4. Hose rollers

a. Hand roller

Type: Wall-mounted, hand crank.

Construction and material: roller made of steel which pivots on a pin bracket which mounts on a post or wall. Equipped with quick release and designed for 1- or 1½ -inch, 50- and 100-foot fire hose.

Available: Fire equipment suppliers (see appendix G).

b. Rhode Island hose roller

Type: Action roll (roll fold).

Construction: Commercially available hose roller modified by Rhode Island to be powered by an electric motor.

Available: Rhode Island Division of Forest Environment and Wildfire Equipment Inc.

c. Fire cache hose roller

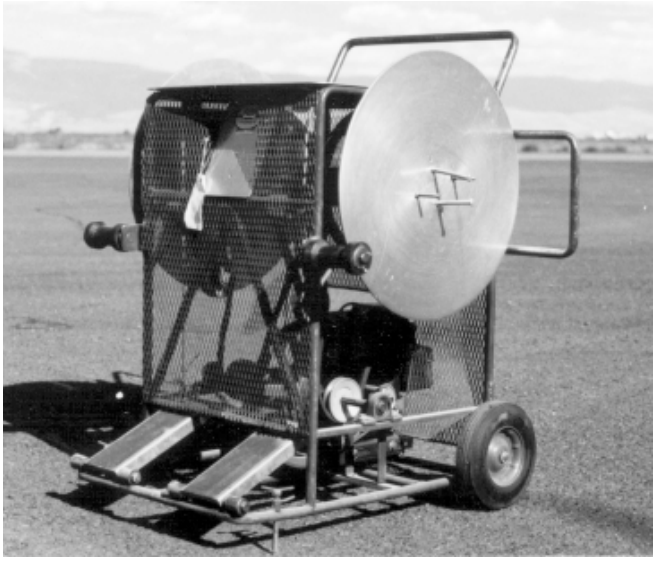
Type: Electric single roll for 1 inch, 1½ inch, 1¾ inch, 2 inch, and quarter-turn coupled hose.

Construction and material: Push plate release mechanism. Two roller bearings provide the tension. Powered by a ¼-hp single-phase electric motor which is activated by foot pedal. A portable generator may also be ordered to provide power source.

Available: Specifications available from:

USDA Forest Service
Technology and Development Center
444 East Bonita Avenue
San Dimas, CA 91773
909–599–1267

d. Redmond cache hose roller



Type: Gas powered.

Construction and material: A 5-hp Briggs & Stratton engine; two stations that will roll single- or double-rolled hose, with foot controls.

Available: Specifications available from:

USDA Forest Service
Redmond Fire Center
Airport Way
Redmond, OR 97756

e. Synthetic garden hose hand roller

Type: Hand-held.

Construction and materials: Hand crank operated plastic roller designed to roll 50-foot lengths of synthetic garden hose (pencil hose).

Available: National Fire Cache System, NFES 0666.

5. Hydrant and spanner wrenches

Hydrant wrenches can be obtained in various sizes to fit water hydrant stems. Spanner wrenches can be obtained in various sizes to fit any connection combination (rocker, slotted, or pin lugs). Combination wrenches are available that can handle both hydrant stems and spanner lugs.

a. Hydrant wrench

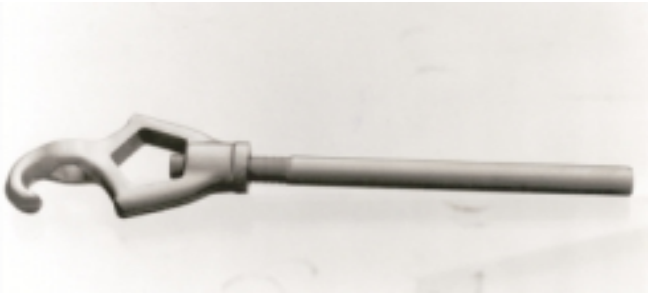
Type: Municipal fire hydrant.

Construction and material: Designed to fit multiple valve stem sizes. Other optional uses for rocker pin lug spanner may be included. Made of steel or other alloy metal.

Size: ¾, 1, and 1½ inch.

Available: Fire equipment suppliers (see appendix G).

b. Adjustable hydrant wrench



Type: Rocker lug, pin, or slotted.

Construction and material: Adjustable, cast or forged. Made from manganese bronze, aluminum alloy, or bronze.

Sizes: Fire coupling ¾ to 2 inch, and other sizes.

Available from GSA: NSN 5120-00-288-8849.

c. Lightweight spanner wrench

Type: Pin or rocker lug.

Construction and material: Combination sizes, pocket fit; Forest Service specification 5100-101b.

Size: 1 to 1½ inch.

Available from GSA: NSN 5120-00-596-1426.

d. Universal spanner

Type: Pin or rocker lug.

Construction and material: Standard type is provided with gas cock slot and pin bar at end.

Sizes: Fit pin or rocker lugs ¾ to 3 inch.

Available: Fire equipment suppliers (see appendix G).

e. Combination spanner

Type: Pin or rocker lug.

Construction and material: Combination sizes, pocket fit.

Size: 1 to 2½ inch.

Available from GSA: NSN 5120-00-596-1427.

f. Folding spanner

Type: Slotted or rocker lug.

Construction and material: Folding, plastic, metal, or fiberglass.

Sizes: 1½ to 2½ inch.

Available: Fire equipment suppliers (see appendix G).

g. Quick-connect (quarter-turn) spanners

Type: Rocker lug

Construction and material: Cast aluminum alloy

Size: ¾ to 2 inch

Available: Fire equipment suppliers (see appendix G).

D. Hose Test and Maintenance Equipment
Testing and maintenance equipment for hoses and fire pumps is available from fire equipment companies. This type of equipment is useful in fire cache maintenance facilities and in fire stations. For proper maintenance, hoses should be washed, dried, and repaired. Pumps should be cleaned, adjusted, and repaired. Engines, pumps, and hoses should be pressure tested. All this requires appropriate tools and equipment. See appendix C for gauge quality and accuracy information.

1. In-line gauge

Type: In-line pump discharge pressure.

Construction and material: Short tube inlet and male outlet, and a pressure gauge on the side of the tube. Female end may be swiveled and have lugs. Hose threads are on both ends. Sizes are varied up to 2½ inches. Pressure gauge ranges up to 600 psi. The tube is made of steel or brass.

Purpose: Testing pump discharge and hose pressure performance.

Available: Fire equipment suppliers (see appendix G).

2. Hose washers

a. Mechanical hose washer

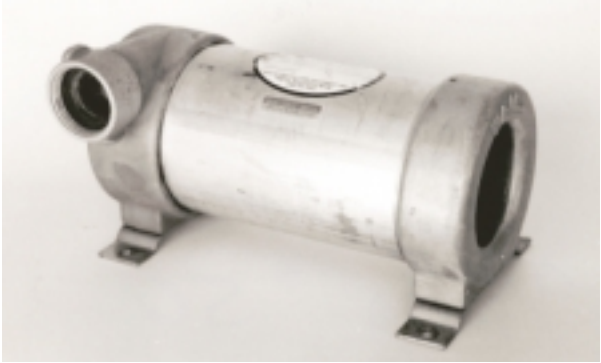
Type: Powered mechanical hose washer.

Construction and material: Inlet for water-source connection. Uniform washing, multiple scrub brushes, one-person operation. Use clear water or detergent.

Purpose: High-volume hose washing.

Available: Fire equipment suppliers (see appendix G).

b. Manual hose washer



Type: Cylinder.

Construction: Cylinder with 1½-inch water source connection.

Action: Hose is passed through cylinder against water stream so that dislodged particles are washed away from hose.

Available: Fire equipment suppliers (see appendix G).

3. Hose dryers

a. Electric dryer

Though many fire control agencies rely on air-drying of fire hose, mechanical dryers are available with either gas or electric heat for fast, safe, and effective drying of fire hose as well as clothing. The systems work with prewarmed dry air circulating through the drying chamber with five to six air changes per minute.

Available: Fire equipment suppliers (see appendix G).

b. Air dryers

Typical hose drying rack.

South Zone Fire Cache hose tower.
Drawings available from:

USDA Forest Service
South Zone Fire Cache
1310 South Cucamonga Avenue
Ontario, CA 91761

4. Hose cutters and coupling expanders

a. Hose cutters

When fabric-type fire hoses are to be cut and recoupled, a reasonably accurate cutting tool should be used to produce a square and clean-cut edge. The cutter illustrated above was designed to specifically cut fire hoses. It is capable of cutting hose sizes up to 2½ inches.

Written material: Fire equipment suppliers (see appendix G).

b. Expanders

Expanders, either manual or power operated, are used for attaching fire hose couplings. Expanders are available in 1- to 3-inch sizes, with larger sizes available.

Available: Fire equipment suppliers (see appendix G).

- **Hand expander**

- **Hand-operated hydraulic expander**

• **Power expander**

5. Hose testers

Fire hose is subject to deterioration after use on fires and prolonged storage (subject to the elements of nature). A high-pressure test pump is essential for acceptance and service testing of all fire hose to assure compliance with specification, determine serviceability, permit discarding or repair of defective material, and for testing the adequacy of recoupling jobs. Standard equipment usually includes a pump, suction connection, hose connection(s), pressure gauge, bypass and pressure-regulating valves, and may be hand operated or engine driven. Specific features and additional details are given in suppliers' catalogs.

E. Fittings and Connections

1. General

Connections and fittings considered in this *Guide* are those that are normally connected by hand or spanner wrenches. Threads are varied, and each fire agency has its own standards. The NFPA standards are prevalent. Construction materials are brass, aluminum, or others as specified by purchaser. Lugs are rocker, pin, or long-handled type. Gaskets are usually located with each female hose thread connection. Quick-connect type couplings are in service. Water handling technical specifications are available from the GSA website at fss.gsa.gov/fire.

2. Lugs, threads, couplings, and gaskets

a. Lugs

Pin hole lug

The photograph illustrates the many variations found among lugs made by different manufacturers. Other types of lugs include the pin, pinhole, and long handle. A knurled, nonslip surface is often used on the base of a nozzle to assist in breaking the connection. Two or three lugs are required on the swivel section of couplings, connections, valves, and wyes. Lugs are acceptable, but not required, on male coupling sections.

b. Threads

Hose threads are said to be straight or parallel. A water seal is formed as the external thread lip seats against a recessed gasket in the internal thread section. In contrast, water-pipe threads are tapered and seal against themselves.

"NH" is an abbreviation of American National Fire Hose Connection Screw Thread for garden, chemical, and fire protection hose. "NPSH" is the abbreviation for American National hose coupling threads; i.e., National Pipe Straight Hose couplings for threads and nipples. The tables below show the threads currently in use.

Hose Thread Tables

Table 4—Threads used in current Municipal/ Department of Defense practices.

Nominal size (inch)	Threads per inch	Maximum male diameter (inch)	NFPA symbol
¾	8	1.38	NH
1	8	1.38	NH
1½	9	1.99	NH
2	8	2.52	NH
2½	7½	3.07	NH
3	6	3.62	NH
3½	6	4.24	NH
4	4	5.01	NH

Table 5—Threads currently used by many wildland fire agencies.

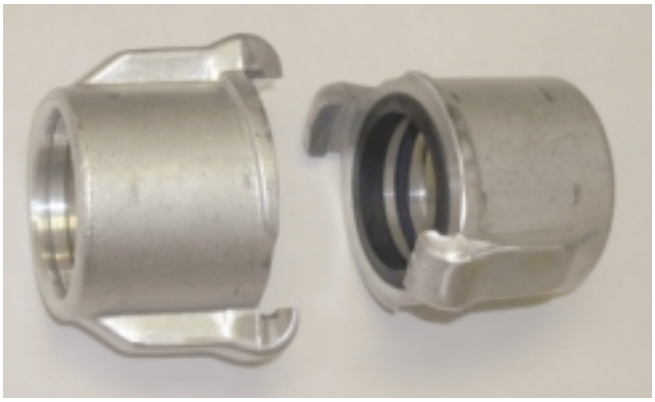
Nominal size (inch)	Threads per inch	Maximum male diameter (inch)	NWCG symbol
¾	11½	1.06	GHT
1	11½	1.30	NPSH
1½	9	1.99	NH
2	11½	2.35	NPSH
2½	7½	3.07	NH
4	4	5.01	NH

In wildland fire service, the larger diameter threads are used primarily for suction hose couplings. The 1½-inch size is by far the most common in forestry practice and is used for distribution lines. The 1-inch connection is used on most nozzle bases, on 1-inch hose, and on ¾-inch hard-rubber hose for reels.

The tips for straight stream and fog nozzles have ¾ inch 11½ GHT thread in general forestry/wildland practice as provided in Forest Service Specification 5100-244b. The NFPA standard calls for ¾-inch connections to be 8 NH threads. Use of ¾-inch garden hose couplings are designed for low pressure, low flow (mop-up) fire service use.

Higbee cut. To prevent mutilation and cross threading, and to facilitate rapid coupling, fire hose connections and fittings are manufactured with the first thread cut away or blunted. This is referred to as "blunt start" or the Higbee cut.

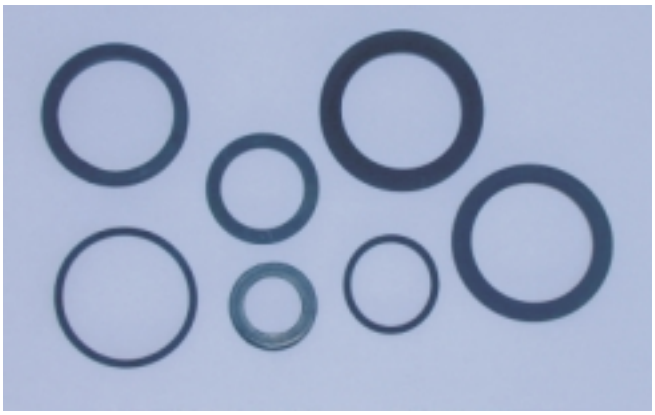
c. Quick-connect (quarter-turn) couplings



The quarter-turn (QT) hose coupler has become standard within some agencies. This coupler has the advantage of being quick and sexless. There are no male or female fittings, and one coupler size can be used on a range of hose size from ¾ to 1½ inch. This allows for a simple system to reducing hose size, as it is not necessary to stock 1- and 1½-inch thread adapters, double male couplings and double female couplings, reducers, and increasers. Adapters are available for connecting to pumps, wyes, and nozzles. Fittings of 1 and 1½ inch connect interchangeably. Only a quarter of a turn is required to couple and uncouple hose, connections, and fittings.

d. Gaskets

Gaskets provide a seal for threaded connections to prevent leakage when fire hose and fittings are coupled together. They are made of soft rubber, and fit into the female end of the hose fitting against a seat provided in the manufacturing process. Gaskets are commonly 1⁄16 inch larger than the normal ID of the hose on which used. They vary in thickness with the hose diameter (⅛ inch for hose of ¾- to 1½-inch ID, 3⁄16 inch for 2½- inch ID, to ¼ inch for hose of 4-inch ID, and ⅜ inch for 5-inch ID and larger). Other gasket sizes are also commercially available.



The OD of gaskets has never been standardized, and depends entirely on the width of the gasket seat in the hose bowl. On rubber-lined hose, this dimension must be measured and a gasket provided with an OD wide enough to prevent seepage between the rubber liner and the outside emerging, ensuring a watertight fit. Seepage will cause hose “blistering” to develop and eventually rupture the hose.

Available from GSA (Forest Service Specification 5100-190a):

1 inch
NSN 5330-00-720-2621

1½ inch
NSN 5330-00-239-1873

2 inch
NSN 5330-00-239-1875

2½ inch
NSN 5330-00-239-1877

4 inch
Available through various fire equipment suppliers (see appendix G).

3. Fittings and connections

These items include the many different types of couplings, connections, adapters, increasers, reducers, wyes, and valves required in wildland fire hose lays. If the item attaches to a fire hose lay, it should be found here. Consult the GSA *Wildfire Protection Equipment and Supplies Catalog* for many of these items or visit the website at fss.gsa.gov/fire.

a. Thread adapter

Type: Female to male with lugs.

Threads: Different hose threads on opposite ends as specified.

Size: Same on opposite ends.

Available from GSA:

1½ inch NH-F by 1½ inch NPSH-M
NSN 4210-01-079-9284

1½ inch NPSH-F by 1½ inch NH-M
NSN 4210-01-079-9283

Quick-connect quarter-turn (QT) male and female adapters

Type: Threaded to quick-connect with lugs.

Threads: As specified.

Size: 1 or 1½ inch to 1½ inch QT

Available: Fire equipment suppliers (appendix G)

1 inch NPSH by 1½ inch QT

1½ inch NH by 1½ inch QT

b. Reducer

Type: Female to male with lugs.

Threads: Same or different hose threads on both ends as specified.

Size: Different on opposite ends.

Available from GSA:

1 inch NPSH by ¾ inch NH
NSN 4210-01-079-9286

1½ inch NH by 1 inch NPSH
NSN 4210-00-975-2969

1½ inch NPSH by 1 inch NPSH
NSN 4210-00-294-2648

2½ inch NH by 1½ inch NH
Available from national fire cache:
NFES #2230
or, from fire equipment suppliers
(appendix G).

c. Increaser

Type: Female to male with lugs.

Threads: Same or different hose threads on both ends as specified.

Size: Different on opposite ends.

Available from GSA:

¾ inch NH by 1 inch NPSH
NSN 4210-01-080-6531

1 inch NPSH by 1½ inch NH
NSN 4210-01-080-6532

d. Double female coupling

Type: Swivel female ends with lugs.

Threads: Same hose threads on both ends as specified.

Size: Same on both ends as specified.

Available from GSA:

1 inch NPSH
NSN 4210-01-080-1457

1½ inch NH
NSN 4210-01-081-8749

e. Double male coupling

Type: Male ends with lugs.

Threads: Same hose threads on both ends as specified.

Size: Same on both ends as specified.

Available from GSA:

1 inch NPSH
NSN 4210-01-080-1458

1½ inch NH
NSN 4210-01-079-9285

f. Hose line tee

Type: Three-port design: inlet, branch, and outlet, with chain and cap for branch port.

Threads: Inlet and outlet same hose threads as specified.

Size: Same both ends and branch or as specified.

Available from GSA:

1 inch NPSH by 1 inch NPSH by ¾ inch NH
NSN 4210-01-081-0418

1 inch NPSH by 1 inch NPSH by 1 inch NPSH
NSN 4210-01-080-1459

1½ inch NH by 1½ inch NH by 1 inch NPSH
NSN 4210-01-080-1460

g. Hose line tee with valve

Type: With valve branch, female with lug one end, male opposite end and on branch.

Threads: Inlet and outlet same hose threads as specified.

Size: As specified.

Available from GSA:

1½ inch NH by 1½ inch NH by 1 inch NPSH
NSN 4210-01-081-0417

h. Ejector

Type: Straight type with foot valve.

Threads: Pipe thread adapted to hose thread as specified.

Size: As specified.

For further information regarding ejectors, reference *Water Ejectors for Use in Wildland Firefighting, 0251 1205-SDTDC, December 2002* which is available from:

USDA Forest Service
Technology and Development Center
444 East Bonita Avenue
San Dimas, CA 91773
909–599–1267

i. Bleeder valve

Type: In-line hose branch with wrench to bleed water for backpack tank.

Threads: Female one end, male other end, hose threads as specified.

Size: 1½ inch

j. Check and bleeder valve

Type: Swing check valve with bleeder valve with branch male, swivel inlet with lugs.

Threads: Female inlet, male outlet, hose threads as specified, 1 inch NPSH male branch.

Size: 1½-inch inlet and outlet.

k. Ball valve shutoff

Type: Ball with lever handle, swivel inlets.

Threads: Female inlet, male outlet, hose threads as specified.

Size: 1-inch and 1½-inch inlets and outlets as specified.

Available from GSA:

1 inch NPSH
NSN 4210-01-165-6599

1½ inch NH
NSN 4210-01-165-6600

l. Suction strainer

Type: Low-velocity, globe-shaped.

Threads: Female hose threads as specified.

Size: As specified.

Available: Fire equipment suppliers (see appendix G).

m. Foot valve

Type: Spring action with strainer female connection.

Threads: Female adapted to hose threads as specified.

Size: As specified.

Available from GSA:

1½ inch NH
NSN 4820-00-126-5114

n. Pressure relief valve

Type: In-line hose branch with spring-loaded relief valve and adjustment nut, swivel-inlet with lugs.

Threads: Female inlet, male outlet, NH threads, 1 inch NPSH threads.

Size: 1½-inch inlet and outlet.

Available: Fire equipment suppliers (see appendix G).

o. Lightweight pressure reducing valve with gauge

Type: Pressure reducing valve with pressure gauge.

Threads: Female inlet and outlet, NPT threads.

Size: Various sizes available.

Available: Fire equipment suppliers (see appendix G).

p. Gated wye valve

Type: Swivel inlet, gate valve branch outlets with handles.

Threads: Female inlet, male outlets, hose threads as specified.

Available from GSA:

1 inch NPSH
NSN 4210-00-126-5108

1½ inch NH
NSN 4210-00-984-3475

q. Plain wye

Type: Swivel inlet, branch outlets.

Threads: Female inlet, male outlets, hose threads as specified.

Size: 1½- to 6-inch inlet and 1½- or 2½-inch outlets are available.

Available: Fire equipment suppliers (see appendix G).

r. Siamese gated wye valve

Type: Two swivel inlets, ball gate valve branch inlets with handles.

Threads: Two female inlets, male outlet, threads as specified.

Size: 1½-inch and 2½-inch inlets and outlets same size as specified.

Available: Fire equipment suppliers (see appendix G).

s. Siamese wye

Type: Two swivel inlets, single outlet.

Threads: Two female inlets, male outlet, threads as specified.

Size: 1½-inch and 2½-inch inlets and outlets same size as specified.

Available: Fire equipment suppliers (see appendix G).

F. Nozzles

1. General

There are many varieties of fire hose nozzles available to the firefighter. The municipal types, which apply large volumes of water, are ***not*** often practical in wildland fire situations. The shortage of water precludes any excessive usage. Nozzles are designed to do a variety of tasks. The types of nozzles found most often for wildland fires are the adjustable combination barrel, plain, twin, or multiple tips.

2. Design criteria

The following design or selection criteria have evolved from many years of wildland fire practices and numerous detailed studies.

a. Rate of application

Normally, flow is limited to 30 gpm for ¾- and 1-inch lines and 100 gpm for the 1½-inch lines.

b. Application characteristics

Combination nozzles that provide both straight stream and spray patterns are required.

Good pattern—Nozzles that produce solid cone patterns are highly desirable. Less desirable nozzles have distinct hollow cones, voids, and flat, fan-shaped patterns. Some sprays look like the ribs of an umbrella as water is projected in jet streams. While combination features are desirable, some nozzles show a wide range of discharge flows, increasing with the spray cone angle. These latter patterns are a potential waste of water.

Water droplet size—Fine sprays offer better cooling and more protection to the nozzle person from excessive fire temperatures. Water droplets should be in the 0.14- to 0.39-inch size range to be most effective. Nozzles should produce uniform droplet size over a wide range of pressures.

c. Nozzle pressure

The operating range for the nozzles presented in this section are described for a 100-psi nozzle discharge pressure. Flow is reduced to about 70 percent when the nozzle pressure is reduced from 100 to 50 psi.

d. Control valves

Nozzle shutdown, flow, and pattern variations are controlled on ball valve types by a one-quarter-turn lever or handle, or tip selection. Shutdown and patterns from straight stream to fog on other nozzles are controlled by rotating the body of the nozzle from shutoff through fog to straight stream. The best of these nozzles are marked, indexed, or referenced to allow efficient operation by inexperienced firefighters.

e. Tips

If flows and patterns are varied by exchanging tips, the tips will be provided with ¾-inch GH threads and meet the requirements of USDA Forest Service Specification 5100-244d. Standard spray tips are available from 3 to 24 gal/min. Numerous adjustable nozzles go to much higher flow rates. Ability to vary the spray is important. Variable straight streams are required for the full range of working pressures. Straight stream tips range from ⅛ to ⅜ inch.

f. Clogging

Since water delivery equipment picks up water in open sources at the nearest water chance, foreign matter and silt are often a problem; thus, spray nozzles should be equipped with adequate screens that can be easily removed and serviced.

g. Base-inlet

All 1-inch nozzles are provided with 1-inch 11½ NPSH threads. All 1½-inch nozzles are provided with 1½ inch 9 NH threads. Rocker lugs or a knurled base are required on all nozzles.

h. Weight

Weight is an important factor, so lightweight material is desirable. Most all-brass nozzles have been eliminated from practical wildland fire use. Nozzles should preferably weigh no more than 2 pounds. Lightweight plastic materials may not withstand higher working pressures and rigorous use under wildland fire applications.

i. Cost

Simple, trouble-free construction providing the performance listed in items “a” through “h” is necessary. Expensive materials, such as brass, and highly polished or plated hardware and accessories, are not necessary for wildland fire applications.

Representative nozzles in widespread use that meet most of the above requirements are available under Forest Service Specification 5100-240 (nozzle, twin-tip, shutoff, 1-inch base, straight stream and fog tip). Twin tip nozzles are furnished by the Federal Supply Service as catalog item NSN 4210-00-640-1892; Barrel nozzles are available under Forest Service Specification 5100-539 (nozzle with shutoff, combination barrel). A 1-inch base is furnished by the Federal Supply Service as item NSN 4210-01-165-6603. The 1½-inch base is furnished as item 4210-01-167-1123.

3. Nozzle types and descriptions

For simplicity, nozzles can be grouped into several broad classes. If the nozzle can produce either a straight stream or a spray, it is classed as a combination type. A few nozzles can produce both patterns simultaneously, but their flow requirements are high. The more common types are listed as follows:

a. Ball shutoff with tip

Type: Single-tip, ball or cylinder lever valve shutoff, ½-inch bore, ¾-inch GHT outlet for interchangeable tips.

Action: Sequence shutoff (lever forward), straight stream or spray.

Available from GSA: NSN 4210-00-203-3519.

Weight: Approximately 1 pound, 3 ounces.

Base (inlet): 1 inch, 11½ NPSH.

Material and finish: Smooth sand-cast brass, or forged aluminum.

Performance: See twin-tip nozzle performance table for flow and pressure ranges.

b. Smooth bore screw tip

Type: Plain 3⁄16-inch, ¼-inch and ⅜-inch bore, ¾-inch GHT outlet, with tip holder bracket.

Action: Nonadjustable, interchangeable tips (straight stream or spray).

Weight: Approximately 2 pounds, without tips.

Length: 7-inch maximum.

Base (inlet): 1½ inch 9 NH.

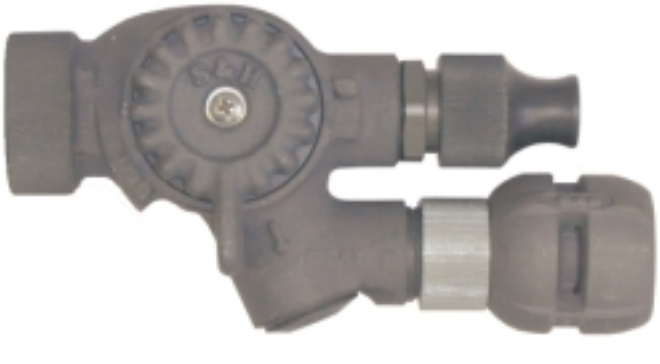
Material and finish: Smooth sand cast brass or lexan.

Performance (flow and pressure):

Tip size (inch)	Average Flow @ 100 psi (gal/min)	Minimum Horizontal range (feet)
3⁄16	10.5	34
¼	18.7	40
⅜	42.1	41

Available: Fire equipment suppliers (see appendix G).

c. Twin tip (forester)



Type: Combination spray, straight stream, ½-inch bore, two ¾-inch GHT outlets.

Action: Sequence shutoff, spray (fog), straight stream.

Weight: Approximately 2 pounds, 2 ounces.

Length: 7 inch.

Base (inlet): 1 inch, 11½ NPSH.

Material and finish: Brushed cast aluminum alloy, knurled handgrip.

Performance (flow and pressure): Nozzle used with straight stream and spray tips (see tables on pages 171 and 172).

Available from GSA: NSN 4210-00-640-1892.

d. Adjustable barrel combination

Type: Adjustable combination.

Action: Sequence shutoff, straight stream, spray.

Available from GSA:

1 inch NPSH polycarbonate
NSN 4210-00-085-2291

1½ inch NH polycarbonate
NSN 4210-00-181-8872

1 inch NPSH anodized aluminum
NSN 4210-01-165-6603

1½ inch NH anodized aluminum
NSN 4210-01-167-1123

e. Hydro-fog combination

Type: Adjustable combination barrel.

Action: Fog, straight stream, shutoff.

Weight: Varies by manufacturer and material.

Length: Varies by manufacturer and material.

Base (inlet): 1 inch NPSH; 1½ inch NH.

Material and finish: Brushed anodized aluminum, neoprene rubber bumper, stainless steel fog tip.

Typical performance (flow and pressure):

Size (inch)	Flow (gal/min)	Pressure (psi)
1	23	100
1½	95	100

Available: Fire equipment suppliers (see appendix G).

f. Selectable gallonage

Selectable gallonage fog nozzles with gallonage selections of 5 to 350 gal/min, within operation quick flush.

The wide range of gallonage settings, ease of maintenance, size, weight, and durability make these versatile nozzles. They are available as direct-connect nozzles with integral stainless ball shutoff, or as a fog tip with twist shutoff. Models feature a flush without shutting down.

Type: selectable gallonage.

Action: Constant flow in each setting; quick-change seat.

Material and finish: Hard coat anodized; rubber bumper protection; lightweight construction.

Available: Fire equipment suppliers (see appendix G).

g. Fire hose mop-up nozzle (garden hose)

Garden hose nozzles are used for mop-up work. USDA Forest Service Specification 5100-243 covers material and construction of this nozzle.

Type: Adjustable ¾-inch inlet.

Action: Adjustable spray, straight stream.

Material and finish: Brass or aluminum.

Garden Hose Nozzle Performance Ratings:

Position	Min. discharge @ 100 psi (gal/min)
1—High-velocity, low-discharge, wide-angle spray	4
2—Straight stream spray	5
3—Low-velocity, high-discharge spray	8

Available from GSA: NSN 4730-00-595-1103.

4. Nozzle tips

Since nozzle tips are comparatively small (in size), ¾-inch GHT has been adopted for the base thread. The USDA Forest Service maintains Specification 5100-244 on straight stream and spray tips. This specification lists five different diameter straight stream tips and eight different flows (gal/min) in spray tips. The bore diameter is identified on the outlet flange of the straight stream tips, and the flow (gal/min) is stamped on the body of the spray tips. The spray tips are designed to withstand a pressure of 600 psi. Straight stream tips are designed to withstand a pressure of 200 psi. Materials and construction are detailed in Forest Service Specification 5100-244.

a. Straight stream

Straight stream tips are designed and inspected to produce the following performance:

Tip size (inch)	Min. stream @ 100 psi (feet)*	Min. Flow rate @ 100 psi (gal/min)	Max. Flow rate @ 100 psi (gal/min)
⅛	29	4.2	5.2
3⁄16	34	9.4	11.6
¼	40	16.8	20.6
5⁄16	41	25.3	32.1
⅜	41	37.9	46.3

*Measured 36 inches above the ground, and to the center of the area where the stream strikes the ground.

Available from GSA:

3⁄16 inch
NSN 4210-00-203-3855

¼ inch
NSN 4210-00-177-6135

⅜ inch
NSN 4210-00-203-3845

b. Spray

The spray requirements specify a uniform solid-cone mist with a minimum horizontal range of 12 feet. The flow rate at a tip pressure of 100 psi must be within the range shown in the following table:

Tip No.	Discharge Angle (deg)		Flow rate (gal/min)	
	Min.	Max.	Min.	Max.
3	18	22	2.0	4.0
6	18	22	5.0	7.0
8	18	22	7.0	9.9
9	26	30	8.0	10.0
12	26	30	11.0	13.0
15	26	30	13.5	16.5
18	26	30	16.5	19.5
24	26	30	22.5	25.5

Available from GSA:

Size 3
NSN 4210-00-204-3358

Size 6
NSN 4210-00-204-3386

5. Applicator pipe

An applicator pipe, or wand, is available for reaching under logs, roots, stumps, and into the base of piled fuels. It can be used in deep duff, peat, and sawdust. The applicator is 52 inches long, comes apart in the middle, and has a 15-degree bend near the end. All connections are ¾-inch GHT male threads to accommodate a special low-flow spray tip (3 gal/min with a 60 degree pattern). It is also a component of the Mop-up Kit.

Available from GSA: NSN 4210-01-412-5688

G. Water Storage Tanks (Folding/Collapsible)

Type: Auxiliary storage tank.

Construction and material: May be self-supporting, pyramidal, or pillow-shaped collapsible canvas tanks; or steel or anodized aluminum tubing frame with Hypalon or vinyl tank liner having grommeted edges for attaching to a frame. Each type is foldable for easy storage and transport.

Sizes: 75 to 300 gallons for normal relay type use, large 600-, 1,000-, 1,200-, 1,500-, 1,600-, 1,800-, 2,000-, 2,100-, 2,500-, 3,000-, 4,000- and 5,000-gallon capacities.

Available: Fire equipment suppliers (see appendix G).

Type: Helicopter slingable suppression water bag

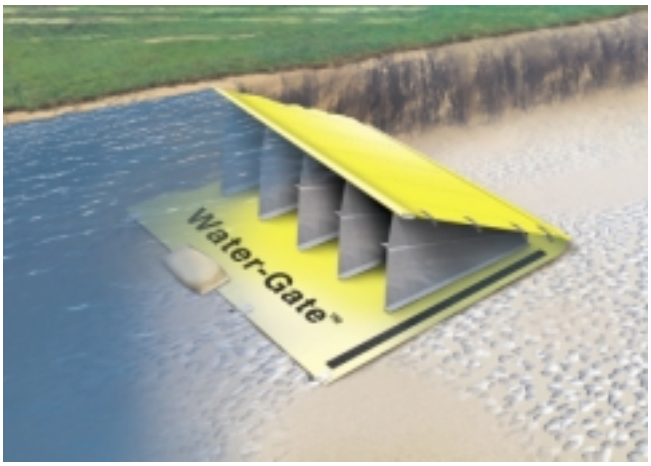
Construction and material: Integral sling straps with a 4-inch steel cargo ring. Replaceable PVC liner inside bag on 55-gallon size. The 72- and 134-gallon sizes are constructed of heavy-duty vinyl with a 4-inch filler and a valved 1-inch discharge hose. Three reinforced straps with a large ring serve as a lifting sling for aerial use.

Sizes: 55-, 72- and 134-gallon

Available from GSA: NSN 8465-01-369-2148 for 55-gallon; 72- and 134-gallon available through fire equipment suppliers (see appendix G). See section C, Hose Accessories for helicopter slingable water suppression bag accessory kit.

H. Water Diversion and Storage Devices

1. Portable dam



Type: Reusable, portable

Construction and material: Polyethylene covered with PVC. Self-supporting. Float system sewn at front of barrier to automatically rise according to water level.

Sizes: 21- or 28-inch height, 35- or 50-foot length standard sizes. Other sizes are also available.

Available: Fire equipment suppliers (see appendix G).

2. Gravity sock

Type: Canvas, 3- to 4-foot long; 8-inch to 15-inch inlet, upstream feed.

Threads: Male hose thread outlet as specified.

Size: 1½ inch.

Available: Fire equipment suppliers (see appendix G).

I. Specialized Equipment

1. Remotely activated pump (structure protection)

Type: Remotely activated BB-4 pump.

Purpose: Provide firefighters with a way to remotely activate pumps from overhead to charge sprinkler systems for structure protection.

Construction and materials: A BB-4 pump, powered by an 18 horsepower Briggs & Stratton engine, is outfitted with an electronic ground receiver system and 12 volt power booster battery pack that allows a handheld transmitter to activate the system. A strobe light attached to the pump signals activation.

Weight: 143 pounds.

Available: Fire equipment suppliers (see appendix G).

Written materials: *Remotely Activated Structure Pump*, Tech Tip 0251 1315, July 2002 - SDTDC, is available from:

USDA Forest Service
Technology and Development Center
444 East Bonita Avenue
San Dimas, CA 91773
Telephone: 909–599–1267

2. Sprinkler kit

Type: Sprinkler kit

Purpose: Provide standardized items necessary to set up sprinkler system.

Construction and materials: Kit consists of eight sprinkler heads, shutoff valves, in-line tees, risers, couplings, adapters, extensions, u-bolts, hold down pins, rope, and tent stakes. An adjustable wrench and hammer are also included in the carton.

Weight: 50 pounds

Available: National Fire Cache System, NFES 0920

APPENDIX A

Flow discharge of smooth bore nozzles in gallons per minute (gal/min)

			Nozzle flow (gal/min) @ ea. tip orifice size*							
Head (psi)	**Head (ft)**	**Velocity of discharge (ft/sec)**	**⅛ inch**	**3⁄16 inch**	**¼ inch**	**⅜ inch**	**½ inch**	**⅝ inch**	**¾ inch**	**1 inch**
10	23.1	38.6	1.5	3.3	5.9	13	24	37	53	95
15	34.6	47.3	1.8	4.1	7.3	16	29	45	65	116
20	46.2	54.6	2.1	4.7	8.4	19	34	52	75	134
25	57.7	61.0	2.3	5.3	9.4	21	38	59	84	150
30	69.3	66.9	2.6	5.8	10	23	41	64	92	164
35	80.3	72.2	2.8	6.2	11	25	44	69	100	177
40	92.4	77.2	3.0	6.7	12	27	47	74	107	190
45	103.9	81.8	3.1	7.1	13	28	50	79	113	201
50	115.5	86.3	3.3	7.5	13	30	53	83	119	212
55	127.0	90.4	3.5	7.8	14	31	56	87	125	222
60	138.6	94.5	3.6	8.2	15	33	58	91	131	232
65	150.1	98.3	3.8	8.5	15	34	60	94	136	242
70	161.7	102	3.9	8.8	16	35	63	98	141	251
75	173.2	106	4.1	9.1	16	37	65	101	146	260
80	184.8	109	4.2	9.4	17	38	67	105	151	268
85	196.3	113	4.3	9.7	17	39	69	108	156	277
90	207.9	116	4.4	10	18	40	71	111	160	285
95	219.4	119	4.6	10	18	41	73	114	164	292
100	230.9	122	4.7	11	19	42	75	117	169	300
105	242.4	125	4.8	11	19	43	77	120	173	307
110	254.0	128	4.9	11	20	44	79	123	177	315
115	265.5	131	5.0	11	20	45	80	126	181	322
120	277.1	134	5.1	12	21	46	82	128	185	329
125	288.6	136	5.2	12	21	47	84	131	189	335
130	300.2	139	5.3	12	21	48	86	134	192	342
135	311.7	142	5.4	12	22	49	87	136	196	349
140	323.3	144	5.5	12	22	50	89	139	200	355
145	334.8	147	5.6	13	23	51	90	141	203	361
150	346.4	150	5.7	13	23	52	92	144	207	367
175	404.1	161	6.2	14	25	56	99	155	223	397
200	461.9	173	6.6	15	27	60	106	166	239	424
250	577.4	193	7.4	17	30	67	119	185	267	474
300	692.8	211	8.1	18	32	73	130	203	292	520

* Based on **gal/min= $30d^2(NP)^{1/2}$**

Where: d = nozzle diameter, inches
NP = nozzle pressure head, psi

APPENDIX B

Background
During fire suppression activities that require hose lays it is important to sizeup the situation and make some quick but beneficial hydraulic calculations. Some items to consider are pump capability needed, adequacy of water source, and the type of hose lay to use. Friction loss in fire hose may result in the inability of firefighters to complete their mission.

Friction loss is the result of turbulence within the water (fluids) and the resistance along the inside wall of fire hose. Friction loss is one of the factors that must be taken into consideration when determining pump capabilities. The amount of friction loss is affected by diameter and length of hose, and the number of fittings (appliances) used.

San Dimas Technology and Development Center has tested pressure loss due to friction on a number of commonly used fire hose and have developed tables that can be copied, cut, and laminated for use in the field. Also there are formulas to assist in friction loss determination.

Five Significant Hydraulic Relationships...Governing Friction Loss

1. *For the same flow, friction loss varies approximately inversely as the* ***fifth power*** *of the diameter of the hose.*

   This means if the flow remains the same, increasing the size of the hose can drastically reduce the friction loss; or, the bigger the hose (with the same flow) the smaller the friction loss. Double the diameter of the hose (with the same flow) and the friction loss will be reduced to $\frac{1}{32}$,or about 3 percent.

2. *In the same size hose, friction loss varies approximately as the square of the flow.*

   This means that the resultant friction loss increases more rapidly than the increase in flow. For example, if the flow is doubled, the friction loss becomes 4 times as much. If the flow is tripled, the friction loss becomes 9 times as much; if the flow is quadrupled, the friction loss becomes 16 times as much as it was originally.

3. *Friction loss in hose varies directly as the length of the line, provided all other conditions are equal.*

   If identical gallons per minute are flowing, the friction loss in 500 feet of hose will be five times the friction loss in 100 feet of the same size and quality hose. (If you double the length of the line you double the friction loss).

4. *Friction loss is affected by the roughness of the inside of the hose in relation to the diameter*.

   The rougher the hose, the more the friction loss. The smaller the hose with the same roughness, the greater the friction loss.

5. *For a given flow the friction loss in hose is approximately the same no matter what the water pressure may be.*

   This means that when water is flowing through a hose at a certain number of linear feet per minute, the friction loss is the same whether the pressure is 50 psi or 400 psi.

Friction loss (psi/100 ft) in hose
(SDTDC test values except for 2½ inch which is from NFPA C* = 2)

	Hose size (ID) and type												
Flow (gal/min)	⅝-in GH	¾-in (HP) Straight High Pressure Rubber Hardline	¾-in (HP) Spooled High Pressure Rubber Hardline	1-in High Pressure Rubber Hardline (Booster)	1 in CSRL [186]	1-in Lightweight Synthetic I [187]	1-in Lightweight Synthetic II [187]	1-in Woven Fabric Hardline	1½-in CSRL [186]	1½-in Lightweight Synthetic I [187]	1½-in Lightweight Synthetic II [187]	1¾-in Lightweight Synthetic II	2½-in (Lined)
5	6	5	6		1	1	2						
10	23	13	17	3	3	3	4	2	1				
15	45	27	34	6	5	8	9	6	1	1	1		
20	78	42	53	9	9	9	16	9	2	2	2		
25	92	62	79	15	14	11	24	15	3	2	3	2	
30		86	109	21	20	18	34	20	3	3	5	2	
40		91	115	37	33	24	59	35	5	6	8	2	
50				56	49	42	80	55	8	8	12	3	
60				71	67	63		71	11	12	18	5	
70									15	16	24	6	
80									19	19	31	8	
90									24	25	39	11	
100									27			14	2
150													5
200													8
250													13
300													18
350													25
400													32
C**	1931	1010	1130	228	212	286	379	228	31	33	49	14	2

* C = coefficient of friction
** average friction loss coefficient
[ ] USFS specification

Comparative Diameters and Weights (100-ft) Lengths (Coupled)

Hose Type	ID (in)	FS Spec	Jacket	Working (Rated) Pressure (psi)	Dry Weight (psi)	Water (gal) (lb)	Weight Water (lb)	Total Weight (lb)
Garden (GH)	5/8	None	Single	200	2	1.6	13	15
High pressure rubber hardline	3/4	185	—	600	56	2.3	19	75
High pressure rubber hardline (Booster)	1	None	—	800	63	4.1	34	97
Cotton-synthetic rubber-lined (CSRL)	1	186	Single	450	20	4.1	34	54
Lightweight Synthetic I	1	187	Single	450	9	4.1	34	43
Lightweight Synthetic II	1	187	Single	450	9	4.1	34	43
Woven fabric hardline	1	None	Single	300	17	4.1	34	51
Cotton-synthetic rubber-lined (CSRL)	1-1/2	186	Single	450	27	9.2	77	104
Lightweight Synthetic I	1-1/2	187	Single	450	16	9.2	77	93
Lightweight Synthetic II	1-1/2	187	Single	450	14	9.2	77	91
Lightweight Synthetic II	1-3/4	None	Single	450	20	12.5	104	124
Lined	2-1/2	None	Double	400	23	25.4	213	236

NA = not available

Coupling sets (1½ inch) vary in weight from 0.9 to 1.6 pounds.

Friction Loss Tables

The following tables should help the firefighter in determining the required pump pressure. The chart includes different hose diameters, hose lengths, tip orifice sizes, elevations above the nozzle, and nozzle pressure of 100 psi. When looking at the tables the firefighter can see that some required pump pressures are larger than their pump capabilities. This should alert the engine captains that 2 to 3 pumps (Mark III) might be required to obtain the desired flow.

Friction loss in hose lays and appliances is very complex; however, very good predictions of the pressure loss of hose lays can be made by applying the following formula:

This formula was used to generate the pump pressures in the following tables:

$$FL = C(Q/100)^2(L/100) + Z/2.31 + 100$$

Where: **FL** is friction loss in psi
C varies with corresponding hose size and is specified below each table
Q is gallons per minute
L is hose length, ft
Z is nozzle elevation above pump, ft
100 is nozzle pressure in psi

Note: To calculate head pressure multiply 43 psi per 100 feet vertical change in elevation.
Example: 500 feet vertical change would be 5 x 43 = 215 psi head pressure.

Pump Pressures for 100-psi Nozzle Pressure
⅝ inch hose (high pressure)

Tip orifice size (in)		⅛	3/16	¼	5/16	⅜
Flow (gal/min)		4.7	10.5	18.7	28.7	42.1
Nozzle reaction (lb)		2.5	5.5	9.8	15.3	22.0
Loss/100 ft (psi)		4	22	70	165	354
Hose length (ft)	Nozzle above pump (ft)	Required pump pressure (psi)				
100	0	104	122	170	265	454
100	100	148	165	213	308	498
150	0	107	133	205	347	632
150	100	150	176	248	390	675
200	0	109	144	240	429	809
200	100	152	187	283	473	852
250	0	111	155	275	512	986
250	100	154	198	318	555	1,029
300	0	113	166	310	594	1,163
300	100	157	209	353	638	1,207
300	200	200	253	396	681	1,250
400	0	118	188	380	759	1,518
400	100	161	231	423	802	1,561
400	200	204	275	466	846	1,605
400	300	248	318	510	889	1,648
500	0	122	210	450	924	1,872
500	100	165	254	493	967	1,916
500	200	209	297	536	1,010	1,959
500	300	252	340	580	1,054	2,002

C = 2,000 for practical use

Pump Pressures for 100-psi Nozzle Pressure
¾ inch hose (high pressure)

Tip orifice size (in)		⅛	3⁄16	¼	5⁄16	⅜
Flow (gal/min)		4.7	10.5	18.7	28.7	42.1
Nozzle reaction (lb)		2.5	5.5	9.8	15.3	22.0
Loss/100 ft (psi)		2	12	38	91	195
Hose length (ft)	Nozzle above pump (ft)	Required pump pressure (psi)				
100	0	102	112	138	191	295
100	100	146	155	182	234	338
150	0	104	118	158	236	392
150	100	147	161	201	279	436
200	0	105	124	177	281	490
200	100	148	168	220	325	533
250	0	106	130	196	327	587
250	100	149	174	239	370	631
300	0	107	136	215	372	685
300	100	151	180	259	415	728
300	200	194	223	302	458	771
400	0	110	149	254	462	880
400	100	153	192	297	506	923
400	200	196	235	340	549	966
400	300	240	278	384	592	1,010
500	0	112	161	292	553	1,075
500	100	155	204	336	596	1,118
500	200	199	247	379	640	1,161
500	300	242	291	422	683	1,205

C = 1,100 for practical use
If a significant amount of hose is left on the live reel, the friction loss will be increased.

Pump Pressures for 100-psi Nozzle Pressure
1-inch hose

Tip orifice size (in)		⅛	3⁄16	¼	5⁄16	⅜	½
Flow (gal/min)		4.7	10.5	18.7	28.7	42.1	74.7
Nozzle reaction (lb)		2.5	5.5	9.8	15.3	22.0	39.3
Loss/100 ft (psi)		1	3	8	19	40	127
Hose length (ft)	Nozzle above pump (ft)	Required pump pressure (psi)					
100	0	101	103	108	119	140	227
100	100	144	146	151	162	184	271
200	0	101	105	116	138	181	354
200	100	144	148	159	181	224	398
300	0	102	108	124	156	221	482
300	100	145	151	167	200	265	525
300	200	188	194	210	243	308	568
400	0	102	110	132	175	262	609
400	100	145	153	175	218	305	652
400	200	189	197	218	262	348	695
400	300	232	240	262	305	392	739
500	0	103	113	140	194	302	736
500	100	146	156	183	237	345	779
500	200	189	199	226	280	389	823
500	300	232	242	270	324	432	866
1,000	0	105	125	180	288	504	1,372
1,000	100	148	168	223	331	547	1,416
1,000	200	192	212	266	374	591	1,459
1,000	300	235	255	310	418	634	1,502
1,000	400	278	298	353	461	677	1,545
1,000	500	321	342	396	504	721	1,589
1,000	600	365	385	439	548	764	1,632

C = 228 for practical use

Pump Pressures for 100-psi Nozzle Pressure
1½ inch hose (high pressure)

Tip orifice size (in)		⅛	3/16	¼	5/16	⅜	½
Flow (gal/min)		4.7	10.5	18.7	28.7	42.1	74.7
Nozzle reaction (lb)		2.5	5.5	9.8	15.3	22.0	39.25
Loss/100 ft (psi)		0	0	1	2	5	17
Hose length (ft)	Nozzle above pump (ft)	Required Pump pressure (psi)					
100	0	100	100	101	102	105	117
100	100	143	144	144	146	149	160
200	0	100	101	102	105	111	133
200	100	143	144	145	148	154	177
300	0	100	101	103	107	116	150
300	100	143	144	146	151	159	194
300	200	187	188	190	194	203	237
400	0	100	101	104	110	121	167
400	100	144	145	147	153	165	210
400	200	187	188	191	196	208	254
400	300	230	231	234	240	251	297
500	0	100	102	105	112	127	184
500	100	144	145	149	156	170	227
500	200	187	188	192	199	213	270
500	300	230	232	235	242	256	314
1,000	0	101	103	110	125	153	267
1,000	100	144	147	154	168	196	311
1,000	200	187	190	197	211	240	354
1,000	300	231	233	240	255	283	397
1,000	400	274	276	284	298	326	441
1,000	500	317	320	327	341	370	484
1,000	600	360	363	370	384	413	527
2,000	0	101	107	121	149	206	435
2,000	100	145	150	164	193	250	478
2,000	200	188	193	208	236	293	521
2,000	300	231	236	251	279	336	565
2,000	400	274	280	294	323	380	608
2,000	500	318	323	337	366	423	651
2,000	600	361	366	381	409	466	695
2,000	700	404	410	424	452	509	738
2,000	800	448	453	467	496	553	781
3,000	0	102	110	131	174	260	602
3,000	100	145	153	175	217	303	645
3,000	200	189	197	218	261	346	689
3,000	300	232	240	261	304	389	732
3,000	400	275	283	305	347	433	775
3,000	500	318	326	348	391	476	819
3,000	600	362	370	391	434	519	862
3,000	700	405	413	435	477	563	905
3,000	800	448	456	478	520	606	949

C = 30 for practical use

Pump Pressures for 100-psi Nozzle Pressure
1¾ inch hose (high pressure)

Tip orifice size (in)		⅛	3⁄16	¼	5⁄16	⅜	½
Flow (gal/min)		4.7	10.5	18.7	28.7	42.1	74.7
Nozzle reaction (lb)		2.5	5.5	9.8	15.3	22.0	39.25
Loss/100 ft (psi)		0	0	0	1	2	8
Hose length (ft)	Nozzle above pump (ft)	Required pump pressure (psi)					
100	0	100	100	100	101	102	108
100	100	143	143	144	144	146	151
200	0	100	100	101	102	105	116
200	100	143	144	144	146	148	159
300	0	100	100	101	103	107	123
300	100	143	144	145	147	151	167
300	200	187	187	188	190	194	210
400	0	100	101	102	105	110	131
400	100	143	144	145	148	153	175
400	200	187	187	189	191	197	218
400	300	230	230	232	234	240	261
500	0	100	101	102	106	112	139
500	100	143	144	146	149	156	182
500	200	187	187	189	192	199	226
500	300	230	231	232	236	242	269
1,000	0	100	102	105	112	125	178
1,000	100	144	145	148	155	168	221
1,000	200	187	188	191	198	211	265
1,000	300	230	231	235	241	255	308
1,000	400	273	275	278	285	298	351
1,000	500	317	318	321	328	341	395
1,000	600	360	361	365	371	385	438
2,000	0	101	103	110	123	150	256
2,000	100	144	146	153	166	193	300
2,000	200	187	190	196	210	236	343
2,000	300	230	233	240	253	279	386
2,000	400	274	276	283	296	323	429
2,000	500	317	320	326	340	366	473
2,000	600	360	363	370	383	409	516
2,000	700	404	406	413	426	453	559
2,000	800	447	449	456	469	496	603
3,000	0	101	105	115	135	174	334
3,000	100	144	148	158	178	218	378
3,000	200	188	191	201	221	261	421
3,000	300	231	235	245	264	304	464
3,000	400	274	278	288	308	348	508
3,000	500	317	321	331	351	391	551
3,000	600	361	364	374	394	434	594
3,000	700	404	408	418	438	477	637
3,000	800	447	451	461	481	521	681

C = 14 for practical use

APPENDIX C

This appendix was developed to showcase reliable and inexpensive methods to determine flow rates and pressure requirements for wildland engines. These methods have proven effective given the lower flow rates experienced with wildland engines. Additionally, this appendix defines the appropriate gauges needed to properly perform these test methods.

Hose Flow Rate Determination by the Splash Method

Firefighting personnel can determine the flow rate of fire hose or a pump by using readily available equipment at almost no cost. The equipment used is a short piece of pipe, a tape measure, a level, and a plumb bob. Knowing how to perform the splash flow rate test can be very handy, since accurate flow meters are often not readily available.

This method of determining pump flow rate is very accurate and needs no calibration. It is based on the principle that when an object is released, it falls at a given rate, independent of its horizontal velocity. (This is the same principle as when a gun is level and on level ground when fired and at the same time a second bullet is dropped from the same height as the gun, both bullets will hit the ground at the same time.) When water is released from a pipe positioned at a given height from the ground, it always hits the ground in the same time regardless of horizontal velocity.

As explained in detail below, how far away from the pipe exit that the water hits the ground is directly proportional to the water's horizontal velocity as it exits the pipe. Further, the horizontal velocity is directly proportional to the amount of water coming out of the pipe, and depends on the area of the pipe opening. Knowing this area, the height of the pipe exit above the ground, and the distance out from the pipe that the water hits the ground; the water flow rate can be accurately calculated using the formula given at the very end of this text. The splash pump/hose flow method is as follows:

A. Couple a short length of 3 to 4 feet of pipe, of known inside diameter, to the hose coming from the pump. In some cases, as flow rates approach maximum, hose ripple can occur. To prevent this, use either hard suction hose or a longer pipe.

B. Mount the pipe level, horizontally, at a convenient height "h" above the ground. Select the height suggested in the table for the pipe size and flow range you are going to use to avoid having to do a sequence of calculations.

C. Run the pump and have the water splash on the ground.

D. Measure the distance ("D") along the ground from the end of the pipe to where the water hits the ground. At the time of the measurement, the hose must be running full of water. Let a plumb bob hang from the pipe exit down to the ground. Start measuring "D" at this point. (See figure C1.)

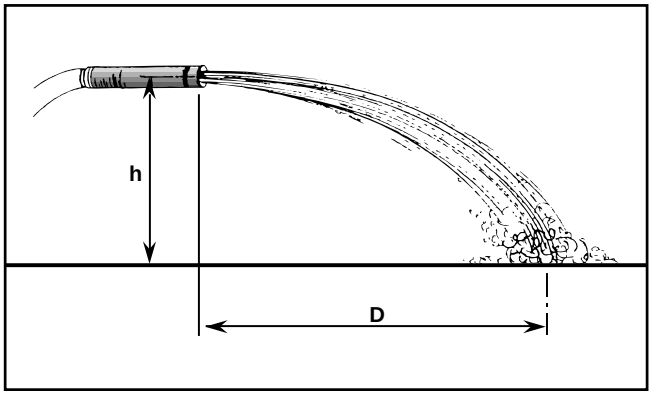


Figure C1—Relation of pipe exit to "h" and "D"

How far out from the end of the pipe that the water hits the ground, depends on the horizontal velocity as the water exits the end of the pipe. The higher the exit velocity, the higher the "D" i.e., "D" is directly proportional to water flow velocity. Knowing "D" and the height of the pipe ("h") above the ground, the velocity of the water out of the pipe can be determined. From this and the pipe exit area, the flow rate can be calculated.

To obtain the flow rate in gallons per minute (gal/min) for the pipe size being used when employing the height suggested in table C1, multiply "D" by the gal/min per inch found in the final column of the table. Be sure to check the inside diameter of the pipe being used to see if it is as listed in the table. If it is not, the flow formula, presented following the table, must be used—as would be the case for any setup, pipe size, or height, that is not presented in the table.