1231

NFPA 1231
Standard on Water Supplies for Suburban and Rural Fire Fighting
1993 Edition

NFPA

National Fire Protection Association, 1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101
An International Codes and Standards Organization

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Policy Adopted by NFPA Board of Directors on December 3, 1982

The Board of Directors reaffirms that the National Fire Protection Association recognizes that the toxicity of the products of combustion is an important factor in the loss of life from fire. NFPA has dealt with that subject in its technical committee documents for many years.

There is a concern that the growing use of synthetic materials may produce more or additional toxic products of combustion in a fire environment. The Board has, therefore, asked all NFPA technical committees to review the documents for which they are responsible to be sure that the documents respond to this current concern. To assist the committees in meeting this request, the Board has appointed an advisory committee to provide specific guidance to the technical committees on questions relating to assessing the hazards of the products of combustion.

Statement on NFPA Procedures

This material has been developed under the published procedures of the National Fire Protection Association, which are designed to assure the appointment of technically competent Committees having balanced representation. While these procedures assure the highest degree of care, neither the National Fire Protection Association, its members, nor those participating in its activities accept any liability resulting from compliance or noncompliance with the provisions given herein, for any restrictions imposed on materials or processes, or for the completeness of the text.

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NFPA 1231

Standard on

Water Supplies for Suburban and Rural Fire Fighting

1993 Edition

This edition of NFPA 1231, *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 the National Fire Protection Association, Inc. at its Annual Meeting held May 24-27, 1993, in Orlando, FL. It was issued by the Standards Council on July 23, 1993, with an effective date of August 20, 1993, and supersedes all previous editions.

The 1993 edition of this document has been approved by the American National Standards Institute.

Origin and Development of NFPA 1231

This text originally was NFPA 25, *Recommended Practices for Water Supply Systems for Rural Fire Protection*, and originally was 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. This edition underwent a title change to *Water Supplies for Suburban and Rural Fire Fighting* and was renumbered NFPA 1231.

The 1984 edition represented a complete revision to include both mandatory and advisory material.

The 1989 edition was the fourth revision and incorporated some significant changes and additions.

The 1993 edition represents a complete revision that includes both mandatory and advisory material.

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

Committee Scope: This Committee shall have primary responsibility for developing documents on fire protection and prevention for rural and suburban areas and forest, grass, brush, and tundra areas.

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

Information on referenced publications can be found in Chapter 8 and Appendix H.

Chapter 1 Administration

1-1* Scope. This standard identifies minimum requirements for water supplies for fire fighting purposes in rural and suburban areas in which adequate and reliable water supply systems for fire fighting purposes do not exist.

1-2 Purpose. This standard specifies minimum requirements for water supply for fire fighting purposes to protect property from fire in areas where water must be transported from a river, lake, canal, bay, stream, pond, well, cistern, or other similar source of water that is available as suction supply for fire department use. Water obtained by methods outlined in this standard can be used to supplement water for fire fighting available from hydrants on a traditional municipal-type distribution system. Likewise, a hydrant served by a water distribution system shall be permitted to be the source of supply for water that is transported to the rural fire area.

It is the intent of this standard to provide and maintain minimum water supplies for fire fighting purposes through the establishment of a cooperative working arrangement among the authority having jurisdiction, the fire department having jurisdiction, and the property owners in the jurisdiction.

This standard provides minimum requirements, and nothing herein shall be interpreted to mean that the authority having jurisdiction cannot exceed any or all of these requirements where, in the judgment of such authority having jurisdiction, additional protection is warranted.

This standard is restricted to identifying minimum requirements for water supplies for fire fighting purposes. Much information has been included in the appendixes of this standard concerning rural water supplies, hauling of water, transporting water through large diameter hose, portable pumping equipment, automatic sprinkler protection, and secondary water supply, any or all of which may comprise a rural "water system."

1-3 General.

1-3.1 The requirements of Chapters 5 and 6 are performance oriented and allow the authority having jurisdiction the option to specify how these water supplies are made available, thereby giving consideration to local conditions and need.

1-3.2 Although the water requirements developed by this standard are performance oriented, it must be emphasized that they are minimum in scope. The water available to the fire department, which may come from a single water point or multiple water points, must be delivered to the fire scene. The authority having jurisdiction shall be permitted to determine that additional water supplies are warranted. Appendix G contains secondary water supply requirements, useful where the authority having jurisdiction determines additional water supplies are desirable.

1-3.3 Fire apparatus and associated equipment are important components of the water transport process. Many alternative approaches to fulfilling this process are provided in Appendixes C, D, and E.

Apparatus shall meet the requirements outlined in NFPA 1903, *Standard for Mobile Water Supply Fire Apparatus*, and other applicable NFPA standards.

1-3.4 Fire control and extinguishment is probable only where a prompt alarm notification initiates an immediate response, which in return results in effective agent application confining the fire to the area of origin.

1-3.5 The effectiveness and reliability of fixed fire protection systems is a documented fact. Serious consideration shall be given to installation of sprinkler systems as outlined in 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 Mobile Homes*; and NFPA 13R, *Standard for the Installation of Sprinkler Systems in Residential Occupancies Up to and Including Four Stories in Height*.

1-4 Definitions.

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.

Approved. Acceptable to the "authority having jurisdiction."

NOTE: 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 or 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 concerned with product evaluations which is in a position to determine compliance with appropriate standards for the current production of listed items.

Authority Having Jurisdiction. The "authority having jurisdiction" is the organization, office or individual responsible for "approving" equipment, an installation or a procedure.

NOTE: 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, 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 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."

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

Building. Any structure erected for the support, shelter, or enclosure of persons, animals, or property of any kind.

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 for this standard only.

Dry Hydrant. A permanent piping system, normally a drafting source, that provides access to a water source other than a municipal-type water system.

Exposure Hazard. A structure within 50 ft (15.2 m) of another building and 100 ft^2 (9.3 m^2) or larger in area. If a structure is a Class 3 or Class 4 occupancy hazard, it is considered an exposure hazard if within 50 ft (15.2 m) of another building, regardless of size.

Fire Department Having Jurisdiction. The fire department serving the municipality, or any portion of the municipality, governed by the authority having jurisdiction. The authority having jurisdiction and the fire department having jurisdiction can be the same agency.

Labeled. Equipment or materials to which has been attached a label, symbol or other identifying mark of an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

Large Diameter Hose. Fire department hose having an inside diameter of 3½ in. (89 mm) or larger.

Listed. Equipment or materials included in a list published by an organization acceptable to the "authority having jurisdiction" and concerned with product evaluation, that maintains periodic inspection of production of listed equipment or materials and whose listing states either that the equipment or material meets appropriate standards or has been tested and found suitable for use in a specified manner.

NOTE: The means for identifying listed equipment may vary for each organization concerned with product evaluation, some of which do not recognize equipment as listed unless it is also labeled. The "authority having jurisdiction" should utilize the system employed by the listing organization to identify a listed product.

Minimum Requirements for Water Supply. The smallest quantity of water supply suggested for any degree of fire control. In some fires, this supply may be suitable for protecting exposures only.

Mobile Water Supply. A vehicle designed primarily for transporting (pickup, transportation, and delivery) of water to fire emergency scenes to be applied by other vehicles or pumping equipment.

Municipality. A town, city, county, fire district, or community having powers of local self-government.

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) and 20 psi (139 kPa) residual pressure for a 2-hour duration.

Mutual Aid. A plan developed between two or more departments to render assistance to the parties of the agreement. Often the request for such aid to be rendered comes only after an initial response has been made and the fire scene status has been determined.

Normal Living Area — Dwelling. This area shall include typical rooms, such as living room, dining area, parlor, kitchen, bath, bedroom, halls, library, music room, family room, laundry room, etc., and includes any other areas that are normally heated or cooled plus attic-basement provisions, enclosed parking (garage), and storage areas.

Occupancy Hazard Classification Number. A series of numbers from three through seven that are mathematical factors used in a formula to determine total water supply requirements of this standard only.

Protected Property. Property protected by a water supply that is minimally adequate in volume and duration and by a fire department capable of using this water supply to suppress a possible fire within the property.

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

Shall. Indicates a mandatory requirement.

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

Single Water Point. The point or site at which water supply, such as a pumper with portable folding tank or dry hydrant, etc., can be located to protect a cluster of buildings, such as a subdivision or an estate.

Tanker. See "Mobile Water Supply."

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

Water Tender. See "Mobile Water Supply."

Chapter 2 Structure Surveys

2-1 General.

2-1.1* The fire department having jurisdiction shall perform an on-site survey of all buildings, including type of construction, occupancies, and exposures, within the applicable jurisdiction to obtain the information needed to compute the minimum water supplies required. At the time of the on-site survey, a record shall be prepared of available water supplies. This information shall be utilized for prefire planning purposes as well as by the WSO.

2-1.2 Areas specified in 5-2.1, 5-3.1, 5-4.1, 5-5.1, and 5-6.1 can be surveyed as areas to determine the square footage or cubic footage and square meters or cubic meters of each structure and the distance to structural exposure hazards, but without a survey of contents.

2-1.3 These surveys can be combined with fire prevention or prefire planning inspections.

Chapter 3 Classification of Occupancy Hazard

3-1 General.

3-1.1 The fire department having jurisdiction, upon completing the survey specified in Chapter 2, shall determine the occupancy hazard classification number from the appropriate sections of this chapter.

3-1.2 Occupancy hazard classification numbers shall not be assigned to any structure not surveyed as specified in Chapter 2.

3-1.3 An occupancy hazard classification number shall not be assigned to any building where such building is protected by an automatic sprinkler system installed in accordance with applicable NFPA standards.

3-1.4* Storage of products that are potentially hazardous from the standpoint of increased fire volume, or those having an explosive nature, exists at many rural locations, and such products can exist in sufficient quantities to increase the occupancy hazard classification number of the building.

3-2* Occupancy Hazard Classification Number.

3-2.1 The occupancies listed in each section are only examples of types of occupancies for the particular classification, and these lists of examples shall not be interpreted as being exclusive. Similar occupancies shall be assigned the same occupancy hazard classification number.

3-2.2 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.

3-2.3 Occupancy Hazard Classification 3.

3-2.3.1 Occupancies in this classification shall be considered SEVERE HAZARD OCCUPANCIES, where quantity and combustibility of contents are very high. Fires in these occupancies can be expected to develop very rapidly and have high rates of heat release. (*See 5-5.1.*)

3-2.3.2 Where an exposing structure is of occupancy hazard classification 3, it shall be considered an exposure hazard if within 50 ft (15.2 m), regardless of size.

3-2.3.3 Occupancy hazard classification 3 examples include:

(a) Aircraft hangars

(b) Cereal or flour mills

(c) Chemical works and plants

(d) Cotton picker and opening operations

(e) Distilleries

(f) Explosives and pyrotechnics manufacturing and storage

(g) Feed and grist mills

(h) Grain elevators and warehouses

(i) Linseed oil mills

(j) Lumberyards

(k) Oil Refineries

(l) Plastics manufacturing and storage

(m) Saw mills

(n) Solvent extracting

(o) Straw or hay in bales

(p) Varnish and paint manufacturing.

3-2.4 Occupancy Hazard Classification 4.

3-2.4.1 Occupancies in this classification shall be considered HIGH HAZARD OCCUPANCIES, where quantity and combustibility of contents are high. Fires in these occupancies can be expected to develop rapidly and have high rates of heat release.

3-2.4.2 Where an exposing structure is of occupancy hazard classification 4, it shall be considered an exposure hazard if within 50 ft (15.2 m), regardless of size.

3-2.4.3 Occupancy hazard classification 4 examples include:

(a) Barns and stables (commercial)

(b) Building materials

(c) Department stores

(d) Exhibition halls, auditoriums, and theaters

(e) Feed stores (without processing)

(f) Freight terminals

(g) Mercantiles

(h) Paper and pulp mills

(i) Paper processing plants

(j) Piers and wharves

(k) Repair garages

(l) Rubber products manufacturing and storage

(m) Warehouses, such as those used for:

Furniture
General storage
Paint
Paper
Whiskey

(n) Woodworking industries.

3-2.5 Occupancy Hazard Classification 5.

3-2.5.1 Occupancies in this classification shall be considered MODERATE HAZARD OCCUPANCIES, where quantity and combustibility of contents are moderate and stockpiles of combustibles do not exceed 12 ft (3.7 m) in height. Fires in these occupancies can be expected to develop quickly and have moderately high rates of heat release.

3-2.5.2 Occupancy hazard classification 5 examples include:

(a) Amusement occupancies

(b) Clothing manufacturing plants

(c) Cold storage warehouses

(d) Confectionery product warehouses

(e) Farm storage buildings, such as:

Corn cribs
Dairy barns
Equipment sheds

(f) Hatcheries

(g) Laundries

(h) Leather goods manufacturing plants

(i) Libraries (with large stockroom areas)

(j) Lithography shops

(k) Machine shops

(l) Metalworking shops

(m) Nurseries (plant)

(n) Pharmaceutical manufacturing plants

(o) Printing and publishing plants

(p) Restaurants

(q) Rope and twine manufacturing plants

(r) Sugar refineries

(s) Tanneries

(t) Textile manufacturing plants

(u) Tobacco barns

(v) Unoccupied buildings.

3-2.6 Occupancy Hazard Classification 6.

3-2.6.1 Occupancies in this classification shall be considered LOW HAZARD OCCUPANCIES, where quantity and combustibility of contents are moderate and stockpiles of combustibles do not exceed 8 ft (2.4 m) in height. Fires in these occupancies can be expected to develop at a moderate rate and have moderate rates of heat release.

3-2.6.2 Occupancy hazard classification 6 examples include:

(a) Armories

(b) Automobile parking garages

(c) Bakeries

(d) Barber or beauty shops

(e) Beverage manufacturing plants

(f) Boiler houses

(g) Breweries

(h) Brick, tile, and clay product manufacturing plants

(i) Canneries

(j) Cement plants

(k) Churches and similar religious structures

(l) Dairy products manufacturing and processing

(m) Doctors' offices

(n) Electronics plants

(o) Foundries

(p) Fur processing plants

(q) Gasoline service stations

(r) Glass and glass products manufacturing plants

(s) Mortuaries

(t) Municipal buildings

(u) Post offices

(v) Slaughterhouses

(w) Telephone exchanges

(x) Watch and jewelry manufacturing plants

(y) Wineries.

3-2.7 Occupancy Hazard Classification 7.

3-2.7.1 Occupancies in this classification shall be considered LIGHT HAZARD OCCUPANCIES, where quantity and combustibility of contents are low. Fires in these occupancies can be expected to develop at a relatively low rate and have relatively low rates of heat release.

3-2.7.2 Occupancy hazard classification 7 examples include:

(a) Apartments

(b) Colleges and universities

(c) Dormitories

(d) Dwellings

(e) Fire stations

(f) Fraternity or sorority houses

(g) Hospitals

(h) Hotels and motels

(i) Libraries (except large stockroom areas)

(j) Museums

(k) Nursing and convalescent homes

(l) Offices (including data processing)

(m) Police stations

(n) Prisons

(o) Schools.

Chapter 4 Classification of Construction

4-1 General.

4-1.1 The fire department having jurisdiction, upon completing the survey specified in Chapter 2, shall determine the construction classification number from the sections of this chapter.

4-1.2 For the purpose of this standard, each building surveyed shall be classified as to type of construction and shall be assigned a construction classification number. However, no dwelling shall be assigned a construction classification number higher than 1.0.

4-1.3 Construction classification numbers shall not be assigned to any structure not surveyed, as specified in Chapter 2.

4-1.4 Where more than one type of construction is present in a structure, the higher construction classification number shall be used for the entire structure.

4-1.5 Where a building is located within 50 ft (15.2 m) of the surveyed building and is 100 ft^2 (9.3 m^2) or greater in total area, the building shall be treated as an exposure, with the water requirement as calculated in accordance with this standard multiplied by 1.5.

4-2* Construction Classification Type.

4-2.1 The construction classifications listed in this standard have been simplified for quick use. Where a more complete definition is needed, refer to NFPA 220, *Standard on Types of Building Construction*, or the local building code.

4-2.2 Type I (Fire-Resistive) Construction — Construction Classification Number 0.5. A building constructed of noncombustible materials (reinforced concrete, brick, stone, etc., and having any metal members properly "fireproofed") with major structural members designed to withstand collapse and to prevent the spread of fire.

4-2.3 Types II and IV (Noncombustible) and Heavy Timber Construction — Construction Classification Number 0.8. A building having all structural members (including walls, floors, and roofs) of noncombustible materials and not qualifying as fire-resistive construction.

Also, heavy timber construction in which walls are masonry, columns are 8-in. (20.3-cm) wood supports, floors are 3-in. (76-mm) tongue-and-grooved plank, and roof decks are 2-in. (51-mm) tongue-and-grooved plank. All wood beams and girders are 6 in. (15.2 cm) wide and 10 in. (25.4 cm) deep.

4-2.4* Type III (Ordinary) Construction — Construction Classification Number 1.0. Any structure having exterior walls of masonry, or other noncombustible material, in which the other structural members are wholly or partly of wood or other combustible material.

4-2.5* Type V (Wood Frame) Construction — Construction Classification Number 1.5. Any structure, other than dwellings, in which the structural members are wholly or partly of wood or other combustible material and in which the construction does not qualify as ordinary construction.

Where a dwelling is classified as wood frame construction (that is, having structural members wholly or partly of wood or other combustible material), a construction classification number of 1.0 shall be assigned.

Chapter 5 Determining Minimum Water Supplies

5-1 General.

5-1.1 The fire department having jurisdiction for structural surveys specified in Chapter 2, after completing the survey and determining the construction classification number and the occupancy hazard classification number, shall compute the minimum water supply, in gallons (liters), needed for the structure under its authority. As the water supplies developed by this standard are minimum and in many cases are or will be suitable for exposure protection only, the authority having jurisdiction shall review the calculations to see that adequate flows are available to meet the needs indicated by the preplans.

5-2 Single Structures Without Exposure Hazards.

5-2.1* For single structures with no portion of any unattached structural exposure hazard within 50 ft (15.2 m), unless it is smaller than 100 ft^2 (9.3 m^2), the minimum water supply, in gallons (liters), shall be determined by the total cubic footage (m^3) of the structure, including any attached structures, divided by the occupancy hazard classification number determined from Chapter 3, and multiplied by the construction classification number determined from Chapter 4; or Table 5-9(a) shall be referenced.

MINIMUM WATER SUPPLY =

$$\frac{\text{Total ft}^3\ (\text{m}^3)\ \text{of Structure}}{\text{Occupancy Hazard Classification No.}} \times \text{Construction Classification No.}$$

5-2.1.1 The minimum water supply required for any structure, without exposure hazards, shall not be less than 2000 gal (7570 L). [*See Table 5-9(b).*]

5-2.1.2 The minimum water supply, as determined for any structure specified in 5-2.1 and 5-2.1.1, shall be available on the fireground at, and the fire department shall be capable of utilizing the total water supply at, the rates specified in Table 5-9(c).

5-3 Single Structures with Exposure Hazards.

5-3.1* For all single structures with unattached structural exposure hazards closer than 50 ft (15.2 m) to any portion of the dwelling and larger than 100 ft^2 (9.3 m^2), the minimum water supply, in gallons (liters), shall be determined by the total cubic footage (m^3) of the structure, including any attached structures, divided by the occupancy hazard classification number determined from Chapter 3, multiplied by the construction classification number determined by Chapter 4, and multiplied by 1.5; or Table 5-9(a) shall be referenced.

MINIMUM WATER SUPPLY =

$$\frac{\text{Total ft}^3\ (\text{m}^3)\ \text{of Structure}}{\text{Occupancy Hazard Classification No.}} \times \text{Construction Classification No.} \times 1.5$$

5-3.1.1 The minimum water supply required for a single structure with exposure hazards specified in 5-3.1 shall not be less than 3000 gal (11 355 L). [*See Table 5-9(b).*]

5-3.1.2 The minimum water supply, as determined for any structure specified in 5-3.1 and 5-3.1.1, shall be available on the fireground at, and the fire department shall be capable of utilizing the minimum water supply at, the rates specified in Table 5-9(c).

5-4 Multiple Structures — Single Water Point Without Exposure Hazards.

5-4.1* For all multiple structures with no portion of any unattached structural exposure hazard within 50 ft (15.2 m), unless it is smaller than 100 ft^2 (9.3 m^2), the minimum water supply, in gallons (liters), shall be determined by the total cubic footage (m^3) of the structure, including any attached structures, divided by the occupancy hazard classification number as determined by Chapter 3, multiplied by the construction classification number determined by Chapter 4; or Table 5-9.1(a) shall be referenced.

$$\text{MINIMUM WATER SUPPLY} = \frac{\text{Total ft}^3\ (\text{m}^3)\ \text{of Structure}}{\text{Occupancy Hazard Classification No.}} \times \text{Construction Classification No.}$$

Where structures are close enough together that they may be served from a single water point, the water supply shall be computed from the structure having the largest minimum water supply requirement.

5-4.1.1 The minimum water supply required for multiple structures specified in 5-4.1 shall not be less than 3000 gal (11 355 L). [*See Table 5-9(b).*]

5-4.1.2 The minimum water supply, as determined for any structure specified in 5-4.1 and 5-4.1.1, shall be available on the fireground at, and the fire department shall be capable of utilizing the minimum water supply at, the rate specified in Table 5-9(c).

5-5 Multiple Structures — Single Water Point with Exposure Hazards.

5-5.1* For all multiple structures with unattached structural exposure hazards within 50 ft (15.2 m) of any portion of the structure and larger than 100 ft^2 (9.3 m^2), the minimum water supply, in gallons (liters), shall be determined by the cubic footage (m^3) of the structure, including any attached structures, divided by the occupancy hazard classification number determined from Chapter 3, multiplied by the construction classification number determined from Chapter 4, and multiplied by 1.5; or Table 5-9(a) shall be referenced.

$$\text{MINIMUM WATER SUPPLY} = \frac{\text{Total ft}^3\ (\text{m}^3)\ \text{of Structure}}{\text{Occupancy Hazard Classification No.}} \times \text{Construction Classification No.} \times 1.5$$

5-5.1.1 The minimum water supply required for multiple structures specified in 5-5.1 shall not be less than 3000 gal (11 355 L). [*See Table 5-9(b).*]

5-5.1.2 The minimum water supply, as determined for any structure specified in 5-5.1 and 5-5.1.1, shall be available on the fireground at, and the fire department shall be capable of utilizing the minimum water supply at, the rate specified in Table 5-9(c).

5-6 Special Fire Protection Problems.

5-6.1* This standard is not intended to 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. For suggested protection, consult appropriate NFPA standards.

5-7 Structures with Automatic Sprinkler Protection.

5-7.1* For any structure 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 Mobile Homes*; or NFPA 13R, *Standard for the Installation of Sprinkler Systems in Residential Occupancies Up to and Including Four Stories in Height*, the fire department having jurisdiction shall be permitted to waive any requirement for additional water supply required by this standard. (*See Appendix F.*)

5-7.1.1* The water supply for automatic sprinkler systems meeting the requirements of NFPA 13, *Standard for the Installation of Sprinkler Systems*, contemplates the use of outside hose lines; therefore, this water supply shall be available to the fire department outside the structure for manual fire fighting purposes.

5-7.1.2 Automatic sprinkler systems meeting the requirements of NFPA 13, *Standard for the Installation of Sprinkler Systems*, shall, in all cases, be provided with a fire department connection as described in NFPA 13.

5-7.2 For a structure protected by an automatic sprinkler system that does not fully meet the requirements of NFPA 13, *Standard for the Installation of Sprinkler Systems*, and NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Mobile Homes*, or NFPA 13R, *Standard for the Installation of Sprinkler Systems in Residential Occupancies Up to and Including Four Stories in Height*, the fire department having jurisdiction shall be permitted to reduce the minimum water supply required by this standard, for fire fighting purposes, in Sections 5-2, 5-3, 5-4, or 5-5, whichever is applicable.

5-8* 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 5-7.1, the fire department having jurisdiction shall determine the minimum water supply required for fire fighting purposes.

5-9 Precalculated Water Supply. Table 5-9(a) provides a quick method for determining the water requirements suggested by this standard for structures without exposures. For structures with exposures, multiply the water requirements developed by Table 5-9(a) by 1.5.

Example: A farm storage building housing a barn (occupancy hazard classification 4) of ordinary construction (construction classification number 1.0) with a cubic area of 160,000 ft^3 (4480 m^3) will produce, using Table 5-9(a), a water requirement of 40,000 gal (151 400 L).

Table 5-9(a) Precalculated Minimum Water Supplies by Occupancy Hazard and Construction Classification (no exposures)

Occupancy Hazard Classification	3				4				5				6				7			
Construction Classification	**0.5**	**0.75**	**1.0**	**1.5**	**0.5**	**0.75**	**1.0**	**1.5**	**0.5**	**0.75**	**1.0**	**1.5**	**0.5**	**0.75**	**1.0**	**1.5**	**0.5**	**0.75**	**1.0**	**1.5**
Cubic Feet	**Gallons**				**Gallons**				**Gallons**				**Gallons**				**Gallons**			
8,000		2,000	2,667	4,000			2,000	3,000				2,400				2,000				
12,000	2,000	3,000	4,000	6,000		2,250	3,000	4,500			2,400	3,600			2,000	3,000				2,571
16,000	2,667	4,000	5,333	8,000	2,000	3,000	4,000	6,000		2,400	3,200	4,800		2,000	2,667	4,000			2,286	3,429
20,000	3,333	5,000	6,667	10,000	2,500	3,750	5,000	7,500	2,000	3,000	4,000	6,000		2,500	3,333	5,000		2,143	2,857	4,286
24,000	4,000	6,000	8,000	12,000	3,000	4,500	6,000	9,000	2,400	3,600	4,800	7,200	2,000	3,000	4,000	6,000		2,571	3,429	5,143
28,000	4,667	7,000	9,333	14,000	3,500	5,250	7,000	10,500	2,800	4,200	5,600	8,400	2,333	3,500	4,667	7,000	2,000	3,000	4,000	6,000
32,000	5,333	8,000	10,667	16,000	4,000	6,000	8,000	12,000	3,200	4,800	6,400	9,600	2,667	4,000	5,333	8,000	2,286	3,429	4,571	6,857
36,000	6,000	9,000	12,000	18,000	4,500	6,750	9,000	13,500	3,600	5,400	7,200	10,800	3,000	4,500	6,000	9,000	2,572	3,857	5,143	7,714
40,000	6,667	10,000	13,333	20,000	5,000	7,500	10,000	15,000	4,000	6,000	8,000	12,000	3,333	5,000	6,667	10,000	2,857	4,286	5,714	8,571
44,000	7,333	11,000	14,667	22,000	5,500	8,250	11,000	16,500	4,400	6,600	8,800	13,200	3,667	5,500	7,333	11,000	3,143	4,714	6,286	9,429
48,000	8,000	12,000	16,000	24,000	6,000	9,000	12,000	18,000	4,800	7,200	9,600	14,400	4,000	6,000	8,000	12,000	3,429	5,143	6,857	10,286
52,000	8,667	13,000	17,333	26,000	6,500	9,750	13,000	19,500	5,200	7,800	10,400	15,600	4,333	6,500	8,667	13,000	3,715	5,571	7,429	11,143
56,000	9,333	14,000	18,667	28,000	7,000	10,500	14,000	21,000	5,600	8,400	11,200	16,800	4,667	7,000	9,333	14,000	4,000	6,000	8,000	12,000
60,000	10,000	15,000	20,000	30,000	7,500	11,250	15,000	22,500	6,000	9,000	12,000	18,000	5,000	7,500	10,000	15,000	4,286	6,429	8,571	12,857
64,000	10,667	16,000	21,333	32,000	8,000	12,000	16,000	24,000	6,400	9,600	12,800	19,200	5,333	8,000	10,667	16,000	4,572	6,857	9,143	13,714
68,000	11,333	17,000	22,667	34,000	8,500	12,750	17,000	25,500	6,800	10,200	13,600	20,400	5,667	8,500	11,333	17,000	4,857	7,286	9,714	14,571
72,000	12,000	18,000	24,000	36,000	9,000	13,500	18,000	27,000	7,200	10,800	14,400	21,600	6,000	9,000	12,000	18,000	5,143	7,714	10,286	15,429
76,000	12,667	19,000	25,333	38,000	9,500	14,250	19,000	28,500	7,600	11,400	15,200	22,800	6,333	9,500	12,667	19,000	5,429	8,143	10,857	16,286
80,000	13,333	20,000	26,667	40,000	10,000	15,000	20,000	30,000	8,000	12,000	16,000	24,000	6,667	10,000	13,333	20,000	5,715	8,571	11,429	17,143
84,000	14,000	21,000	28,000	42,000	10,500	15,750	21,000	31,500	8,400	12,600	16,800	25,200	7,000	10,500	14,000	21,000	6,000	9,000	12,000	18,000
88,000	14,667	22,000	29,333	44,000	11,000	16,500	22,000	33,000	8,800	13,200	17,600	26,400	7,333	11,000	14,667	22,000	6,286	9,429	12,571	18,857
92,000	15,333	23,000	30,667	46,000	11,500	17,250	23,000	34,500	9,200	13,800	18,400	27,600	7,667	11,500	15,333	23,000	6,572	9,857	13,143	19,714
96,000	16,000	24,000	32,000	48,000	12,000	18,000	24,000	36,000	9,600	14,400	19,200	28,800	8,000	12,000	16,000	24,000	6,857	10,286	13,714	20,571
100,000	16,667	25,000	33,333	50,000	12,500	18,750	25,000	37,500	10,000	15,000	20,000	30,000	8,333	12,500	16,667	25,000	7,143	10,714	14,286	21,429
104,000	17,333	26,000	34,667	52,000	13,000	19,500	26,000	39,000	10,400	15,600	20,800	31,200	8,667	13,000	17,333	26,000	7,429	11,143	14,857	22,286
108,000	18,000	27,000	36,000	54,000	13,500	20,250	27,000	40,500	10,800	16,200	21,600	32,400	9,000	13,500	18,000	27,000	7,715	11,571	15,429	23,143
112,000	18,667	28,000	37,333	56,000	14,000	21,000	28,000	42,000	11,200	16,800	22,400	33,600	9,333	14,000	18,667	28,000	8,000	12,000	16,000	24,000
116,000	19,333	29,000	38,667	58,000	14,500	21,750	29,000	43,500	11,600	17,400	23,200	34,800	9,667	14,500	19,333	29,000	8,286	12,429	16,571	24,857
120,000	20,000	30,000	40,000	60,000	15,000	22,500	30,000	45,000	12,000	18,000	24,000	36,000	10,000	15,000	20,000	30,000	8,572	12,857	17,143	25,714
124,000	20,667	31,000	41,333	62,000	15,500	23,250	31,000	46,500	12,400	18,600	24,800	37,200	10,333	15,500	20,667	31,000	8,857	13,286	17,714	26,571
128,000	21,333	32,000	42,667	64,000	16,000	24,000	32,000	48,000	12,800	19,200	25,600	38,400	10,667	16,000	21,333	32,000	9,143	13,714	18,286	27,429
132,000	22,000	33,000	44,000	66,000	16,500	24,750	33,000	49,500	13,200	19,800	26,400	39,600	11,000	16,500	22,000	33,000	9,429	14,143	18,857	28,286
136,000	22,667	34,000	45,333	68,000	17,000	25,500	34,000	51,000	13,600	20,400	27,200	40,800	11,333	17,000	22,667	34,000	9,715	14,571	19,429	29,143
140,000	23,333	35,000	46,667	70,000	17,500	26,250	35,000	52,500	14,000	21,000	28,000	42,000	11,667	17,500	23,333	35,000	10,000	15,000	20,000	30,000
144,000	24,000	36,000	48,000	72,000	18,000	27,000	36,000	54,000	14,400	21,600	28,800	43,200	12,000	18,000	24,000	36,000	10,286	15,429	20,571	30,857
148,000	24,667	37,000	49,333	74,000	18,500	27,750	37,000	55,500	14,800	22,200	29,600	44,400	12,333	18,500	24,667	37,000	10,572	15,857	21,143	31,714
152,000	25,333	38,000	50,667	76,000	19,000	28,500	38,000	57,000	15,200	22,800	30,400	45,600	12,667	19,000	25,333	38,000	10,857	16,286	21,714	32,571
156,000	26,000	39,000	52,000	78,000	19,500	29,250	39,000	58,500	15,600	23,400	31,200	46,800	13,000	19,500	26,000	39,000	11,143	16,714	22,286	33,429
160,000	26,667	40,000	53,333	80,000	20,000	30,000	40,000	60,000	16,000	24,000	32,000	48,000	13,333	20,000	26,667	40,000	11,429	17,143	22,857	34,286

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

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

Table 5-9(a) Continued

Occupancy Hazard Classification	3				4				5				6				7			
Construction Classification	**0.5**	**0.75**	**1.0**	**1.5**	**0.5**	**0.75**	**1.0**	**1.5**	**0.5**	**0.75**	**1.0**	**1.5**	**0.5**	**0.75**	**1.0**	**1.5**	**0.5**	**0.75**	**1.0**	**1.5**
Cubic Feet	**Gallons**				**Gallons**				**Gallons**				**Gallons**				**Gallons**			
175,000	29,167	43,750	58,333	87,500	21,875	32,813	43,750	65,625	17,500	26,250	35,000	52,500	14,583	21,875	29,167	43,750	12,500	18,750	25,000	37,500
200,000	33,333	50,000	66,667	100,000	25,000	37,500	50,000	75,000	20,000	30,000	40,000	60,000	16,667	25,000	33,333	50,000	14,286	21,429	28,571	42,857
225,000	37,500	56,250	75,000	112,500	28,125	42,188	56,250	84,375	22,500	33,750	45,000	67,500	18,750	28,125	37,500	56,250	16,071	24,107	32,143	48,214
250,000	41,667	62,500	83,333	125,000	31,250	46,875	62,500	93,750	25,000	37,500	50,000	75,000	20,833	31,250	41,667	62,500	17,857	26,786	35,714	53,571
275,000	45,833	68,750	91,667	137,500	34,375	51,563	68,750	103,125	27,500	41,250	55,000	82,500	22,917	34,375	45,833	68,750	19,643	29,464	39,286	58,929
300,000	50,000	75,000	100,000	150,000	37,500	56,250	75,000	112,500	30,000	45,000	60,000	90,000	25,000	37,500	50,000	75,000	21,429	32,143	42,857	64,286
325,000	54,167	81,250	108,333	162,500	40,625	60,938	81,250	121,875	32,500	48,750	65,000	97,500	27,083	40,625	54,167	81,250	23,214	34,821	46,429	69,643
350,000	58,333	87,500	116,667	175,000	43,750	65,625	87,500	131,250	35,000	52,500	70,000	105,000	29,167	43,750	58,333	87,500	25,000	37,500	50,000	75,000
375,000	62,500	93,750	125,000	187,500	46,875	70,313	93,750	140,625	37,500	56,250	75,000	112,500	31,250	46,875	62,500	93,750	26,786	40,179	53,571	80,357
400,000	66,667	100,000	133,333	200,000	50,000	75,000	100,000	150,000	40,000	60,000	80,000	120,000	33,333	50,000	66,667	100,000	28,571	42,857	57,143	85,714
425,000	70,833	106,250	141,667	212,500	53,125	79,688	106,250	159,375	42,500	63,750	85,000	127,500	35,417	53,125	70,833	106,250	30,357	45,536	60,714	91,071
450,000	75,000	112,500	150,000	225,000	56,250	84,376	112,500	168,750	45,000	67,500	90,000	135,000	37,500	56,250	75,000	112,500	32,143	48,214	64,286	96,429
475,000	79,167	118,750	158,333	237,500	59,375	89,063	118,750	178,125	47,500	71,250	95,000	142,500	39,583	59,375	79,167	118,750	33,929	50,893	67,857	101,786
500,000	83,333	125,000	166,667	250,000	62,500	93,751	125,000	187,500	50,000	75,000	100,000	150,000	41,667	62,500	83,333	125,000	35,714	53,571	71,429	107,143
525,000	87,500	131,250	175,000	262,500	65,625	98,438	131,250	196,875	52,500	78,750	105,000	157,500	43,750	65,625	87,500	131,250	37,500	56,250	75,000	112,500
550,000	91,667	137,500	183,333	275,000	68,750	103,126	137,500	206,250	55,000	82,500	110,000	165,000	45,833	68,750	91,667	137,500	39,286	58,929	78,571	117,857
575,000	95,833	143,750	191,667	287,500	71,875	107,813	143,750	215,625	57,500	86,250	115,000	172,500	47,917	71,875	95,833	143,750	41,071	61,607	82,143	123,214
600,000	100,000	150,000	200,000	300,000	75,000	112,501	150,000	225,000	60,000	90,000	120,000	180,000	50,000	75,000	100,000	150,000	42,857	64,286	85,714	128,571
625,000	104,167	156,250	208,333	312,500	78,125	117,188	156,250	234,375	62,500	93,750	125,000	187,500	52,083	78,125	104,167	156,250	44,643	66,964	89,286	133,929
650,000	108,333	162,500	216,667	325,000	81,250	121,876	162,500	243,750	65,000	97,500	130,000	195,000	54,167	81,250	108,333	162,500	46,429	69,643	92,857	139,286
675,000	112,500	168,750	225,000	337,500	84,375	126,563	168,750	253,125	67,500	101,250	135,000	202,500	56,250	84,375	112,500	168,750	48,214	72,321	96,429	144,643
700,000	116,667	175,000	233,333	350,000	87,500	131,251	175,000	262,500	70,000	105,000	140,000	210,000	58,333	87,500	116,667	175,000	50,000	75,000	100,000	150,000
725,000	120,833	181,250	241,667	362,500	90,625	135,938	181,250	271,875	72,500	108,750	145,000	217,500	60,417	90,625	120,833	181,250	51,786	77,679	103,571	155,357
750,000	125,000	187,500	250,000	375,000	93,750	140,626	187,500	281,250	75,000	112,500	150,000	225,000	62,500	93,750	125,000	187,500	53,571	80,357	107,143	160,714
775,000	129,167	193,750	258,333	387,500	96,875	145,313	193,750	290,625	77,500	116,250	155,000	232,500	64,583	96,875	129,167	193,750	55,357	83,036	110,714	166,071
800,000	133,333	200,000	266,667	400,000	100,000	150,001	200,000	300,000	80,000	120,000	160,000	240,000	66,667	100,000	133,333	200,000	57,143	85,714	114,286	171,429
825,000	137,500	206,250	275,000	412,500	103,125	154,688	206,250	309,375	82,500	123,750	165,000	247,500	68,750	103,125	137,500	206,250	58,929	88,393	117,857	176,786
850,000	141,667	212,500	283,333	425,000	106,250	159,376	212,500	318,750	85,000	127,500	170,000	255,000	70,833	106,250	141,667	212,500	60,714	91,071	121,429	182,143
875,000	145,833	218,750	291,667	437,500	109,375	164,064	218,750	328,125	87,500	131,250	175,000	262,500	72,917	109,375	145,833	218,750	62,500	93,750	125,000	187,500
900,000	150,000	225,000	300,000	450,000	112,500	168,751	225,000	337,500	90,000	135,000	180,000	270,000	75,000	112,500	150,000	225,000	64,286	96,429	128,571	192,857
925,000	154,167	231,250	308,333	462,500	115,265	173,439	231,250	346,875	92,500	138,750	185,000	277,500	77,083	115,625	154,167	231,250	66,071	99,107	132,143	198,214
950,000	158,333	237,500	316,667	475,000	118,750	178,126	237,500	356,250	95,000	142,500	190,000	285,000	79,167	118,750	158,333	237,500	67,857	101,786	135,714	203,571
975,000	162,500	243,750	325,000	487,500	121,875	182,814	243,750	365,625	97,500	146,250	195,000	292,500	81,250	121,875	162,500	243,750	69,643	104,464	139,286	208,929
1,000,000	166,667	250,000	333,333	500,000	125,000	187,501	250,000	375,000	100,000	150,000	200,000	300,000	83,333	125,000	166,667	250,000	71,429	107,143	142,857	214,286

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

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

Table 5-9(b) Minimum Water Requirements (Examples)

Paragraph	Type of Occupancy	Minimum Water Requirements (gallons)
5-2.1.1	Single Structures Without Exposure Hazards	2000 (7570 L)
5-3.1.1	Single Structures with Exposure Hazards	3000 (11 335 L)
5-4.1.1	Multiple Structures — Single Water Point Without Exposure Hazards	3000 (11 335 L)
5-5.1.1	Multiple Structures — Single Water Point with Exposure Hazards	3000 (11 335 L)

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

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

Chapter 6 Water Supply

6-1 Water Supply for Fire Fighting. The water supplies for fire fighting purposes, as specified in Chapter 5, can be supplied from natural bodies of water and constructed sources of water. Natural bodies of water are defined as bodies of water contained by earth only and include ponds, lakes, rivers, streams, bays, creeks, springs, artesian wells, and irrigation canals. Constructed sources of water include aboveground tanks, elevated gravity tanks, livestock watering tanks, cisterns, swimming pools, wells, quarries, mines, reservoirs, aqueducts, mobile water supplies, and hydrants served by a water system. (*See Appendix B.*)

6-1.1 The surface at the water access point shall be adequate to support heavy vehicles at all times of the year. Provisions shall be made so that such water suction points are visible and usable in all weather conditions, including heavy snow or brush conditions and mud slides.

6-1.2 If a dry hydrant is located close to vehicular traffic, suitable barriers shall be constructed to protect fire fighters, equipment, and the dry hydrant.

6-2 Water Supply Transfer. The transfer of water from a water source to the scene of the fire can be done by a number of different methods. These methods include mobile water supply shuttles, pumper relays using large diameter [normally 3½-in. (89-mm) or greater] hose, pumper relays, portable piping, irrigation piping and ditching, helicopters, railroad tank cars, etc. (*See Appendixes C, D, and E.*)

6-3 Minimum Water Supply. The minimum water supply from whatever source or combination of sources shall meet the requirements of Chapter 5.

6-4* Accessibility. Water supplies for fire fighting purposes shall be accessible to fire fighting equipment. The fire department having jurisdiction shall determine, as part of its property survey, maximum safe load limits of roadways, laneways, and bridges, and determine accessibility during various climatic conditions.

6-4.1 Any means of access shall be constructed in accordance with NFPA 1141, *Standard for Fire Protection in Planned Building Groups.*

6-5 Identification. An appropriate sign shall be erected at each water point identifying the site for fire department emergency use. (*See B-1.2.11.*)

Chapter 7 Reports and Records

7-1 Plans for New Construction and Additions.

7-1.1* Where the appropriate governmental entity has building laws that require plans to be submitted for review before building construction is started, the plans shall be submitted to the fire department for review and approval.

7-1.2 Where no building laws exist or plans are not required for review, the fire department shall request the cooperation of the property owner(s) in voluntary compliance with provisions of this standard.

7-2 Requirements for the Fire Department.

7-2.1 The fire department having jurisdiction for property surveys specified in Chapter 2, after completing the survey and computing the minimum water supply required, shall notify, in writing, the authority having jurisdiction of the results of the surveys and the minimum water supplies required. In all cases, the building(s) owner(s) shall be advised of the minimum water supply required. Fire department personnel shall be available to citizens for appropriate consultation.

7-3 Requirements for Property Owners or Occupants.

7-3.1 The property owner shall notify the authority having jurisdiction in writing before any structures are erected or any alterations are made to any existing structure that will increase the total cubic footage (m^3) of the structure. The property owner shall provide the authority having jurisdiction with complete written plans and drawings of any proposed structure, including all measurements, construction, intended occupancy, and a description of contents.

7-3.2 The property owner or occupant shall notify, in writing, the authority having jurisdiction before any changes are made in the contents of a structure or occupancy of a structure, other than residential occupancies, that would materially affect the occupancy hazard classification number as specified in Section 3-2. The property owner or occupant shall provide the authority having jurisdiction with a complete written report of contents or occupancy changes.

7-4 Smoke Detectors.

7-4.1* Each family living unit shall be provided with smoke detectors as required in NFPA 72, *National Fire Alarm Code*.

7-5 Changes in Automatic Sprinkler Protection.

7-5.1 The property owner or occupant shall notify the authority having jurisdiction in writing whenever any alterations are made that cause any change to an automatic sprinkler system covered in Section 5-7. The property owner or occupant shall provide the authority having jurisdiction with a complete written report of alterations to any existing sprinkler system or of installation of a new sprinkler system.

7-5.2* The property owner or occupant shall promptly notify the authority having jurisdiction whenever any automatic sprinkler system or other automatic suppression system or portion of any system is shut off or is to be out of service for any reason.

7-6 Retention of Reports. The fire department shall file all plans, reports, and surveys by street address and shall retain a copy of all reports specified in this standard.

Chapter 8 Referenced Publications

8-1 The following documents or portions thereof are referenced within this standard and shall be considered part of the requirements of this document. The edition indicated for each reference is the current edition as of the date of the NFPA issuance of this document.

8-1.1 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*, 1991 edition.

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Mobile Homes*, 1991 edition.

NFPA 13R, *Standard for the Installation of Sprinklers Systems in Residential Occupancies Up to and Including Four Stories in Height*, 1991 edition.

NFPA 72, *National Fire Alarm Code*, 1993 edition.

NFPA 220, *Standard on Types of Building Construction*, 1992 edition.

NFPA 1141, *Standard for Fire Protection in Planned Building Groups*, 1990 edition.

NFPA 1903, *Standard for Mobile Water Supply Fire Apparatus*, 1991 edition.

Appendix A Explanatory Material

This Appendix is not a part of the requirements of this NFPA document, but is included for information purposes only.

A-1-1 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 appendix should be applied in water supply matters.

A-2-1.1 Information needed to compute the minimum water supplies that should be collected during the building survey includes:

(a) Area of all floors, including attics, basements, and crawl spaces.

(b) Height between floors or crawl spaces and in the attics from floor to ridgepole.

(c) Construction materials used in each building, including walls, floors, roofs, ceilings, interior partitions, stairs, etc.

(d) Occupancy (occupancies) of buildings.

(e) Occupancy (occupancies) of yard areas.

(f) Exposures to buildings and yard storage and distances between them.

(g) Fire protection systems — automatic and manual protection systems, hydrants, yard mains, and other protection facilities.

(h) On-premises water supplies, including natural and constructed sources of water.

A-3-1.4 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:

(a) Bulk storage of petroleum fuels, more frequently fuel oil, but often gasoline and propane. While some tanks are underground, many are aboveground and often located within 50 ft (15.2 m) of farm buildings.

(b) Many farmers use and store blasting agents such as dynamite, often extended with ammonium nitrate (the latter of greater explosive impact per unit weight).

(c) 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 independent of each other may be very hazardous to the fire fighter where mixed together in a fire situation.

(d) 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 life potential hazard 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 (a) through (d) by means of the survey of the farm by the WSO or other inspector, and appropriate measures should be taken to protect the membership of the department from potential hazards.

A-3-2 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 is assigned to the highest hazard group. The highest occupancy hazard classification number is 7 and is assigned to the lowest hazard group.

A-4-2 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 number 0.5. The fastest burning or highest hazard type of construction, wood frame, is construction classification number 1.5. All dwellings should be assigned a construction classification number of 1.0 or lower where construction is noncombustible or fire-resistive.

A-4-2.4 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 truss 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 prefire 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 condition, and plan alternate fire tactics.

A-4-2.5 See A-4-2.4.

A-5-2.1 Single Structures Without Exposure Hazards. Examples of calculating minimum water supply:

Residential:

Dwelling: 50 ft by 24 ft; 2 stories, 8 ft each; pitched roof, 8 ft from attic floor to ridgepole; wood frame construction.

$50 \times 24 = 1200$ (ft^2)

Height $= 8 + 8 + 4^* = 20$ (ft)

$1200 \times 20 = 24{,}000$ (ft^3)

Occupancy hazard classification number 7 (*See 3-2.7.*)

Construction classification number 1.0, frame dwelling (*See 4-2.5.*)

$(24{,}000 \div 7) \times 1.0 = 3429$ gal

Minimum water supply = 3429 gal

For SI Units: 1 ft = 0.305 m; 1 ft^2 = 0.092 m^2; 1 ft^3 = 0.028 m^3; 1 gal = 3.785 L.

*For pitched roofs, calculate half the distance from attic floor to ridgepole.

If a structure is of occupancy hazard classification number 3 or 4, it is considered an exposure hazard if within 50 ft, regardless of size. (*See 5-3.1.*) For a dwelling, the construction classification number is no larger than 1.0.

Commercial:

Farm equipment shed: 125 ft × 100 ft; height 14 ft; 1 story; flat roof; noncombustible construction.

$125 \times 100 = 12{,}500$ (ft^2)

Height = 14 (ft)

$12{,}500 \times 14 = 175{,}000$ (ft^3)

Occupancy hazard classification number 5 (*See 3-2.5.*)

Construction classification number 0.75 (*See 4-2.3.*)

$(175{,}000 \div 5) \times 0.75 = 26{,}250$

Minimum water supply = 26,250 gal

For SI Units: 1 ft = 0.305 m; 1 ft^2 = 0.092 m^2; 1 ft^3 = 0.028 m^3; 1 gal = 3.785 L.

If a structure is of occupancy hazard classification number 3 or 4, it is considered an exposure hazard if within 50 ft, regardless of size.

A-5-3.1 Single Structures with Exposure Hazards. Examples of calculating minimum water supply:

Residential:

Dwelling 50 ft × 24 ft; 1 story, 8 ft high; pitched roof, 8 ft from attic floor to ridgepole; brick construction and exposed on one side by a frame dwelling with a separation of less than 50 ft and with areas greater than 100 ft^2.

$50 \times 24 = 1200$ (ft^2)

Height $= 8 + 4^* = 12$ (ft)

$1200 \times 12 = 14{,}400$ (ft^3)

Occupancy hazard classification number 7 (*See 3-2.7.*)

Construction classification number 1.0, brick dwelling, (*See 4-2.4.*)

$(14{,}400 \div 7) \times 1.0 = 2057$

Since the dwelling is exposed by a frame dwelling, multiply by the exposure factor of 1.5

$2057 \times 1.5 = 3086$

Minimum water supply = 3086 gal

For SI Units: 1 ft = 0.305 m; 1 ft^2 = 0.092 m^2; 1 ft^3 = 0.028 m^3; 1 gal = 3.785 L.

*For pitched roofs, calculate half the distance from attic floor to ridgepole.

If a structure is of occupancy hazard classification number 3 or 4, it is considered an exposure hazard if within 50 ft, regardless of size. For a dwelling, the construction classification number is no larger than 1.0.

A-5-4.1 Multiple Structures — Single Water Point Without Exposure Hazards. Example of calculating minimum water supply:

Assembly:

Church: 130 ft × 60 ft; height 25 ft to ridgepole (15 ft from ground to eaves, with pitched ridgepole 10 ft above the eaves); brick construction with fire-resistive constructed office building within 40 ft of church.

$130 \times 60 = 7800$ (ft^2)

$$\text{Height} = 15 + \frac{10^*}{2} = 20 \text{ ft}$$

$7800 \times 20 = 156{,}000$ (ft^3)

Occupancy hazard classification number 6 (*See 3-2.6.*)

Construction classification number 1.0 (*See 4-2.4.*)

$(156{,}000 \div 6) \times 1.0 = 26{,}000$

As church is exposed by a brick office building, multiply by the exposure factor of 1.5

$26{,}000 \times 1.5 = 39{,}000$

Minimum water supply = 39,000 gal

*For pitched roofs, calculate half the distance from attic floor to ridgepole.

The fire-resistive office building:

Office building is 175 ft × 100 ft; 2 stories, each floor 10 ft; with a flat roof.

$175 \times 100 = 17{,}500$ (ft^2)

Height $= 10 + 10 = 20$ (ft)

$17{,}500 \times 20 = 350{,}000$ (ft^3)

Occupancy hazard classification number 7 (*See 3-2.7.*)

Construction classification 0.5 (*See 4-2.2.*)

$(350{,}000 \div 7) \times 0.5 = 25{,}000$

Minimum water supply = 25,000 gal

As this is a multiple structure location served from a single water point with the supply computed from the structure having the larger water supply requirement, the church will control the water supply requirement.

Water supply for church = 39,000 gal
Water supply for office = 25,000 gal

Therefore, the church has the larger water supply requirement.
Minimum water supply for these multiple structures = 39,000 gal

For SI Units: 1 ft = 0.305 m; 1 ft^2 = 0.092 m^2; 1 ft^3 = 0.028 m^3; 1 gal = 3.785 L.

A-5-5.1 Multiple Structures — Single Water Point with Exposure Hazards. Example of calculating minimum water supply:

A row of five dwellings, identical to the residential occupancy in A-5-2.1, except one has a brick barn measuring 80 ft by 40 ft located 35 ft from the dwelling. The barn is larger than 100 ft^2 in area and is closer than 50 ft to the dwelling. Therefore, the minimum water supply for this dwelling (3429 gal) should be multiplied by 1.5 for the exposure.

$3429 \times 1.5 = 5144$ gal

If the dwellings and barn are to be protected by the same water supply, as is likely, the water supply should be calculated on the structure that requires the largest minimum water supply, which is the barn in this case. Thus, if the barn has no hay storage and is 25 ft in height to the pitched ridgepole, and the ridgepole is 10 ft above the eaves, the calculations would be as follows:

$80 \times 40 = 3200$ (ft^2)
Height = 15 + 5* = 20 (ft)
$3200 \times 20 = 64{,}000$ (ft^3)
Occupancy hazard classification number 4, for the barn with no hay storage (*See 3-2.4.*)
Construction classification number is 1.0 (*See 4-2.4.*)
$(64{,}000 \div 4) \times 1.0 = 16{,}000$
$16{,}000 \times 1.5$ (for exposure hazard – the dwelling) = 24,000
Minimum water supply = 24,000 gal

If a structure is of occupancy hazard classification number 3 or 4, it is considered an exposure hazard if within 50 ft, regardless of size.

For SI Units: 1 ft = 0.305 m; 1 ft^2 = 0.092 m^2; 1 ft^3 = 0.028 m^3; 1 gal = 3.785 L.

*For pitched roofs, calculate half the distance from attic floor to ridgepole.

Farm equipment shed, identical to commercial occupancy in A-5-2.1, except with a one-story, pitched-roof dwelling measuring 50 ft by 25 ft located 45 ft from the equipment shed. The dwelling is larger than 100 ft^2 in area and is closer than 50 ft to the equipment shed. Therefore, the minimum water supply for the equipment shed (26,250 gal) is multiplied by 1.5.

$26{,}250 \times 1.5 = 39{,}375$ (gal)
Minimum water supply = 39,375 gal
The total water supply for the dwelling is: $50 \times 25 = 1250$ (ft^2)
Height = 8 + 4 = 12 (ft)
$1250 \times 12 = 15{,}000$ (ft^3)
Occupancy hazard classification number 7 (*See 3-2.7.*)
Construction classification number 1.0 (*See 4-2.5.*)
$(15{,}000 \div 7) \times 1.0 = 2143$ gal

For SI Units: 1 ft = 0.305 m; 1 ft^2 = 0.092 m^2; 1 ft^3 = 0.028 m^3; 1 gal = 3.785 L.

Since the equipment shed requires the larger minimum water supply, if these two buildings were to be protected by the same water supply, that minimum water supply would be 39,375 gal.

If a structure is of occupancy hazard classification number 3 or 4, it is considered an exposure hazard if within 50 ft, regardless of size. For a dwelling, the construction classification number is no larger than 1.0.

A-5-6.1 The fire department having jurisdiction should consider the number of fire streams needed to control a potential fire in such an occupancy, multiplying the estimated total application rate in gpm by a liberal estimate of the time in minutes (60 minutes or more) necessary to control and extinguish the fire. A review of appropriate NFPA standards is suggested, as properties having special fire protection problems are beyond the scope of this standard on rural water supplies. (*See G-1 for additional information on fire flows.*)

A-5-7.1 It is the intent of NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Mobile Homes*, and NFPA 13R, *Standard for the Installation of Sprinkler Systems in Residential Occupancies Up to and Including Four Stories in Height*, to provide additional life safety as the primary goal, with property protection as a secondary goal. NFPA, federal agencies, and private organizations are united to provide the research and to develop sprinkler protection for residential occupancies at a low cost. Researchers have developed a new sprinkler head for the residential system that has a uniform discharge density and quick response capabilities. The reports from those areas that have adopted NFPA 13D for dwellings, apartments, mobile homes, hotels, and motels show promise.

A-5-7.1.1 The fire department should employ measures to supplement the sprinkler system to ensure adequate water and pressure for efficient operation of the sprinklers and should use care not to "rob" water from the supply for the sprinklers to supply hand lines. (*See Appendix F.*)

A-5-8 Other automatic suppression systems could include foam, carbon dioxide, dry chemical, etc., installed in part or in all of the structure.

A-6-4 Accessibility to water supplies should incorporate whatever features necessary to ensure the ability for year-round travel, taking into consideration local climatic conditions and topography.

The state Department of Transportation (DOT), in most cases, can provide the fire department with a computer printout showing safe load limits for bridges located within the boundaries of any city, town, county, or fire district, etc. This information has proved invaluable to a number of fire departments in checking bridges used to carry fire equipment. (*See B-6 and B-7 for further information on access to water supplies.*)

A-7-1.1 Where a subdivision or other "planned building group" is proposed, it should be in accordance with NFPA 1141, *Standard for Fire Protection in Planned Building Groups.*

Fire and municipal officials having jurisdictional authority in areas where structures interface with wildlands should establish and enforce protective measures in accordance with generally accepted principles and applicable NFPA standards.

A-7-4.1 Smoke detectors work and are needed. In any given year, statistics reveal that well over 50 percent of all persons killed by fire die in residential fires. The encouraging news is that current estimates indicate that smoke detectors are in approximately 75 percent of the nation's homes. (*See NFPA 72, National Fire Alarm Code.*) The primary concern of the standard is with life protection, and many water-hauling fire departments have developed programs to promote the installation, maintenance, and testing of smoke detectors as a first step in saving life and property through early detection. Early detection of a fire will go a long way toward reducing the water requirements needed for fire fighting purposes and reducing the water necessary for a water-hauling fire department to transport.

A-7-5.2 When the fire department is advised of a sprinkler system impairment, every effort should be made to restore the protection to service as quickly as possible. In some cases, the property owner might be able to provide a makeshift arrangement or to secure a part that will enable the restoration of the system, either completely or with only a very small number of sprinkler heads out of service during restoration.

Appendix B Water Supply

This Appendix is not a part of the requirements of this NFPA document, but is included for information purposes only.

The following numbering system is not intended to correlate with the standard.

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 may be constructed or natural, or (2) from supplies transported to the scene. This appendix discusses the variety and potential of these sources.

B-1.2 Water Supply Officer (WSO). Many progressive rural fire departments depend on a WSO. The work of a properly trained and equipped WSO makes it possible for the officer supervising the actual fire attack to plan it 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 must divert too much personal attention from the attack to the logistics of backing it up.

B-1.2.1 Duties of Water Supply Officer (WSO). The officer is designated to provide sufficient water at the fire site, to plan availability of additional water sources, and to determine water requirements at the various locations over the district. The WSO should maintain and even carry a complete set of files, which should include cards showing water points and lists of automatic and mutual aid mobile water supply apparatus available. Modern technology in optics and computers makes it feasible for even a relatively low-budget department to reduce this data to microfiche or photographic slides, which can be maintained in the fire alarm communication center and taken to the scene of every fire and used on small, even hand-held, viewers. The WSO is, basically, the individual who implements the water supply prefire planning.

As the WSO visits neighboring fire departments, a list of all apparatus, equipment, and personnel available to the officer's department should be developed. At this time, arrangements can be developed where certain apparatus and personnel will respond under an automatic aid agreement (first alarm response) or a mutual aid agreement (called as needed), depending on the needs of the department. These needs will be dictated, of course, by the nature of the structure(s) involved.

B-1.2.2 Duties at Fire. At the fire scene, the WSO becomes the rural equivalent of the water department representative who responds to major municipal fires. The WSO's duty to maintain continuous fire streams in rural areas is frequently a very complicated task involving setting up several water hauling facilities, assembling water-carrying equipment of automatic and mutual aid departments, calculating estimated arrival times of mobile water supply apparatus, and having a thorough knowledge of available water supplies throughout a wide area of fire department jurisdiction.

B-1.2.3 Communication Coordination. In water supply operations, efficient radio communication is absolutely necessary. To develop and sustain large fire flow requires the use of several water sources as well as several drop tanks where water may be dumped. Therefore, good radio communication is necessary in readily directing mobile water supplies so that time is not lost at the fill and the dump points. To obtain this level of mobile water supplies 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 also needs to have efficient communication with the incident commander.

B-1.2.4 Duties Before the Fire. Before the fire, the WSO participates in the prefire 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. This means close coordination between the WSO and the fire department training officer and 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.

The WSO or designee must meet with property owners and secure their permission to use the water supply (*see B-1.2.6*), to develop an all-weather road to the supply (*see B-6*) and to install dry hydrants (*see B-5*). The installation of roads to or dry hydrants in navigable water or wetlands might require a permit from appropriate local, state, or national agencies. Fire departments should contact these groups early in the planning process to avoid violations of the law.

If called upon, the WSO should be available to consult with the owner in the design of a water source on a property to be protected.

B-1.2.5 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. Also, it is advisable to note 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.

B-1.2.6 Water Usage Agreement. 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.)

B-1.2.7 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.

B-1.2.8 Inspection of Water Supplies. 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.

B-1.2.9 Reliability of an Impounded Supply. 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 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.

Sample
Water Usage Agreement

I, We the undersigned owner(s) of a lake or pond located at ________________________________
do hereby 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
Anytown Fire
Department

________________________ ________________________
Owner Date Secretary
Anytown Fire
Department

____
Chief
Anytown Fire
Department

B-1.2.10 Reliability of a Flowing Stream. For a supply from a flowing stream, the quantity to be considered available is the minimum rate of flow during a drought with an average 50-year frequency (certified by a registered professional engineer). The maximum rate of flow is determined by testing using the pumper(s), hose arrangement, and dry hydrant normally used at this site.

B-1.2.11 Sign. 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.

B-1.2.12 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 deenergization 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, three types of water supplies might be needed: (1) first-aid via the domestic water system; (2) a bulk water supply at the property, which may be a stream, pond, elevated tank, ground-level tanks, or cistern; or (3) an area system of static water supplies with drafting points and means for transporting the water to the fire site. Alternative power supplies should be considered.

B-3 Natural Water Sources.

B-3.1 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 factors:

(a) *Flowing Capacity.* The stream should deliver water in capacities compatible with those outlined in the water requirements of this standard. (*See Chapter 5.*)

(b) *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 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.

(c) *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 B-6 and Appendix E, Portable Pumps.*) Where roadways are provided to the water supply, they should be constructed in accordance with B-6.2.

(d) *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.

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 1 ft (0.3 m). Therefore:

$W \times D \times TD$ = cubic feet ft^3 (m^3) of water

where:

W = width = 4 ft (1.2 m)
D = depth = 6 in. (15.2 cm) = $\frac{1}{2}$ ft (0.15 m)
TD = travel distance = 10 ft (3.1 m)
T = time in seconds = 45 sec
0.00223 ft^3/sec = 1 gal

4 (1.2 m) $\times$ $\frac{1}{2}$ (0.15 m) $\times$ 10 (3.1 m) = 20 ft^3 (0.56 m^3) of water

The cork takes 45 seconds to flow the 10-ft (3.1-m) distance.

ft^3 of water/time = ft^3/sec (m^3 water/time = m^3/sec)

20/45 = 0.444 ft^3 of water/sec (0.558/45 = 0.0124 m^3 water/sec)

0.444/0.00223 = 199 gpm flowing in the creek (0.0124/0.00223 = 5.56 L/min).

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

B-3.2 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 listed in B-3.1 relative to streams are pertinent to ponds, with the following items to be considered:

(a) Minimum annual level should be adequate to meet water supply needs of the fire problem the pond serves.

(b) Freezing of a stationary water supply, contrasted with the flowing stream, presents a greater problem.

(c) 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.

(d) 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.

B-3.3 Other Natural Sources. These 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.

B-4 Developed Sources of Water.

B-4.1 General. The 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.

B-4.2 Cisterns. 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 5 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.

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 since 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 Figures B-4.6(e), B-4.6(f), and B-4.6(g).*]

B-4.3 Protection from Freezing.

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, but are not limited to:

(a) Floating a log or a bale of hay or straw, etc., on the surface of the water.

(b) Placing a partly filled, floating barrel on the surface of the water.

B-4.4 Guide to Cistern Capacity. A ready guide to the capacity of cisterns with vertical sides is provided in Table B-4.7.

B-4.5 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:

(a) Base, walls, and roof should be designed for the prevailing soil conditions and for the loads encountered where heavy vehicles are parked adjacent.

(b) If groundwater conditions are high, the cistern should not float when empty.

(c) Suction piping should be designed to minimize whirlpooling.

(d) 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-4.6 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 are specifications for cistern design and construction used by one governing body. [*See Figures B-4.6(a) through (h).*]

1. Cisterns should be located no more than 2200 feet (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 gallons (113 550 L) minimum, available through the suction piping system.

4. The suction piping system should be capable of delivering 1000 gpm (3800 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 an acceptable registered professional engineer.

6. The entire cistern should be rated for highway loading, unless specifically exempted by the authority having jurisdiction.

7. All drawings are for estimating purposes only and are not intended for use as design.

8. Each cistern should be sited to the particular location by a registered engineer and approved by the authority having jurisdiction.

9. Cast-in-place concrete should achieve a 28-day strength of 3000 psig (20 700 kPag). It should be placed with a minimum of 4-in. (10.2-cm) slump and vibrated in a professional manner.

10. 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.

11. 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.

12. All PVC piping should have glued joints.

13. The 8 in. × 5 in. (20.3 cm × 12.7 cm) eccentric reducer is available from suppliers.

14. The final suction connection should be a minimum of 4½ in. (11.4 cm). It should be capped.

15. The filler pipe siamese should have 2½-in. (64-mm) National Standard female threads with plastic caps.

16. The entire cistern should be completed and inspected before any backfilling is done.

17. 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.

18. 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.

19. Filler pipe siamese should be 36 in. (91.4 cm) above final backfill grade.

20. 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.

21. Suction pipe should be supported either to top of tank or to a level below frost.

22. Base should be designed so that cistern will not float when empty.

23. Perimeter of tank at floor/wall joint should be sealed with 8-in. (20.3-cm) PVC waterstop.

24. After backfilling, tank should be protected by fencing or large stones.

25. Backfill over the tank should be:

(a) 4 ft (1.2 m) of fill; or

(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.

26. Bottom of suction pipe to pumper connection should not exceed 14 ft (4.25 m) vertical distance.

27. Pitch of shoulder and vehicle pad from edge of pavement to pumper suction connection should be 1 to 6 percent downgrade.

28. 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.

29. All construction, backfill, and grading material should be in accordance with proper construction practices and acceptable to the authority having jurisdiction.

30. All horizontal suction piping should slope slightly uphill toward pumper connection.

31. Installer is responsible for completely filling cistern until accepted by the authority having jurisdiction.

(Specifications furnished by the New Boston Fire Department, New Boston, NH.)

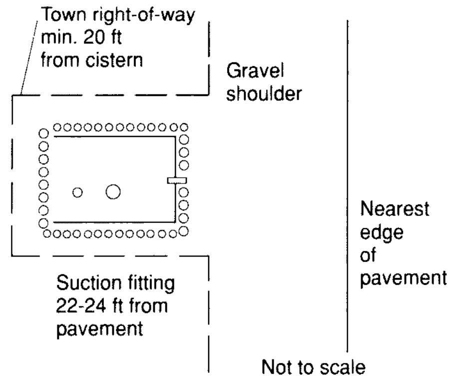


Figure B-4.6(a) Cistern site.

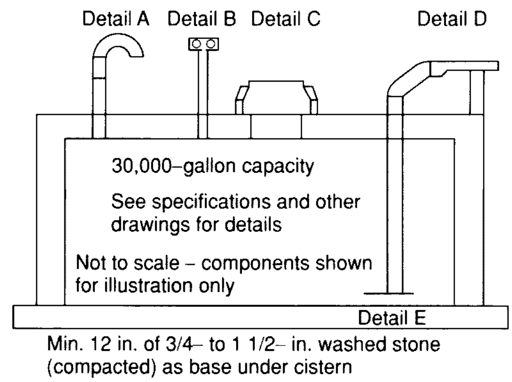


Figure B-4.6(b) Cistern.

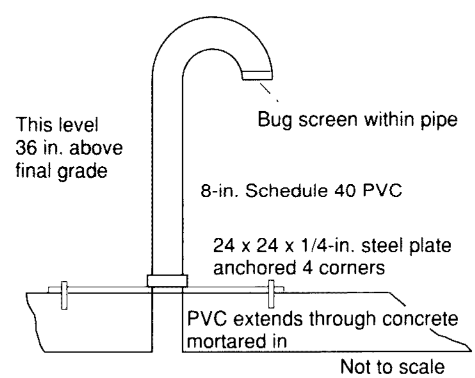


Figure B-4.6(c) Detail A — vent pipe.

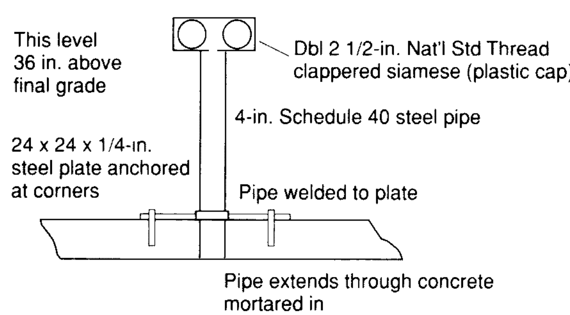


Figure B-4.6(d) Detail B — fill pipe.

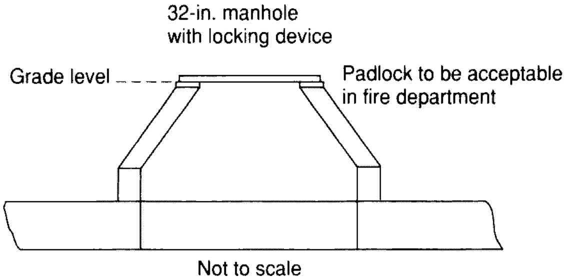


Figure B-4.6(e) Detail C — manhole.

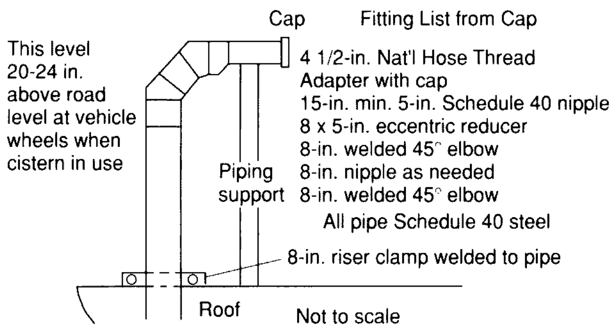


Figure B-4.6(f) Detail D — upper suction pipe.

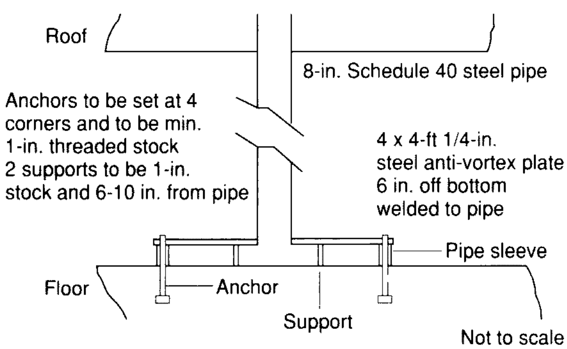


Figure B-4.6(g) Detail E — lower suction pipe.

B-4.7 Guide to Circular Cistern Capacity.

A ready guide to the capacity of cisterns with vertical sides is provided in Table B-4.7.

A formula for calculating the storage capacity of a rectangular cistern is the same as the formula for "pool capacity." *(See B-4.8.2.)*

Table B-4.7 Cistern Storage Capacity

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

For SI units: 1 ft³ = 7.48 gal of water; 1 ft³ = 0.02832 m³.

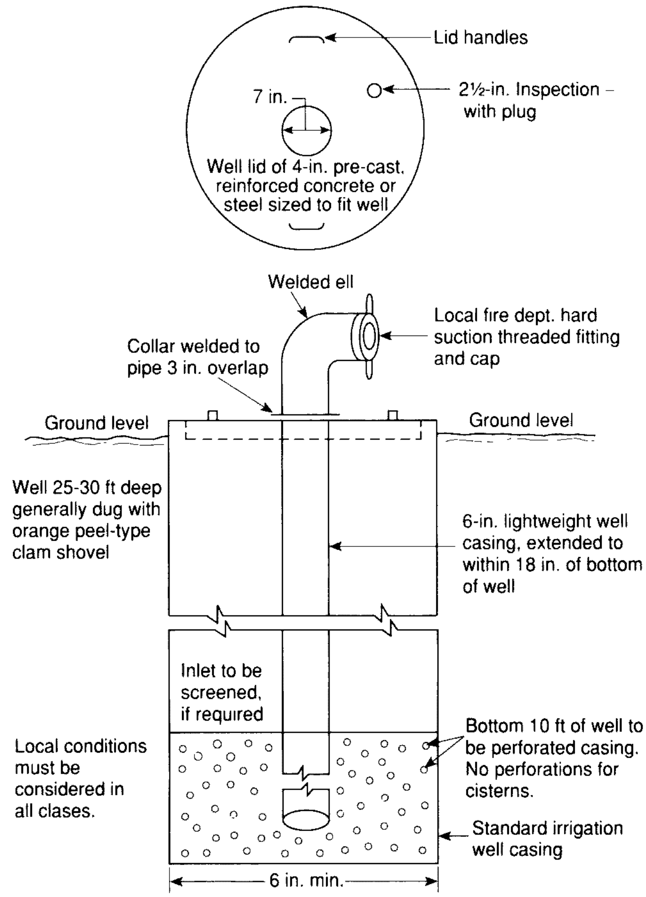


Figure B-4.6(h) Typical well (cistern) with dry hydrant installed. Same design suitable for cistern if bottom of casing is not perforated. For usable water depth, see B-4.7 warning.

WARNING: Reference is made to water depths in cisterns, swimming pools, streams, lakes, and other sources in a number of places in this appendix. 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-4.8 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-4.8.1 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, syphon 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-1.2.6.*)

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-4.8.1.*)

Figure B-4.8.1 Pool accessibility. Where plans are made before a fire, it might not take elaborate preparation to use a swimming pool as a water supply.

B-4.8.2 Pool Capacity. A short-form method of estimating pool capacity is:

L × W × D × 7.5 gal (1000 L) = estimated capacity in gallons (litres).

where:

L = length in feet (m).

W = width in feet (m).

D = estimated average depth in feet, from water line in feet (m).

NOTE: These dimensions should be estimated or rounded off if pool is of stylized construction. 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 prefire 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-4.8.3 Care in Use of Pools. Care must 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. There is a further possibility that a pool in extremely wet soil will tend to float upwards when drained; therefore, it may be necessary to 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-4.9 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.

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-4.10 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.

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 preplan 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 Appendix F for additional information on sprinkler systems.*)

B-4.11 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-5 Dry Fire Hydrants.

B-5.1 General. As the installation of rural dry fire 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 fire 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-5.1(a).*]

Figure B-5.1(a) Dry hydrant.

B-5.2 Planning and Permits. The planning, permitting, and design processes should be completed before the actual construction can begin. Planning should involve all affected agencies and private concerns so a coordinated effort can be undertaken. Some factors to consider in determining the need and locations for a dry fire hydrant system are:

(a) Current and future population and building trends.

(b) Property values protected.

(c) Potential for loss.

(d) Fire history of the area protected.

(e) Current water supply systems.

(f) Potential water supply sources — constructed or natural.

(g) Cost of project.

(h) Other factors of local concern.

B-5.2.1 Permits. Permits to install a dry fire 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.

B-5.3 Dry Fire Hydrant Design. 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. All installations should be a minimum of 6-in. (15.2-cm) pipe. With longer lateral runs and higher volume gpm (L/min) flow, 8-in. or 10-in. (20.3-cm or 25.4-cm) pipe sizes can become necessary. 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. [*See Figure B-5.3(a).*] However, in many parts of the country, schedule 40 or 80 PVC pipe, fittings, and connections are becoming more common. [*See Figure B-5.3(b).*] Many fire service manufacturers are now offering premade and preassembled PVC suction screens, hydrant heads, and supports that come ready to attach to the pipe. [*See Figure B-5.3(b).*] Steamers should be fire department's hard suction hose size and thread type.

B-5.3.1 Design Criteria. The design of dry fire hydrant installations has been carefully planned to incorporate several desirable advantages that tend to bring the installation of the PVC dry fire hydrants within the personnel and financial resources of a large number of rural fire departments or property owners. The design criteria are listed here to simplify the understanding of the design of the dry fire hydrant.

Design Criteria for Dry Hydrants.

(a) It is recommended that all dry hydrants be constructed of 6-in. (15.2-cm) or larger pipe and fittings.

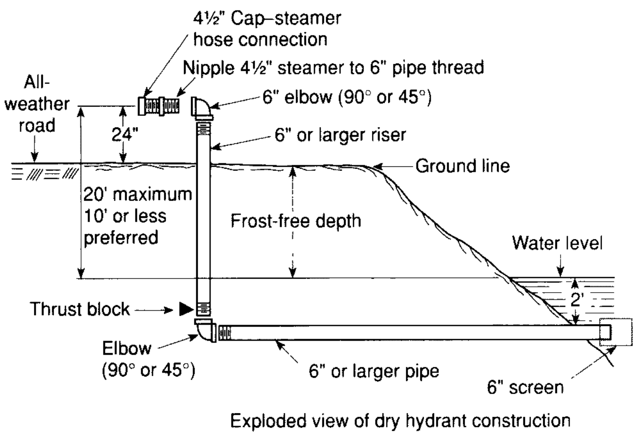


Figure B-5.3(a) Dry fire hydrant construction using iron, steel, or PVC pipe.

(b) Only schedule 40 or heavier PVC should be used in PVC systems.

(c) All exposed PVC or metal surfaces and all underground metal surfaces should be primed and painted to prevent deterioration of the material.

(d) A minimum number of 90-degree elbows, preferably no more than two, are suggested to be used in the total system. It might be desirable to have a wide-sweep elbow 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 2½-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 wide-sweep elbow can be constructed using two 45-degree elbows and a 2-ft (0.6-m) length of pipe.

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

(f) 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.

(g) In areas where frost is a problem, the design should ensure that no frost will ever 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.

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

B-5.3.2 Useful Depth of Water Sources. Careful note should be made of the fact that installation of dry fire hydrants, as noted in B-5, calls for care in measuring water

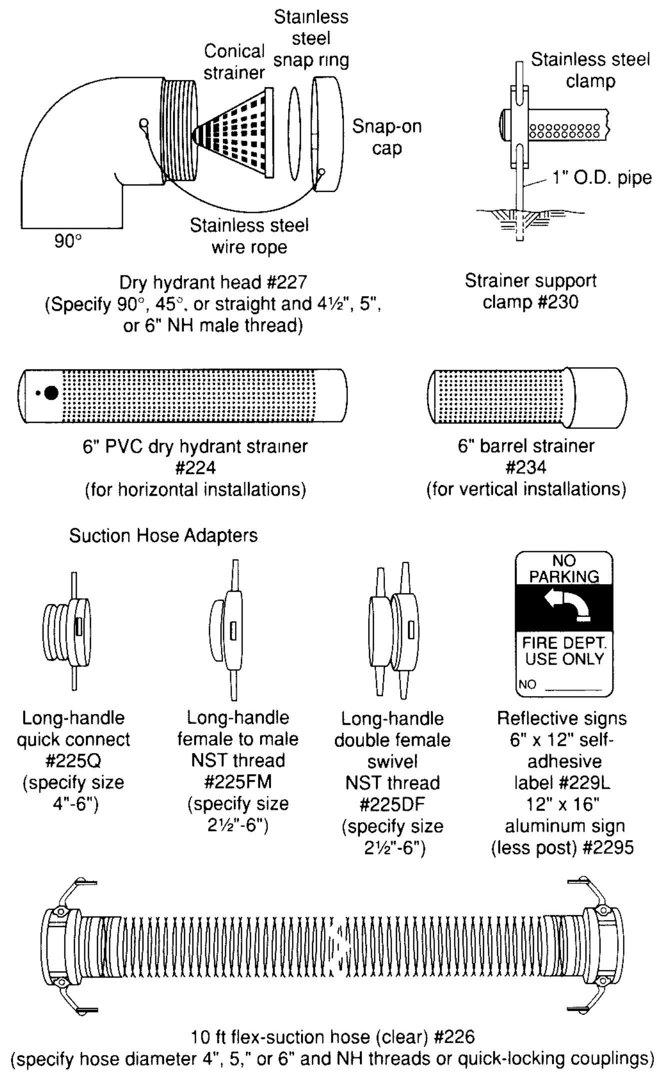


Figure B-5.3(b) Commercially available dry fire hydrant components. *(Courtesy of Wisconsin Dept. Natural Resources)*

storage capacities. The useful depth of a lake with a dry fire hydrant installation, for instance, is from the minimum foreseeable low-water surface level to the top of the suction strainer, not to the bottom of the lake, and must be not 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 a 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 antiswirl 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 water control officer when estimating the effective rate at which water can be drawn from all suction supplies.

B-5.3.3 Design Worksheet and Charts for PVC Dry Fire Hydrant Installations. The following worksheet (*see Figure B-5.3.3*) and charts [*see Figures B-5.3.3(a), (b), (c)*] can be used to assist in the design of a dry fire hydrant installation. These charts 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. The charts are for PVC pipe. Charts are available for other types of pipe material. Some factors to consider in designing the dry fire hydrant are:

(a) 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.

(b) Total head loss should not exceed 20 ft (6.1 m), or the pump might not supply its rated gpm (L/min). If using portable pumps on the dry fire hydrant, keep total head loss as low as possible.

How to use the charts:

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

(b) Using Figure B-5.3.3(a), 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.

(c) Add the numbers from step 1 and step 2 together to obtain the TOTAL STRAIGHT PIPE EQUIVALENT of the hydrant. Write this figure down on the design worksheet at step 3.

(d) 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.

(e) Using Figure B-5.3.3(b), 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 chart. Example: TOTAL STRAIGHT PIPE EQUIVALENT is 75 ft (22.9 m) and the desired volume is 1950 gpm (7441 L/min) — head loss from the chart 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.

(f) From Figure B-5.3.3(c), 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.

(g) 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 — this is a vertical measurement and represents "dead" lift.

(h) 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.

Design Worksheet

FIRE DEPARTMENT ______________________
DRY FIRE HYDRANT LOCATION ______________

Step 1
Screen length ______________________
Lateral run length __________________
Riser height _______________________

Straight Pipe = ____________________

Step 2
Use Figure B-5.3.3(a) 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 Figure B-5.3.3(b) to determine Head Loss for Pipe and Fittings.
Head Loss for Pipe and Fittings = ______________

Step 6
Using Figure B-5.3.3(c), 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 to 25 ft, the pump might not be able to flow its rated GPM.

Figure B-5.3.3 Design worksheet.

PVC Pipe Diameter	2.5"	3.0"	4.0"	5.0"	6.0"	8.0"	10.0"
90° Elbow, Standard	6.5	8.5	11.0	14.0	16.0	22.0	27.0
90° Elbow, Medium Sweep	5.5	7.0	9.5	12.0	14.0	18.0	22.0
90° Elbow, Long Sweep	4.5	5.5	7.0	9.0	11.0	14.0	18.0
45° Elbow	3.0	4.5	5.0	6.5	7.5	10.0	13.0
Hydrant Connection (6" × 4.5")					2.5		
Reducer (8" × 6")						3.5	

Source: *Handbook of PVC Pipe*.
For SI units: 1 in. = 2.54 cm; 1 ft = 0.305 m.

Figure B-5.3.3(a) Straight pipe equivalents for fittings (in feet).

Pipe Size	3"	4"	5"	6"	7"	8"	10"
GPM							
100	2.4	0.6	0.2	0.1			
200	8.6	2.1	0.7	0.3	0.1	0.1	
250	13.0	3.2	1.1	0.5	0.1	0.1	
300	18.2	4.5	1.5	0.6	0.2	0.2	0.1
350	24.2	6.0	2.0	0.8	0.3	0.2	0.1
400	30.9	7.6	2.6	1.1	0.4	0.3	0.1
500	46.8	11.5	3.9	1.6	0.8	0.4	0.1
600	65.6	16.2	5.5	2.2	1.1	0.6	0.2
700	87.2	21.5	7.3	3.0	1.4	0.7	0.2
750	99.1	24.4	8.3	3.4	1.6	0.8	0.3
800	111.7	27.5	9.3	3.8	1.8	0.9	0.3
900	138.9	34.3	11.6	4.8	2.3	1.2	0.4
1000	168.8	41.6	14.1	5.8	2.7	1.4	0.5
1100	201.4	49.7	16.8	6.9	3.3	1.7	0.6
1200	236.7	58.4	19.7	8.1	3.8	2.0	0.7
1300	274.5	67.7	22.9	9.4	4.4	2.3	0.8
1400	314.9	77.7	26.2	10.8	5.1	2.7	0.9
1500	357.7	88.5	29.8	12.3	5.8	3.0	1.0
1600	403.2	99.5	33.6	13.8	6.5	3.4	1.2
1700	451.1	111.3	37.6	15.5	7.3	3.8	1.3
1800	501.5	123.7	41.8	17.2	8.1	4.2	1.4
1900	554.3	136.7	46.1	19.0	9.0	4.7	1.6
2000	609.5	150.4	50.8	20.9	9.9	5.2	1.7
2100	667.2	164.6	55.6	22.9	10.8	5.6	1.9
2200	727.2	179.4	60.6	24.9	11.8	6.2	2.1
2300	789.6	194.8	65.8	27.1	12.8	6.7	2.3
2400	854.4	210.7	71.2	29.3	13.8	7.2	2.4
2500	921.4	227.3	76.7	31.6	14.9	7.8	2.6
2600	990.9	244.4	82.5	34.0	16.1	8.4	2.8
2700	1062.6	262.1	88.5	36.5	17.2	9.0	3.0
2800	1136.6	280.4	94.7	39.0	18.4	9.6	3.2
2900	1213.0	299.2	101.0	41.6	19.7	10.3	3.5
3000	1291.6	318.6	107.6	44.3	21.0	10.9	3.7

For SI units: 1 GPM = 0.0631 L/sec.

Figure B-5.3.3(b) Head loss (ft per 100 ft of PVC pipe).

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

Hose Size	1½"	2½"	4"	4½"	5"	6"
GPM						
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.

Figure B-5.3.3(c) Head loss (ft per 100 ft of hard rubber suction hose).

B-5.3.4 Step-by-Step Installation Procedure for a Dry Fire Hydrant.

(a) Check for any underground or overhead utilities before digging. Contact the appropriate authorities, e.g., water, power, telephone, cable, gas, etc.

(b) Using a backhoe or excavator, dig in the trench starting at the point where the suction screen will be placed in the water.

(c) Maintain a uniform level trench cut all the way from the screen location to the point where the riser begins.

(d) 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.

(e) Sink the screen end and allow the assembly to sink into the bottom of the trench. IT IS CRITICAL THAT AT NO TIME SHOULD ANYONE BE ALLOWED INTO OR CLOSE TO THE TRENCH. IT IS NOT NECESSARY.

(f) 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.

(g) 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.

(h) 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.

(i) 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.

(j) Set the guards and hose supports. Level, seed, and mulch the area to prevent erosion.

(k) Test pump the hydrant.

B-5.4 Maintenance of Dry Fire Hydrant. These facilities require periodic checking, testing, and maintenance at least quarterly. 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 might 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.

B-5.4.1 Maintenance Record for Dry Fire Hydrant. It is suggested that a record of inspection be maintained with a separate card on each dry fire hydrant. (*See Figure B-5.4.1.*)

B-5.4.2 Map and Location/Detail Drawing. An official record should be kept of all pertinent information recommended for each dry fire hydrant area. An example of one type is Figure B-5.4.2. The record will provide invaluable information whenever the need for such is required.

B-5.5 Pressurized Dry Fire Hydrant Sources. There can be two types of pressurized dry fire hydrants—those flowing through a dam (or dike) and 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.

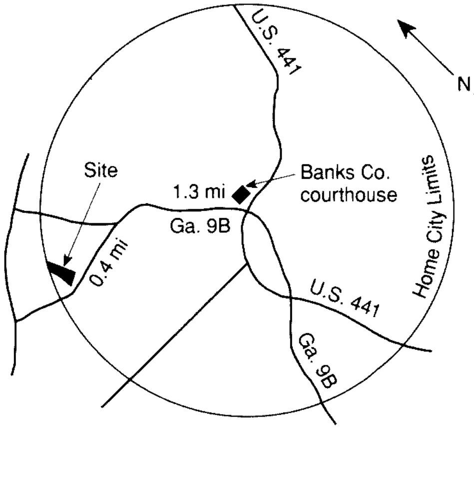
Location and Directions: ______________________________ Depth of Water Above Intake ____________

Date ______________________________

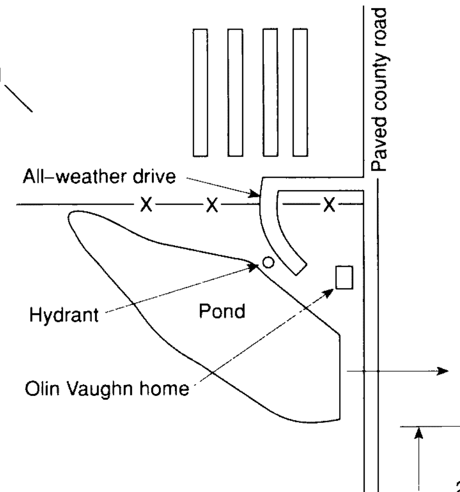
Date of Insp.	By	Depth of Water[1]	Amount of Water Available[2]	Condition of Water[3]	Erosion[4]	Dry Hydrant		Weed Control[7]	Road Condition[8]	Sign[9]	Remarks[10]
						Test[5]	Flow[6]				

Figure B-5.4.1 Maintenance record for dry fire hydrant.

[1] Depth of water from the surface to top of strainer.
[2] Amount of water available calculated from surface to at least 2 ft (0.61 m) above top of strainer.
[3] Condition of water will cover any time, the deterioration of which over a period of time will reduce the water available. Special attention should be given to such items as silting, debris, aquatic growth, etc.
[4] Erosion covers the area around the hydrant, access road, and bank of the water supply.
[5] Test is recorded 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 clear of any stoppage, and supports and/or gravel is in place. Any problems that had to be corrected are recorded under "remarks."
[6] Flow is the 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] Weed control should be according to the department's SOP. Grass should be trimmed. Chemicals are not recommended for the control of weeds; however, where chemicals are used, the records should be complete as to the chemicals and process used
[8] Road condition used to note condition of roadway, drainage, etc.
[9] Sign will show information pertaining to accuracy and clarity of information on sign. Was it repainted or replaced?
[10] Remarks to be used to cover general information about the dry fire hydrant as found at the time of inspection.



General location



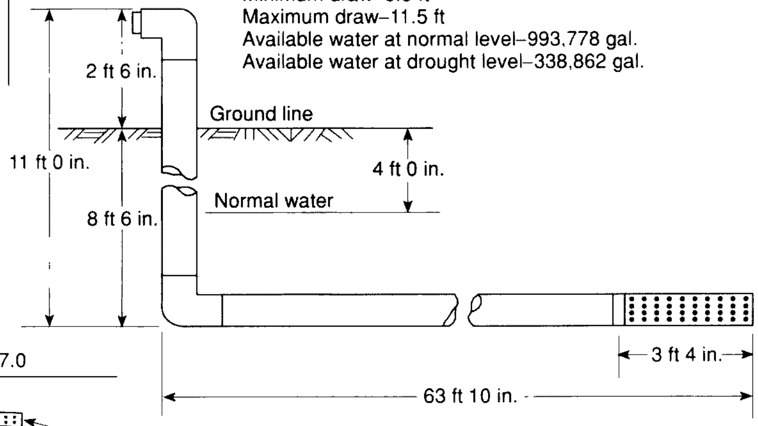
Hydrant location

Bill of Materials

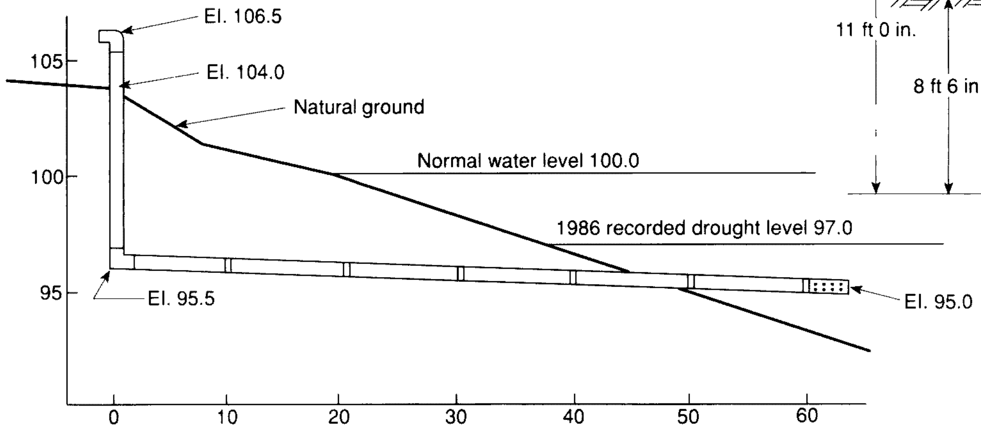
Quantity	Item
1 ea.	Dry hydrant adapter–Schedule 40 PVC 6-in. to 4½-in. suction line 90° bend
1 ea.	Strainer with snap ring
1 ea.	Hydrant cap
1 ea.	6-in. x 3-ft 4-in. PVC strainer
1 ea.	6-in. Schedule 40 PVC 90° bend
70 L. ft	6-in. Schedule 40 PVC pipe
6 ea.	6-in. PVC couplings–Schedule 40
1 ea.	Can PVC glue

Quantities

Source of water–pond and stream
Size of normal pool–0.84 AC.
Size of drought pool–0.38 AC.
Minimum draw–6.5 ft
Maximum draw–11.5 ft
Available water at normal level–993,778 gal.
Available water at drought level–338,862 gal.



Pipeline dimensions



Profile of pipeline

Figure B-5.4.2 Example map and location/detail drawing.

B-5.6 Variations in Dry Fire Hydrant Design. There are numerous adaptations to the basic design of a dry fire hydrant. These have been developed to overcome local or regional problems and can have applications over a large geographical area. [*See Figures B-5.6(a) and (b).*]

Figure B-5.6(a) A dry fire hydrant innovation has eliminated the top 90-degree or 45-degree elbow on each hydrant. (*Photo by Nahunta Volunteer Fire Department, NC*)

Figure B-5.6(b) Hard suction hose is connected to the pumper. The driver maneuvers the truck as the fire fighter walks the suction end of the hose to the dry fire 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 fire 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 fire 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-5.6(c).*]

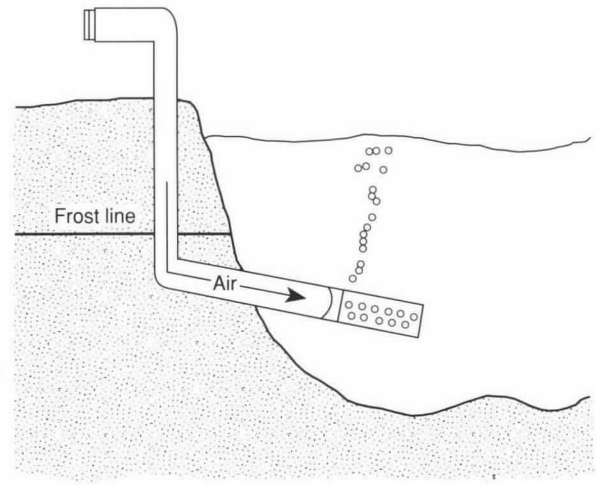


Figure B-5.6(c) Air injection frost-proofing system (developed by Wascott Volunteer Fire Department, WI).

Install an air pressure gauge and air chuck in the cap of the hydrant by drilling and tapping into the metal. The chain for the hydrant cap will have to be removed. Use Teflon® tape on the threads of the gauge and chuck. This method has the advantage that if the chuck or gauge is damaged, it will not effect the airtight integrity of the hydrant while drafting, because the cap is removed. [*See Figure B-5.6(d).*]

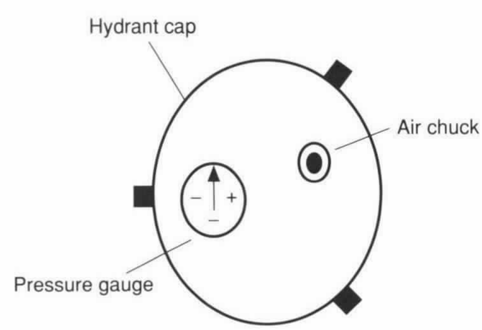


Figure B-5.6(d) Cap design for air injection system.

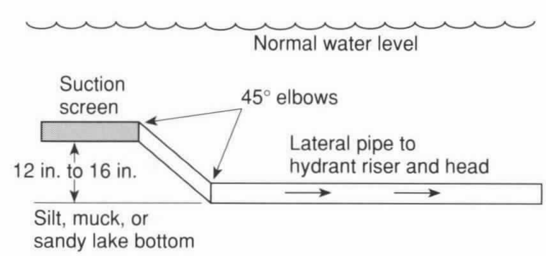


Figure B-5.6(e) Offset screen installation (developed by Weyerhaeuser Volunteer Fire Department, WI).

B-6 Access to Water Supplies.

B-6.1 General. 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. Each site should be evaluated by the WSO to determine the best way, within the fire department's means, for using the water supply.

B-6.2 Roadway Access. 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 B-6.2 details considerations that should be kept in mind when planning access.

Table B-6.2 Recommendations for Roads to Water Supplies

Width:	Roadbed — 12 ft (3.7 m) Tread — 8 ft (2.4 m) Shoulders — 2 ft (0.6 m)
Alignment:	Radium 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 watertable 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 should be 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.

B-6.2.1 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.

B-6.2.2 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.

B-6.3 Dry Fire Hydrant with Suction Line. In some cases, it may be desirable to install a dry fire 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 in Table B-6.2 can be useful in the design of such an area so that pumpers can be used efficiently and safely.

B-7 Bridges.

B-7.1 General. 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.

The condition of the nation's bridges was brought to the public's attention in the late 1960s, when the collapse of a large bridge received headline reporting from the news services. Furthermore, it became evident that many of the states did not provide complete bridge inspection and maintenance programs.

B-7.1.1 Federal Legislation. As a result of this bridge failure, the Federal Highway Act of 1968 was passed, which required, among other things, that all states, counties, and cities receiving federal highway funding implement a program to inspect each bridge in the federally funded system every two years. Additional bridge collapses prompted amendment of this law in 1976 to include all bridges on the public roads system.

B-7.1.2 Bridge Inspection Programs. 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.

B-7.1.3 Repair Programs. Highway departments are doing what is possible with the money available to improve bridge safety. Priority is given to bridge upkeep on primary roads, with bridges on less-traveled roads having to take what is left. Some highway departments are upgrading or raising the tonnage on their bridges as much as possible through repairs; however, many cannot be brought up to standard without complete rebuilding. Most states do not have money available for such an overhaul program.

In some states, the state highway department has consulted fire officials, explained the situation, and required that the fire department list the unsafe bridges in order of their importance to the fire service. The highway departments then attempt to upgrade these bridges on the basis of fire department priority.

B-7.1.4 Effect on the Fire Service. The long-range nature of the bridge problem makes it a matter for serious consideration when planning purchases of apparatus. Mobile water supply size must be restricted to volumes that will not cause overloading.

Whether or not a fire service 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.

B-7.1.5 Fire Department Responsibility. The fire department should check every bridge in its response districts, both primary response and mutual aid, to ensure that all bridges will safely carry the fire department load. This might not be the overwhelming task it appears. In view of the current use of computers by state highway departments to inventory their bridges, load limits should be readily available.

The fire department will need to make whatever special provision is indicated to protect an accessible area by an unsafe bridge. For example, providing temporary station-to-house equipment in the isolated area, using a pumper taking suction from the river to pump water across the bridge through large hose lines, or servicing the area from another station that has a safe bridge to the area or, even better, does not have to use a bridge to respond.

B-8 Preplanning Water Supply.

B-8.1 Preplanning. Structures within the district of responsibility of the fire department should be surveyed in accordance with Chapter 2. 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, since 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 section.

Appendix C Water Hauling

This Appendix is not a part of the requirements of this NFPA document, but is included for information purposes only.

C-1 Moving Water by Mobile Water Supply.

C-1.1 General. The fire service has always experienced fire control difficulties in isolated areas. The difficulties have been many and varied, but one of the big factors is the lack of an adequate water supply. An adequate amount of water for control and extinguishment is a major consideration of most rural fire chiefs and influences the majority of their fire fighting decisions. A portion of the training of the 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. Therefore, this appendix 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 fire hydrant, a lake, a cistern, a swimming pool, etc., some means must be provided for transporting the water from the supply to the fire. Most fire departments use a fire department pumper having a pump capacity of 750 gpm (2842 L/min) or more and having a minimum 500-gal (1895-L) tank.

As this vehicle is always assigned to the supply, some departments provide it with little equipment beyond the pumps, the necessary hose for loading, and some preconnected hand lines.

Several departments report that they have developed water supplies where the pumper is actually driven into shallow water at the water supply. 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 that will carry water and have exercised a great deal of ingenuity to make it work. 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- to 1500-gal (3785- to 5678-L) range. Significant progress has been made in such mobile water supply apparatus techniques as loading, unloading, and 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 big asset to a department having a weak municipal-type water system. While specially built and designed mobile water supply apparatus are ideal, many fire chiefs are facing fires without adequate standard equipment. Since 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, utmost care should be exercised to consider safety and serviceability of the equipment as well as the safety of the membership 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 baffling of tank and center of gravity, are just as important as the engine, axles, and other drive line components and should not be overlooked.

Some fire departments, where their pumpers are 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. In the purchase or construction of a mobile water supply apparatus, it is necessary that careful attention be given to ensure that engine, chassis, baffling, center of gravity, and brakes of adequate specifications are obtained. NFPA 1903, *Standard for Mobile Water Supply Fire Apparatus*, covers mobile water supply apparatus, and it is suggested 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 to 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.

Terrain to be traveled, weather to be encountered, and bridge and road conditions should be considered in buying or building safe mobile water supply apparatus.

It is suggested that, for a mobile water supply apparatus with a capacity greater than 1,500 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 a dangerous vehicle could result from assembly. Safe, reliable equipment that at least meets the minimum standards is a must.

It is further recommended that the maximum water tank capacity for mobile water supply apparatus should not exceed 4,800 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.

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 published by the tire manufacturer's rating, when apparatus is loaded. Compliance should be determined by weighing of the loaded apparatus.

C-1.3 State Regulations.

Regardless of rear axle configuration, definite consideration should be given to the state legal weight per axle requirement. All states have single-axle weight limits, which are imposed solely due to road surface conditions and longevity of highways. Although axles are designed to carry their rated weight, and vehicle and fire department planners can specify precise chassis requirements to fall within the safe tolerances of total vehicle operation and weight, this still does not legally permit the fire apparatus to exceed the state's legal weight rating per axle. Since some single-axle weight ratings are 26,000 lb (11,778 kg), the consideration and attention paid to state single-axle weight limits can become quite 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, etc., 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 road-safe chassis.

C-1.4 Mobile Water Supply. In general terms, mobile water supply vehicles are units made for specific water-hauling requirements. In some wildland areas, where fire fighting is 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, terrain and bridge and road weight restrictions limit the capacity of mobile water supplies to the 1,000-gal to 1,500-gal (3785-L to 5678-L) range. (*See B-7.1.*) However, the department operating mobile water supplies with capacities of 1,000 gal (3785 L) or more will normally find it easy to meet minimum water requirements outlined in this standard where water supplies are readily available.

It is desirable to have 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. Some consider the age-old problem associated with tank baffles or swash partitions as 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. Therefore, careful consideration should be given to baffles by the designers and builders of the 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 1600-Gallon Mobile Water Supply (Tanker) Gravity Flows

Outlet in Inches	Discharge Time in Minutes
$2\frac{1}{2}$ (65 mm)	20
$4\frac{1}{2}$ (11.4 cm)	7
6 (15.2 cm)	5
10 (20.0 cm)	$1\frac{2}{3}$
12 (30.5 cm)	$1\frac{1}{2}$

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. There must be adequate provision for air to be driven from the tank when it is being filled with water and for air to enter the tank when that tank is being emptied. It is recommended that, as a minimum, the vent opening should be four times the cross-sectional area of the inlet. Inadequate venting can result in the tank being bowed outward when it is being filled rapidly, or in impairing the discharge flow when emptying.

An 8 in. × 8 in. (20.3 cm × 20.3 cm) vent extending approximately 12 in. (30.1 cm) high is an adequate vent size. Also, a 3-in. (76-mm) overflow pipe is suggested in NFPA 1903, *Standard for Mobile Water Supply Fire Apparatus*. This overflow pipe located in the vent pipe area has worked very well for a number of departments to provide an important 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, this can be a major limitation of efficiency.

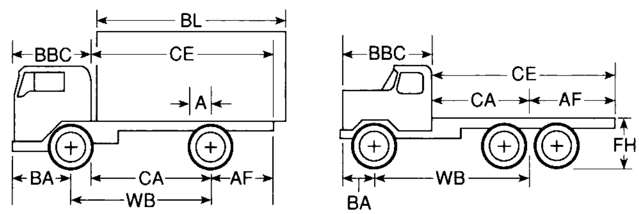
Of major concern, in a water-hauling system involving mobile water supply apparatus, is the fact that the mobile water supply might not be completely filled at the source of water or water supply or completely emptied at the fire. Some mobile water supplies are so designed that as little as 10 gal (38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

Applicable NFPA standards such as NFPA 1903, *Standard for Mobile Water Supply 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 fill pumper and the mobile water supply. If this is the case, considerable time can be saved by using either a quarter-turn coupling, or some type of flexible hose with a quick discharge, 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 and should be properly designed into the unit and then verified by actual weighing of each axle. Only a slight change in the load carried or the distribution of the load might 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 as to data necessary to figure accurate weight distribution and how to use this data to make the weight distribution calculation.



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 = Center of rear axle to end of frame
FH = Frame height
BL = Body length
FA = Front axle weight
RA = Rear axle weight
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 centerline of front and rear axle or tandem suspension.

Terms:

Chasis — Basic vehicle cab, frame, and running gear
Curb Weight — Weight of chassis only

Gross Vehicle Weight Rating (GVWR) — Total of curb, body, and payload weight

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

$$\frac{(B + PL)\,A}{WB} = FA \text{ (Front Axle Weight)}$$

$$(B + PL) - FA = RA \text{ (Rear Axle Weight)}$$

Figure C-1.7 Weight distribution for mobile water supplies.

Data required pertains to "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 in using a new chassis, this data 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 such standard factory-provided data, and it is consequently preferable to weigh the chassis upon starting construction planning.

Dimensional data is easily obtained by use of a tape measure or carpenter's ruler. Again, it 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 a combination of the steel and other materials used in the body, the water in the tank itself, and the components added to that basic list. These include such items as any reels, hose, or miscellaneous equipment planned. While 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 appendix 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 chassis and the weight placed on that 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 those 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. Since 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. (30.1-cm) quick dump or 6-in. (15.2-cm) jet dumps might actually move more water to the fire location than longer wheelbase tractor trailers and dual tandem axle mobiles water supply apparatus.

C-1.9 Nonwater Mobile Water Supply Modification. Special care should be used when modifying a mobile water supply built for one purpose to be used for another purpose, such as the prevalent practice of adapting an oil tanker 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 may exceed the manufacturer's permissible gross vehicle weight limits. For this reason, it might be prudent to reduce the tank's size to avoid undesirable effects on weight distribution. However, in doing so, special attention should be paid to the problem of altering the center of gravity, which makes the vehicle's cornering characteristics more hazardous.

Special attention should be paid to the baffling of such 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 considerations:

A stainless steel milk tanker might be made out of very light gauge metal with no baffling and be difficult to baffle crosswise and lengthwise.

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.

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.

There is an inherent danger in modifying gasoline tankers — that of an explosion. All gasoline tanks should be thoroughly steam-cleaned before modifications requiring welding are undertaken.

Gasoline and milk tankers are usually designed to be filled with the product each morning for distribution of that product during the day under normal traffic conditions rather than emergency conditions, as is the case with fire equipment. It is not necessary for an oil tanker or milk tanker to stand in the station fully loaded day after day.

Weights of Various Fluids

Milk — 8.5 lbs/gal

Water — 8.3 lbs/gal

Gasoline — 6.2 lbs/gal

For SI units: 1 lb = 0.454 kg; 1 gal = 3.785 L.

C-1.10 Driver Training. An important consideration frequently overlooked by the rural fire department is that of driver training. There are few people trained to drive a tractor-trailer combination under emergency conditions, and the fire department planning to use one should be trained. Even a 2- or 3-axle vehicle used as a mobile water supply will probably have driving characteristics highly unlike other apparatus, and driver training is a must. Individual state operator licensing requirements should be met.

C-1.11 Calculating Water-Carrying Potential. Two primary factors to be considered in the development of tank water supplies are: (1) the amount of water carried on initial responding units and (2) the amount that can be continuously delivered thereafter.

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. This 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.

An appropriate formula to calculate the maximum continuous flow capability at the fire scene is:

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

Where:

Q = Maximum continuous flow capability in gallons per minute (L/min);

V = Mobile water supply capacity in gallons (L);

A = Time in minutes (for the mobile water supplies) to drive 200 ft (61 m), dump water into a drop tanks, and return 200 ft (61 m) to starting point;

T_1 = Time in minutes (for the mobile water supply) to travel from fire to water source, calculated by the formula $T_1 = 0.65 + XD_1$ [*see Table C-1.11(b)*];

T_2 = Time in minutes for the same mobile water supply to travel from water source back to fire, calculated by the formula $T_2 = 0.65 + XD_2$ [*see Table C-1.11(b)*];

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;

-10% = Amount of water supply (mobile water supply capacity) considered not available 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), as this is calculated using the following equation:

$$T = 0.65 + XD$$

Where:

T = Time in minutes of average one-way trip travel

D = One-way distance.

Where an apparatus is equipped with an adequate engine, chassis, baffling, and brakes, a safe constant speed of 35 mph (56.3 kph) 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 kph).

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

NOTE: The factor 0.65 represents an acceleration/deceleration factor constant developed by the Rand Corp.

Precalculated values of "X" using various speeds in mph have been inserted into the above formula, (T = 0.65 + XD) as follows:

Table C-1.11(a)

T = 0.65 + 1.7 D	Constant Speed of 35 mph
T = 0.65 + 2.0 D	Constant Speed of 30 mph
T = 0.65 + 2.4 D	Constant Speed of 25 mph
T = 0.65 + 3.0 D	Constant Speed of 20 mph
T = 0.65 + 4.0 D	Constant Speed of 15 mph

For SI units: 1 mph = 1.609 km/hr.

Table C-1.11(b) Time Distance Table Using an Average Safe Constant Speed of 35 mph, T = 0.65 + 1.70 D

Distance (Miles)	Time (Minutes)	Distance (Miles)	Time (Minutes)	Distance (Miles)	Time (Minutes)	Distance (Miles)	Time (Minutes)
0	0						
0.1	0.82	2.6	5.07	5.1	9.32	7.6	13.57
0.2	0.99	2.7	5.24	5.2	9.49	7.7	13.74
0.3	1.16	2.8	5.41	5.3	9.66	7.8	13.91
0.4	1.33	2.9	5.58	5.4	9.83	7.9	14.08
0.5	1.50	3.0	5.75	5.5	10.00	8.0	14.25
0.6	1.67	3.1	5.92	5.6	10.17	8.1	14.42
0.7	1.84	3.2	6.09	5.7	10.34	8.2	14.59
0.8	2.01	3.3	6.26	5.8	10.51	8.3	14.76
0.9	2.18	3.4	6.43	5.9	10.68	8.4	14.93
1.0	2.35	3.5	6.60	6.0	10.85	8.5	15.10
1.1	2.52	3.6	6.77	6.1	11.02	8.6	15.27
1.2	2.69	3.7	6.94	6.2	11.19	8.7	15.44
1.3	2.86	3.8	7.11	6.3	11.36	8.8	15.61
1.4	3.03	3.9	7.28	6.4	11.53	8.9	15.78
1.5	3.20	4.0	7.45	6.5	11.70	9.0	15.95
1.6	3.37	4.1	7.62	6.6	11.87	9.1	16.12
1.7	3.54	4.2	7.79	6.7	12.04	9.2	16.29
1.8	3.71	4.3	7.96	6.8	12.21	9.3	16.46
1.9	3.88	4.4	8.13	6.9	12.38	9.4	16.63
2.0	4.05	4.5	8.30	7.0	12.55	9.5	16.80
2.1	4.22	4.6	8.47	7.1	12.72	9.6	16.97
2.2	4.39	4.7	8.64	7.2	12.89	9.7	17.14
2.3	4.56	4.8	8.81	7.3	13.06	9.8	17.31
2.4	4.73	4.9	8.98	7.4	13.23	9.9	17.48
2.5	4.90	5.0	9.15	7.5	13.40	10.0	17.65

For SI units: 1 mile = 1.609 km.

These formulas make it possible to plan water availability at any point in an area. As an example of how to calculate the water available from a supply where the water must 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 mobile water supply load of 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 miles (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, 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 average mobile water supply speed going from the fire to the water source is 35 mph (56.3 kph).

Therefore:

$T = 0.65 + XD_1$
$X = 1.7$
$D_1 = 2.10$ miles

At a constant speed of 35 mph:

$T_1 = 0.65 + 1.7\ D_1$
$T_1 = 0.65 + 1.7 \times 2.10$
$T_1 = 0.65 + 3.57$
$T_1 = 4.22$ minutes

[*Also see Table C-1.11(b).*]

At a constant speed of 35 mph (56.3 kph), a mobile water supply traveling 2.1 miles (3.4 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 kph).

Therefore:

$T = 0.65 + XD_2$
At 30 mph:
$X = 2.0$
$D_2 = 1.80$ miles
$T_2 = 0.65 + 2.0\ D_2$
$T_2 = 0.65 + 2.0 \times 1.8$
$T_2 = 0.65 + 3.60$
$T_2 = 4.25$ minutes

Substituting in the formulas

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

Where:

Q = Maximum continuous flow capability in gpm with V = 1500
A = 3.0
T_1 = 4.22
T_2 = 4.25
B = 4.0

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

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

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

Q = 97 - 10% = 87 gpm maximum continuous flow capacity available from this 1500-gal mobile water supply.

For SI units: 1 mile = 1.609 km.

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

(a) Increase the capacity of the mobile water supply

(b) Reduce the fill time

(c) Develop and provide additional fill points, thus reducing travel time

(d) 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 capacity of a mobile water supply is to reduce the distance between the source and the building or fire. This can be accomplished by increasing the number of water supplies and/or the drafting points. (*See Figure C-1.11.*)

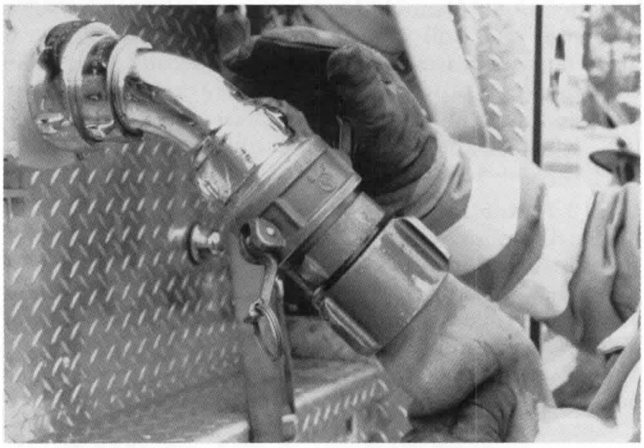


Figure C-1.11 One way to increase water-hauling capacity is to reduce the fill time of the mobile water supply. Here is one type of quick coupling that can help to reduce the fill time.

C-1.12 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 protocols adapted. 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 type of operation. An increasing number of fire departments are incorporating the use of large dump valves or jet-assisted dump arrangements. To decide 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 most significant 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 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.

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. (25.4 cm), 12 in. (30.1 cm), or larger are often used. It should be remembered that 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, actual 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. (15.2-cm) discharge piping and valve. Pumps supplying such jet arrangements should be capable of delivering a minimum of 250 gpm (946 L/min) at 150 psig (1034 kPag). However, some departments have obtained good results with pumps that deliver flows at less than 150 psig (1034 kPag) 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-Assist 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 150 psig (1034 kPag). Nozzle jets range in size from 3/4 in. to 1 1/4 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.

The installation of a jet dump requires answers to several important questions. In what location will the dump prove to be most useful, the side or the back? Will the fixed piping need to be 1 1/2 in. (38 mm) in diameter or 2 in. (51 mm) in diameter? What is the preferable location for the jet, in-line or at the rear of the tank? The answers to these and other questions should be resolved before construction begins.

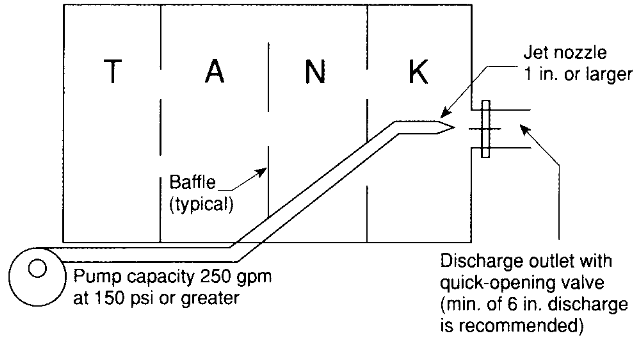


Figure C-1.12.3(a) Traditional internal jet dump.

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.

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. (10.2 cm to 30.1 cm). Normally, a 6-in. or 8-in. (15.2-cm or 20.3-cm) 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. (15.2 cm) 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 1 1/2-in. (38-mm) hose is attached to the female coupling on the jet device. The length of the added dump piping can be anywhere from 2 ft to 4 ft (0.6 m to 1.2 m), depending on whether or not a flexible tube is utilized during the dump process.

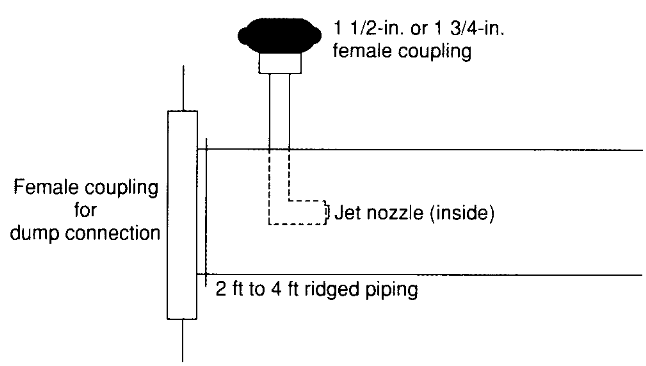


Figure C-1.12.3(b) Traditional external jet dump.

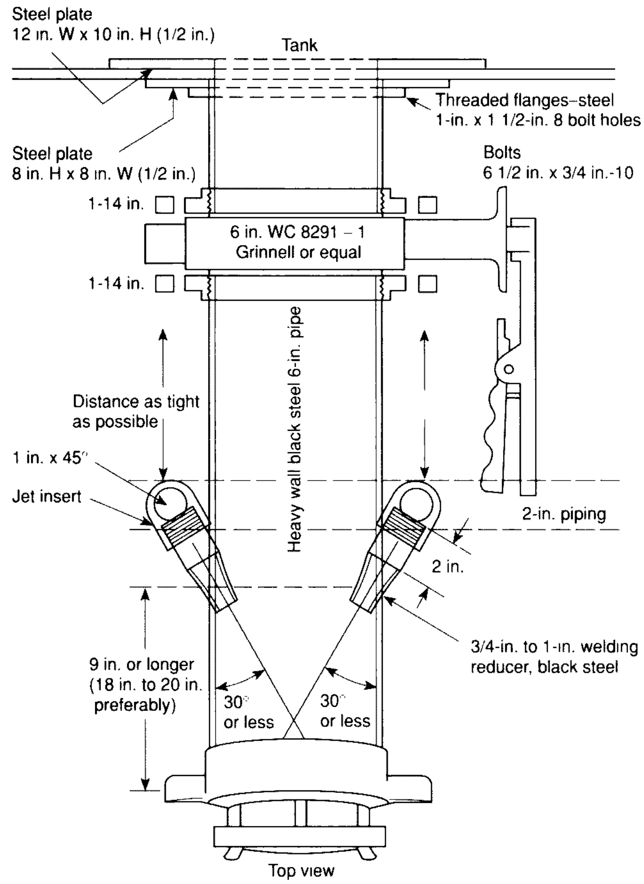
To properly operate, a jet should be able to produce between 50 psig and 150 psig (345 kPag and 1034 kPag) pressure. Higher pressures normally increase operational effectiveness. The diameter of the jet selected should be appropriate for the capacity and pressure capabilities of the pump being utilized. 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 in terms of system maintenance. Disadvantages might include the need to provide for adequate air exchange during water flow, more time for the initial setup to affix appliances, the restriction of movement around the vehicle, and the general appearance of such extensions.

C-1.12.4 Peripheral Jet-Assist Arrangement. The peripheral application of jet-assist nozzles has proved highly effective. This approach 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 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 3/4-in. (19-mm) nozzles in a 6-in. (15.2-cm) dump valve configuration. Figures C-1.12.4(a) and C-1.12.4(b) represent a typical installation.

C-1.12.5 Other Jet-Assist Devices. Innovative fire organizations have put syphons and jet-related devices to good use. Some syphons use only water level differential to transfer water from one tank to another. Normally constructed of PVC pipe, such syphons 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, 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 syphon transfer piping using a jet was developed and has proved useful to many departments. Although 4-in. (10.2-cm) PVC and aluminum piping have been used for such devices, 6-in. (15.2-cm) units usually are more practical. Using a 1/2-in. (13-mm) jet nozzle supplied by a 1 1/2-in. (38-mm) hose makes possible transfer flows of 500 gpm (1900 L/min). Some departments merely add the jet to a length of suction. [*See Figures C-1.12.5(a) and C-1.12.5(b).*]

Syphons are commercially available that use the jet principle and are, in some cases, supplied by 2 1/2-in. (64-mm) hose. These devices are used to remove water from basement areas or increase 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 1 1/2-in., 1 3/4-in., or 2 1/2-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



NOTE: 6-in. (15.2-cm) NST, 6-in. (15.2-cm) Stortz, or 6-in. (15.2-cm) Bell cap with quick-lock lugs or other quick-connect coupling recommended.

Figure C-1.12.4(a) Peripheral jet-assist installation.

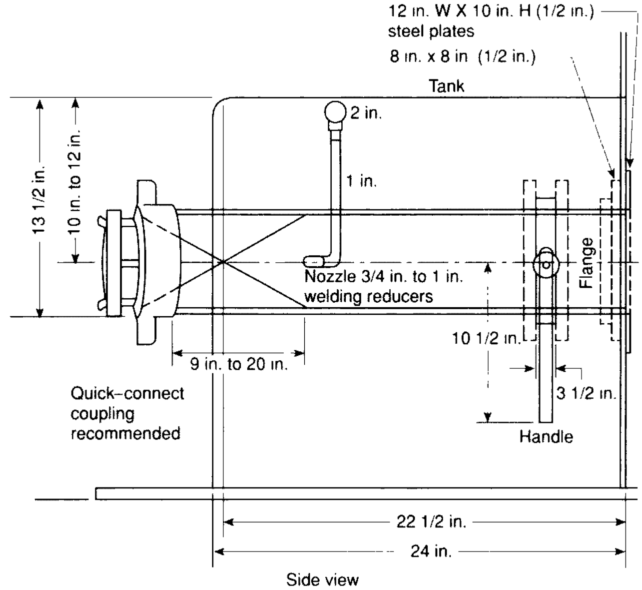


Figure C-1.12.4(b) Peripheral jet-assist installation.

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. (10.2-cm or 15.2-cm) lightweight pipe. This supply piping concept is used to fill mobile water supply apparatus through their discharge gates or via top loading or large inlets capable of filling mobile water supply apparatus at the rate of 1000 gpm (3785 L/min) or greater.

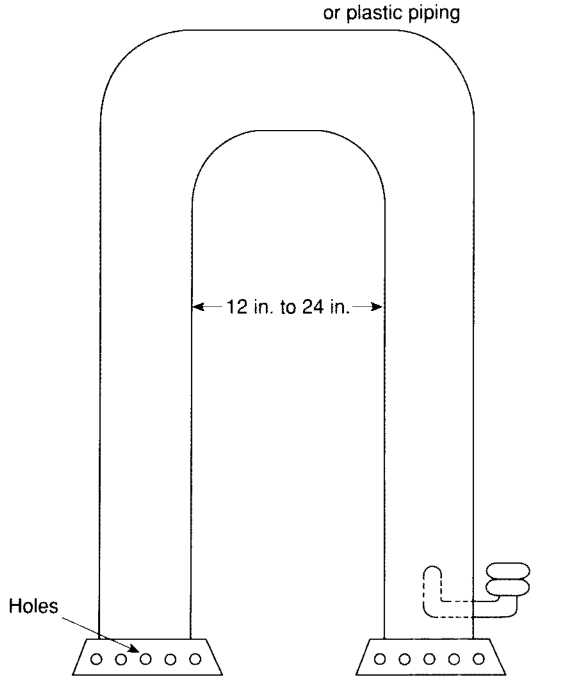


Figure C-1.12.5(a) Jet-assisted transfer syphon.

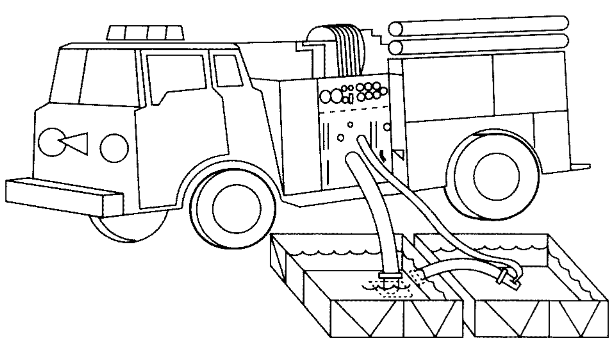


Figure C-1.12.5(b) Modified hard suction jet syphon.

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 have been suggested and should be accomplished as follows:*

(a) Weigh the mobile water supply without any water on board.

(b) Again weigh the mobile water supply when it has been completely filled with water.

(c) Using only gravity, off-load the mobile water supply for 1 minute.

(d) Reweigh the mobile water supply and determine the gal (L) off-loaded by gravity.

(e) Again refill the mobile water supply and weigh it.

(f) Off-load the mobile water supply for 1 minute using the jet arrangement.

(g) Reweigh the mobile water supply and determine the gal (L) off-loaded via the jet.

(h) Make a comparison of the gal (L) used by gravity and those depleted using the jet.

(i) Once again, fill the mobile water supply and weigh it.

(j) For 1 minute, off-load the mobile water supply by opening the gravity dump and pumping through a $2^1/_2$-in. (64-mm) discharge.

(k) After weighing the mobile water supply, determine the number of gal (L) 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. There are, generally, three types of drop tanks: (1) the self-supporting tank, (2) the fold-out frame tank, and (3) a 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-type 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 and/or outlet built into the side of the tank. 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 as the more popular. The addition of the drop tank for "stockpiling" water has yielded highly desirable results. This stockpiling allows for the continuous operation of low-volume supplies and creates a source from which a pumper can draft for supplying hose lines in a direct fire attack. [*See Figures C-1.13(a) and (b).*]

*General procedure referenced from Larry Davis, *Rural Firefighting Operations Book II*, Chapter 15, page 342, IFSFI, Ashland, MA, 1986.

Figure C-1.13(a) Portable drop tanks should be simple to set up. Note the portable tank compartment (door open) on the mobile water supply. (*Photo by Nahunta Volunteer Fire Department, NC*)

Figure C-1.13(b) 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.

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 outline 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, etc. (*See Chapter 5.*) 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. (12.7-cm or 15.2-cm) discharge pipe, or a large 12-in. (30.5-cm) 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. 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 responded to the water supply, connected to the water supply, and primed its pump. When the empty mobile water supply arrives at the water supply, the pumper is ready to fill the mobile water supply. The refilled mobile water supply returns to the fire site, discharges its water, and the cycle is repeated. It is suggested that it is more efficient to fill one mobile water supply at a time rather than to fill two or more mobile water supply apparatus at a slower rate. Also, if all mobile water supply apparatus in the department have the same capacity, they will not "stack up" at the source of supply or the fire while waiting for a large mobile water supply 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.

Figure C-1.14 The aluminum irrigation discharge pipe, in the shape of an "L," allows discharge from either side or rear of the mobile water supply. Four hard suction hose lines are used to minimize any clogging of the strainers.

It is possible that local fire departments will be unable to accommodate the demands of the initial alarm response to certain occupancies that require a large volume of water, based on the study producing the water flow requirements. Automatic aid pumpers and mobile water supply apparatus can be set up to run automatically on first alarm, thereby conserving valuable time and delivering fire flows calculated in Chapter 5.

It is desirable that each mobile water supply 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 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. Since 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. The need for fire fighting foams occurs 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, 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 298, Foam Chemicals for Wildland Fire Control.*)

Class B foam is designed for fighting fires involving flammable or combustible liquids where foam becomes 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 and Combined Agent Systems.*)

The appropriate listings on the label should be consulted to determine proper application rates and methods. If there are no listings for application rates and methods, do not assume any. However, the word "foam" appears in the usage of wetting agent instructions as well as in 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 have occurred if the additive had not been used. Visual inspection should be made during wet water operations.

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 run-off is decreased.

Wetting agents are broadly defined as being surfactants (surface acting agents). All wetting agents are concentrated and are mixed with a liquid at varying percentages. The wetting agent can be liquid or powder. The liquid into which it is mixed for fire fighting purposes is water. However, the primary sales for some wetting agents are for use as a carrier for liquid fertilizers, fungicides, insecticides, and herbicides. These wetting agents can be, and are, used for fire fighting purposes. They don't have additives that will protect tanks, pumps, valves, and bushings, etc., and it is recommended that unused mixtures be drained out of the tank and a flush of all parts be made with plain water. With all wetting agents, hard water usually does require 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.

Wetting agents are available in both liquid and powder form. Both forms result in the same extinguishment characteristics.

The use of wetting agents is as a soaking or penetrating agent for wildland fuels, sawdust, cotton (bales, bedding, upholstery), rags, paper, etc. These agents are used very effectively on smoldering or glowing combustibles. All of the commercially available products that fall into the above category will satisfactorily suppress Class A fires.

Many of the wet water additive products have instructions that make note of the production of a foam material through increasing the amount of the product.

No additional equipment is needed for the production of this foam. Caution should be exercised, as well as actual on-site testing 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 above, 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 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.

Appendix D Large Diameter Hose

This Appendix is not a part of the requirements of this NFPA document, but is included for information 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 that with an inside diameter of 3½ in. (89 mm) or larger.

D-1.2 Characteristics. Large diameter hose is available in either single- or double-jacketed construction, generally in the following sizes: 3½ in. (89 mm), 4 in. (10.2 cm), 4½ in. (11.4 cm), 5 in. (12.7 cm), and 6 in. (15.2 cm). The lower friction loss characteristics of such hose increases the usable distance between water source and 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 increased size, its lower friction loss, and the relationship of these factors. They can be explained by studying the carrying capacities and friction loss factors shown in Tables D-1.3(a) and D-1.3(b).

D-1.3 Carrying Capacity of Large Diameter Hose. Tables D-1.3(a) and D-1.3(b) show, for example, that one 5-in. (12.7-cm) hose line delivers a volume of water approximately equivalent to six 2½-in. (64-mm) lines or four 3-in. (76-mm) lines at a given pressure and distance. [To use Table D-1.3(a) to obtain these numbers, read horizontally from the 5-in. (12.7-cm) hose column on the far left. Thus, the table shows one 5-in. (12.7-cm) length of hose to have 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, etc.]

D-1.3.1 Selecting Large 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. To assist in hose selection, Table D-1.3.1 can be helpful. The table is designed to be used primarily in relaying water with pumps discharging at 150 psig (1034 kPag) and at 20 psig (138 kPag) residual pressure at the point receiving the flow.

Table D-1.3(a) Relative Carrying Capacity of Fire Hose in Hose Lengths

	2½ in.	3 in.	3½ in.	4 in.	4½ in.	5 in.	6 in.
2½ in.	1	0.617	0.413	0.29	0.213	0.161	0.1
3 in.	1.62	1	0.667	0.469	0.345	0.261	0.162
3½ in.	2.42	1.5	1	0.704	0.515	0.391	0.243
4 in.	3.44	2.13	1.42	1	0.735	0.556	0.345
4½ in.	4.69	2.90	1.94	1.36	1	0.758	0.469
5 in.	6.20	3.83	2.56	1.8	1.32	1	0.619
6 in.	10	6.19	4.12	2.9	2.13	1.61	1

This table shows the relative carrying capacities of hose, 2½ in. (65 mm) to 6 in. (152 mm) in diameter for the same friction loss. The values in the table are based on the Hazen-Williams equation.
For SI units: 1 in. = 25.4 mm.

Table D-1.3(b) Approximate Friction Losses in Fire Hose (psig per 100 feet)

Internal diameter of hose	2½ in.	3 in.	3½ in.	4 in.	5 in.	6 in.
Flow in gpm:						
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
2000	—	—	—	70	25	10

For SI units: 1 in. = 25.4 mm; 1 gpm = 3.785 L/min; 1 psig = 0.0689 bar (g).

Table D-1.3.1 Distance in Feet that a Given Size Hose Can Deliver a Quantity of Water

GPM Discharge at 150 psig Pump Pressure

Hose Size Inches	250 gpm	500 gpm	750 gpm	1000 gpm	1500 gpm	2000 gpm
2½	866 ft	236 ft				
3	2166 ft	520 ft	288 ft	168 ft		
3½	6500 ft	1300 ft	650 ft	361 ft	158 ft	
4		2600 ft	1181 ft	684 ft	325 ft	185 ft
5		6500 ft	3250 ft	2166 ft	928 ft	520 ft
6			8666 ft	5200 ft	2166 ft	1300 ft

Example: A 750-gpm fire flow is needed on a fire that is located 6500 ft from the water supply. A pumper rated 750 gpm at 150 psig can relay 750 gpm at 20 psig discharge for a distance of only 650 ft if 3½-in. (89-mm) hose is used or 8666 ft 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.
For SI units: 1 in. = 25.4 mm; 1 gpm = 3.785 L/min; 1 ft = 0.305 m; 1 psig = 0.0689 bar (g).

D-1.4 Load Capacity. Another important item to consider is hose load capacity. Most large diameter hose is of a lightweight design, which results in a coupled 100-ft (30.5-m) length of 5-in. (12.7-cm) hose weighing approximately 105 lb (48 kg) — little heavier than a length of 100 ft (30.5 m) 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 the large diameter hose with one engine speeds up the operation that would otherwise involve multiple smaller lines with additional pumpers, personnel, and equipment to accomplish the same job.

D-1.5 Large Cities Using 5-in. (12.7-cm) Hose. 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 throughout the U.S. now employ large 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 miles (3.2 km) of 5-in. (12.7-cm) hose for this purpose. While the large diameter hose is being laid, the initial fire attack is made from hydrants. Where the large 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-1.6 Hose Reels. A number of powered "reel trucks" with various hose load capacities are now in use.

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 minimum personnel (2), and the unit is in service within minutes.

Double reels mounted in the hose bed of a reel truck can produce a carrying capacity of large diameter hose of up to 6000 ft (1829 m). The large diameter hose then becomes over 1 mile (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-1.7 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 (described below) have been developed to be used with large diameter hose.

D-1.7.1 Clappered Siamese with Indicator. (*See Figure D-1.7.1.*) This valve is added to the supply line one length from the hydrant or pumper at draft and allows for the addition of a second pumper without shutting down the flow of water. The indicator shows the position of the single clapper.

D-1.7.2 Line Relay Valve. (*See Figure D-1.7.2.*) Should relay pumping be 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 psig (1034 kPag). 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.

Figure D-1.6(a) Field cleaning large diameter hose.

Figure D-1.6(b) Apparatus with reels for large diameter hose.

Figure D-1.6(c) Many departments have installed large diameter hose with a flat lay in the hose bed.

Figure D-1.6(d) Fire fighters quickly reload 5-in. (12.7 cm) hose as the apparatus straddles the hose. Note that the hose is loaded over the bar between the stanchions.

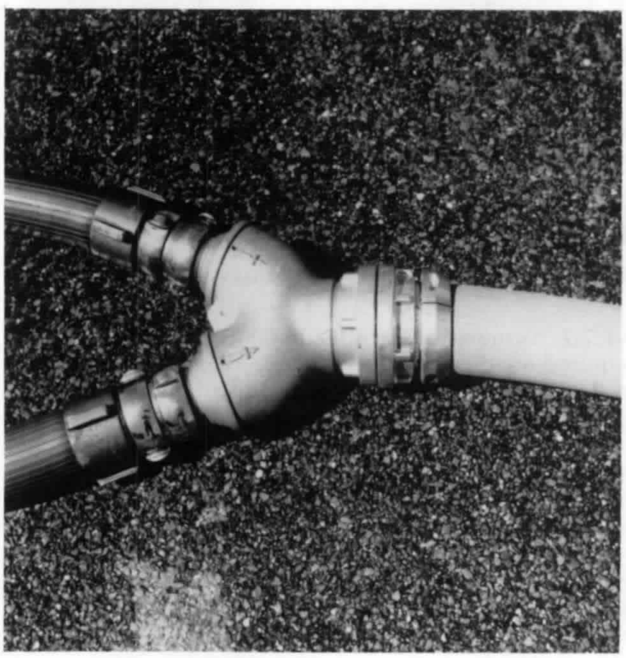


Figure D-1.7.1 Clappered siamese with indicator.

Figure D-1.7.2 Line relay valve.

D-1.7.3 Hydrassist Valve. (*See Figure D-1.7.3.*) This versatile valve 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 lay 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.

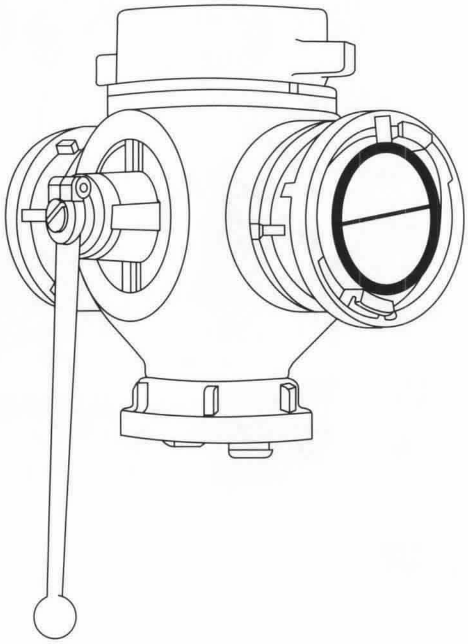


Figure D-1.7.3 Hydrassist valve.

D-1.7.4 Manifold Valve. (*See Figure D-1.7.4.*) This valve contains a 4-in. or 5-in. (10.2-cm or 12.7-cm) inlet and four $2^1/_2$-in. (64-mm) gated, threaded male or female outlets as well as a gated 4-in. or 5-in. (10.2-cm or 12.7-cm) outlet. The manifold is available with relief valve adjustable from 50 psig to 200 psig (345 kPag to 1379 kPag). A pressure gauge is optional. The manifold is portable, allowing the fire department to establish its own portable hydrant.

D-1.7.5 Distributor Valve. (*See Figure D-1.7.5.*) This valve contains a 4-in. (10.2-cm) opening and waterway with two $2^1/_2$-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.

D-1.7.6 Incoming Gated Relief Valve. (*See Figure D-1.7.6.*) This 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 gate valve, an automatic air bleeder, and an adjustable dump valve. The gate 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.

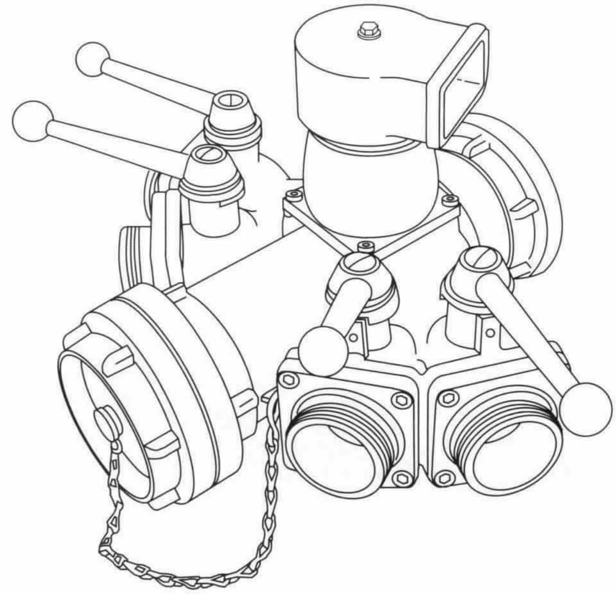


Figure D-1.7.4 Manifold valve.

Figure D-1.7.5 Distributor valve.

D-1.7.7 Automatic Air Bleeder. (*See Figure D-1.7.7.*) Required at all points where a large diameter hose is connected to an engine inlet or at any distribution point.

D-1.8 Irrigation Piping.

D-1.8.1 General. Irrigation piping shares many of its characteristics of low friction loss and capability of transferring large volumes of water with large diameter hose. Irrigation use 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 found on the fireground in farming areas. The fire department should know which of its potential hazards can be served by such a system.

Figure D-1.7.6 Incoming gated relief valve.

Figure D-1.7.7 Automatic air bleeder.

The 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 an area in which piped irrigation systems are used should be alert to the adapters, etc., that might be needed to turn the conventional agricultural fittings into useful fireground fittings. Adapters from the pipe coupling to fire department threads might be required and can be easily fabricated in local machine shops. They are not offered by either pipe or fire hose manufacturers. Minimum requirements are for one supply adapter; for instance, four 2$\frac{1}{2}$-in. (64-mm) NH (American National Fire Hose connection screw thread) thread female inlets × pipe section, and one discharge adapter; or, four 2$\frac{1}{2}$-in. (64-mm) NH thread gated male outlets × pipe section.

Additional fittings to provide discharge gates at 100-ft to 300-ft (30.5-m to 91.4-m) intervals [1 or more 2$\frac{1}{2}$-in. (64-mm) NH × pipe section] might be desirable. In areas where large diameter hose is available, adapters permitting its integration with the pipe are highly recommended.

Appendix E Portable Pumps

This Appendix is not a part of the requirements of this NFPA document, but is included for information purposes only.

E-1 Portable Pumps.

E-1.1 General. Both diesel- and gasoline-driven portable pumps are available. The use of portable pumps is a common method for moving water by the rural fire department. The rural fire fighter should not be required to be a pump expert; however, the fire fighter should have the skill to place all portable pumps used by the department in operation, obtain draft, and perform each procedure in a minimal amount of time.

E-1.1.1 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, available water supplies, and the capabilities of the department to use portable pumps. The accessibility and the reliability of water supplies are determining factors in 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.

Portable pump selection 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 vs. pressure characteristics.

E-1.1.2 Portable Pumps. 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 not weigh more than from 150 lb to 175 lb (68 kg to 79 kg) and should have carrying handles, be so constructed as to be easily carried in a compartment on the apparatus, and be capable of supplying at least two 1$\frac{1}{2}$-in. (38-mm) hand lines. 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 to be a permanent arrangement and plan to buy a fire department pumper, in addition to the portable pump(s), when finances permit.

E-1.2 Classification for Portable Pumps. Portable pumps for the fire service are covered under NFPA 1921, *Standard for Fire Department Portable Pumping Units*, which sets forth specifications to be followed when obtaining portable pumps. This standard classifies portable pumps by capacity and operating pressure.

E-1.2.1 Rating of Portable Pumps.

(a) *Small Volume — Relatively High Pressure.* This pumping unit should be capable of pumping 20 gpm (76 L/min) at 200 psig (1380 kPag) 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 pumps 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 pumping uphill in rugged terrain. Such an arrangement will provide good nozzle reach.

(b) *Medium Volume — Medium Pressure.* This pumping unit shall be capable of discharging 60 gpm (227 L/min) at 90 psig (621 kPag) net pressure and 125 gpm (473 L/min) at 60 psig (414 kPag) 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.

(c) *Large Volume — Relatively Low Pressure.* This pumping unit shall be capable of supplying 125 gpm (473 L/min) at 60 psig (414 kPag) net pressure and 300 gpm (1136 L/min) at 20 psig (138 kPag) 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 pumping unit 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 can result in fire streams of reduced quality and quantity that might not be suitable flows for interior fire fighting.

Among the common types of pumps used are:

E-1.2.2 Gear Pumps. Gear pumps (high pressure, low volume) are of positive displacement type, with gears having very close tolerances between gears and case. They can only be used safely in clear water. Dirty water will cause damage to gears and case. They are not very useful for tank filling or relay work, as they are generally of low capacity in the lighter models.

They 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-1.2.3 Piston Pumps. Piston pumps (high pressure, low volume) are operated by a piston, sleeve, or cylinder with two check valves. They can be either single or double action with one or more cylinders. They are positive displacement type and should be operated with clean water. They are usually high-pressure pumps. Piston-type pumps are limited to small capacities and weigh more than centrifugal or gear pumps. They are capable of very high lift and should be equipped with a relief valve.

E-1.2.4 Low-Pressure Centrifugal Pumps. The 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 psig to 80 psig (345 kPag to 552 kPag). Usually these pumps will not discharge rated capacities when operating with suction lift in excess of 5 ft (1.5 m).

Some of these pumps do not use running rings or seal rings. These types 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 hold up as long when 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 from 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 rpms. (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 the pump will not heat up as rapidly as others if run without water.

E-1.2.5 High-Pressure Centrifugal Pumps. High-pressure 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 psig to 250 psig (862 kPag to 1724 kPag) range.

The impeller is usually geared twice as fast as the engine to get the pressure at single stage. This type uses running rings or seal rings the same as larger fire pumpers and usually incorporates closed volutes in the impeller.

E-1.2.6 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 set inside a float that resists breakage and needs no maintenance. Some entire units weigh under 50 lb (23 kg), including fuel, and provide from 60 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 nozzles and strainers of a pump supplied by the floating pump. (*See Figure E-1.2.6.*)

E-1.2.7 High-Lift Pumps. The high-lift pump is a small, portable pump that uses water to drive a water motor, which in turn drives an impeller and pumps water to high elevations into a fire pumper for relay into hose lines for fire fighting.

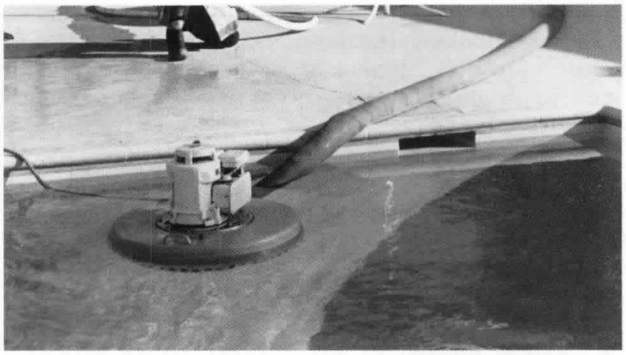


Figure E-1.2.6 Floating 500-gpm (1893 L/min) pump in swimming pool supplying the department pumper through large diameter hose.

The high-lift pump is designed to obtain a water supply from a river, lake, stream, swimming pool, etc., where not accessible by a pumper or 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. This, 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 hose lines.

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

E-1.2.8 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 $1^{1}/_{2}$ 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-1.2.9 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-1.3 Methods of Using Portable Pumps.

E-1.3.1 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 hose lines.

Departments should, when locating pumping sites 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 availability under weather conditions anticipated and, if such conditions can make their use difficult, how to prepare the sites for all-weather utilization.

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, 4-cycle engines are considered more suitable for fire service use, although 2-cycle or the new turbine-driven pumps can be used. However, 4-cycle engines should be used with the engine in a level position or the engine will be damaged, whereas 2-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-1.3.2 Uses of Pumps. Portable pumps can be used in single or multiple combinations to accomplish the following:

(a) Filling truck tanks where no fire pumper is available

(b) Supplying fire fighting hose lines

(c) Relaying water from a source in a variety of combinations or hookups

(d) Dewatering operations

(e) Pump-and-roll operations.

E-1.3.3 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.*)

A few of the ways in which a fire department can make use of portable pumps are:

E-1.3.4 Pumping Directly onto the Fire. The portable pump can be used to pump water into hose lines directly onto a fire. It can be carried to nearby sources of water, e.g., a swimming pool, out of reach of regular fire apparatus. Where these water sources are close to the fire, only small amounts of hose are needed and can be quickly carried into position for rapid attack on the fire.

An effective portable pump for this purpose would need to be of at least a medium-volume type with enough discharge pressure to provide an effective fire fighting stream.

For an example of this type of operation, see Figure E-1.3.4.

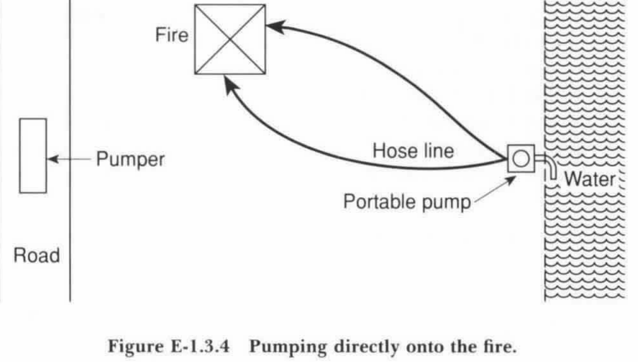


Figure E-1.3.4 Pumping directly onto the fire.

E-1.3.5 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 becomes feasible at a greater distance from water, if large diameter hose is used. (*See Figure E-1.3.5.*)

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

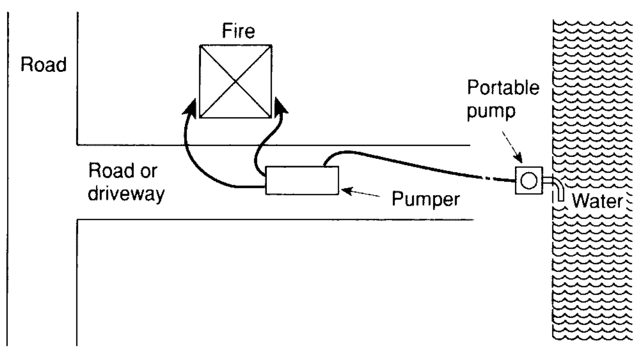


Figure E-1.3.5 Single relay from portable pump to pumper.

E-1.3.6 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. Should the water supply be a stream with a small flow, for instance 150 gpm (568 L/min), or 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.*) (*See Figure E-1.3.6.*)

It is not prudent to put the discharge line from portable pumps into the tops of booster tanks or mobile water supply apparatus unless no other way is possible or a special filling device is provided. Placing lines into 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 for filling mobile water supply apparatus in place of a pumper; 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 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 are suggested. 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.

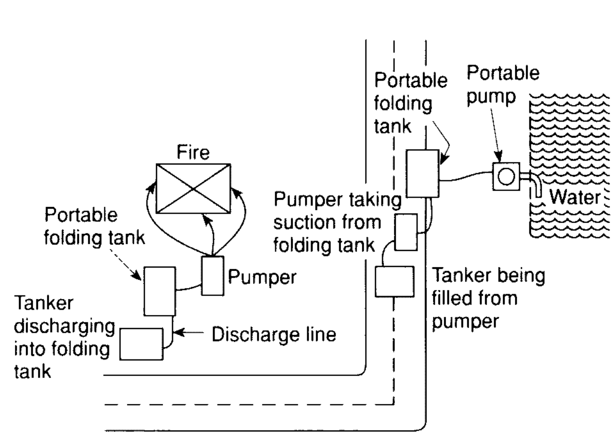


Figure E-1.3.6 Portable pump filling portable folding tank.

E-1.3.7 Fire Fighting from Mobile Water Supply 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. This use 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. Since 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.

E-1.3.8 Summary of Portable Pump Evolutions. There are many factors to consider in deciding what 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.

Appendix F Automatic Sprinkler Protection

This Appendix is not a part of the requirements of this NFPA document, but is included for information purposes only.

F-1 Automatic Sprinkler Protection.

F-1.1 Sprinkler Protection of Rural Buildings.

F-1.1.1 General. 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 hose line 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 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 heads. In the 3 to 4 percent with unsatisfactory performance, the following human failures have been noted:

(a) Sprinkler system was shut off and not in service.

(b) Fire department shut off water to sprinkler heads before fire was completely extinguished.

(c) Fire department robbed sprinkler system of water supply.

(d) Fire department did not use fire department connection.

(e) Sprinkler system was not designed to protect existing contents or occupants.

F-2 Water Supply for Automatic Sprinkler System.

F-2.1 Sprinklered Building — Possible Water Source. 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 make contact with the property owner for permission to use the water supply in the elevated tank in 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 that extends into the tank and allows 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 for a rural fire department.

F-3 Supervision for Sprinkler System.

F-3.1 In rural areas where sprinklered properties are isolated with a good possibility that the outside sprinkler alarm will not be heard in case of fire, it is desirable that automatic sprinkler systems be fully supervised by either a competent guard on 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 on Guard Service in Fire Loss Prevention*.

F-3.1.2 It is desirable that the alarm system include supervision of sprinkler water flow, sprinkler control valve tamper, building temperature, low air pressure on dry sprinkler systems, fire pump operation, fire pump electric power, fire pump battery charger, temperature of water in tanks, and level of water in tanks where any of these items 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 Public Fire Service Communication Systems* (formerly NFPA 73), 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 feasible due to unavailability, economic considerations, or both. It is, however, very important that sprinkler alarms be supervised and signals 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 water flow 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 they can tie up the telephone line for long periods. Automatic telephone dialers are not legal on public emergency telephone lines in many jurisdictions.

F-4 Fire Department and the Sprinkler System.

F-4.1 Water supplies for the automatic sprinkler system referred to in Section 5-7, which consist of pumps and tank combinations feeding yard mains and a hydrant system, should be installed in accordance with NFPA 20, *Standard for the Installation of Centrifugal Fire Pumps*; NFPA 22, *Standard for Water Tanks for Private Fire Protection*; and NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*.

F-4.1.1 In addition to NFPA 13, *Standard for the Installation of Sprinkler Systems*, the following NFPA standards apply where applicable: NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*; NFPA 16, *Standard on the Installation of Deluge Foam-Water Sprinkler and Foam-Water Spray Systems*; NFPA 231, *Standard for General Storage*; and NFPA 231C, *Standard for Rack Storage of Materials*.

F-4.1.2 Use of Fire Department Connection. The standard operating procedures (SOP) of each rural fire department should require one of the first-due pumpers to pump to the fire department connection of the sprinkler system. In this way, water pressure and volume to the system can be increased, making the sprinklers more effective. Also, the fire department connection ties into the system beyond all valves that might be shut off; therefore, even with the valve controlling the water supply to the sprinkler system shut off, sprinkler heads can always be supplied with water through the fire department connection. After assessment by the officer in charge, the word to charge the system might be warranted. The pressure available from the fire department pumper will not burst the piping or heads of the sprinkler system, as all parts of the system are designed and tested to withstand at least 200 psig (1380 kPag).

F-4.1.3 Shutting Off Sprinkler System in Case of Fire. The sprinkler system should not be shut down until the chief officer is convinced that the fire is extinguished or controlled and hand lines are in place for overhauling operations. Even then, the fire department pumper should not be disconnected from the fire department connection to the sprinkler system. Make sure that the fire is out. Station a person at the control valve of the sprinkler system, ready to reopen the valve in case of a flare-up during fire department mop-up operations.

Appendix G Secondary Water Supply

This Appendix is not a part of the requirements of this NFPA document, but is included for information purposes only.

G-1 Secondary Water Supply.

G-1.1 General. The water supply for fire fighting purposes, as specified in Chapter 5, is considered the minimum water supply. It is assumed that water is available to the fire department from a single water point, often using a mobile water supply shuttle or mobile water supply relay in conjunction with a portable folding tank or dry hydrant, etc.

The authority having jurisdiction can determine that an additional, secondary water supply is warranted. This determination might be made as a result of on-site survey of buildings by the fire department having jurisdiction or by review of architectural plans of proposed construction and planned development.

G-1.2 Determination of Secondary Water Supply. The determination of need of a secondary water supply anticipates a large-scale fire situation. Where such conditions exist, this would require a water supply delivery system consisting of multiple water points. Generally this can best be achieved by a water system that includes hydrants, a distribution system, storage, and a source of supply capable of delivering a minimum flow of 250 gpm (946 L/min) at 20 psig (139 kPag) residual pressure for a 2-hour duration.

G-1.3 Procedure for Developing Secondary Water Requirement. Construction and occupancy hazard classification Tables G-1.5.2(a), (b), (c), and (d) have been developed from equation information derived from the formula in G-1.5.

The factors considered in developing the secondary water requirement for a building are as follows:

(a) *Type of Construction (C_i).* Combustibility and fire resistance of the building itself greatly influence the development and spread of a fire and, to a large extent, determine the amount of water needed to control and extinguish a fire.

(b) *Size of Building (A_i).* The greater the story height and larger the undivided floor area, without walls or other fire separation, the greater the potential for a large fire and the greater the secondary water requirement.

(c) *Occupancy (O_i).* A fire in a building having highly combustible contents will require a higher rate of water application than a fire in a building with low-combustible contents. Examples would be a wastepaper warehouse at one end of the scale, and a steel pipe warehouse at the other, with many variations in between.

(d) *Exposures (X_i) and Communications (P_i).* In addition to the water needed on the fire in the building under consideration, additional water might be needed to prevent the fire from spreading to nearby buildings. The amount of this extra water will depend on such factors as the distance between buildings and the type of construction and size of the exposed and communicating buildings.

The method of determining secondary water requirement is not intended to provide details for calculating an adequate amount of water for large, special fire protection problems, such as lumberyards, petroleum storage, refineries, grain elevators, and large chemical plants. For suggested protection, see appropriate NFPA standards.

For any building or structure protected by an automatic sprinkler system that fully meets the requirements of NFPA 13, *Standard for the Installation of Sprinkler Systems*, the fire department having jurisdiction can waive any requirement by this standard for additional water supply. (*See Appendix F.*)

G-1.4 Calculation. The calculation of a secondary water supply for a subject building in gallons per minute (gpm) considers the construction (C_i), occupancy (O_i), exposure (X_i), and communication (P_i) factors of each selected building or fire division and is done as outlined below:

G-1.5 Construction Factor (C_i):

NOTE: There follows a brief digest of the calculation of the secondary water requirement for a given facility. An example of an actual calculation is included in G-1.6. That portion of the secondary water requirement attributed to the type of construction and area of the selected building or fire division is determined by the following formula:

$$C_i = 18F(A_i)^{0.5}$$

Where:

F = Coefficient related to the class of construction:

F = 1.5 for wood frame construction
= 1.0 for ordinary construction
= 0.8 for noncombustible construction
= 0.6 for fire-resistive construction

A_i = Effective area.

The effective area is the total ft² (m²) area of the largest floor in the building plus the following percentage of the other floors:†

(a) Buildings of Construction Types II, III, IV, and V, 50 percent of all other floors.

(b) Buildings of Construction Type I.

i. If all vertical openings in the building have 1½-hour or greater protection, 25 percent of the area not exceeding the second and third largest floors.

ii. In other buildings, 50 percent of the area not exceeding 8 additional floors.†

NOTE: Do not include basements and sub-basement areas that are vacant or are used for building maintenance, or that are occupied by light-hazard or low-hazard occupancies. (*See G-1.6.*)

G-1.5.1 Calculating Predominant Construction. In buildings of mixed construction types, the predominant construction class shall be determined as follows:

NOTE: In applying the rules below, basement walls and the lowest floor level shall be disregarded.

(a) *Fire Resistive:* Any building with 66⅔ percent or more of the total wall area and 66⅔ percent or more of the total floor and roof area defined as construction type I.

(b) *Noncombustible:* Any building with 66⅔ percent or more of the total wall area and 66⅔ percent or more of the total floor and roof area defined as construction types II and IV, or

Any building not qualifying under (a) above, with 66⅔ percent or more of the total wall area and 66⅔ percent or more of the total floor and roof area constructed in two or more of construction types I, II, and IV, but with no single type in itself equaling 66⅔ percent or more of the total area.

(c) *Ordinary:* Any building not qualifying under (a) or (b) above, with 66⅔ percent or more of the total wall area of construction type III, or

Any building not qualifying under (a) or (b) above, with 66⅔ percent or more of the total wall area and 66⅔ percent or more of the total floor and roof area constructed in two or more of construction types I, II, III, and IV, but with no single type in itself equaling 66⅔ percent or more of the total area.

(d) *Frame:* Any building not qualifying under (a) through (c) above, or any building with over 33⅓ percent of the total wall area of combustible construction, regardless of the type of construction of the balance of the building, should be defined as construction type V.

The maximum value of (C_i) is limited by the following:

8000 gpm (30 280 L/min) for wood frame and ordinary construction;

6000 gpm (22 710 L/min) for noncombustible and fire-resistive construction;

6000 gpm (22 710 L/min) for a one-story building of any type of construction.

The minimum value of (C_i) is 250 gpm (945 L/min). The calculated value of (C_i) should be rounded to the nearest 250 gpm (945 L/min).

G-1.5.2 Occupancy Factor (O_i).

The factors below reflect the influence of the occupancy in the selected building on the secondary water requirement.

Occupancy Hazard Classification Number	Occupancy Factor (O_i)
No. 7 Light Hazard	0.75
No. 6 Low Hazard	0.85
No. 5 Moderate Hazard	1.00
No. 4 High Hazard	1.15
No. 3 Severe Hazard	1.25

Representative lists of occupancies by classification of occupancy hazard are located in Chapter 3.

NOTE: Tables G-1.5.2(a) through G-1.5.2(d) include the occupancy factors (O_i) applied for each type of construction.

G-1.5.3 Exposure (X_i) and Communication (P_i) Factors.

These factors reflect the influence of exposed and communicating buildings on the secondary water requirement. A value of ($X_i + P_i$) should be developed for each side of the building:

NOTE: The following is a brief digest of the calculation of exposure and communication. An example of an actual calculation is included in G-1.6.

$$(X + P)_i = 1.0 + \sum_{i=1}^{n} (X_i + P_i),$$ maximum 1.55, where n = number of sides of subject building

NOTE: The exposure factor should apply to only one side of the subject building. It is determined by the following method.

(a) Factor for exposure (X_i):

The factor for (X_i) depends on the construction and the length-height value (length of wall in feet times height in stories) of the exposed building and the distance between facing walls of the subject building and the exposed building and should be selected from Table G-1.5.3(a).

NOTE: The following buildings shall not be charged as exposures:

- Buildings fully protected by automatic sprinklers;
- Buildings with a residential occupancy;
- Buildings that are Type I construction;
- Buildings with a blank masonry wall.

†If division walls are rated 1-hour or more with labeled Class B fire doors on openings, subdivide a floor. The maximum area on any one floor used shall be the largest undivided area plus 50 percent of the second largest undivided area on that floor.

Table G-1.5.2(a) Wood Frame Construction and Occupancy Hazard Classification (F = 1.5)

Occupancy Class 7 $O_i = 0.75$			Occupancy Class 6 $O_i = 0.85$			Occupancy Class 5 $O_i = 1.00$			Occupancy Class 4 $O_i = 1.15$			Occupancy Class 3 $O_i = 1.25$		
Effective Area		GPM	Effective Area		GPM	Effective Area		GPM	Effective Area		GPM	Effective Area		GPM
From 0	To 950	500	From 0	To 750	500	From 0	To 550	500	From 0	To 400	500	From 0	To 350	500
951	1850	750	751	1450	750	551	1050	750	401	800	750	351	650	750
1851	3100	1000	1451	2400	1000	1051	1750	1000	801	1300	1000	651	1100	1000
3101	4600	1250	2401	3600	1250	1751	2600	1250	1301	1950	1250	1101	1650	1250
4601	6450	1500	3601	5000	1500	2601	3600	1500	1951	2750	1500	1651	2300	1500
6451	8550	1750	5001	6650	1750	3601	4800	1750	2751	3650	1750	2301	3100	1750
8551	11000	2000	6651	9600	2124	4801	6200	2000	3651	4700	2000	3101	3950	2000
11001	13750	2250	9601	10700	2250	6201	7750	2250	4701	5850	2250	3951	4950	2250
13751	16800	2500	10701	13100	2500	7751	9450	2500	5851	7150	2500	4951	6050	2500
16801	20150	2750	13101	15700	2750	9451	11350	2750	7151	8550	2750	6051	7250	2750
From 20151	To 23800	3000	From 15701	To 18550	3000	From 11351	To 13400	3000	From 8551	To 10150	3000	From 7251	To 8550	3000
23801	27750	3250	18551	21600	3250	13401	15600	3250	10151	11800	3250	8551	10000	3250
27751	32050	3500	21601	24950	3500	15601	18000	3500	11801	13650	3500	10001	11550	3500
32051	36600	3750	24951	28500	3750	18001	20600	3750	13651	15550	3750	11051	13200	3750
36601	41500	4000	28501	32300	4000	20601	23350	4000	15551	17650	4000	13201	14950	4000
41501	46650	4250	32301	36350	4250	23351	26250	4250	17651	19850	4250	14951	16800	4250
46651	52150	4500	36351	40600	4500	26251	29350	4500	19851	22200	4500	16801	18750	4500
52151	57950	4750	40601	45100	4750	29351	32600	4750	22201	24650	4750	18751	20850	4750
57951	64050	5000	45101	49850	5000	32601	36000	5000	24651	27250	5000	20851	23050	5000
64051	70450	5250	49851	54850	5250	36001	39600	5250	27251	29950	5250	23051	25350	5250
From 70451	To 77150	5500	From 54851	To 60050	5500	From 39601	To 43400	5500	From 29951	To 32800	5500	From 25351	To 27750	5500
77151	84150	5750	60051	65500	5750	43401	47350	5750	32801	35800	5750	27751	30300	5750
84151	91450	6000	65501	71200	6000	47351	51450	6000	35801	38900	6000	30301	32950	6000
91451	99100	6250	71201	77150	6250	51451	55750	6250	38901	42150	6250	32951	35650	6250
99101	107000	6500	77151	83300	6500	55751	60200	6500	42151	45500	6500	35651	38550	6500
107001	115250	6750	83301	89700	6750	60201	64850	6750	45501	49000	6750	38551	41500	6750
115251	123800	7000	89701	96350	7000	64851	69650	7000	49001	52650	7000	41501	44550	7000
123801	132600	7250	96351	103250	7250	69651	74600	7250	52651	56400	7250	44551	47750	7250
132601	141750	7500	103251	110350	7500	74601	79750	7500	56401	60300	7500	47751	51050	7500
141751	151200	7750	110351	117750	7750	79751	85050	7750	60301	64300	7750	51051	54450	7750
151201	160950	8000	117751	125300	8000	85051	90550	8000	64301	68450	8000	54451	57950	8000

For SI units: 1 gpm = 0.0631 L/sec.

Table G-1.5.2(b) Ordinary Construction and Occupancy Hazard Classification (F = 1.0)

Occupancy Class 7 $O_i = 0.75$			Occupancy Class 6 $O_i = 0.85$			Occupancy Class 5 $O_i = 1.00$			Occupancy Class 4 $O_i = 1.15$			Occupancy Class 3 $O_i = 1.25$		
Effective Area		GPM	Effective Area		GPM	Effective Area		GPM	Effective Area		GPM	Effective Area		GPM
From 0 To	2150	500	From 0 To	1650	500	From 0 To	1200	500	From 0 To	900	500	From 0 To	750	500
2151	4200	750	1651	3250	750	1201	2350	750	901	1800	750	751	1500	750
4201	6950	1000	3251	5400	1000	2351	3900	1000	1801	2950	1000	1501	2500	1000
6951	10350	1250	5401	8050	1250	3901	5850	1250	2951	4400	1250	2501	3750	1250
10351	14500	1500	8051	11250	1500	5851	8150	1500	4401	6150	1500	3751	5200	1500
14501	19300	1750	11251	15000	1750	8151	10850	1750	6151	8200	1750	5201	6950	1750
19301	24750	2000	15001	21600	2124	10851	13950	2000	8201	10550	2000	6951	8900	2000
24751	30950	2250	21601	24100	2250	13951	17400	2250	10551	13150	2250	8901	11150	2250
30951	37800	2500	24101	29400	2500	17401	21250	2500	13151	16050	2500	11151	13600	2500
37801	45350	2750	29401	35300	2750	21251	25500	2750	16051	19300	2750	13601	16300	2750
From 45351 To	53550	3000	From 35301 To	41700	3000	From 25501 To	30150	3000	From 19301 To	22800	3000	From 16301 To	19300	3000
53551	62500	3250	41701	48650	3250	30151	35150	3250	22801	26550	3250	19301	22500	3250
62501	72100	3500	48651	56100	3500	35151	40550	3500	26551	30650	3500	22501	25950	3500
72101	82350	3750	56101	64150	3750	40551	46350	3750	30651	35050	3750	25951	29650	3750
82351	93350	4000	64151	72650	4000	46351	52500	4000	35051	39700	4000	29651	33600	4000
93351	105000	4250	72651	81750	4250	52501	59050	4250	39701	44650	4250	33601	37800	4250
105001	117350	4500	81751	91350	4500	59051	66000	4500	44651	49900	4500	37801	42250	4500
117351	130350	4750	91351	101500	4750	66001	73350	4750	49901	55450	4750	42251	46950	4750
130351	144100	5000	101501	112200	5000	73351	81050	5000	55451	61300	5000	46951	51850	5000
144101	158500	5250	112201	123400	5250	81051	89150	5250	61301	67400	5250	51851	57050	5250
From 158501 To	173550	5500	From 123401 To	135150	5500	From 89151 To	97650	5500	From 67401 To	73850	5500	From 57051 To	62500	5500
173551	189350	5750	135151	147400	5750	97651	106500	5750	73851	80550	5750	62501	68150	5750
189351	205800	6000	147401	160250	6000	106501	115750	6000	80551	87550	6000	68151	74100	6000
205801	222950	6250	160251	173600	6250	115751	125400	6250	87551	94850	6250	74101	80250	6250
222951	240800	6500	173601	187450	6500	125401	135450	6500	94851	102400	6500	80251	86700	6500
240801	259300	6750	187451	201900	6750	135451	145850	6750	102401	110300	6750	86701	93350	6750
259301	278500	7000	201901	216850	7000	145851	156650	7000	110301	118450	7000	93351	100250	7000
278501	298400	7250	216851	232300	7250	156651	167850	7250	118451	126900	7250	100251	107400	7250
298401	318950	7500	232301	248350	7500	167851	179400	7500	126901	135650	7500	107401	114850	7500
318951	340250	7750	248351	264900	7750	179401	191400	7750	135651	144700	7750	114851	122500	7750
340251	362150	8000	264901	281950	8000	191401	203700	8000	144701	154050	8000	122501	130400	8000

For SI units: 1 gpm = 0.0631 L/sec.