an access road. This can be true in marsh or swamp areas. In this case, the fire department will have access to the hydrant from the shoulder of the main road. So as not to block the road during pumper operations, a suitable parking area on the shoulder of the road should be provided. Basic recommendations such as those in Table A.9.4.7 can be useful in the design of such an area so that pumpers can be used efficiently and safely.

B.9 Preplanning Water Supply.

B.9.1 Preplanning. Structures within the district of responsibility of the fire department should be surveyed in accordance with Chapter 4. The water requirement should be calculated, and the type and amount of equipment that should respond on first alarm should be designated. The response of fire apparatus, in conjunction with capacity of mobile water supply apparatus, travel distance to haul water, and the volume of water supply, can then be arranged so that a constant flow to equal the water flow requirements is obtained. The procedure should be verified under training conditions prior to a fire emergency. This training exercise should include the spotting of equipment to protect the fire property and the exposures, exploration of the water sources, designation of fire lanes or routes, and review and modification of the operations to meet unusual conditions.

Aircraft and aerial photographs can be very helpful in the survey of static water availability. Such photographs are usually available from the county agriculture department or the county office of planning and zoning. Topographical maps from the United States Geological Survey also can be of value in this survey. However, the value should be determined by the date that the map was made or revised, because an out-of-date map can prove to be of little value. Once sites are located, they need to be prepared for use according to the recommendations of this annex.

Annex C Water Hauling

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

C.1 Mobile Water Supplies.

C.1.1 General. The fire service has always experienced fire control difficulties in isolated areas. The difficulties are many and varied, but one of the major problems is the lack of an adequate water supply. The availability of an adequate amount of water for control and extinguishment is a major consideration for most rural fire chiefs and a factor that influences the majority of their fire-fighting decisions. A portion of the training of a rural fire department emphasizes the need for the conservation of the meager water supply that is available in many areas.

A limited water supply condition at a working fire in a rural area challenges all phases of fire fighting. This annex discusses the procedures for moving water in those areas where there are no municipal-type water distribution systems with fire hydrants.

If the water supply is a dry hydrant, a lake, a cistern, a swimming pool, and so forth, operating procedures have to be developed for transporting the water from the supply to the fire. Most fire departments use a fire department pumper with a pump capacity of at least 750 gpm (2842 L/min) and a minimum 500-gal (1895-L) tank.

Because the pumper is always assigned to the supply, some departments provide it with little equipment beyond the pumps, the necessary hose for loading, and some preconnected handlines.

Several departments report that they have developed shallow water supplies into which the pumper is actually driven. Others have developed a trailer with a pump, and the trailer is pulled to the water supply. Still other departments have received good service from a permanently installed pump at the supply.

Over the years, rural departments depending on hauled water have tended to utilize any means to carry water and have exercised a great deal of ingenuity in doing so. Recently, there has been a trend in fire departments in rural areas to use standard pumpers and mobile water supply apparatus with tanks in the 1000-gal to 1500-gal (3785-L to 5678-L) range. Significant progress has been made in such mobile water supply apparatus techniques as loading and unloading, and in maintaining a continuous fire stream, based on the fire flow study, during the entire fire-fighting operation.

Mobile water supply apparatus are necessary for most rural departments and can be a major asset to a department having a weak municipal-type water system. Although specially built and designed mobile water supply apparatus are ideal, many fire chiefs are forced to fight fires without adequate standard equipment. Because the job of putting out fires will require, on occasion, water-carrying capacity far above normal capability, a sound mutual or automatic aid program is necessary and far superior to makeshift equipment that is not designed for emergency service and is unsafe.

In building and buying nonstandard apparatus, serious consideration should be given to the safety and serviceability of the equipment as well as the safety of the members of the department. A department that depends on an assortment of mobile water supply apparatus designed primarily for other use might need expert assistance in checking the equipment for safety before putting it in service.

If satisfactory service is to be obtained from mobile water supply apparatus, the size of chassis necessary to safely carry the load, the horsepower of the engine necessary to perform on the road and at the fire site, the completed vehicle's weight distribution, and the gear train combination best suited for the operation in that specific locale are factors that should be carefully considered in the purchase or construction of the apparatus. The apparatus components, such as the baffling of the tank and the center of gravity, are just as important as the engine, axles, and other driveline components and should not be overlooked.

Some fire departments that have pumpers equipped with large booster tanks have retrofitted these pumps with a dump system.

C.1.2 Purchase or Construction of a Mobile Water Supply Apparatus. When purchasing or constructing a mobile water supply apparatus, careful attention should be paid to ensure that engine, chassis, baffling, center of gravity, and brakes of adequate specifications are obtained. NFPA 1901, *Standard for Automotive Fire Apparatus*, covers mobile water supply apparatus, and it is recommended that this standard be carefully followed.

The tank should be properly constructed and baffled. Particular attention should be paid to flow rates to and from the tank. Consideration should be given to discharging the mobile water supply apparatus to the receiving vehicle, portable tank, or other equipment as rapidly as possible so that the mobile apparatus can get back on the road and bring another load of water to the fireground. Some departments are installing very large dump valves with gravity flow, while other departments are providing a dump with a jet dump arrangement to reduce the emptying time.

The terrain, weather, and bridge and road conditions expected should be considered when buying or building safe mobile water supply apparatus.

It is suggested that, for a mobile water supply apparatus with a capacity greater than 1500 gal (5678 L), it might be necessary to utilize a semitrailer or tandem rear axles, depending on tank size and chassis characteristics. Consideration should be given to utilizing limited slip differential or all-wheel drive capabilities. Certain types of chassis might not provide safe carrying capabilities and could result in a dangerous vehicle. Equipment that at least meets the minimum standards is necessary.

It is further recommended that the maximum water tank capacity for mobile water supply apparatus should not exceed 4800 gal (18,168 L) or 20 tons of water. In some cases, it might even be found that the cost of two smaller mobile water supply apparatus will be little more, if any, than the cost of one large mobile water supply. The mobility, cost of upkeep, state weight restrictions, and highway bridge weight restrictions can convince many rural fire departments of the need to restrict the weight of their mobile water supply. The weight of the vehicle plus the load carried should not be greater than the rated capacity of the tires.

When apparatus is loaded, each load-bearing tire and rim of the apparatus should carry a weight not in excess of the recommended load for truck tires of the size used as specified by the tire manufacturer's rating. Compliance should be determined by weighing the loaded apparatus.

C.1.3 State Regulations. Regardless of rear axle configuration, specific consideration should be given to the state's legal weight-per-axle requirement. All states have single-axle weight limits, which are imposed based on road surface conditions and the longevity of highways. Although axles are designed to carry their rated weight, and vehicle and fire department planners can specify precise chassis requirements that fall within the safe tolerances of total vehicle operation and weight, such specifications do not legally permit the fire apparatus to exceed the state's legal weight rating per axle. Because some single-axle weight ratings are 26,000 lb (11,778 kg), the consideration given and attention paid to state single-axle weight limits can be significant.

The use of dead (or dummy) axles serves only to reduce the weight-per-axle load (on weighing scales). In no manner does it allow the engineering parameters of motor, transmission, drive shaft, brakes, and so forth, designed for the gross vehicle weight rating (GVWR) of the chassis to be functional. Using a nonworking axle for load-carrying purposes does not make a chassis road-safe.

C.1.4 Mobile Water Supply Capacity. In general terms, mobile water supply vehicles are units made for specific water-hauling requirements. In some wildland areas, where fire fighting is performed off the road and up steep grades, a 200-gal (757-L) slip-on unit is a mobile water supply. East of the Mississippi River, there is a trend in fire departments in rural areas to use mobile water supplies in the 1000-gal to 1500-gal (3785-L to 5678-L) range. In flat areas west of the Mississippi, fire departments successfully use mobile water supply apparatus with capacities of 3000 gal to 5000 gal (11,355 L to 18,925 L) and, occasionally, more.

In many parts of the country, the terrain, along with bridge and road weight restrictions, limit the capacity of mobile water supplies to the 1000-gal to 1500-gal (3785-L to 5678-L) range. However, a department operating mobile water supplies with capacities of 1000 gal (3785 L) or more will normally find it easy to meet the minimum water requirements outlined in this standard where water supplies are readily available.

It is desirable to use mobile water supplies of similar fill and discharge capability and equal water-carrying capacities to prevent them from "stacking" at the fill and discharge points.

C.1.5 Tank Baffles. The tank baffle or swash partition is often considered to be the weakest and most dangerous area of fire engine and mobile water supply design and construction. Considerable improvements have been made in baffles since the advent of the computer age. Poor baffling has been responsible for many accidents and accounts for a number of deaths throughout the country each year. Careful consideration should be given to baffles by the designers and builders of tanks.

C.1.6 Plumbing. It is important to have an outlet of adequate size to empty the tank. The reason is evident when the time needed to empty a 1600-gal (6056-L) mobile water supply apparatus by gravity flow is considered. *(See Table C.1.6.)*

Table C.1.6 Emptying Time for 1600-Gal (6056-L) Mobile Water Supply by Gravity Flow

Outlet Size		
in.	mm	Discharge Time (min)
2½	65	20
4½	114	7
6	152	5
10	254	1⅔
12	305	1½

Adequately sized plumbing is also important in those mobile water supply apparatus equipped with a pump with a jet dump arrangement. Many jet dump mobile water supply apparatus are capable of discharging at the rate of 1000 gpm (3785 L/min) or more.

Proper venting is a prerequisite for filling and emptying tanks, but it is imperative for rapid filling and discharging of tanks. Air must be driven from the tank as it is being filled with water, and air has to enter the tank as that tank is being emptied. As a minimum, the vent opening should be four times the cross-sectional area of the inlet. Inadequate venting can cause the tank to bow outward when it is being filled rapidly or can impair the discharge flow when emptying.

An 8 in. × 8 in. (203 mm × 203 mm) vent extending upward for approximately 12 in. (305 mm) is an adequate vent size. This overflow pipe located in the vent pipe area works as a venting source when the vent top is closed.

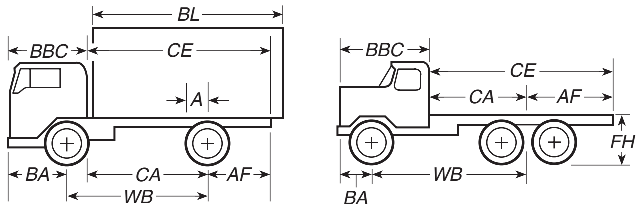
Adequate pump-to-tank plumbing size is also essential to provide for rapid discharge of water from a mobile water supply through its pump. Many pieces of fire apparatus are in service that cannot deliver the full capacity of their pumps from their tanks because of undersized tank-to-pump plumbing. In a mobile water supply operation in which the emphasis can be placed on rapid, low-pressure emptying of a tank, undersized plumbing can be a major limitation to efficiency.

A major concern in a water-hauling system involving mobile water supply apparatus is the fact that the mobile water supply might not be completely filled at the water supply source or completely emptied at the fire. Some mobile water supplies are so designed that as little as 10 gal (38 L) of water is left in the tank while others can have 100 gal (379 L) or more left in the tank.

Applicable NFPA standards such as NFPA 1901, *Standard for Automotive Fire Apparatus*, contain data on adequate plumbing. Many departments are now exceeding the nominal pipe size requirements for their pumps in order to overcome friction loss and increase their capability to rapidly empty a tank by use of the pump.

C.1.6.1 Fill Line Couplings. Often, time wasted at mobile water supply fill locations is due to difficulties in coupling and uncoupling the threaded couplings between the fill pumper and the mobile water supply. If such difficulties exist, considerable time can be saved by using either a quarter-turn coupling (or some type of flexible hose with a quick discharge), a specially designed large-diameter fill pipe, or a rapid-fill device that drops into the tank fill opening, thus providing quick breakaway from the fill supply.

C.1.7 Weight Distribution. Weight distribution is all-important in the handling of a heavy piece of fire apparatus



Dimensions

BBC = bumper to back of cab
BA = bumper to centerline of front axle
CE = back of cab to end of frame
CA = back of cab to centerline of rear axle or tandem suspension
AF = centerline of rear axle to end of frame
FH = frame height
BL = body length
A = distance from centerline of rear axle to centerline of body or payload (centerline of body at ½ body length)
WB = wheelbase distance — distance between centerlines of front and rear axle or tandem suspension

Terms

Chassis — basic vehicle cab, frame, and running gear
Curb weight — weight of chassis only

Gross vehicle weight rating (GVWR) — total of curb, body, and payload weights

Formulas

The weight carried by the front and rear axles can be calculated from the following formulas:

$$\frac{(B + PL)\,A}{WB} = FA \qquad (B + PL) - FA = RA$$

where:

B = body weight — weight of complete body to be installed on chassis
PL = payload weight — weight of commodity to be carried
A = distance from centerline of rear axle to centerline of body or payload (centerline of body at ½ body length)
WB = wheelbase distance — distance between centerlines of front and rear axle or tandem suspension
FA = front axle weight
RA = rear axle weight

FIGURE C.1.7 Weight distribution for mobile water supplies.

and should be properly designed into the unit and then verified by weighing each axle. Even the slightest change in the load carried or the distribution of the load can cause the design limits of the truck to be exceeded and turn a safe vehicle into an unsafe vehicle.

Figure C.1.7 provides information necessary to calculate accurate weight distribution.

The measurements to be used in the weight distribution calculation are the "as is" weights of the chassis to be used, dimensions of the chassis, and weights to be placed on the chassis. "As is" weights are best determined by weighing the chassis, with separate weights obtained on front and rear axles. If the unit has dual rear axles, they should be weighed together. In some cases, particularly where using a new chassis, data for calculation of weight distribution can be obtained from the agency providing the chassis, but it should be noted that such items as changes in tire size, lengthening, shortening, or reinforcement can alter standard factory-provided data. Consequently, it is preferable to weigh the chassis when starting construction planning.

Dimensional data are easily obtained by using a tape measure or carpenter's ruler. These data might be available from the source providing the chassis but should be verified.

The weight of the body to be added to the chassis is primarily the weight of the steel and other materials used in the body, the water in the tank itself, and any associated components. Components include such items as any reels, hose, or miscellaneous equipment expected to be used. Although it is not necessary to make an individual calculation for minor items (minor in terms of weight), it is certainly important to calculate weight distribution of items of a few hundred pounds or more.

This annex does not attempt to provide complete information on mobile water supply construction or the weight distribution of such a mobile water supply. The chassis manufacturer's recommended weight distribution — generally expressed as a percentage of total weight, including both the weight of the chassis and the weight placed on the chassis for front and rear axle(s) — is a prudent guideline for the final weight distribution desired. Component weights should be obtained from the manufacturers of the components. Steel weights should be obtained from the steelyard providing the material.

C.1.8 Turning Radius and Wheelbase. An important consideration in mobile water supply shuttle operations is the area available for turning. Because the mobile water supply might be called on to reverse direction or to maneuver for position at the water source or the fire site, a multiple of small, single-axle, mobile water supplies with 12-in. (305-mm) quick dump or 6-in. (152-mm) jet dump might actually move more water to the fire location than longer wheelbase tractor trailers and dual, tandem-axle, mobile water supply apparatus.

C.1.9 Modification of Nonwater Tankers for Use as Mobile Water Supply Apparatus. Special care should be used when modifying a tanker built for a purpose other than for mobile water supply use, such as the prevalent practice of adapting an oil tanker for use as a mobile water supply apparatus. The majority of oil or gasoline tankers are constructed to carry a volatile liquid whose specific gravity is less than that of water. When utilized as a mobile water supply apparatus, the weight might exceed the manufacturer's permissible gross vehicle weight limits. For this reason, it might be preferable to reduce the tank's size to avoid undesirable effects on weight distribution. In doing so, special attention should be paid to any alteration in the vehicle's center of gravity that could affect its safety when turning corners.

Special attention should be paid to the baffling of such modified mobile water supply apparatus, and the truck should be rejected if it does not meet the demands of cornering, braking, and acceleration required by the fire service.

Other special factors to be considered where modifying nonwater tankers are as follows:

(1) A stainless steel milk tanker might be made out of very light gauge metal with no baffling and might be difficult to baffle crosswise and lengthwise.
(2) The steel used in gasoline tankers will corrode extremely fast due to the uncoated interior of such tanks. In addition, the steel used is not of the copper-bearing or stainless type used in most fire apparatus tanks.
(3) Aluminum fuel oil tanks have been found to be subject to corrosion from chlorinated water and corrosive rural water supplies. They can have a life expectancy less than that of steel if not properly coated and protected.
(4) An inherent danger in modifying gasoline tankers is the possibility of an explosion. All gasoline tanks should be thoroughly steam cleaned before modifications requiring welding are started.
(5) Gasoline and milk tankers are usually designed to be filled each morning for distribution of the product during the day under normal traffic conditions rather than emergency conditions, as is the case with fire equipment.

Table C.1.9 Weights of Various Fluids

Fluids	Weights lb/gal	kg/L
Milk	8.5	1.02
Water	8.3	0.99
Gasoline	6.2	0.74

It is not necessary for an oil tanker or milk tanker to stand in the station fully loaded day after day. *(See Table C.1.9.)*

C.1.10 Driver Training. An important consideration frequently overlooked by the rural fire department is that of driver training. Few people are trained to drive a tractor-trailer combination under emergency conditions, and the fire department planning to use such a vehicle should provide specific training for drivers of this type of apparatus. Even a two- or three-axle vehicle used as a mobile water supply will probably have driving characteristics very different from other apparatus, and driver training is extremely important. Individual state operator licensing requirements should be met.

C.1.11 Calculating Water-Carrying Potential. The following are two primary factors to be considered in the development of tank water supplies:

(1) The amount of water carried on initial responding units
(2) The amount of water that can be continuously delivered after initial response

A number of fire departments have developed water-hauling operations to the point where they have a maximum continuous flow capability (a sustained fire flow) of 1000 gpm to 2000 gpm (3785 L/min to 7570 L/min) at the fire scene. Such continuous flow requires several mobile water supply apparatus to haul such large quantities of water, with a developed water source near the fire site. To improve the safety factor by reducing congestion on the highways, the departments often send the mobile water supply apparatus to the water source by one road and use another route for the mobile water supply apparatus to return to the fire scene. Therefore, the time for the department to travel from the fire to the water source (T_1) might be a different time than the travel time back to the fire (T_2). The reduction of congestion on the highway provides for a safer operation and can increase the actual amount of water hauled.

The maximum continuous flow capability at the fire scene is calculated as follows:

$$Q = \frac{V}{A + (T_1 + T_2) + B} \times 0.9$$

where:

Q = maximum continuous flow capability [gpm (L/min)]
V = mobile water supply capacity [gal (L)]
A = time (min) for the mobile water supplies to drive 200 ft (61 m), dump water into a drop tank, and return 200 ft (61 m) to starting point
T_1 = time (min) for the mobile water supply to travel from fire to water source
T_2 = time (min) for the same mobile water supply to travel from water source back to fire
B = time in minutes for the mobile water supply to drive 200 ft (61 m), fill mobile water supply at water source, and return 200 ft (61 m) to starting point
0.9 factor = amount of water supply (mobile water supply capacity) considered unavailable due to spillage, underfilling, and incomplete unloading

The dumping time *(A)* and filling time *(B)* for the formula should be determined by drill and by close study of water sources. Equipment does not have to be operated under emergency conditions to obtain travel time, *(T)* which is calculated using the following equation:

$$T = 0.65 + XD$$

where:

T = time (min) of average one-way trip travel
X = average safe constant speed factor
D = one-way distance (miles)

The factor 0.65 represents an acceleration/deceleration constant based on miles per hour developed by the Rand Corporation.

Where an apparatus is equipped with an adequate engine, chassis, baffling, and brakes, a safe constant speed of 35 mph (56.3 km/hr) can generally be maintained on level terrain, in light traffic, and on an adequate roadway. Where conditions will not permit this speed, the average safe constant speed should be reduced.

Using an average safe constant speed of 35 mph (56.3 km/hr), the X factor is calculated as follows:

$$X = \frac{60}{\text{average safe constant speed}} = \frac{60}{35 \text{ mph}} = 1.70$$

Precalculated values of X using various speeds, in miles per hour, have been inserted into the formula for travel time ($T = 0.65 + XD$) as indicated in Table C.1.11(a) and Table C.1.11(b):

Table C.1.11(a) Precalculated Values of *X*

Speed (mph)	*X*	Speed (kph)	*X*
15	4.000	24.135	2.486
20	3.000	32.180	1.865
25	2.400	40.225	1.492
30	2.000	48.270	1.243
35	1.714	56.315	1.065

Table C.1.11(b) Time–Distance Table Using an Average Safe Constant Speed of 35 mph ($T = 0.65 + 1.7\ D$)

Distance miles	Distance km	Time (min)
0.0	0.00	0.00
0.1	0.16	0.82
0.2	0.32	0.99
0.3	0.48	1.16
0.4	0.64	1.33

(continues)

Table C.1.11(b) *Continued*

Distance		
miles	km	Time (min)
0.5	0.80	1.50
0.6	0.97	1.67
0.7	1.13	1.84
0.8	1.29	2.01
0.9	1.45	2.18
1.0	1.61	2.35
1.1	1.77	2.52
1.2	1.93	2.69
1.3	2.09	2.86
1.4	2.25	3.03
1.5	2.41	3.20
1.6	2.57	3.37
1.7	2.74	3.54
1.8	2.90	3.71
1.9	3.06	3.88
2.0	3.22	4.05
2.1	3.39	4.22
2.2	3.54	4.39
2.3	3.70	4.56
2.4	3.86	4.73
2.5	4.02	4.90
2.6	4.18	5.07
2.7	4.34	5.24
2.8	4.51	5.41
2.9	4.67	5.58
3.0	4.83	5.75
3.1	4.99	5.92
3.2	5.15	6.09
3.3	5.31	6.26
3.4	5.47	6.43
3.5	5.63	6.60
3.6	5.79	6.77
3.7	5.95	6.94
3.8	6.11	7.11
3.9	6.28	7.28
4.0	6.44	7.45
4.1	6.60	7.62
4.2	6.76	7.79
4.3	6.92	7.96
4.4	7.08	8.13
4.5	7.24	8.30
4.6	7.40	8.47
4.7	7.56	8.64
4.8	7.72	8.81
4.9	7.88	8.98
5.0	8.05	9.15
5.1	8.21	9.32
5.2	8.37	9.49
5.3	8.53	9.66
5.4	8.69	9.83
5.5	8.85	10.00
5.6	9.01	10.17
5.7	9.17	10.34
5.8	9.33	10.51
5.9	9.49	10.68
6.0	9.65	10.85
6.1	9.81	11.02
6.2	9.98	11.19

Table C.1.11(b) *Continued*

Distance		
miles	km	Time (min)
6.3	10.14	11.36
6.4	10.30	11.53
6.5	10.46	11.70
6.6	10.62	11.87
6.7	10.78	12.04
6.8	10.94	12.21
6.9	11.10	12.38
7.0	11.26	12.55
7.1	11.42	12.72
7.2	11.58	12.89
7.3	11.75	13.06
7.4	11.91	13.23
7.5	12.07	13.40
7.6	12.23	13.57
7.7	12.39	13.74
7.8	12.55	13.91
7.9	12.71	14.08
8.0	12.87	14.25
8.1	13.03	14.42
8.2	13.19	14.59
8.3	13.35	14.76
8.4	13.52	14.93
8.5	13.68	15.10
8.6	13.84	15.27
8.7	14.00	15.44
8.8	14.16	15.61
8.9	14.32	15.78
9.0	14.48	15.95
9.1	14.64	16.12
9.2	14.80	16.29
9.3	14.96	16.46
9.4	15.12	16.63
9.5	15.29	16.80
9.6	15.45	16.97
9.7	15.61	17.14
9.8	15.77	17.31
9.9	15.93	17.48
10.0	16.09	17.65

The formulas in this annex make it possible to determine water availability at any point in an area. As an example of how to calculate the water available from a supply where the water has to be trucked to the fire scene, consider the following applications of the formula.

If tank capacity *(V)* is 1500 gal (5678 L), the time *(A)* to fill the mobile water supply with water is 3.0 minutes, and the time *(B)* to dump the water into a portable tank is 4.0 minutes.

The distance (D_1) from the fire to the water source is 2.10 miles (3.38 km). As the mobile water supply returns by a different road, the distance (D_2) from the water source is 1.80 mi (2.9 km).

First, solve for T_1, the time for the mobile water supply to travel from the fire to the water source, and then solve for T_2, the time for the mobile water supply to travel from the water source back to the fire.

Due to good weather and road conditions, the constant mobile water supply speed traveling from the fire to the water source is 35 mph (56.3 km/hr).

Use the travel time formula as follows:

$$T = 0.65 + XD_1$$

where:

X = 1.7
D_1 = 2.10

and where at a constant speed of 35 mph (56.3 km/hr):

T_1 = 0.65 + 1.7 D_1
T_1 = 0.65 + 1.7 × 2.10
T_1 = 0.65 + 3.57
T_1 = 4.22

[See also Table C.1.11(b).]

At a constant speed of 35 mph (56.3 km/hr), a mobile water supply traveling 2.10 mi (3.8 km) will take 4.22 minutes. Due to traffic lights, the average mobile water supply speed between the fire and the water source is 30 mph (48.3 km/hr).

Use the time travel formula as follows:

$$T = 0.65 + XD_2$$

where:

X = 2.0
D_2 = 1.80

and where at a constant speed of 30 mph (48.3 km/hr):

T_2 = 0.65 + 2.0D_2
T_2 = 0.65 + 2.0 × 1.8
T_2 = 0.65 + 3.60
T_2 = 4.25

Use the following formula for calculating the maximum continuous flow capability:

$$Q = \frac{V}{A + (T_1 + T_2 + B)} - 10\%\ V$$

where:

Q = maximum continuous flow capability (gpm)
V = 1500
A = 3.0
T_1 = 4.22
T_2 = 4.25
B = 4.0

Therefore,

$$Q = \frac{1500}{3.0 + (4.22 + 4.25) + 4.0} - 10\%\ V$$

$$Q = \frac{1500}{3.0 + 8.47 + 4.0} - 10\%\ V$$

$$Q = \frac{1500}{15.47} - 10\%\ V$$

$$Q = 97 - 10\% = 87 \text{ gpm } (329.3 \text{ L/min})$$

The maximum continuous flow capacity available from this 1500-gal (5678-L) mobile water supply is 87 gpm (329.3 L/ min).

To increase the maximum continuous flow capability of a mobile water supply, any of the following changes can be made:

(1) Increase the capacity of the mobile water supply
(2) Reduce the fill time *(See Figure C.1.11.)*
(3) Develop and provide additional fill points, thus reducing travel time
(4) Reduce the dump time

With rural fire response distances normally being very long, the number and size of mobile water supply apparatus available to the department is of paramount importance. This information will assist the department in calculating the probable mobile water supply volume that will be available at various fire locations. Equally important in increasing the maximum continuous flow capability of a mobile water supply is the reduction of the distance between the source and the building or fire. The distance can be reduced by increasing the number of water supplies, the drafting points, or both.

FIGURE C.1.11 Example of a quick coupling that can help to reduce the fill time.

C.1.12 Filling and Discharging the Mobile Water Supply. During water-hauling operations, mobile water supply dump/fill rates directly affect the fire flow capabilities established at the fire scene. Local needs usually determine mobile water supply configuration and the water-hauling procedures. A wide variety of off-loading and filling systems are currently in use. Some departments prefer to pump off their water into portable tanks, while others utilize a nursing operation. An increasing number of fire departments are incorporating the use of large dump valves or jet-assisted dump arrangements. Deciding which system is best requires an evaluation of effectiveness, efficiency, and overall compatibility with other segments of the water delivery.

During a comprehensive evaluation, many factors should be considered. Travel distances, operating site location, and topography greatly affect water-hauling turnaround time periods. Usually, the greatest amount of time can be saved during the filling and discharge segments of the shuttle operation. Normally, greater quantities of water are made available as filling/discharge rates increase. Of course, increased quantities should be logistically supported by ample water source locations and tanking vehicles.

As with other segments of fireground operations, strategic preplanning is vital to water-hauling evolutions. Preplanning and practice reduce unnecessary actions and minimize unsafe practices. For example, a properly established dump site should eliminate or substantially reduce the need to back up vehicles (an act that not only requires precious time but causes

33 percent of all vehicle accidents). The use of flexible discharge tubing or side dumps in conjunction with properly set up dump sites can often eliminate the necessity of backing up the vehicles to the water supply.

Because two of the key periods for saving time during water-hauling operations center around mobile water supply filling and discharge, many fire departments have incorporated the use of large gravity dump valves or jet dump valve arrangements.

C.1.12.1 Mobile Water Supplies Equipped with Large Gravity Dumps. A number of rural fire departments have increased the size of their gravity discharge dumps to reduce the time necessary to empty other water-hauling mobile water supply apparatus. Gravity dumping with discharge valves of 10 in. (254 mm), 12 in. (301 mm), or larger are often used. Dump valve discharge rates will vary as the depth of the water in a given tank decreases. Adequate air intakes and tank baffle cuts should be provided, or inefficiency and possible tank damage can result. To check the efficiency of a dump system, weight tests should be conducted to determine discharge rates.

C.1.12.2 Mobile Water Supplies Equipped with Jet-Assisted Dumps. Basically, a jet is a pressurized water stream used to increase the velocity of a larger volume of water that is flowing by gravity through a given size dump valve. The water jet principle used to expel water from mobile water supply apparatus has also been effectively applied to several other devices that can transfer water between portable dump tanks, fill mobile water supply apparatus from static water sources, and reduce suction losses at draft. Water jets properly installed in the discharge piping of a mobile water supply or fire apparatus can more than double their water-hauling efficiency. Effective jet-assisted arrangements have exceeded a 1000-gpm (3785-L/min) discharge rate when using 6-in. (152-mm) discharge piping and valve. Pumps supplying such jet arrangements should be capable of delivering a minimum of 250 gpm (946 L/min) at a gauge pressure of 150 psi (1034 kPa). Some departments have obtained good results with pumps that deliver flows at a gauge pressure of less than 150 psi (1034 kPa) where larger discharge openings are provided. The size and design of the jet nozzle and the diameter and length of the dump valve piping directly affect unit efficiency.

C.1.12.3 Traditional In-line Jet-Assisted Arrangement. Figure C.1.12.3(a) illustrates how the traditional jet is installed. A smooth-tipped jet nozzle is usually supplied by a pump capable of delivering at least 250 gpm (946 L/min) at a gauge pressure of 150 psi (1034 kPa). Nozzle jets range in size from ¾ in. to 1¼ in. (19 mm to 32 mm). The diameter of the tip will be determined by the capacity of the pump being used and the diameter of the discharge piping and dump valve.

Before a jet dump is installed, questions including, but not limited to, the following should be answered:

(1) In what location will the dump prove to be most useful, the side or the back?
(2) Will the fixed piping need to be 1½ in. (38 mm) in diameter or 2 in. (51 mm) in diameter?
(3) What is the preferable location for the jet, in-line or at the rear of the tank?

In the interest of site versatility, many departments are utilizing lightweight flexible discharge tubes equipped with quick-lock or quarter-turn couplings. Such tubing arrangements allow rapid discharge of water to either side of the vehicle and reduce the need for hazardous backing at the dump site.

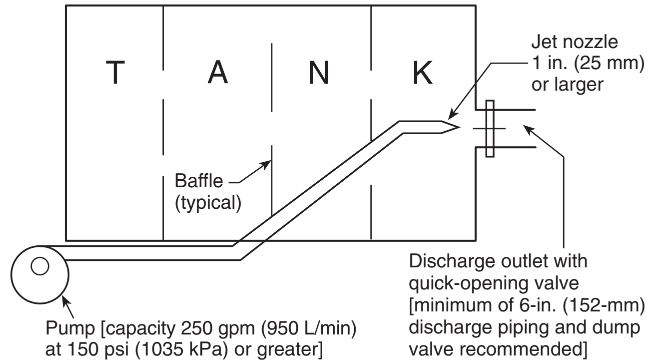


FIGURE C.1.12.3(a) Traditional internal jet dump.

The rate of discharge will be governed by the size of the dump valve and piping, which can range from 4 in. to 12 in. (102 mm to 301 mm). Normally, a 6-in. or 8-in. (152-mm or 203-mm) diameter dump configuration permits adequate flow capacities where water jet systems are employed. Again, it is stressed that adequate air exchange and water flow passages should be provided for a jet-assisted dump arrangement to function properly. Tanks can collapse where air exchange is restricted. Lack of adequate gravity water flow to the jet area will also adversely affect the discharge efficiency of the water-hauling unit.

Although some authorities recommend that the nozzle of the in-line jet be up to 6 in. (152 mm) from the center of the discharge opening, other effective designs have included placement of the nozzle inside the discharge piping. Figure C.1.12.3(b) details how the traditional jet arrangement can be externally added to an existing dump valve. A short length of 1½-in. (38-mm) hose is attached to the female coupling on the jet device. The length of the added dump piping can range from 2 ft to 4 ft (0.6 m to 1.2 m), depending on whether a flexible tube is utilized during the dump process.

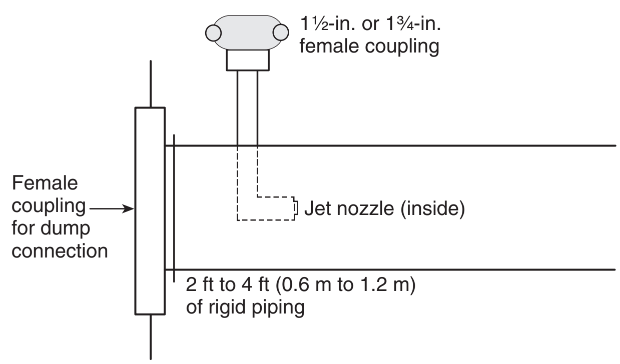
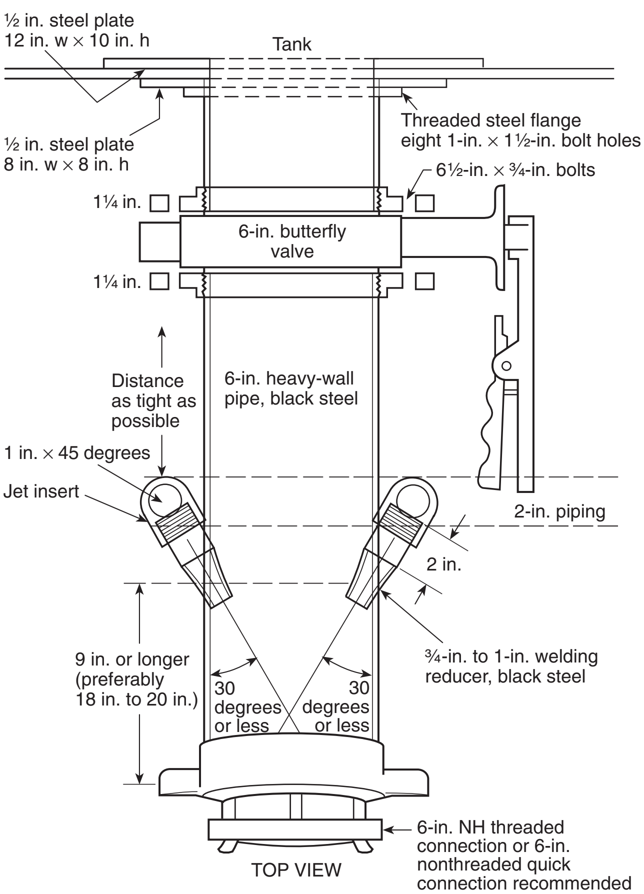


FIGURE C.1.12.3(b) Traditional external jet dump.

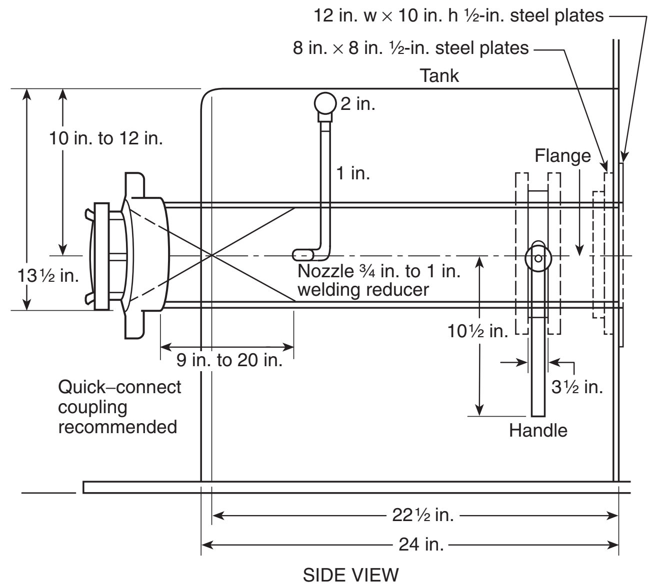
To properly operate, a jet should be able to produce between a gauge pressure of 50 psi and 150 psi (345 kPa and 1034 kPa). Higher pressures normally increase operational effectiveness. The diameter of the jet selected should be appropriate for the capacity and pressure capabilities of the pump being utilized. Also important is the size of the piping and valves that make up the jet dump system. External jets do have several advantages over internally fixed units, particularly with respect to system maintenance. Disadvantages might include the need to provide for adequate air exchange during water flow, more time necessary for the initial setup in order to affix appliances, the restriction of movement around the vehicle, and the general appearance of the jets themselves.

C.1.12.4 Peripheral Jet-Assisted Arrangement. The peripheral application of jet-assisted nozzles has proved highly effective. This arrangement utilizes two or more jets installed in the sides of the discharge piping just outside the quick-dump valve. In addition to the reported discharge advantages of peripheral jet streams, the externally fed system is easier to plumb and has fewer maintenance problems. The jets, installed 25 degrees to 30 degrees from the piping wall, contact more surface area of the discharging water, thereby increasing water discharge efficiency. Because the water is drawn through the dump valve, less turbulence is created, and the eddy effect often present with traditional in-line jets is overcome. Nozzles made of welding reducer pipe fittings work very effectively as jets. Flow rates of 2000 gpm (7570 L/min) have been obtained using a 300-gpm (1136-L/min) pump to supply two ¾-in. (19-mm) nozzles in a 6-in. (152-mm) dump valve configuration. Figure C.1.12.4(a) and Figure C.1.12.4(b) represent two views of a typical installation.



Note: For SI units, 1 in. = 2.54 cm.

FIGURE C.1.12.4(a) Peripheral jet-assisted installation (top view).



Note: For SI units, 1 in. = 2.54 cm.

FIGURE C.1.12.4(b) Peripheral jet-assisted installation (side view).

C.1.12.5 Other Jet-Assisted Devices. Innovative fire organizations have put siphons and jet-related devices to good use. Some siphons use only water-level differential to transfer water from one tank to another. Normally constructed of PVC pipe, such siphons are placed between portable tanks to equalize water levels. Transfer is initiated by filling the U-shaped tubing with water, placing the caps on the tubing until it is put in place, and then removing the caps to allow water flow. Such an arrangement, though useful, has often proved too slow for the type of transfer operations required. A modification of the siphon transfer piping using a jet was developed and has proved useful to many departments. Although 4-in. (102-mm) PVC and aluminum piping have been used for such devices, 6-in. (152-mm) units usually are more practical. Using a ½-in. (13-mm) jet nozzle supplied by a 1½-in. (38-mm) hose makes possible transfer flows of 500 gpm (1890 L/min). Some departments merely add the jet to a length of suction. *[See Figure C.1.12.5(a) and Figure C.1.12.5(b).]*

Siphons that use the jet principle are commercially available and are, in some cases, supplied by 2½-in. (64-mm) hose. These devices are used to remove water from basement areas or increase the water supply to fire department pumpers.

In-line jets have also been developed to reduce suction losses during drafting operations. In-line and peripheral jets supplied by 1½-in., 1¾-in., or 2½-in. (38-mm, 44-mm, or 64-mm) hose lines can increase the output capacity of a centrifugal pump at draft up to 40 percent. The jets are placed at the intake and at every 10 ft (3.1 m) of suction in use. *[See Figure C.1.12.5(a).]* The design characteristics of strainers used during such application should permit adequate water flow capacity.

Some departments have developed a jet system for delivering water from a static source to mobile water supply apparatus through 4-in. or 6-in. (102-mm or 152-mm) lightweight pipe. This supply piping concept is used to fill mobile water supply apparatus through their discharge gates or via top load-

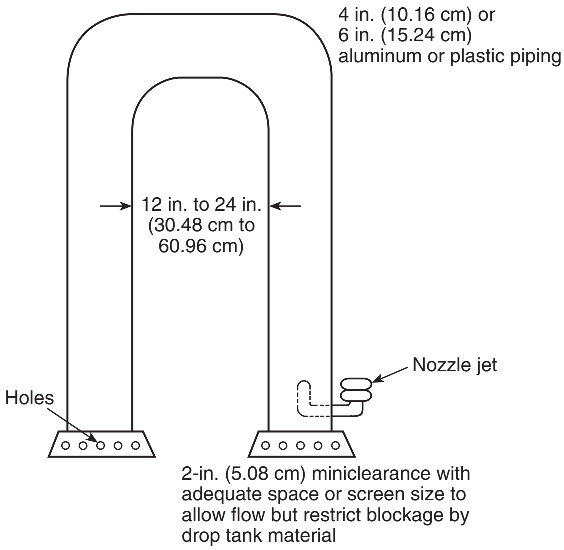


FIGURE C.1.12.5(a) Jet-assisted transfer siphon.

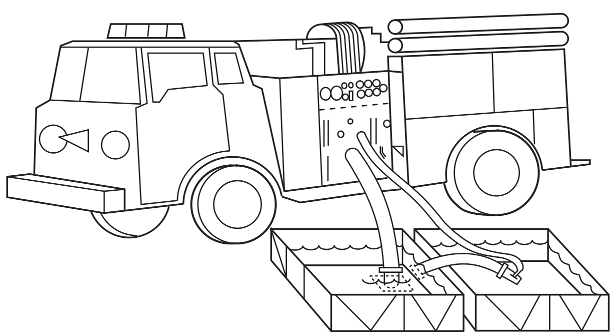


FIGURE C.1.12.5(b) Modified hard suction jet siphon.

ing or large inlets capable of filling mobile water supply apparatus at the rate of 1000 gpm (3785 L/min) or greater.

C.1.12.6 Testing Dump Valve Capacity. Departments using large gravity dump valves or jet-assisted dump valve arrangements need to determine the flow rate at which they can dump and fill each mobile water supply in use. Generally accepted procedures for determining flow capacities, as found in *Rural Firefighting Operations Book II (see Additional Publications in Annex I)*, have been developed and should be accomplished as follows:

(1) Weigh the mobile water supply without any water on board.
(2) Weigh the mobile water supply again when it has been completely filled with water.
(3) Off-load the mobile water supply for 1 minute using only gravity.
(4) Weigh the mobile water supply and determine the gallons (liters) off-loaded by gravity.
(5) Refill the mobile water supply and weigh it.
(6) Off-load the mobile water supply for 1 minute using the jet arrangement.
(7) Weigh the mobile water supply and determine the gallons (liters) off-loaded via the jet.
(8) Make a comparison of the gallons (liters) used by gravity and those depleted using the jet.
(9) Refill the mobile water supply and weigh it.
(10) Off-load the mobile water supply for 1 minute by opening the gravity dump and pumping through a 2½-in. (64-mm) discharge.
(11) Weigh the mobile water supply and then determine the number of gallons (liters) off-loaded by pumping and dumping.

An effective jet-assisted dump arrangement should produce at least twice the volume that would be expected when off-loading by gravity. A good jet arrangement will exceed the volume experienced during the dumping and pumping test. Whether using large dumps or jet dump arrangements, turnaround drop times and ease of operations should be the primary considerations.

C.1.13 Portable Drop Tanks. The following are, generally, the three types of drop tanks:

(1) Self-supporting tank
(2) Fold-out frame tank
(3) High-sided fold-out tank for helicopter bucket-lift mobile water supply service

The self-supporting tank is built with the sides reinforced to support the water inside the tank. The fold-out frame tank is similar to a child's wading pool — an open tank supported by a steel frame — and is the most common in fire service use. Tanks are available with an inlet or outlet, or both, built into the side of the tank. The capacities of drop tanks normally run from 1000 gal to 2500 gal (3785 L to 9463 L), with 1500-gal to 2000-gal (5676-L to 7570-L) tanks being those used most often.

The addition of the drop tank for "stockpiling" water has yielded highly desirable results. Stockpiling allows for the continuous operation of low-volume supplies and creates a source from which a pumper can draft for supplying hose lines during a direct fire attack. *[See Figure C.1.13(a) and Figure C.1.13(b).]*

FIGURE C.1.13(a) Fire fighters setting up portable drop tank. *(Courtesy of Nahunta Volunteer Fire Department, NC)*

Portable drop tanks should be simple to set up. Note the portable tank compartment (door open) on the mobile water supply in Figure C.1.13(a).

FIGURE C.1.13(b) Portable tank with strainer.

Each mobile water supply should carry a portable tank that is 40 percent greater than the capacity of the mobile water supply. Note the strainer that minimizes whirlpooling and allows departments to draft to a depth of 1 in. to 2 in. (25 mm to 51 mm) in the portable tank in Figure C.1.13(b).

C.1.14 Use of Portable Drop Tanks and Mobile Water Supply Vehicles. The development of the portable drop tank or portable folding tank and the jet-assisted dump or large gravity dump to assist the mobile water supply in quickly discharging its load of water has enabled many rural fire departments to utilize isolated water supplies and, for the first time, to obtain sufficient water for effective fire fighting. The following is a brief summary of how the system is being employed by some departments.

When an alarm of fire is received, equipment is dispatched on a preplanned basis determined by such factors as fire flow needs, hazards involved, water supply available, and so forth *(see Chapter 7)*. A minimum of one mobile water supply and one pumper respond to the fire, and the pumper begins the fire attack with water from its booster tank.

The first responding mobile water supply can act as a nurse unit or can set up a portable drop tank and begin discharging its load of water into the drop tank. With the use of a jet-type pump, discharging through a 5-in. or 6-in. (127-mm or 152-mm) discharge pipe, or a large 12-in. (305-mm) quick dump valve, the water in the mobile water supply can be transferred to the portable drop tank at a rate of approximately 1000 gpm (3785 L/min). A short piece of aluminum pipe with an "L" on one end gives the mobile water supply the flexibility to discharge into the drop tank with the mobile water supply backed up to the drop tank or with the drop tank located on either side of the mobile water supply. In Figure C.1.14, four hard suction hose lines are used to minimize any clogging of the strainers.

As soon as the mobile water supply has emptied its load, it immediately heads to the water supply. In the meantime, another fire department pumping unit has arrived at and has connected to the water supply and primed its pump. When the empty mobile water supply apparatus arrives at the water supply, the pumper is ready to fill the mobile water supply apparatus. The refilled mobile water supply apparatus returns to the fire site, discharges its water, and the cycle is repeated.

It can be more efficient to fill one mobile water supply apparatus at a time rather than to fill two or more mobile water supply apparatus at a slower rate. Also, if all mobile water

FIGURE C.1.14 Portable drop tank with "L"-shaped aluminum irrigation discharge pipe.

supply apparatus in the department have the same capacity, they will not stack up at the source of the supply or the fire while waiting for a large mobile water supply apparatus to be filled at the source or to discharge its water at the fire.

Although preplanned, each step of this hauling operation is under the direction of the WSO, and local conditions can dictate variations in this basic system.

As additional mobile water supply apparatus arrive at the fire site and dump their water, they fall into the water-hauling cycle. It might be necessary for the WSO to open up additional water supply points with additional pumpers. Portable pumps can sometimes be used in this operation if the additional supply is not readily accessible; however, refill time can be greatly increased. The WSO at the fire site needs to be in radio contact with the officer in charge of each water supply or suction point. The WSO will also advise the drivers of which route to take to the fire site. Wherever possible, an alternate route should be selected for returning vehicles so that emergency vehicles will not be meeting on sharp turns or narrow country roads.

It is possible that local fire departments will be unable to accommodate the demands of an initial alarm response to certain occupancies that require a large volume of water, based on the study producing the water flow requirements provided in C.1.11 and C.1.12. Automatic aid pumpers and mobile water supply apparatus can be set up to run automatically on first alarm, thereby conserving valuable time and delivering the fire flows calculated in Chapter 7.

Each mobile water supply should carry a portable drop tank with a capacity at least 40 percent greater than the capacity of the mobile water supply.

C.1.15 Chemical Additives and the Water Supply.

C.1.15.1 General. Fire departments are using chemicals to increase their fire-fighting capacity. This is important to the rural fire fighter working with a limited water supply, because these chemicals can provide more extinguishing capability per gallon (liter) of water. Because the chemical additives will create an additional expense, it becomes very important to be aware of the various capabilities and characteristics of chemical additives, as well as their advantages and disadvantages, relative to the types of fires encountered by each fire department.

C.1.15.2 Foam. Fire-fighting foams are used on surfaces where the cooling effect of water is needed and wherever a continuous foam blanket can provide the benefits of vapor suppression, insulation, delayed wetting, or reflection. Foam products are commercially available for Class A fuel fires and Class B fuel fires (commonly referred to as Class A foam and Class B foam, respectively).

Class A foam is designed for fighting fires involving wildland fuels, sawdust, cotton, paper, rubber, and other Class A fuels. Class A foam is a mechanically generated aggregation of bubbles having a lower density than water. The foam is made by introducing air into a mixture of water and foam concentrate. The bubbles adhere to the Class A fuels and gradually release the moisture they contain. The greater surface area–to–mass ratio of water in the foam of a bubble enables foamed water to absorb heat more effectively than unfoamed water.

Foam provides a barrier of oxygen, which is necessary to sustain combustion. The reduced rate of water release results in more efficient conversion of water to steam, providing enhanced cooling effects, and, along with surfactants contained in the solution, allows the water to penetrate the fuels and reach deep-seated fire sites. Foam also provides a protective barrier for unburned, exposed fuels by wetting and insulation. *(See NFPA 1150, Standard on Fire-Fighting Foam Chemicals for Class A Fuels in Rural, Suburban, and Vegetated Areas.)*

Class B foam is designed for fighting fires involving flammable or combustible liquids and is the only permanent extinguishing agent used on fires of this type. Class B foam is lighter than the aqueous solution from which it is formed and lighter than flammable liquids; therefore, it floats on all flammable or combustible liquids, producing an air-excluding, cooling, continuous layer of vapor-sealing, water-bearing material for purposes of halting or preventing combustion. *(See NFPA 11, Standard for Low-Expansion Foam.)*

The appropriate listings on the foam concentrate label should be consulted to determine proper application rates and methods. If there are no listings for application rates and methods, none should be assumed. However, the word "foam" appears in wetting agent instructions as well as in the instructions for the use of water expansion system (WES) units.

C.1.15.3 Other Water Additives (Wetting Agents). A wetting agent is a chemical compound that, when added to water in amounts indicated by the manufacturer, will materially reduce the water's surface tension, increase its penetrating and spreading abilities, and might also provide emulsification and foaming characteristics. Decreased surface tension disrupts the forces holding the film of water together, thereby allowing it to flow and spread uniformly over solid surfaces and to penetrate openings and recesses over which it would normally flow. Water treated in this manner not only spreads and penetrates but displays increased absorptive speed and superior adhesion to solid surfaces. Therefore, leaks in plumbing and pump packing can occur that would not occur if the additive had not been used. Visual inspection should be made during wet water operations.

Water mixed with wetting agent, also known as "wet water," should be applied directly to the surface of the combustible. These agents do not increase the heat absorption capacity of water, but the greater spread and penetration of the wet water increase the efficiency of the extinguishing properties of water, as more water surface is available for heat absorption and runoff is decreased.

Wetting agents are broadly defined as surfactants (surface-acting agents). All wetting agents (whether liquid or powder) are concentrated and are mixed with a liquid at varying percentages. The liquid into which it is mixed for fire-fighting purposes is water. With all wetting agents, hard water usually requires a greater amount of additive to produce the same results.

Wetting agents designed for fire department use will normally contain rust inhibitors to protect the tank, pump, piping, and valves. Generally, the mixture will lose some of its rust-inhibiting characteristics if left in the tank.

However, some wetting agents are sold primarily for use as a carrier for liquid fertilizers, fungicides, insecticides, and herbicides. These wetting agents can be used for fire-fighting purposes; however, they lack the additives that will protect tanks, pumps, valves, bushings, and so forth. Unused mixtures should be drained out of the tank and the pump and valves generously flushed with plain water.

Wetting agents are used as soaking or penetrating solutions for Class A fires involving wildland fuels, sawdust, cotton (bales, bedding, upholstery), rags, paper, and so forth. These solutions are used very effectively on smoldering or glowing combustibles.

Many of the wet water additive products include instructions to produce a foam by increasing the amount of the product mixed with water.

No additional equipment is needed for the production of this foam. Caution should be exercised, and on-site testing should be performed, in order to determine what the resultant foam will display in terms of extinguishment and fire fighter safety.

Additionally, a few wet water additives produce a foam through the use of a foam gun (generally a tube-type aerator and some nozzles). The instructions indicate this is generally a Class A fire-extinguishing agent. As stated previously, local on-site testing should be performed to determine the product's capabilities.

There is available commercially a water additive that will suppress Class A and Class B fires. The product accomplishes the extinguishment of Class B fires by altering the water properties in such a manner that the increasing heat converts the water to a vapor, rather than steam, thereby cooling the fire.

Annex D Large-Diameter Hose

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

D.1 Transporting Water Through Large-Diameter Hose.

D.1.1 General. The advent of large-diameter hose as an accepted tool of fire fighting has major significance in the field of rural water supplies. This hose is viewed as an aboveground water main from a water source to the fire scene, and its use is growing in the United States. Where delivery rates exceed 500 gpm (1893 L/min) and water is moved long distances, large-diameter hose provide a most efficient means of minimizing friction losses and developing the full potential of both water supplies and pumping capacities. For practical purposes, NFPA defines large-diameter hose as hose with an inside diameter of 3½ in. (89 mm) or larger.

D.1.2 Characteristics. Large-diameter hose is available in either single-jacketed or double-jacketed construction, generally in the following sizes:

(1) 3½ in. (89 mm)
(2) 4 in. (102 mm)

(3) 4½ in. (114 mm)
(4) 5 in. (127 mm)
(5) 6 in. (152 mm)

The lower friction loss characteristics of such hose increase the usable distance between the water source and the fire. The department unable to use water sources more than 1000 ft (304.8 m) from a potential fire site might find that 3000 ft (914 m) or more can become a reasonable distance where using large-diameter hose.

The basic reasons large-diameter hose moves water more efficiently are its larger size, its lower friction loss, and the relationship between these factors. The relationship can be explained by studying the carrying capacities and friction loss factors shown in Table D.1.2(a) and Table D.1.2(b).

Table D.1.2(a) Relative Water Capacity of Fire Hose in Hose Lengths

Internal Diameter of Hose (in.)	Carrying Capacity in Hose Length(s) — Internal Diameter of Hose (in.)						
	2½	3	3½	4	4½	5	6
2½	1.00	0.617	0.413	0.29	0.213	0.161	0.1
3	1.62	1.0	0.667	0.469	0.345	0.261	0.162
3½	2.42	1.5	1.0	0.704	0.515	0.391	0.243
4	3.44	2.13	1.42	1.0	0.735	0.556	0.345
4½	4.69	2.90	1.94	1.36	1.0	0.758	0.469
5	6.20	3.83	2.56	1.8	1.32	1.0	0.619
6	10.00	6.19	4.12	2.9	2.13	1.61	1.0

Note: Table D.1.2(a) shows the relative carrying capacities of hose, 2½ in. to 6 in. in diameter for the same friction loss. The values in the table are based on the Hazen-Williams equation.

Table D.1.2(b) Approximate Friction Losses in Fire Hose

Flow (gpm)	Friction Loss (psi/100 ft) — Internal Diameter of Hose (in.)					
	2½	3	3½	4	5	6
250	15	6	2	—	—	—
500	55	25	10	5	2	—
750	—	45	20	11	4	1.5
1000	—	77	36	19	6	2.5
1500	—	—	82	40	14	6.0
2000	—	—	—	70	25	10.0

Note: For SI units, 1 in. = 25.4 mm; 1 gpm = 3.785 L/min;
1 psi = 0.0689 bar.

D.1.2.1 Carrying Capacity of Large-Diameter Hose. Large-diameter hose is superior to traditional standard fire hose in its ability to carry more water per section. Table D.1.2(a) shows, for example, that one 5-in (127-mm) hose line delivers a volume of water approximately equivalent to six 2½-in. (64-mm) lines or four 3-in. (76-mm) lines at any given pressure or distance.

To use Table D.1.2(a), find the desired hose diameter in the left-hand column and read horizontally to find the corresponding hose size equivalent. For example, the table shows that one length of 5-in. (127-mm) diameter hose has the carrying capacity of 6.2 lengths of 2½-in. (64-mm) hose, 3.83 lengths of 3-in. (76-mm) hose, 2.56 lengths of 3½-in. (89-mm) hose, and so on. In other words, it would require over six lengths of 2½-in. (64-mm) hose to equal the capacity of only one section of 5-in. (127-mm) hose.

Large-diameter hose also has less friction loss per flow rate than smaller diameter hose. Table D.1.2(b) shows the relative friction loss of 2½-in. (65-mm) to 6-in. (152-mm) diameter hose for the same flow rate (in gpm). The values in the table are based on the Hazen-Williams equation.

D.1.2.2 Selecting Large-Diameter Hose. The size and the amount of hose to be carried by the fire department should be selected to fit the needs of the area served and the financial resources of the department. Table D.1.2.2 can be used to assist in hose selection. For example, a 750-gpm (2839 L/min) water flow is needed on a fire that is located 6500 ft (1981 m) from the water supply. A pumper rated 750 gpm (2839 L/min) at 150 psi (1034 kPa) can relay 750 gpm (2839 L/min) at 20 psi (138 kPa) discharge for a distance of only 650 ft (1981 m) if 3½-in. (89-mm) hose is used or 8666 ft (2641 m) if 6-in. (152-mm) hose is used. Therefore, the department should consider using 6-in. (152-mm) hose to deliver its needed water requirements. The table is designed to apply primarily to situations in which a fire department is relaying water with pumps discharging at 150 psi (1034 kPa) and at 20 psi (138 kPa) residual pressure at the point receiving the flow.

Table D.1.2.2 Distance a Hose Can Deliver Water Discharged at 150 psi (1034 kPa) Pump Pressure

Internal Diameter of Hose (in.)	Distance (ft) — Quantity of Water (gpm)					
	250	500	750	1000	1500	2000
2½	866	236	—	—	—	—
3	2166	520	288	168		—
3½	6500	1300	650	361	158	—
4	—	2600	1181	684	325	185
5	—	6500	3250	2166	928	520
6	—	—	8666	5200	2166	1300

Note: For SI units, 1 in. = 25.4 mm; 1 gpm = 3.785 L/min; 1 ft = 0.305 m; 1 psi = 0.0689 bar.

D.1.3 Load Capacity. Another important advantage associated with large-diameter hose is hose load capacity. Most large-diameter hose is of a lightweight design. For example, a coupled 100-ft (30.5-m) length of 5-in. (127-mm) hose weighs approximately 105 lb (48 kg), a little heavier than a 100-ft (30.5-m) length of conventionally constructed 2½-in. (64-mm) hose, which can weigh approximately 100 lb (45 kg).

One engine company laying large-diameter hose instead of multiple smaller lines is much more efficient in its water-moving capacity. The use of large-diameter hose with one engine speeds up the operation, which would otherwise need multiple smaller lines with additional pumpers, personnel, and equipment to accomplish the same job. *[See Figure D.1.3(a) and Figure D.1.3(b).]* In Figure D.1.3(a), the apparatus

FIGURE D.1.3(a) Fire fighters reloading 5-in. (127-mm) hose.

FIGURE D.1.3(b) Large-diameter hose with a flat lay in the hose bed.

straddles the hose. Note that the hose is loaded over the bar between the stanchions.

D.1.4 Use of Large-Diameter Hose in Major Cities. Use of large-diameter hose is not limited to the rural fire service. Because of its increased water-carrying capacity and efficiency, 40 percent of the 200 largest cities in the United States now employ large-diameter hose, and it is one of the fastest growing items of technology in the fire service. It has demonstrated further utility as, literally, a portable pipeline used to bridge the gap in a water system when a main ruptures and is being repaired. It has further been used in some drought-stricken areas to bring water to the scene of a fire from a distant lake or stream, conserving municipal water supplies that would otherwise be used. Several communities have installed as much as 2 mi (3.2 km) of 5-in. (127-mm) hose for this purpose. While the large-diameter hose is being laid, the initial fire attack is made from hydrants. Where the large-diameter hose carrying the water from the lake is available at the fireground, the hydrants are shut down, and supplies in the municipal water system are conserved.

D.1.5 Powered Reel Trucks for Large-Diameter Hose. A number of trucks with powered hose reels with various hose load capacities are now in use. *(See Figure D.1.5.)*

FIGURE D.1.5 Apparatus with reels for large-diameter hose.

Much of the lightweight large-diameter hose now available is of a construction that permits field cleaning and does not require drying. The use of the reel truck permits rapid reloading using a minimum number of personnel (two), and the unit is capable of service within minutes.

Double reels mounted in the hose bed of a reel truck can produce a carrying capacity for large-diameter hose of up to 6000 ft (1829 m). The large-diameter hose then becomes equivalent to over 1 mi (1.6 km) of aboveground water main.

Such reel trucks generally require special power-driven systems to rewind the hose. The size of the reels is not conducive to fitting on most standard fire department pump bodies. Therefore, trucks specially designed for this operation are generally used as hose reel vehicles.

D.1.6 Fittings. Large-diameter hose is available from many fire hose manufacturers with either standard threaded couplings or quick-connect hermaphrodite-type fittings that eliminate the male-female feature of couplings and, consequently, many adapters.

Special fittings, as described in D.1.6.1 through D.1.6.7, have been developed to be used with large-diameter hose.

D.1.6.1 Clappered Siamese Connection. A clappered siamese connection added to the supply line one length from the hydrant or pumper at draft allows for the addition of a second pumper without shutting down the flow of water. *(See Figure D.1.6.1.)*

FIGURE D.1.6.1 Clappered siamese connection.

D.1.6.2 Line Relay Valve. If relay pumping is required, a line relay valve is inserted during the hose lay. This valve has a straight-through waterway, so water delivery can be started upon completion of the lay. The valve contains a gated outlet and a clappered inlet. Upon arrival of the relay pumper, a line is attached from the gated outlet to the suction of the pump, with a discharge line connected from the pump discharge into the clappered inlet. The pump pressure closes the clapper, and the full flow is relayed to the fireground or another relay pumper. In addition, this valve contains an automatic air bleeder and a pressure dump valve set at 150 psi (1034 kPa). It is important to note that the relay pumper can be added to or removed from the line without shutting down the flow of water to the fireground. *(See Figure D.1.6.2.)*

D.1.6.3 Hydrassist Valve. A hydrassist valve is a versatile valve that can be utilized on a hydrant where water is available but pressure is limited. The valve is attached to the hydrant and the normal lay of supply line is initiated. Where additional pressure is required, a pumper is attached to the valve and begins boosting pressure to the fire scene without interrupting the flow of water from hydrant to fire. In rural applications, this valve can be equipped to lie in a line during hose lay and to allow a pumper to hook into the line and boost pressure without interrupting flow to the fire scene. *(See Figure D.1.6.3.)*

D.1.6.4 Manifold Valve. A manifold valve contains a 4-in. or 5-in. (102-mm or 127-mm) inlet and four 2½-in. (64-mm), gated, threaded male or female outlets, as well as a gated 4-in. or 5-in. (102-mm or 127-mm) outlet. The manifold is available with a relief valve that is adjustable from 50 psi to 200 psi (345 kPa to 1379 kPa). A pressure gauge is optional. The manifold is portable, allowing the fire department to establish its own portable hydrant. *(See Figure D.1.6.4.)*

FIGURE D.1.6.2 Line relay valve.

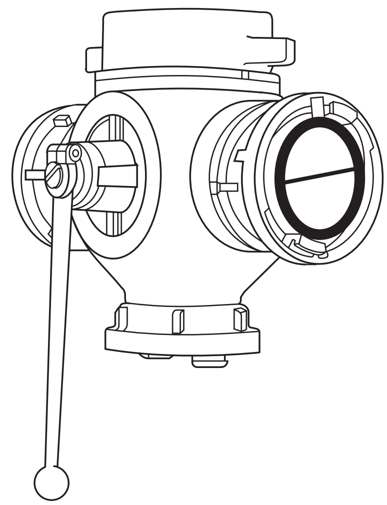


FIGURE D.1.6.3 Hydrassist valve.

D.1.6.5 Distributor Valve. A distributor valve contains a 4-in. (102-mm) opening and waterway with two 2½-in. (64-mm) threaded male outlets. It is placed at the end of the supply line at the fireground, allowing distribution of water to one or more attack pumpers. The valve utilizes ball shutoffs plus an adjustable dump valve. *(See Figure D.1.6.5.)*

D.1.6.6 Incoming Gated Relief Valve. An incoming gated relief valve is attached to the large suction inlet of the pumper. The supply line is connected directly to the valve. It is equipped with a fine-threaded, slow-acting gated valve, an automatic air bleeder, and an adjustable dump valve. The gated valve allows connection to the supply line while utilizing the booster tank water. It is also used to control the volume of water from the supply line to the pump. The dump valve helps protect the pumper and supply line against sudden pressure surges and water hammer. *(See Figure D.1.6.6.)*

D.1.6.7 Automatic Air Bleeder. An automatic air bleeder is needed at all points where a large-diameter hose is connected

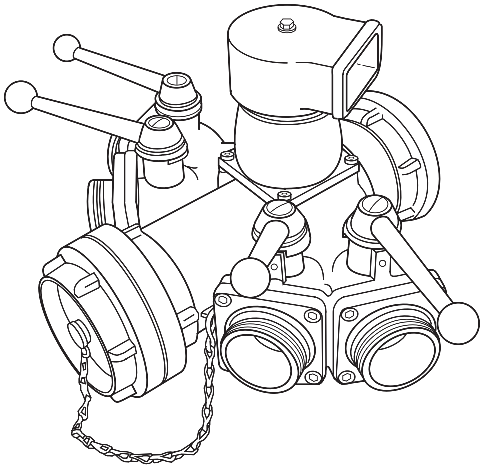


FIGURE D.1.6.4 Manifold valve.

FIGURE D.1.6.5 Distributor valve.

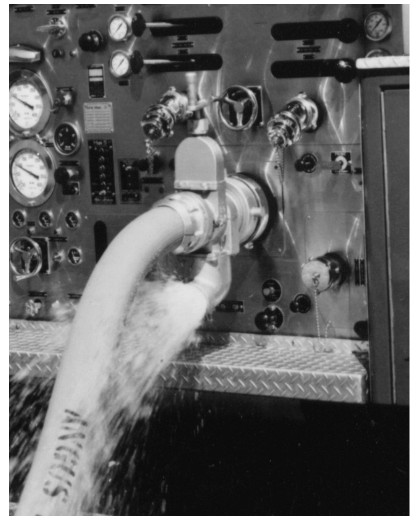


FIGURE D.1.6.6 Incoming gated relief valve.

FIGURE D.1.6.7 Automatic air bleeder.

to an engine inlet or at any distribution point. *(See Figure D.1.6.7.)*

D.1.7 Irrigation Piping. Irrigation piping shares the characteristics of low friction loss and capability of transferring large volumes of water with large-diameter hose. The use of irrigation is increasing throughout the country, which has resulted in much lightweight aluminum pipe becoming available to the fire service. It can be carried on vehicles or used where available on the fireground in farming areas. The fire department should be aware of the potential hazards to which an irrigation system might apply.

Irrigation pipe can be coupled, but usually the couplings are not of a type that permits drafting. The pipe has the advantage of being a relatively permanent installation for long-duration fire fighting and is not susceptible to the rupture problems of fire hose. Generally, it is an excellent tool for major disaster situations but is less often used for conventional fire-fighting evolutions, especially since the introduction of large-diameter fire hose.

Departments working in areas in which piped irrigation systems are used should be aware that adapters might be needed to turn conventional agricultural fittings into useful fireground fittings. Adapters used to change the pipe coupling to fire department threads can be easily fabricated in local machine shops. Such adapters are not offered by either pipe or fire hose manufacturers. At least one supply adapter should be available for use — for example, four 2½-in. (64-mm) NH (American National Fire Hose connection screw thread) female inlets per pipe section, and one discharge adapter or four 2½-in. (64-mm) NH gated male outlets per pipe section.

Additional fittings to provide discharge gates at 100-ft to 300-ft (30.5-m to 91.4-m) intervals [one or more 2½-in. (64-mm) NH per pipe section] might be desirable. In areas where large-diameter hose is available, adapters permitting its integration with the pipe are recommended.

Annex E Portable Pumps

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

E.1 General. Both diesel-driven and gasoline-driven portable pumps are available. The use of portable pumps is a common method for moving water by rural fire departments. All rural fire fighters should be able to place all portable pumps used by their department in operation, obtain draft, and perform each procedure in a minimal amount of time.

E.1.1 Description of a Portable Pump. A portable pump in the fire service means a pump that can be carried to a source by fire fighters, sometimes over difficult terrain. In general, two people should be able to conveniently carry the pump. It should weigh no more than 175 lb (79 kg) and be capable of supplying at least two 1½-in. (38-mm) handlines. It should also have handles and should be constructed to be carried in a compartment in the apparatus. Heavier pumps, perhaps trailer- or truck-mounted or otherwise made mobile, are valuable but used less commonly.

Although a number of rural fire departments have used portable-type pumps that are securely mounted on their apparatus as the sole means of pumping, few fire departments consider this arrangement to be permanent and most such departments plan to buy a fire department pumper, in addition to the portable pump(s), when finances permit.

E.1.2 Evaluating Portable Pump Needs. In order to get the maximum benefit from portable pumps, the officers of the rural fire department should carefully study the needs of the department, taking into consideration the potential fire hazard, the available water supplies, and the capabilities of the department to use portable pumps. The accessibility and the reliability of water supplies determine the need for and use of portable pumps. Many rural fire departments have found that both a low-pressure pump and a high-pressure pump are required to fill their needs.

The portable pump selected should fit the fire-fighting system of which it is to be a component; if direct hose streams are to be taken from a portable pump, the nozzles and hose size determine the required pump discharge versus pressure characteristics.

E.1.3 Classifications or Types of Portable Pumps. Portable pumps are rated as follows.

E.1.3.1 Small Volume — Relatively High Pressure. A small-volume pumping unit should be capable of pumping 20 gpm (76 L/min) at 200 psi (1380 kPa) net pressure through a 1-in. (25-mm) discharge outlet while taking suction through a 1½-in. (38-mm) suction inlet. This class of portable pump is especially useful to fire departments for forest fire fighting, which frequently requires long ¾-in. to 1½-in. (19-mm to 38-mm) hose lines and uphill pumping in rugged terrain. Such an arrangement will provide the necessary nozzle reach.

E.1.3.2 Medium Volume — Medium Pressure. A medium-volume pumping unit should be capable of discharging 60 gpm (227 L/min) at 90 psi (621 kPa) net pressure and 125 gpm (473 L/min) at 60 psi (414 kPa) net pressure through a 1½-in. (38-mm) discharge outlet while taking suction through a 2½-in. (64-mm) suction inlet. This class of portable pump has limited utility for small structural fires and can supply a 60-gpm (227-L/min) fog nozzle through 250 ft (76 m) of 1¾-in. (44-mm) hose. It can be used to fill booster tanks or be used with 2½-in. (64-mm) hose to move water a long distance.

E.1.3.3 Large Volume — Relatively Low Pressure. A large-volume pumping unit should be capable of supplying 125 gpm (473 L/min) at 60 psi (414 kPa) net pressure and 300 gpm (1136 L/min) at 20 psi (138 kPa) net pressure through a 2½-in. (64-mm) discharge outlet while taking suction through a 3-in. or 4-in. (76-mm or 102-mm) suction inlet. This class of portable pump is frequently used for tank filling where a pumper cannot get close to a source of water. It is also suitable for draining cellars, manholes, and other areas where water has accumulated. It can be used to supply two 1½-in. or 1¾-in. (38-mm or 44-mm) hose lines of short length with 60-gpm (227-L/min) fog nozzles. This arrangement can result in fire streams of reduced quality and quantity that might not be suitable flows for interior fire fighting.

E.1.4 Common Types of Pumps. The following are among the common types of pumps used.

E.1.4.1 Gear Pumps. Gear pumps (high pressure, low volume) are of the positive displacement type, with gears having very close tolerances between the gears and case. They can only be used safely in clear water. Dirty water will cause damage to the gears and case. Gear pumps are not very useful for tank filling or relay work, as they are generally of low capacity in the lighter models.

Gear pumps are very good for fire fighting where high pressures are desired. These pumps have a shorter life span than the centrifugal type and are easily packed on the back. They should never be operated without water and should be equipped with a relief valve.

E.1.4.2 Piston Pumps. Piston pumps (high pressure, low volume) are operated by a piston, sleeve, or cylinder with two check valves. These pumps can be either single- or double-action with one or more cylinders. They are of the positive displacement type and should be operated with clean water.

Piston-type pumps are limited to discharging small capacities of water and weigh more than centrifugal or gear pumps. They are capable of very high lift and should be equipped with a relief valve.

E.1.4.3 Low-Pressure Centrifugal Portable Pumps. Low-pressure centrifugal portable pumps (high volume) generally are rated at 200 gpm to 300 gpm (757 L/min to 1136 L/min) and are capable of discharge at pressures of 50 psi to 80 psi (345 kPa to 552 kPa). Usually these pumps will not discharge rated capacities when operating with suction lift in excess of 5 ft (1.5 m).

Some low-pressure centrifugal portable pumps do not use running rings or seal rings. These types of pumps do not have close tolerances, so they can be used in dirty water where some debris or abrasives are encountered. These pumps require little maintenance.

Other types of portable pumps in this category do have water or seal rings, which will not last as long as they normally would if pumping water containing substantial amounts of abrasive materials.

At lower discharge pressures, this type of pump can deliver larger volumes, which at times have been metered at 400 gpm to 600 gpm (1514 L/min to 2272 L/min), with adequate-size hard suction hose at very low discharge pressures and high pump rpm (for example, relay from portable pump into fire pump on apparatus or portable drop tank; or relay from water source to drop tank where mobile water supply is filled for relay to fire site).

Operation of these pumps depends on centrifugal force to move water, and they are very effective for relay operations to pumper or for booster tank or mobile water supply filling. There are no special operating problems to watch out for, and these types of pumps will not heat up as rapidly as others if run without water.

E.1.4.4 High-Pressure Centrifugal Portable Pumps. High-pressure centrifugal portable pumps (small volume) generally have a small capacity, with an average of 30 gpm to 40 gpm (114 L/min to 151 L/min) discharge and operating pressures in the 125-psi to 250-psi (862-kPa to 1724-kPa) range.

The impeller is usually geared twice as fast as the engine to achieve single-stage pressure. This type of pump uses running rings or seal rings that are the same as those used for larger fire pumpers and usually incorporates closed volutes in the impeller.

E.1.4.5 Floating Pumps. Pressure- and volume-floating pumps are available. A more recent development in portable pumps is the floating pump that primes and pumps automatically where placed in water. This type of pump is constructed to be set inside a float that resists breakage and needs no maintenance. Some entire units weigh under 50 lb (23 kg), including fuel, and provide 60 minutes to 90 minutes of operating time from the 5-qt (4.73-L) fuel tank.

The pump serves a need for a lightweight, easy-to-operate, portable fire pump that can be placed in the water and does not need suction hose or strainers. However, such pumps tend to pick up leaves and other trash that can block the nozzles and strainers of a pump supplied by the floating pump. *(See Figure E.1.4.5.)*

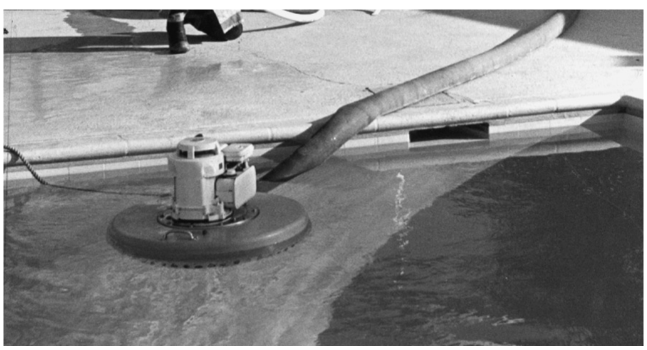


FIGURE E.1.4.5 Floating 500-gpm (1893-L/min) pump in swimming pool supplying the department pumper through large-diameter hose.

E.1.4.6 High-Lift Pumps. High-lift pumps are small, portable pumps that use water to drive a water motor, which in turn drives an impeller and pumps water to high elevations and into a fire pumper for relay into hose lines for fire fighting.

The high-lift pump is designed to obtain a water supply from a river, lake, stream, swimming pool, and so forth, where not accessible by a pumper or a conventional portable pump for drafting operations.

The water used to power the water motor of a high-lift pump is taken from the booster tank of the pumper and discharged at high pressure through the fire pump into the hose to the high-lift pump water motor. Pressurized water, in turn, drives the water motor, which is connected to the high-lift pump impeller, thus forcing volumes of water back into the intake side of the fire pump and on into the fire-fighting hoselines.

High-lift pumps can be hooked into hose lines and lowered or tossed into water sources at lower levels without fire-fighting personnel having to go down to such sources to set the pump.

E.1.4.7 Dewatering-Type Pumps. Dewatering pumps, also known as "trash pumps," are pumps specifically designed to handle muddy, sandy, or otherwise contaminated water. Some are built to handle spherical solids up to 1½ in. (38 mm) in diameter. These pumps could be used in the fire service to pump water out of basements, tubs, or catchalls during salvage operations.

E.1.4.8 Diaphragm Pump. The diaphragm pump uses a piston-type action employing a diaphragm that moves water with each stroke and is capable of handling trash-laden water without damaging the pump.

E.1.5 Methods of Using Portable Pumps.

E.1.5.1 General. Some of the many problems of supplying water in rural areas can frequently be overcome through the use of the proper portable pump. Many departments, through area prefire planning, locate water sources where portable pumps are the only suitable means of using the water supply for filling mobile water supply apparatus or for supplying fire-fighting hoselines.

Departments should, when locating a pumping site for portable pumps, determine whether the site is available year-round or whether it can be used only during certain times of the year. Further determination should be made as to the site's availability under the weather conditions anticipated. If such conditions could make use of the site difficult, a plan to prepare the site for all-weather utilization should be established.

Centrifugal pumps are usually preferred over other types because of their ability to handle dirt and abrasives with less damage and because of their desirable volume–pressure ratio. Similarly, four-cycle engines are considered more suitable for fire service use, although two-cycle or the new turbine-driven pumps can be used. However, four-cycle engines should be used with the engine in a level position or the engine will be damaged, whereas two-cycle engines can be used with the engine in any position (as long as fuel is available to the engine) without damage to the engine.

A wood pallet or other firm base can be useful under soft ground conditions.

E.1.5.2 Uses of Pumps. Portable pumps can be used in single or multiple combinations to accomplish the following:

(1) Filling truck tanks where no fire pumper is available
(2) Supplying fire-fighting hoselines
(3) Relaying water from a source in a variety of combinations or hookups
(4) Dewatering operations
(5) Pump-and-roll operations

There are many factors to consider in deciding which size and type of portable pump will best fill a fire department's needs.

Consideration should be given to the capabilities of the pump and its uses.

E.1.5.3 Relay to Mobile Water Supply Fleet. Under conditions where a fire department pumper cannot get to a source of water and there is considerable distance between the source and the fire (several miles), low-pressure portable pumps of larger volume have proved to be very satisfactory where used to relay water to a mobile water supply fleet that shuttles water to a portable drop tank at the fire. A fire department pumper takes suction from the portable drop tank for discharge onto a fire. *(See C.1.13.)*

E.1.5.4 Pumping Directly onto the Fire. The portable pump can be used to pump water directly into hoselines and onto a fire. It can be carried to nearby sources of water — for example, a swimming pool — that are out of reach of regular fire apparatus. Where these water sources are close to the fire, only small lengths of hose are needed, and they can be quickly carried into position for rapid attack on the fire.

An effective portable pump for use with a water source close to the fire would be at least a medium-volume type with enough discharge pressure to provide an effective fire-fighting stream.

An example of this type of operation is shown in Figure E.1.5.4.

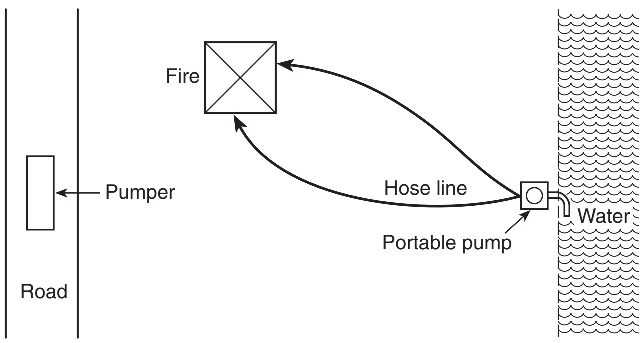


FIGURE E.1.5.4 Pumping directly onto the fire.

E.1.5.5 Single Relay from Portable Pump to Pumpers. Under conditions where a standard fire truck cannot get to a source of water, low-pressure portable pumps of larger volume have proved to be very satisfactory where used to relay water to pumpers. This method becomes feasible at a greater distance from water if large-diameter hose is used. *(See Figure E.1.5.5.)*

A single portable pump often can supply enough water to keep a pumper supplied with effective fire streams. The portable pump can be at the water source and a line laid from the portable pump to the pumper.

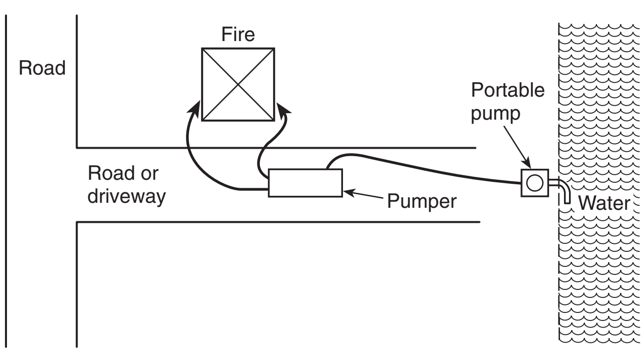


FIGURE E.1.5.5 Single relay from portable pump to pumper.

One of the big advantages of the portable pump is that it can be placed close to the water supply for operation at minimum lift and minimum friction loss in the suction hose, provided adequate-size suction hose is used. Regular pumpers can accept water from portable pumps and increase water pressure for fire streams or use the water in a combination of fire streams and booster tank filling.

A method commonly used is for a pumper to lay hose lines from the fire to the water supply and start pumping from the booster tank into the hose line and onto the fire while the portable pump is being placed and water supply and hose lines from the portable to the regular pumper are being hooked up. *(See Figure E.1.5.5.)*

E.1.5.6 Use of Portable Pumps to Fill Mobile Water Supply Apparatus or Booster Tanks. Many rural fire departments are overcoming problems of limited water supply by using mobile water supply apparatus to relay water to pumpers working at a fire. If the water supply is a stream with a small flow, for instance, 150 gpm (568 L/min), or if the water supply is inaccessible by fire apparatus, the water can be obtained with a portable pump placed at the water supply. This pump supplies a portable folding tank that is used to stockpile water, and mobile water supply apparatus are filled from the portable folding tank for shuttle to the fire. At the fire, the mobile water supply discharges its water into another portable folding tank that is used to stockpile water from which the pumper(s) takes suction and discharges water onto the fire. *(See C.1.13 and Figure E.1.5.6.)*

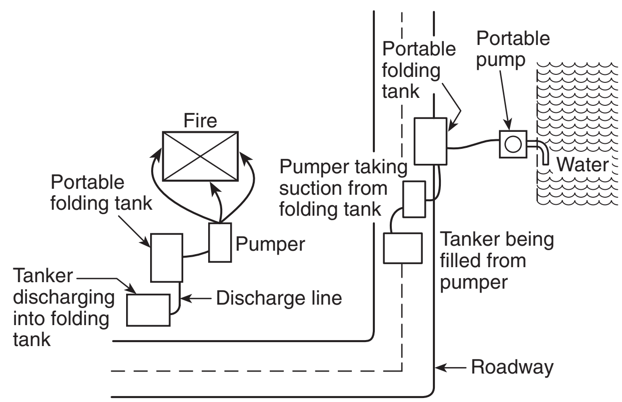


FIGURE E.1.5.6 Portable pump filling portable folding tank.

It is not prudent to put the discharge line from portable pumps into the tops of booster tanks or mobile water supply apparatus unless there is no other way to fill the tank or a special filling device is provided. Placing lines into the tops of mobile water supply apparatus or booster tanks is a slow way of filling the tank and can be dangerous to those working on apparatus. Hooking the portable pump discharge line directly into intake piping of large pumpers or mobile water supply apparatus has proved to be the quickest and safest method of filling tanks.

Any of the portable pumps can be used in place of a pumper for filling mobile water supply apparatus; however, the low-pressure, high-volume-type pumps do the job more quickly than others. Where pumping into tanks, strainers should be used to prevent the passage of trash and debris. Floating strainers have proved to be very effective.

Where the water supply has the capacity, multiple portable pumps for filling mobile water supply apparatus can increase filling efficiency. A 200-gpm to 300-gpm (757-L/min to 1136-L/min) rate results in a slow filling time; therefore, two or three portable pumps should be moved into the operation as mutual-aid mobile water supply apparatus arrive to achieve a 500-gpm (1893-L/min) filling rate. Multiple portable pumps also act as a backup in case of engine failure.

E.1.5.7 Fire Fighting from a Mobile Water Supply While in Motion. Some departments have installed pipes or hard suction lines from their mobile water supply apparatus to portable pumps on the apparatus so they can pump from the tank into discharge lines while the mobile water supply is in motion. The portable pump can be quickly disconnected and taken off the mobile water supply for use in other locations. Fighting fire while in motion is particularly effective for grain, grass, and brush fires, as it provides uniform pressures regardless of the gear the vehicle requires to negotiate the terrain. Because rigging a hard suction line from a pump to the vehicle carrying that pump is frequently awkward, it can be essential to carry a specially prepared length of hard suction hose for this purpose or to otherwise prepare the vehicle or the pump in order to make the evolution rapid and practical.

Annex F Automatic Sprinkler Protection

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

F.1 Sprinkler Protection of Rural Buildings. Farsighted rural fire departments are big boosters of automatic sprinkler protection. With more sprinklered buildings being constructed in rural areas, many rural fire departments are just beginning to understand the friend the fire service has in automatic sprinkler protection. The sprinkler system provides the fire department with built-in hoseline protection. The sprinkler heads and piping are in place and ready to put water (other extinguishing agents can be used) on any fire. Also, the record of the automatic sprinkler system is superior. NFPA records show that 96 percent of all fires in sprinklered buildings are controlled or extinguished by the sprinkler system, with a large percentage of these fires controlled by no more than two or three sprinkler heads. In the 3 percent to 4 percent of automatic sprinkler systems reported to have unsatisfactory performance, the following human failures have been noted:

(1) Sprinkler system was shut off and not in service
(2) Fire department shut off water to sprinkler heads before fire was completely extinguished
(3) Fire department robbed sprinkler system of water supply
(4) Fire department did not use fire department connection
(5) Sprinkler system was not designed to protect existing contents or occupants

F.2 Water Supply for Automatic Sprinkler System. Sprinklered buildings are usually provided with a water supply such as an elevated tank, ground-level suction tank, or pond equipped with a fire pump. In a number of cases, a distribution system with hydrants is also provided.

Ground-level tanks, as well as elevated tanks, can be used by the fire department to supply water-hauling operations. Adequate provisions should be made by the fire department so as not to deplete the tank supply without also making provisions for refilling the tank at the conclusion of water-hauling operations.

When building and sprinkler plans are being reviewed, the fire department has an excellent opportunity to contact the property owner for permission to use the water supply in the elevated tank for water-hauling operations. In case a certain quantity of water needs to be reserved for the sprinkler system, a riser serving a hydrant available to the fire department should be installed. The riser should extend into the tank and allow the fire department to use the water above the water reserved for the sprinkler system.

In some municipalities (as well as some states), certain types of occupancies are required by law to install sprinkler systems. In a number of cases, very limited water supplies, such as pressure tanks, have been provided as the sole water supply for these systems. Such properties should not be considered as a water source for a water-hauling operation by a rural fire department.

F.3 Supervision for Sprinkler System.

F.3.1 In rural areas where sprinklered properties are isolated and a good possibility exists that the outside sprinkler alarm will not be heard in case of fire, the automatic sprinkler systems should be fully supervised by either a competent guard on the premises or by an alarm system with all signals transmitted directly to a central station or a fire alarm center.

F.3.1.1 Where guard service is provided, it should meet the requirements of NFPA 601, *Standard for Security Services in Fire Loss Prevention*.

F.3.1.2 The alarm system should include supervision of the following:

(1) Sprinkler water flow
(2) Sprinkler control valve tamper
(3) Building temperature
(4) Low air pressure on dry sprinkler systems
(5) Fire pump operation
(6) Fire pump electric power
(7) Fire pump battery charger
(8) Temperature of water in tanks
(9) Level of water in tanks where any of these systems exist

F.3.1.3 The central station should meet the requirements of *NFPA 72®, National Fire Alarm Code®*.

F.3.1.4 Fire alarm centers should meet the requirements of NFPA 1221, *Standard for the Installation, Maintenance, and Use of Emergency Services Communications Systems*, and *NFPA 72, National Fire Alarm Code*.

F.3.1.5 In some situations, guard service or fire alarm centers referred to in F.3.1.1 and F.3.1.4 are not provided due to unavailability, economic considerations, or both. It is, however, very important that sprinkler alarms be supervised and signals be transmitted rapidly to the fire department. In some rural areas where public telephone lines are the primary means of alarm transmittal, some sprinkler systems are “supervised” by using combinations of waterflow indicators, microswitches, and the like, with direct telephone lines or automatic phone dialers. Typically, the signal or prerecorded alarm message is sent to a “fire phone” location, police dispatch, or similar location where alarms are handled. In no case should automatic phone dialers be allowed on the circuit used by the public to report emergency messages (fire, police, or ambulance), as