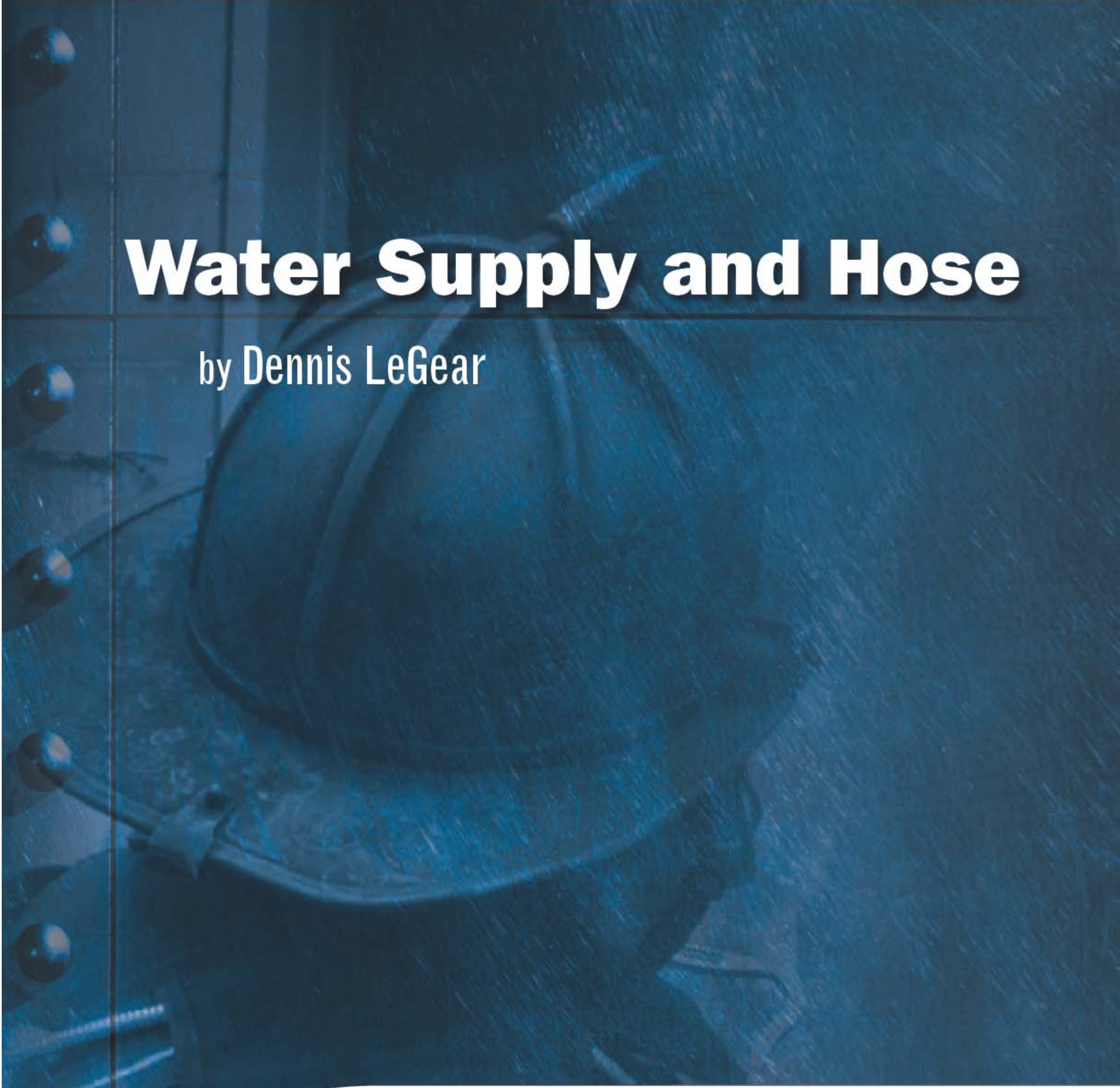


Water Supply and Hose

by Dennis LeGear

This chapter provides required knowledge items for the following NFPA Standard 1001 Job Performance Requirements:

FFI 5.3.10

FFI 5.3.15

FFI 5.5.2

FFII 6.5.5

15

This chapter contains Skill Drills. When you see this icon, refer to your Skill Drill book for step-by-step instructions.

SKILL DRILL

OBJECTIVES

Upon completion of this chapter, you should be able to do the following:

- Identify the basic properties of water
- Differentiate between flow and pressure as they relate to water supply
- Define the term friction loss as it relates to water supply
- Define static and residual pressure
- Identify the common elements of a municipal water system
- Describe the differences between wet barrel and dry barrel fire hydrants
- Describe the proper procedures for opening and closing a fire hydrant
- Identify and describe the proper procedures for inspecting, maintaining, and testing of fire hydrants
- Identify types of rural and auxiliary water supply systems
- Describe the classifications of fire hose
- Identify types of fire hose construction
- Identify the common types of hose and their typical flows that are used by the fire service
- Identify the types of couplings used to connect fire hose together and to various appliances
- Identify the types of hose fitting used by the fire service
- Identify the types of hose appliances used by the fire service
- Identify the types of hose tools used by the fire service
- Describe the proper procedures for testing, maintaining, and cleaning fire hose
- Identify and describe the different methods of storing hose used by the fire service
- Identify and describe the different types of hose rolls used by the fire service
- Describe the different types of hose loads for supply and attack hose
- Describe the different types of hose lays
- Describe the proper procedures for deploying hose at a fire emergency incident

INTRODUCTION TO WATER SUPPLY

Establishing an adequate water supply is the one of the first critical elements of all successful fire attacks. An adequate water supply has to be in place quickly and last for the duration of the incident. Many failed fire attacks can be squarely blamed on a lack of an adequate water supply. Establishing a good water supply is often accomplished under extreme stress, as the firefighter in fig. 15–1 can attest to. From the firefighter to the incident commander, one critical item must be addressed early on at all fires: water supply. Water is the most common extinguishing agent used by fire departments around the world because is relatively plentiful, absorbs large quantities of heat, is easily transported, and follows a fixed set of physical rules and characteristics.

Fig. 15–1. A firefighter struggles at a hydrant to charge a large diameter supply line. (Courtesy of Danny Barlogio)

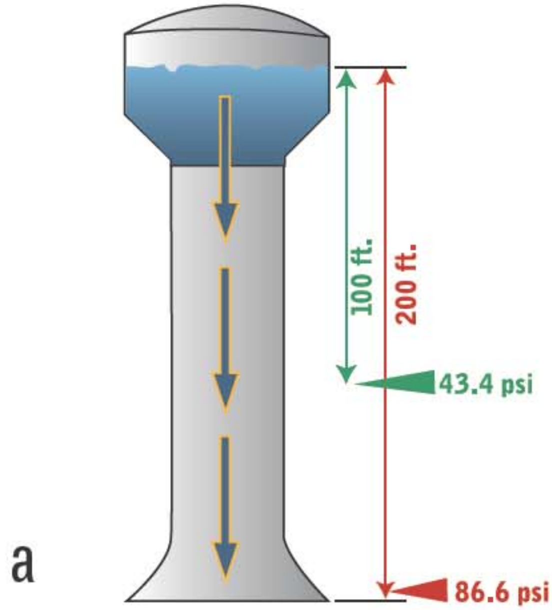
Basic water characteristics and terms

FFI 5.3.10 Two of the most important physical rules governing water supply are that water is **noncompressible** (as far as the fire service is concerned) and is capable of being pumped. This means that one cubic foot of water will occupy one cubic foot (1 ft^3) regardless of the pressure.[1] It also means that it can be moved from one location to another. These two basic physical properties allow water to be easily stored, transported, and moved in pipes and hoses by both gravity and pumps.

Two specific terms are used to describe the movement and use of water on the fireground: **flow** and **pressure**. Flow is the volume of water being moved or used and is expressed in **gallons per minute (gpm)** or **liters per minute (L/min)**. Pressure is a force applied over a given area, commonly expressed as **pounds of force per square inch (psi)** or **kilopascals (kPa)**. Pressure (psi or kPa) is the force used to move the volume (gpm or L/min) of water through a hose and out of a nozzle.

As a member of the fire service, you should know a few other basic properties about water. A gallon of water (3.8 L) weighs about 8.33 lb (3.78 kg), and 1 ft^3 of water (12 in. × 12 in. × 12 in.) is approximately 7.48 gallons (gal) (28.31 L). This means 1 ft^3 of water weighs about 62.4 lb (28.3 kg). Water pressure is commonly measured in psi. If we took a 1-in.^{2} column of water (1 × 1 in.) that is 1 ft tall, the weight exerted at the bottom of that column would be measured as 0.434 psi. A column of water 2 ft high would have a pressure at the base of the column of 2 times 0.434, which equals 0.868 psi, and so on. Take a look at fig. 15–2 to help you understand the concept of water pressure. Expressed a different way, "water pressure increases 1 psi for every 2.3 ft (0.7 m) of depth." The actual pressure at the bottom of a 10-ft (3-m) column of water would be 4.34 psi (30 kPa). One can see the advantage of an elevated water tank. For example, if the water level in the tank in fig. 15–2 (a and b) was 200 ft (60 m) above the ground, the water pressure would be roughly 87 psi (600 kPa) at the bottom. This force (pressure) is due to one thing: gravity, which acts continuously on all objects on earth. The pressure created by a column of water is called **elevation head**.

Alternatively, the fire service commonly uses a rough estimate of 5 psi (34 kPa) for the amount of pressure that is needed to move (force) water up every 10 ft (3 m) of building height, the approximate height of a building story. While we *gain water pressure* (force) at the bottom of an elevated tank (column of water), we must *apply pressure* (force) to move the water up to the top of that tank (water column). Fire department pumpers (engines) are used to provide the pressure to move the water through hoses and up into the upper stories of a building that is on fire.



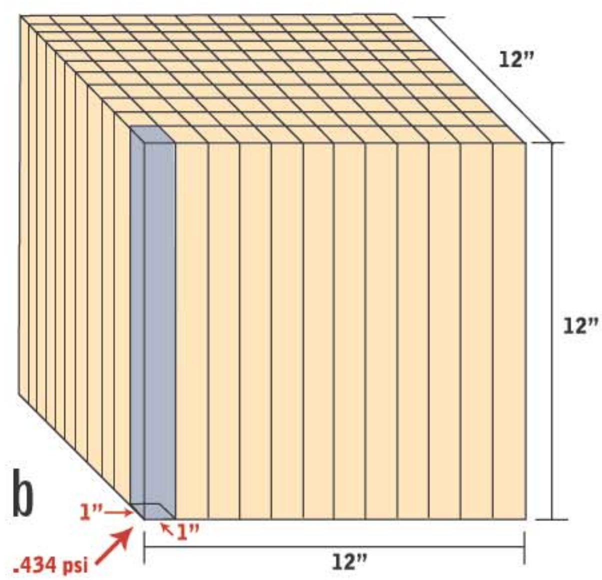


Fig. 15–2 a, b. Understanding water pressure is important to effectively use your water supply on the fireground.

In addition to gravity, we must consider the force of **atmospheric pressure**. That force is literally the weight of the air that makes up the earth's atmosphere that is exerted on objects on the earth. At sea level, a common place to measure atmospheric pressure, the atmosphere produces a pressure of 14.7 psi (100 kPa). Let's take a look at a bottle of liquid (fig. 15–3). The surface of the liquid in the bottle is under the pressure of the atmosphere above it. At sea level that pressure is 14.7 psi (100 kPa). If a straw were placed in the bottle of liquid, the level of liquid inside the straw would be the same as the liquid level surrounding the straw in the bottle. This is because the air in the straw has the same atmospheric pressure, 14.7 psi (100 kPa). However, when you drink from the straw, you lower the pressure inside the straw to below 14.7 psi (100 kPa). The liquid is then forced up the straw because the liquid surrounding the straw is still under the greater atmospheric pressure. If you lowered the pressure in the straw by 1 psi to 13.7 psi (94.5 kPa), the straw could be as long as 2.3 ft (0.7 m) and still force the liquid to the top of the straw. If you were to remove the entire atmosphere (14.7 psi) from inside the straw at sea level—creating a perfect vacuum of 0 psi (0 kPa) inside the straw—it would function to a height of 2.3 ft (0.7 m) × 14.7 psi (100 kPa), or about 33.9 ft (10 m)!

Fig. 15–3. A simple way to demonstrate atmospheric pressure is with liquid and a straw.

To measure pressure, fire department pumpers use pressure gauges. They are mounted on the pumper's **pump panel**, the location where the pumper's operator (chauffeur, motor pump operator, or driver) controls the pumps. All water pressure gauges in the fire service read in **psig**; the "g" stands for gauge, which means that the reading has been corrected to zero psi after taking into the account the weight of earth's atmosphere.

Now that we understand the physical properties of water better, let's move on to how this knowledge is applied in the fire service. For any water supply system to work, one has to be able to move water from one point to another. As we have seen, pressure can be created by gravity, pumping, or the combination of gravity and pumping together. Pressure is used to move the water from short to very long distances. Because pressure is a form of energy, some of this energy will be dissipated (lost) when water is flowing. This loss of pressure (energy) is called **friction loss**. Friction loss is created as water flows through a hose and literally rubs against the inside of the hose, losing pressure all along the way. Friction loss increases as more water is flowed though a given size hose (gpm or L/min); friction loss can be decreased if the size of the hose is increased with the flow kept the same. For example, a 1¾-in. (45-mm) hose flowing 175 gpm (662 L/min) loses more pressure due to friction than a 2½-in. (65-mm) hose of the same length and flow. Since nozzles and other appliances need certain minimum pressures to operate properly (covered in chapter 16, Fire Streams), friction loss is a very important factor to consider.

There are two other terms used to describe types of pressure: **static pressure** and **residual pressure**. Static pressure is the amount of pressure in a hoseline or water main in a street while *no* water is flowing. Residual pressure, on the other hand, is the pressure remaining in a hose or water main while water *is* flowing.

Let's take a look at how a common garden hose is used to define some of these concepts (fig. 15–4).

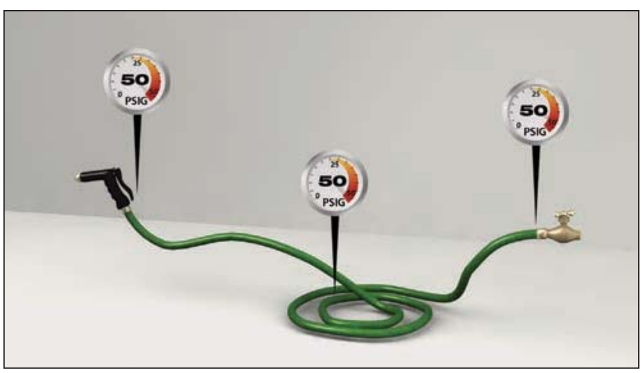


Fig. 15–4. When the garden hose is not flowing, but is charged, it is a closed system, and the water pressure will be equal at all parts along the hose.

Most of us take the common garden hose with an attached spray nozzle for granted. We use the it to wash our cars and to water our plants without wondering how it works. Let's take a closer look at what makes this possible. Once you open up the hose bib, water travels down the hose and stops at the closed nozzle. If you bled the trapped air off by cracking open the nozzle momentarily and then took a pressure reading at the closed nozzle with no water flowing, you would get the static pressure. Imagine that the static pressure reading was 50 psig (350 kPa). If you then went back to the hose bib and took another pressure reading, again with no water flowing, it would read the same 50 psig (350 kPa). The same would be true if you took a third reading halfway between the nozzle and the hose bib. The fact is that if you took a pressure reading anywhere along this charged garden hose with no water flowing, you would get 50 psig (350 kPa). This 50 psig (350 kPa) reading is an example of static pressure; in this example, it represents the **potential energy** of the water in the garden hose waiting to be released.

Now let's take a look at the garden hose and the effect on pressure once we open the nozzle (fig. 15–5). Notice that with water flowing, the pressure is highest at the hose bib and lowest at the nozzle. The 45-psig (315 kPa) reading on the gauge at the house near the hose bib is called the residual pressure. The 45-psig (315 kPa) residual pressure represents the extra capacity left over in the house's water supply system when the garden hose is flowing water. This extra capacity allows other people in the house to still wash the dishes, take a shower, and so on. The 35 psig (245 kPa) on the middle gauge represents the fact that as the water travels down the garden hose, energy is lost to friction. This drop in pressure represents a loss in the kinetic energy available in the hose. In this case the friction loss is 10 lb (4.5 kg) in the first half of this hose. Now take a look at the gauge located at the nozzle; it reads 25 psig (175 kPa), which means the water leaving the nozzle is at 25 psig (175 kPa). This 25 psig (175 kPa) is the energy used to force the water out of the nozzle and throw the stream a distance away from the nozzle.

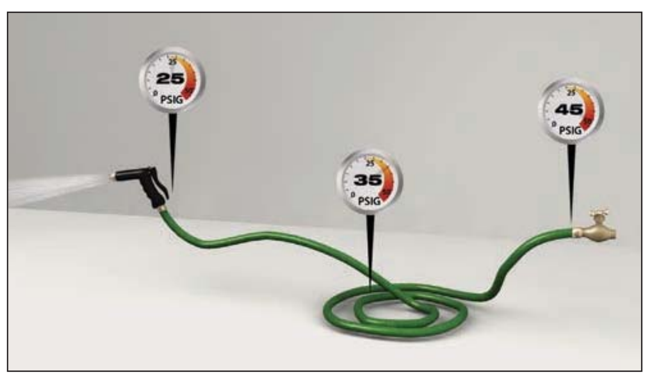


Fig. 15–5. When water is flowing, the residual pressure represents the extra capacity available in the system. The 25 psig (274 kPa) represents the pressure of the water leaving the system. The 20 psi (239 kPa) difference is the friction loss in the system.

Another important concept is water hammer. A typical garden hose will flow about 10 gpm (38 L/min). At 8.3 lb/gal (1 kg/L), a typical garden hose would produce a flow of 83 lb/min (10 kg/min). A typical garden hose squeeze sprayer nozzle stops the water rapidly as soon as you stop squeezing the handle. You may have noticed how garden hoses sometimes jump when you stop flowing water. This is because all that water in motion was abruptly stopped by that closed nozzle. Since we know water does not compress, that energy must be dissipated in one way or another. This violent dissipation of kinetic energy that occurs when flowing water is stopped rapidly in a closed system is called **water hammer**. In this example, the garden hose stretches and moves, and the pipes in the house shake. This small 10-gpm (38 L/min) flow is not enough to cause damage; however, in the fire service where typical flows are 150 to 1,000 gpm (568 to 3,785 L/min), rapidly stopping water by slamming shut intakes, discharges, or nozzles can result in major damage. This includes damage to nozzles, fire hose, pumps, and water mains. The best practice to prevent water hammer is by always operating valves and nozzles in a slow, deliberate, and cautious manner.

MUNICIPAL WATER SYSTEMS

Now that you have a basic understanding of some of the physical concepts and characteristics regarding water, we will discuss larger water supply systems. Most communities have a water supply system that serves both its drinking water needs and fire-suppression flows. This type of **municipal water system** is designed to provide sufficiently clean water for consumption while providing adequate residual capacity of that same water for fire suppression. The modern water supply system is usually run by a public or private water department. The water company bills consumers for their consumption and in return administrates the system under heavy local, state, and federal regulations to ensure that both drinking water standards and minimum fire-suppression capacities are met. Municipal water systems are typically made up of the following critical elements:

- Sources of raw water
- Treatment and storage facilitates
- Distribution system
- Valves
- Hydrants
- Hydrant inspection, maintenance, and testing

Sources of raw water

Typical sources of water are broken into two distinct groups: **groundwater** and **surface water**. Groundwater is stored beneath the ground in naturally occurring aquifers. These groundwater aquifers are exploited by drilling wells. Communities are often supplied by groundwater wells alone, and substantial sustainable amounts of water can be acquired by drilling wells and pumping the water out. Groundwater has accumulated in these aquifers for thousands of years through rainfall in their watersheds, which then percolates down into the aquifer. We can think of large aquifers as lakes underground.

Most of us are also familiar with surface water sources, of which the most typical types are freshwater sources. Some examples of surface freshwater sources are lakes, creeks, rivers, deltas, and engineered freshwater storage such as large reservoirs (fig. 15–6 a and b). Some water departments have now started to use saltwater sources like bays, oceans, and brackish areas of estuaries to augment their fresh surface water sources. Most water districts or departments usually use only one source of raw water; however, as water becomes more valuable and water resources more scarce, many water systems are now taking advantage of multiple sources.

Treatment and storage facilitates

After possible sources of water have been identified, the water has to be transformed from raw water to treated, **potable water**. This process is done at a water treatment plant. The raw water is transported by gravity, pumping, or both to the treatment plant. Sometimes the direct source for a treatment plant is a small-terminal, raw-water-storage reservoir. This type of terminal reservoir acts as a buffer to the main source of water, so that in case of an earthquake, drought, or other natural disaster, the water district or department would still have a limited supply of water for treatment and distribution (fig. 15–7).

Water treatment can be very complex and can have many steps. The amount of water treatment that is required is directly related to how clean the raw water entering the system is. Treatment can include any of the following processes: desalinization, aeration, coagulation, flocculation, sedimentation, filtration, fluoridation, ozone disinfection, and ultraviolet light disinfection. Some of these processes are mechanical, and others are chemical. Some of these treatment processes remove substances and contaminates from the water, while others add things.

However, the main goal of water treatment remains the same no matter what processes are employed. That goal is to ensure that the water is safe for human consumption before it enters into the distribution system. Ideally, these water treatment facilities should be designed to handle emergencies like power failures and other situations, to ensure that both adequate drinking water and fire capacity can be maintained through most foreseeable emergencies.

Fig. 15–6 a, b. A man-made reservoir and a nearby creek

Distribution system

The **distribution system** is the most important part of a municipal water system for fire departments. It is the system of treated water storage reservoirs, tanks, pumps, and water mains or pipes that supply the fire hydrants with water. The system should be designed to provide the best flow of treated water throughout the municipality, maintain safe water quality, and meet the service area's minimum standard fire flow. Figure 15–8 shows a basic water system, where a treatment plant receives raw water from a lake, treats it, then pumps the water into a distribution system of several treated water storage tanks in the community. Using the force of gravity, these storage tanks then provide pressurized treated water to the community's water main system. This pressure is created by the elevation head, discussed earlier in this chapter.

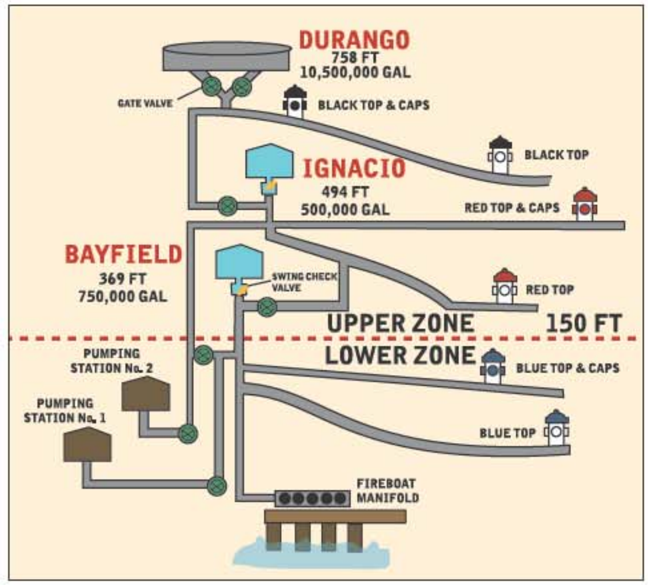


Fig. 15–7. An example of a high pressure system that is fed with non-potable water and is only for firefighting

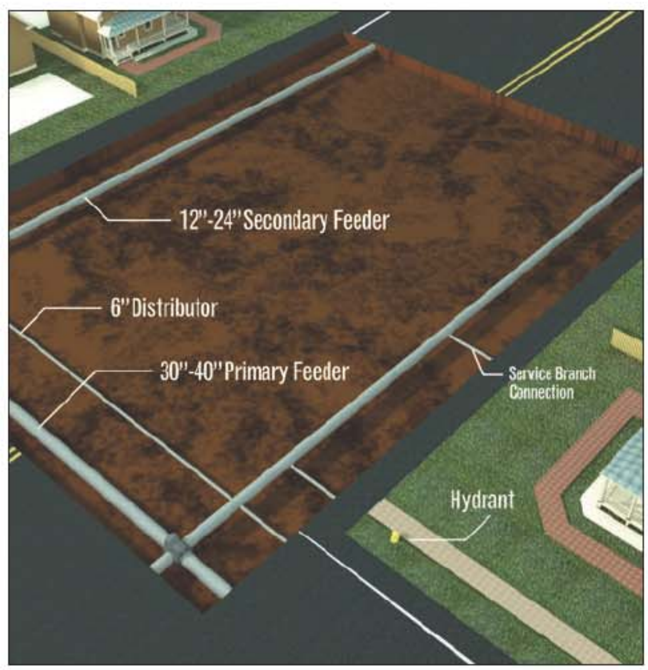


Fig. 15–8. A small water main system

These larger treated water storage tanks ensure sufficient stored treated water capacity for the water main system. This extra capacity could be used to maintain the flow at a large fire. Figure 15–9 (a and b) represents two different examples of treated water tanks that supply the water main systems for the neighborhoods below and around them. Both of them are using gravity to supply their water main systems. Most likely, they are pumped full at night to replace the water used during the day. They are usually refilled at night because demand for water in most communities is lowest at night.

Fig. 15–9 a, b. These treated water tanks use gravity to supply the municipal water supply.

The water main system is very important to the fire department. It is ideally designed to have low friction loss and good residual pressure during normal use. This is done in several ways. First, by laying out the water distribution system in a grid, water is received at most locations from multiple directions and from different sized mains. This efficient design lowers friction loss because no one pipe has to flow all the required water being supplied to a hydrant. Remember, as flow increases in a given size pipe, so does the friction loss. Friction loss can be reduced by increasing the size of the pipe or reducing the flow, which is what happens when flows are split in a grid pipe network (fig. 15–10). Another way water departments and districts lower friction loss in the water main system is to have a series of large-diameter pipes reduced to medium-diameter pipes, and then reduced even further to smaller-diameter pipes that are laid out in a gridlike fashion.

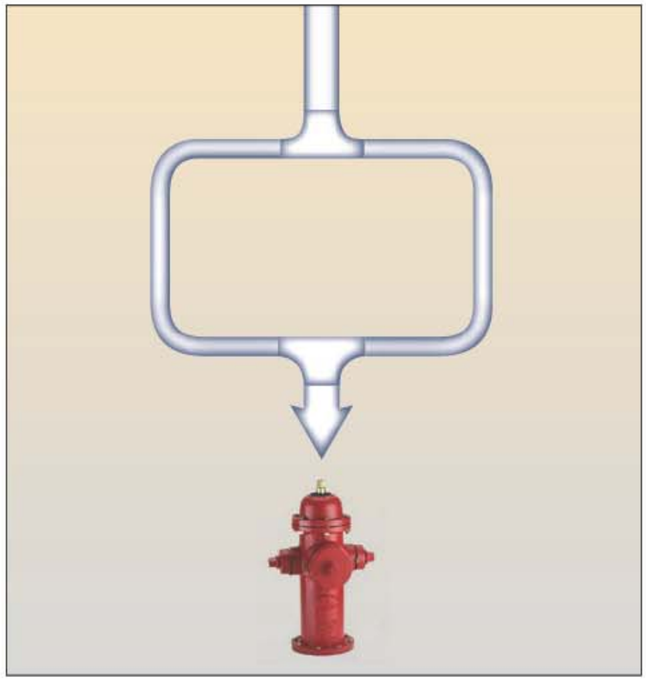


Fig. 15–10. Split flow in a pipe grid is a great way to combat friction loss in a water supply system.

Throughout the water main system, **water main valves** are located at frequent intervals. Water main valves are used by the water district to shut down certain areas of the system or grid for issues like repair and maintenance. Most water main valves are always left in the open position. Water main valves can also be kept in a closed position to separate grids or pressure zones. They are commonly spaced at 500 ft (152 m) and 800 ft (244 m), so only a small section of water main would need to be turned off for repairs, leaving other areas still supplied.

- Large-sized water mains are sometimes called **treated water aqueducts** or **primary feeders**. They can be very large: some are 20 ft (6 m) in diameter in cities with heavy water demand like New York. However, in most cases they are between 30 in. and 48 in. (76 and 122 cm) in diameter. Typically, no hydrants are connected to these primary feeders.
- Medium-sized water mains are commonly referred to as **secondary feeders** and are generally sized from 12 to 24 in. (31 to 61 cm) in diameter. These secondary feeders are common throughout most municipal water main systems. Many fire hydrants are connected to these secondary feeders.
- Smaller-sized water mains are usually referred to as **distributors**. These pipes make up the bulk of most water main systems and generally range in size from the outdated 4-in. (10-cm) main to 12-in. (30-cm) mains. Because of their small size and

high friction loss, 4-in. (100-mm) mains are not commonly used anymore; 6-in. (150-mm) pipe is the current minimum size pipe used to supply hydrants. Hydrants are primarily installed on these small distributors.

Hydrants

Fire hydrants are the main access points for the fire department water supply in municipal water systems. Hydrants are connected directly to the water main system by a pipe. This is typically at 6 in. (150 mm) diameter pipe with a gate **valve** (also called a roadway box valve) located in the street between the hydrant and water main. This valve allows the hydrant to be shut off using a special long wrench called a **hydrant key or tee wrench**. It is sometimes necessary to shut off a hydrant at the gate valve for maintenance or if a hydrant is knocked over during a vehicle accident. Ideally, hydrants are supplied by a water main from two directions. Sometimes it is not possible to easily supply a hydrant from two directions; for example, when a water main goes down a dead end court or cul-de-sac street. This is called a dead end water main, and the hydrants on it are called dead end hydrants. Dead end hydrants have less capacity, as they do not have the same redundant supply as those located within the grid. Some water districts mark these with symbols like an arrow showing the direction of water flow in the main and a vertical line denoting that it is a dead end hydrant.

Typically, you will encounter two types of fire hydrants: wet barrel and dry barrel. **Wet barrel hydrants** have water inside right at street level and are usually used in nonfreezing climates. In fact, wet barrel hydrants were first developed around 1900 in the San Francisco Bay area and are sometimes called California hydrants. A typical modern wet barrel hydrant will have more than one outlet. Each outlet has its own operating stem and valve. Figure 15–11 (a and b) shows a picture and a diagram of a typical wet barrel hydrant installation. Notice some of the terms used in the diagram:

(1) stem guide seal, (2) body, (3) stem, (4) stem O-ring, (5) valve rubber, (6) retainer, (7) O-ring seat, (8) retaining nut, (9) cotter pin, (10) stem guide O-ring, (11) stem guide, (12) carrier, (13) valve seat, (14) cap, (15) cap washer, and (16) chain ring.

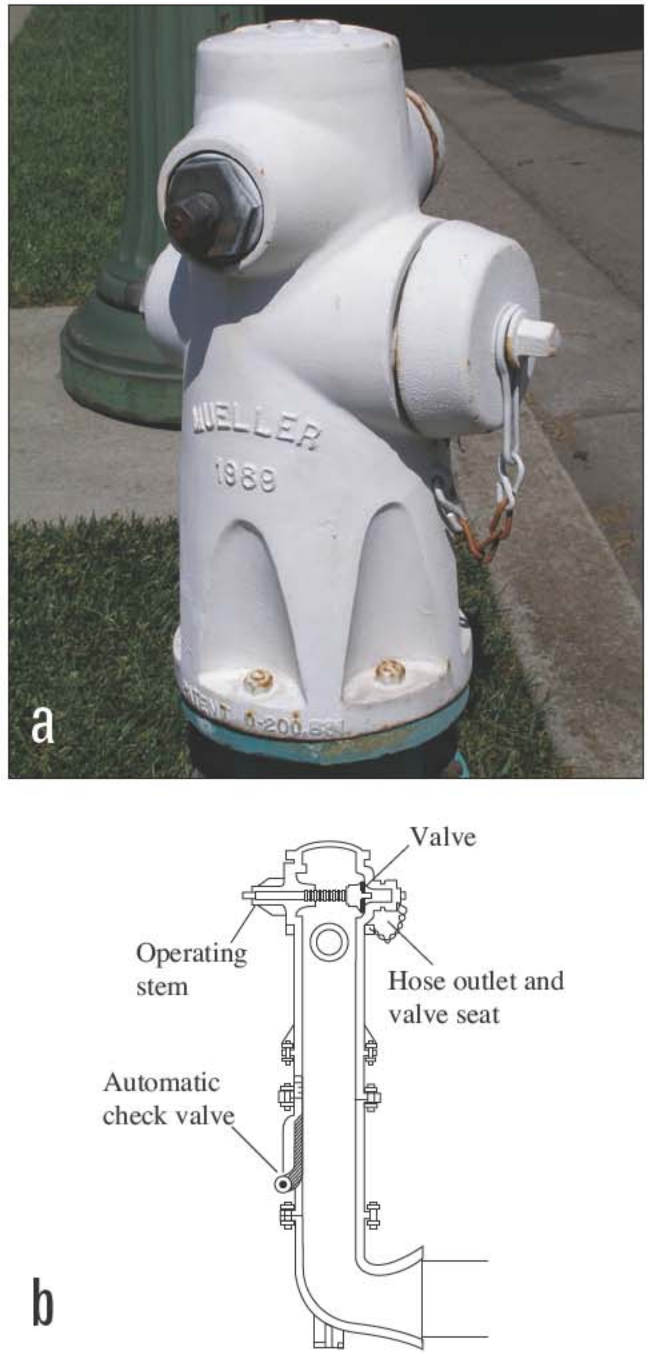


Fig. 15–11 a, b. Wet barrel hydrants are common around the world. Water resides inside the hydrant at street level.

The **dry barrel hydrant** is typically found in freezing climates. However, dry barrel hydrants can be installed in nonfreezing climates as well. This means that you may find dry barrel hydrants, which are specially designed to work in freezing climates, in warmer climates. The main difference between the two designs is that the dry barrel hydrant is just that: dry. In a dry barrel hydrant, the water is held in the pipe serving the hydrant safely below the frost line by a valve that is controlled by an operating nut at the top of the dry barrel hydrant. Figure 15–12 (a and b) contains a picture and a diagram of a typical dry barrel hydrant installation.

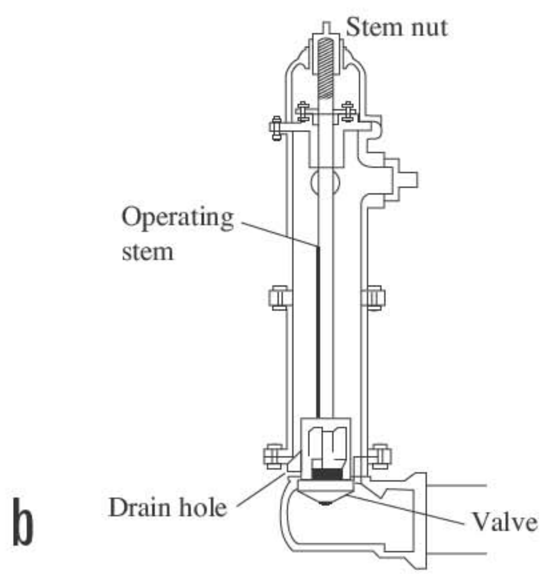


Fig. 15–12 a, b. Dry barrel hydrants are common in freezing climates. The water resides safely below the frost line.

Outlets on both wet and dry barrel hydrants are threaded. The current national standard is **National Standard Hose Thread (NST)**, sometimes known as National Hose Thread (NHT). Most fire hose in the United States uses this standard, although there are a number of cities with their own hose threads. The number and size of hydrant outlets vary, but generally include one or two 2½ in. (65-mm) outlets and a single **steamer** connection (also known as a **pumper** connection) of 4 or 4½ in. (100 or 115 mm) Some cities have incorporated a 5-in. (125 mm) Storz connection on their newer hydrants. (Storz connections are described later in this chapter.)

Basic hydrant operation. **FFI 5.3.15** Before we go any further, it is appropriate to briefly discuss basic hydrant operations. These methods apply to both wet and dry barrel hydrants (fig. 15–13). Hydrant operations begin with sizing up the area around the hydrant and the hydrant itself. It is important to make sure that it is accessible and that there is no exterior damage to the hydrant that would impact its operability. Before charging the hydrant it is important to check the interior of the hydrant for any damage as well. Once it is determined that the hydrant is operational, it is time to charge the hydrant. Prior to charging the hydrant, it is recommended that the hydrant be flushed by removing the steamer cap and opening the hydrant a few turns so that a fair amount of water is discharged from the hydrant. The hydrant is opened by using the hydrant wrench to turn the operating nut. This will vary between wet and dry barrel hydrants. Look on the hydrant for a directional arrow that will indicate the direction to turn the operating nut (clockwise or counter-clockwise). Once it is flushed, close the hydrant and attach the supply hose to the appropriate hydrant discharge opening or nozzle. When you are ordered to "charge" or "open" the hydrant, slowly and smoothly open the hydrant fully, usually 10–14 turns in order to avoid a "water hammer," and then turn back the hydrant wrench a quarter turn.

Fig. 15–13. Understanding basic hydrant operation is crucial to maintaining a proper water supply on the fireground.

Once the operation is completed and the order is given, the hydrant can be shut down. Shutting down the hydrant is the reverse of the procedure to open it. Place the hydrant wrench on the operating nut and turn in the reverse direction you did when you opened it, or look for the indicator arrow on the hydrant and turn in the reverse direction. As before, close it slowly and smoothly, to avoid a "water hammer." Once fully closed, turn the operating nut a quarter turn in the opposite direction to prevent over tightening it. Once the hose has been drained, disconnect it from the hydrant and replace to hydrant discharge caps by hand tightening.

Hydrant inspection, maintenance, and testing. A large percentage of all firefighting around the world is made possible by water supplied from fire hydrants. In the United States, hydrant spacing is typically every 300 ft (90 m) in high-fire-load areas (high value), and 500 ft (150 m) in lower-fire-load areas (low value) such as single-family-dwelling neighborhoods. For example, the City of Oakland, California, with a population of 400,000, has roughly 6,500 hydrants located within 56 square miles (145 sq km).[2] The fact is that an incredible number of hydrants in the world, once installed, will probably never be used unless there is a fire. Based on this fact, inspection, maintenance, and testing of hydrants are critical to ensure that fire hydrants remain functional and perform to their fullest capability during an emergency.

In the United States, it should be the goal to inspect and maintain fire hydrants annually. **Flow testing**, a more detailed test, can be done on a rotating time schedule. Flow testing is covered in chapter 29, Pre-Incident Planning. Many jurisdictions mandate that all of their hydrants must be inspected annually, with a certain percentage to be flow tested. For example, if 20% of hydrants were flow-tested during their annual inspection, it would take 5 years to flow-test every hydrant in the jurisdiction.

Annual company district **hydrant inspections** should address the following items: location, clearance, caps/chains/threads, barrel empty (dry), valves, paint, color code, blue reflector, hydrant gate pot, and curb paint. Minor problems can be corrected immediately, and major problems reported for repair. It is more critical that dry barrel hydrants are inspected annually because they are more susceptible to failures than wet barrel hydrants. Examples of serious failures in dry barrel hydrants are debris in the barrel and failure to drain properly. Both of these issues could easily lead to an unusable dry barrel hydrant. The following list describes what you should look for when performing an inspection of a wet or dry barrel hydrant:

- Location: Make sure the hydrant is on your map, and, if working from a list, confirm the hydrant number or address.
- Clearance: Ensure that the hydrant is readily visible. Typical fire code provisions require that "a 3-ft clear space shall be maintained around the circumference of fire hydrants except as otherwise required or approved." The hydrant shown in fig. 15–14 needs to be dug out and have vegetation trimmed back. If a retaining wall is required to keep it uncovered, it should be reported.
- Caps, chains, and threads: Caps should be free of damage, attach to the hydrant by chains, and turn freely. Remove caps and check for gaskets, because the rubber seals are used to maintain a leakfree condition in unused outlets in dry barrel hydrants when in operation. The other primary purpose of gaskets when hydrants are not in operation is to prevent electrolysis and severe rusting of caps. Ensure that threads are in good condition. The 2½ in. (65 mm) cap nut in fig. 15–15 has broken off, and its chain is missing.

Fig. 15–14. This hydrant needs to be dug out and have the vegetation trimmed to ensure access when needed.

- Barrel empty (dry): With the caps off the hydrant, ensure that dry barrel hydrants are empty and free of visible debris.
- Valves: Check for leaks around the operating stem on wet hydrants and for water in the barrel of dry hydrants. Open the hydrant slowly and operate all valves, making sure that they work easily. It is not important to achieve full flow; just make sure the hydrant works. Turn the hydrant off slowly. Ensure dry barrel hydrants drain completely by verifying that the water is draining down the hydrant barrel. If the water only drains down to the level of the open hydrant outlet, it is not draining properly. This can be pumped out with a dry barrel hydrant pump (fig. 15–16). If the hydrant is not draining properly, it must be repaired. Dry barrel hydrants with frozen water in them will not flow correctly,

if at all. When operated, dry barrel hydrants should be fully opened. When fully opened, water is stopped from flowing out of the drain hole. Partially opened dry barrel hydrants can undermine themselves if pressurized water flows out of their drain holes.

Fig. 15–15. This hydrant is missing a cap nut and chain.

Fig. 15–16. Dry barrel hydrant pump

- Paint: Check the condition of the paint. It should be in good condition, but can have minor cracks and light rust. If the hydrant is severely rusted and needs a complete repainting, report it. The hydrant shown in fig. 15–15 should be repainted.
- Color code: Many jurisdictions use **color codes** from NFPA 291, *Recommended Practice for Fire Flow Testing and Marking of Hydrants*, located on the bonnet indicating the hydrant's available flow at 20 psi residual pressure. If so marked, have the proper paint in aerosol cans for touch-ups (table 15–1).
- Reflector: A roadway reflector is a method for identifying a hydrant's location. If your jurisdiction uses them, check them during the annual inspection and replace damaged ones or install new ones when necessary.

Table 15–1. Properly color coding the hydrants in your jurisdiction helps to rapidly identify expected flow rates.

Class C	Less than 500 gpm (1,892 L/min)	Red
Class B	500–999 gpm (1,892–3,782 L/min)	Orange
Class A	1,000–1,499 gpm (3,782–5,674 L/min)	Green
Class AA	1,500 gpm and above (5,678 L/min and above)	Light blue

- Hydrant valve cover (roadway box): Ensure that the hydrant gate valve cover is not paved over. Some jurisdictions also paint them white to help locate them during emergencies such as sheared hydrants.
- Curb paint: Make sure the curb is painted red. If the red curb paint is missing or needs repainting, report it.

The annual test just described is a good basic inspection for determining serviceability of the hydrant. What it does not determine is the maximum flow of the hydrant, nor does it assess the available capacity of the water distribution system in the area. To attain this important information, one must subject the hydrant to a flow test. Flow tests need to be coordinated with water district. All information collected should be done under a mutual program with shared data. This is because the information will be used by the water district to determine how their distribution system is performing. Has there been a drop in flow in an area? Is it because the pipes have become clogged? Is there a regulator valve not opening properly? Has a change in the system had a negative impact in an area of the distribution system? Is the hydrant street valve partially closed? The data gathered from annual flow testing of hydrants can be an invaluable tool for both fire departments and water districts.

Usually, large municipal water districts will have a telephone number to call at least 24 hours before flow tests are performed. Proper notification of the water department during flow testing is imperative, so the system operators will understand the sudden spike in usage. It is also good for the fire department to foster a solid relationship with the agency that oversees the water distribution system. Large water districts sometimes have an employee or department that is assigned to manage all the flow testing data and hydrant testing programs. Sometimes they will even provide the training and necessary equipment for flow testing.

RURAL AND AUXILIARY WATER SUPPLY

Many firefighters work in rural areas of the country where large portions of their response area are not served by water main systems with fire hydrants, or the systems in place have inadequate capacity and pressures to supply enough water to mount an effective fire attack. In other cases, some older highly urbanized areas have outdated or obsolete water supply systems that are no longer capable of providing an effective fire flow. Municipal water supply systems become obsolete when the size and age of the water mains become inadequate or when regular demand on the system has grown to a point where it no longer has enough reserve capacity to provide large fire flows. Poor maintenance of a water supply system can also lead to dramatically less water capacity from fire hydrants. Furthermore, many cities in earthquake zones have water main systems that may completely fail during a large earthquake.

In all of these cases, it is still necessary to provide an adequate supply of water for fire control. Fortunately, effective fire control may be accomplished if an adequate water supply is established in a timely manner. In the rural firefighting world, many well-prepared fire departments have identified reliable auxiliary sources of water and have made plans to access them during emergencies. To these rural agencies, alternate water supply operations are considered bread and butter. In the urban world of firefighting, many municipal fire departments are now developing these same types of auxiliary systems to ensure adequate water service in times of disaster. Some fire departments, like San Francisco, have good auxiliary water supply systems already in place. Others cities, for example, Seattle, have recently completed a plan that addresses auxiliary water supply.

The following are examples of auxiliary water supply:

- Water tenders and portable tanks
- (Static sources) Drafting hydrants, cisterns, ponds, lakes, swimming pools, and jet siphons
- Relay pumping
- Fireboats and dry main systems
- Reclaimed water main systems and hydrants

Water tenders and portable tanks

FFI 5.3.15 The modern fire engine is a **triple-combination pumper**, which consists of three key critical items: a pump, fire hose, and a water tank. The water in the engine's tank usually does not exceed a storage capacity of 1,000 gal (3,758 L). This water carried on the engine is only good for mounting initial attacks on small fires. However, a purpose-built **water tender** apparatus can have a water tank that holds up to 4,500 gal (17,034 L) of water. These specialized units make large-scale **water shuttle operations** possible. Typically, these water tenders have an easily deployable, folding, portable water tank that has a slightly larger capacity than their water tender tank (fig. 15–17).

Fig. 15–17. Most water tenders have an easily deployable, folding, portable water tank.

An efficient water shuttle operation can supply large fire flows (fig. 15–18). A basic water shuttle operation consists of three elements, a **dump site**, a **fill site**, and the necessary fire apparatus. The dump site is located at the fire. It is usually made up of portable tanks taken off water tenders and then filled by those water tenders. The attack engine then drafts from these portable tanks. As the attack engine uses the water in the portable tanks, the water tenders travel to the fill site and fill their tanks. The water tenders must then return to the dump site and refill the portable water tanks supplying the attack pumper. This must all be accomplished in a safe manner.

The fill site should be located as close as possible to the fire. The fill site should have a capacity of at least 1,000 gpm (3,785 L/min), have good access, and be located on the best available roads that preferably provide a circular traffic pattern between the fill site and the dump site. The fill site does not need to be the nearest good hydrant; a static source of water, such as a lake, river, swimming pool, or bay can also be a good fill site. If your water supply is a static source of water, you must have a means of moving the water. This is usually accomplished by a drafting fire engine, which in turn fills the water tenders.

Fig. 15–18. A simple water shuttle operation can effectively supply water for fireground operations.

The most basic of water shuttle operations from a static water source need the following apparatus, equipment, and actions: (1) A dump site by the fire with a portable tank is initially filled by the water tender. (2) A route is established to a nearby water source with the capacity to fill a water tender in a rapid fashion, preferably at least 1,000 gpm (3,785 L/min). (3) Upon arrival at the fill site, the water tender is filled by an engine drafting from the static water source. (4) Once filled, the water tender returns to the dump site and fills the portable tank again. This completes one shuttle cycle, which provides a limited capacity of water at the fire scene. Ideally, repeating this cycle will supply a continuous water supply to the attack pumper during the fire until the fire is extinguished.

Fire department personnel involved in water shuttle operations should never try to increase the amount of water that can be delivered by speeding up the shuttle cycle. Rushing these types of operations can lead to serious and sometimes fatal injuries. Firefighters have been hit and run over at fill and dump sites. Water tenders are heavy vehicles that demand respect when operated and must be driven cautiously and in a defensive manner at all times. Many firefighters have lost their lives in vehicle-related accidents involving water tenders. The simple fact is that if more water is required, the water shuttle operation must be scaled up. This means using more portable tanks, possibly multiple dump sites, more water tenders, more routes, possibly multiple fill sites, more attack engines, more fill engines, better routes, road closures to all traffic but emergency equipment, and so forth. During this whole process, positions must be assigned at critical areas: dump site officer, fill site officer, traffic control officer, water supply group supervisor, and the like. Many safe options are possible to increase capacity and efficiency in water shuttle operations. Speeding up can be fatal and is not an option in water shuttle operations. In the end, fire departments that rely on this difficult operation must train actively and often.

Obtaining water from static sources

FFI 5.3.15 Many fire departments are surrounded by raw water supplies such as lakes, rivers, bays, and even the ocean. Note that saltwater from the ocean or brackish water from a river that empties into the ocean must be flushed from fire department pumpers, hoses, and nozzles because the saltwater can damage them. Cities across the United States are often located by vast sources of water; these bodies of water are used for commerce and transportation. If a bay-front warehouse is on fire, and the old water mains servicing that district of the city are inadequate for the volume of fire encountered, the fire department can draft water right out of the bay. This is a good, solid tactic, and some fire departments have addressed their outdated water systems further in waterfront areas by installing drafting hydrants and providing some engines with jet siphons to assist with waterfront supply issues.

A drafting hydrant, properly designed on a reliable static water source, will easily provide the full-rated capacity of the engine's pump (fig. 15–19 a and b). A typical **drafting hydrant** is a specialty hydrant that consists of the following components: a strainer basket submerged at least 2 ft (0.6 m) at the end of a 6-in. (15 cm) diameter pipe, and a pumper connection with a female swivel pumper connection in easy reach of an engine's drafting hose. These drafting hydrants are just that: ideally, pipes into a static water source, with less than 10 ft (3 m) of lift. Drafting hydrants function is an easy way to draft water from an untreated static water source. If a drafting hydrant is not provided, you can still draft using the **hard suction hose** on the engine (described in detail later). However, this is usually less efficient and can have many disadvantages when compared to using a drafting hydrant. Some of these disadvantages include access issues, lack of access to water, poor bank conditions, leaves and debris clogging the strainer, and frozen surface water during the winter.

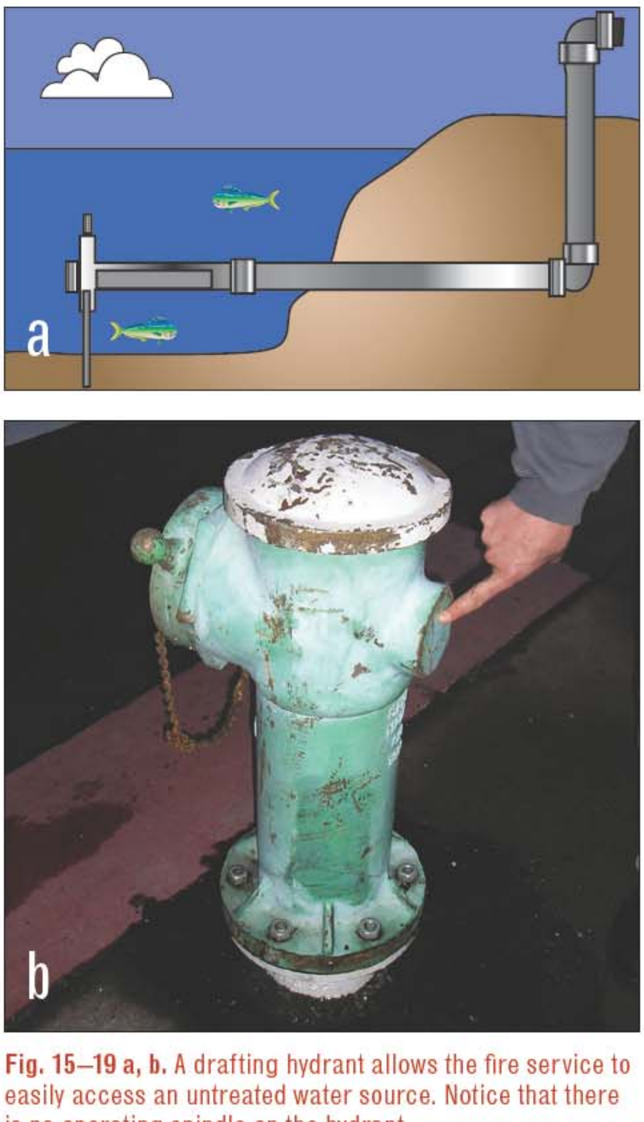


Fig. 15–19 a, b. A drafting hydrant allows the fire service to easily access an untreated water source. Notice that there is no operating spindle on the hydrant.

Cisterns are large, watertight underground tanks used for storing liquids, especially water. In the fire service, jurisdictions that would like to add emergency stored water capacity for firefighting sometimes build cisterns. In cities, cisterns are typically located below ground at major intersections. These cisterns can hold hundreds of thousands of gallons of water. Cisterns in large cities are usually filled by the nearest hydrant via an access plate in the street. This plate also serves as the drafting port. Cisterns are also commonly found in rural areas. Building codes in rural areas are starting to require property owners to provide water for firefighting, and cisterns fill this role. It is now possible to buy precast concrete or plastic cistern kits that have fill ports, vents, and drafting hydrants as part of the overall design. Chemicals are added to prevent the growth of algae and other aquatic organisms. Cisterns, once filled, are basically tanks of nonpotable water for drafting during emergencies.

Jet siphons are typically used to move water from one portable tank to another in water shuttle operations. A **jet siphon** (fig. 15–20) is a device in which water is pumped into a small, 1½-in. (38-mm) intake and then under high pressure, rapidly discharged into a large hard-suction hose. New strainer-equipped jet siphons now can generate up to 700 gpm (2,650 L/min) utilizing regular, soft-suction hose. However, it is always better to try to achieve a true drafting operation using properly sized, traditional hard-suction hose with a total distance of less than 30 ft (9 m) and with no more than 10 ft (3 m) of lift. Drafting in this manner should provide the full rated capacity of an engine's pump.

Relay pumping

Relay pumping in its simplest form refers to one pump supplying water through fire hose to another pump (fig. 15–21). Fire departments relay pumps to overcome water supply problems where the fire is at a distance from the nearest water source, but typically not more that a mile away. Pumping water through hose takes energy, and fire hose has friction loss. For example, a 4½-in. hose at 1,000 gpm (3,785 L/min) has 10 psi (69 kPa) friction loss per 100 ft (30.5 m). A mile (roughly 5,300 ft or 1,609 m) of 4½-in. (115-mm) hose would require 530 psi (3,654 kPa) of pump pressure to overcome the friction loss to continuously supply 1,000 gpm (3,785 L/min) through the mile of hose. 530 psi (3,654 kPa) of friction loss a mile in 4½-in. (115-mm) hose at 1,000 gpm (3,785 L/min) is not possible to achieve with the standard fire department hose and equipment. However, to pump a mile of 4½ in. (115 mm) hose at 1,000 gpm (3,785 L/min), a fire department could place a pumper every 1,000 ft (304.8 m), which would bring the required pressure per pumper down to 100 psi (700 kPa) for each 1,000 ft (304.8 m) section of 4½-in. (115-mm) hose it is assigned to pump for friction loss. Friction loss in hose is the main reason fire departments establish relay operations.

Fig. 15–20. Jet siphons are typically used to move water from one portable tank to another.

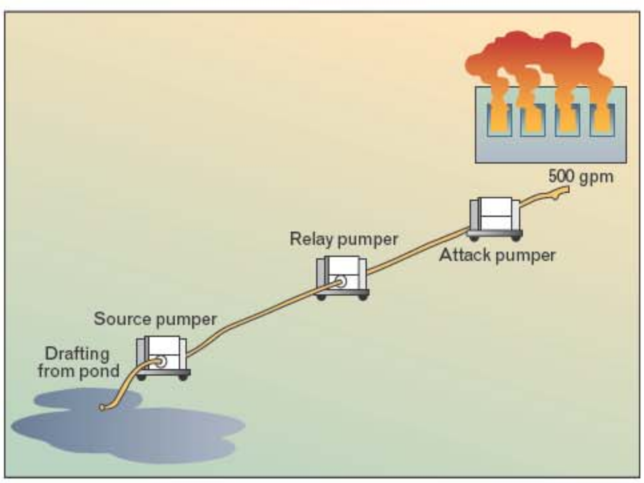


Fig. 15–21. A simple relay operation

For terminology purposes, let's take a look at a three-pumper relay operation. The pumper located at the water source that pumps water to a second pumper is called the **source pumper**. The second pumper, or **inline pumper**, receiving water from the source pumper then pumps the water to a third pumper. The third and last pumper in this example is called the **attack pumper**. It supplies the fire attack lines and is located at the fire. The number of required pumpers, size of hose, length of lay, type of lay, required gpm, and elevation change are just some of the factors that have to be accounted for a successful relay-pumping operations.

Fire departments that routinely use relay operations should be well practiced and drilled; they should also be aware of the limitations of their relay operations in their training. These fire departments sometimes have special hose wagons and relay valves to help speed the deployment of large amounts of hose. This makes engaging in relay-pumping operations in rapid fashion more possible. Long relay-pumping operations can be established in a rapid manner by departments that routinely train in this tactic. In some jurisdictions, fire departments have set up preformed relay-pumping task forces that can be special-called by the incident commander. These task forces then establish any entire secondary water supply upon arrival, with a goal of attaining a certain water supply capacity, usually no less then 1,000 gpm.

Fireboats and dry main systems

Many fire departments located near large bodies of water have **fireboats** with pumping capabilities. These fireboats vary in size and use, but we will discuss them based on solely on pumping capacity. The NFPA classifies fireboats as Class A, B, or C. Class A is the largest class of fireboat.[3] It must be 65 ft (20 m) in length or larger, with at least a 5,000-gpm (18,927 L/min) pumping capacity. This is followed by the Class B fireboat, which is between 40 ft (12 m) and 65 ft (20 m) in length with a minimum of 2,500-gpm (9,463-L/min) pumping capacity. Class C is the smallest class of fireboat, is 20–40 ft (6–12 m) in length, and has a minimum pumping capacity of 500 gpm (1,893 L/min). Many fireboats greatly exceed their suggested minimum pumping capacities. One such example, operated by the Los Angles City Fire Department, is a 105-ft (123-m) fireboat with a pumping capacity of 38,000 gpm (143,846 L/min).

Fireboats are amazing pieces of equipment. Typically, they are designed to continuously pump water at their rated capacity for at least 8 hours. Following the terrorist attack of September 11, 2001, on the World Trade Center in New York City, fireboats were used to fight the ensuing fires and supplied a peak flow of 60,000 gpm (227,125 L/min) to the World Trade Center site through fire hose.[4] Fireboat pumping operations continued for days at Ground Zero.

The 1989 Loma Pretia earthquake caused several major fires in San Francisco's Marina District. San Francisco Fire Department's (SFFD) fireboat *Phoenix* (fig. 15–22) pumped roughly 5.5 million gal (20.8 million L) of water over a 15-hour period through a portable water supply system built out of 5-in. (125-mm) hose because water mains in the area had been severely damaged by the earthquake.[5] No hydrants were working reliably in the area of the main fires near the waterfront. During this conflagration, the pumping capacity of the *Phoenix* was largely credited with saving a whole district of the city. Soon after the 1989 earthquake and fire, SFFD purchased a second fireboat to augment their waterfront fire protection.

Fig. 15–22. SFFD fireboat Phoenix and waterfront-mounted dry hydrant. (Courtesy of Danny Barlogio)

Some cities with fireboats have wet or dry **manifold systems** connected to special water main systems. This type of water main system carries nonpotable or raw water, which can be pumped into fireboats or pumping stations that draw water from a static source, fed by large reservoirs under the force gravity, or a combination of all of these methods. San Francisco's Auxiliary Water Supply System is the best example of this in the United States.

Other cities have a separate high-pressure water supply systems—in some cases using water supplied directly from an adjacent river—in their downtown congested commercial districts. These systems are activated during large fires.

Reclaimed water main systems and hydrants

As drinking water becomes an increasingly scarce natural resource, a new trend has begun on the West Coast: the use of **reclaimed water**. Sometimes called **gray water**, reclaimed water is becoming so regularly used that waste-water treatment plants (sewage treatment plants) are now providing it back to consumers through reclaimed water distribution systems. Gray water is used to water golf courses and flush toilets in high-rises, and it is used in other situations where potable water is not needed. Some fire departments are now requesting hydrants to be installed on these newly installed gray-water main systems and are using these hydrants as auxiliary water supply sources. These gray-water hydrants are painted purple, which is the same color as reclaimed water pipes. See fig. 15–23, which shows just such a gray-water hydrant. This gray-water fire hydrant is located on a reclaimed water main system that waters a very large city park and school grounds.

Fig. 15–23. Reclaimed water wet barrel hydrant

As we conclude our discussion about water supply, you now can see just how important an adequate water supply is. A sufficient water supply is necessary at all fires once an attack has begun, and it needs to last the whole incident without interruption. There are billions of dollars of water supply infrastructure throughout the United States. In addition to the municipal water supply infrastructure, billions of dollars have been spent on fire department equipment to use that available water. In the end, it is up to us, the fire service professionals, to get the most out our available water supply system. As you move forward in your career, it will become necessary to expand your knowledge regarding water supply. This chapter is just a basic introduction to effective and efficient water supply. Remember, poor water supply equals poor service.

INTRODUCTION TO HOSE

Now that we have discussed water supply systems, we need a way of moving the water from place to place. The moving of water in the fire service is accomplished with the use of hose specifically designed and constructed for the fire service. The ideal fire hose must be low in friction lost, durable, lightweight, and easy to couple. Fire hose must also be made in a cost-effective manner. Weighing these needs and characteristics, the major manufacturers of fire hose provide a wide array of choices to the modern fire service. In this discussion about fire hose we will be covering the following topics:

- Classification of hose
- Hose anatomy and construction
- Size and type of hose and common flows
- Couplings
- Fittings, appliances, and hose tools
- Basic hose testing and maintenance
- Hose storage
- Water supply evolutions

Classification of hose

The breakdown in classification of fire service hoses is based on its tactical uses. Typically, hose is discussed in terms of drafting, supply, attack, and wildland. **Drafting hose** is a rigid hose that is used by a pump to acquire water from static water sources. **Supply hose** is designed to move larger volumes of water; naturally these supply hoses have a larger diameter than attack hoses. **Attack hose**, sometimes referred to as hand line hose, must have a diameter large enough to move the required flow, which can be up to 325 gpm (1,230 L/min), but must be small and lightweight enough to be easily moved around the fireground by firefighters. **Wildland hose** is a type of specialty attack hose designed to work well for combating vegetation fires. Wildland hose is not produced in diameters greater than 1½ in. Two main criteria for wildland hose are reduced weight and tolerance for higher pressures. One other type of specialty hose used extensively in the fire service is booster line or reel line. It is basically a big rubber garden hose made in either a ¾- or 1-in. (20- or 25-mm) diameter. The booster line typically is only used for nuisance fires, but has its place in fighting both small urban nuisance fires and in the control of small vegetation fires. Booster line has a limited role in fighting fire due to its low flow and fixed length. The full length of booster line is mounted on a hose reel and is usually no longer than 200 ft (60 m) in length. A typical maximum flow from a booster line is 60 gpm (227 L/min). *A booster line is never to be used for fire attack in a building or for a vehicle fire.*

Hose anatomy and construction

Hose anatomy and construction is another area of the fire service that has seen dramatic changes with the help of technology. Advances in materials science have led to fire hoses that far exceed the performance characteristics of hose manufactured as recently as two decades ago. It is common now to have fire hose capable of withstanding continuous pressure of up to 400 psi (2,800 kPa), even though regular fire service pumps are not designed to operate efficiently at pressures above 250 psi (1,750 kPa). This increased capability is a demonstration of just how tough currently manufactured modern fire hose really is.

When fire hose is constructed, the manufacturers try to build it for the task it will be performing. For example, is the hose going to be used for attack, supply, or wildland? What types of pressures will the hose encounter? Will it be exposed to unduly harsh environments inside fire buildings, or will it mainly be used outside? Is it going to be continually exposed to sunlight in open hosebeds or routinely be exposed to moisture for prolonged periods? Is the overall weight of the hose likely to be a big issue? With these things in mind, manufacturers set out to construct hose based on consultations with fire departments and industry experts while meeting written industry standards and laws. The goal is to make fire hose that performs its function well with low overall weight, low friction loss, and reasonable cost, while maintaining adequate durability and service life.

Hose must be resistant to all types of mechanical damage, such as that caused by sharp objects or being regularly dragged over rough surfaces. It must be able to handle long-term storage without deteriorating in a variety of conditions in apparatus hosebeds, compartments, bundles, packs, rolls, and hose racks. Fire hose needs to absorb heat without failing or easily catching fire. Furthermore, it must be resistant to damage from long-term exposure to sunlight. On top of that, modern fire hose will routinely be put away wet, which promotes mildew and mold. Although constructed to overcome these performance demands, fire hose must maintain its ability to flow water while holding its shape and not easily kinking. Fire hose must also fold easily and store in a space-efficient manner, lying nearly completely flat when not in use. Facing all of these challenges, the fire service hose manufacturers have stepped into a world of synthetic materials and exotic rubbers to meet these demands.

Typical fire hose can be broken down into **lined hose** with either one or two outer reinforcing **jackets**. The linings of the hose can be made out of rubber compounds, thermoplastics, or blends of both, as well as polyurethane or natural rubber latex.[6] This liner must be smooth, watertight, and durable while maintaining a surface that provides a low friction loss based on the amount of water that the hose is designed to flow. A common liner material is an ethylene propylene diene monomer (EPDM) rubber and polyurethane. The inner liner, which is the waterway, is always protected by one or two outer jackets.

The first hose jacket serves many purposes, so it must be tough. The main purpose of the first jacket is to resist the expansion of the waterway, which enables the fire hose to retain its shape and not deform under pressure. Hose jackets or reinforcements are commonly made out of synthetic fiber, natural fiber, or a combination of both.[7] The first, critical jacket allows the liner to operate at high pressures, though usually not more than 250 psig (1,825 kPa) during normal fire service application. In the case of **single jacketed (SJ) hose**, a fire hose designed with only one jacket, the outer sheath must also provide a layer of protection from mechanical, thermal, and chemical damage. The first hose jacket is usually made from nylon, or in some cases, cotton. For example, wildland hose is still sometimes single-jacketed hose lined with cotton and rubber. Wildland hose also comes in SJ nylon rubber–lined hose construction. The cotton jacket performs its functions well, especially under heat, but it is susceptible to mold and mildew damage more than the SJ nylon version of wildland hose. A fire service agency must spec the type of hose they wish to purchase, because there is a wide variety of construction available for similar uses.

Double-jacketed (DJ) hose is used throughout the United States and is commonly referred to as structure fire hose. DJ structure fire hose is a very widespread specification for urban fire departments for operations at building fires. DJ structure fire hose is commonly purchased in sizes ranging from 1½ to 5 in. (38 to 125 mm). The extra outer jacket is usually made of similar material as the first. It is designed to shed water and resist mechanical abrasive forces, heat, and flame. One added benefit of having this extra outer jacket, which encloses the first or single jacket and liner, is that it provides an extra layer of protection against forces on the fireground that can cause hoses to fail. Both jackets are treated to minimize mold and mildew even when put away wet. In addition, modern hose jackets are usually designed to be resistant to petrochemicals. Figure 15–24 (a and b) shows the difference between SJ and DJ fire hose.

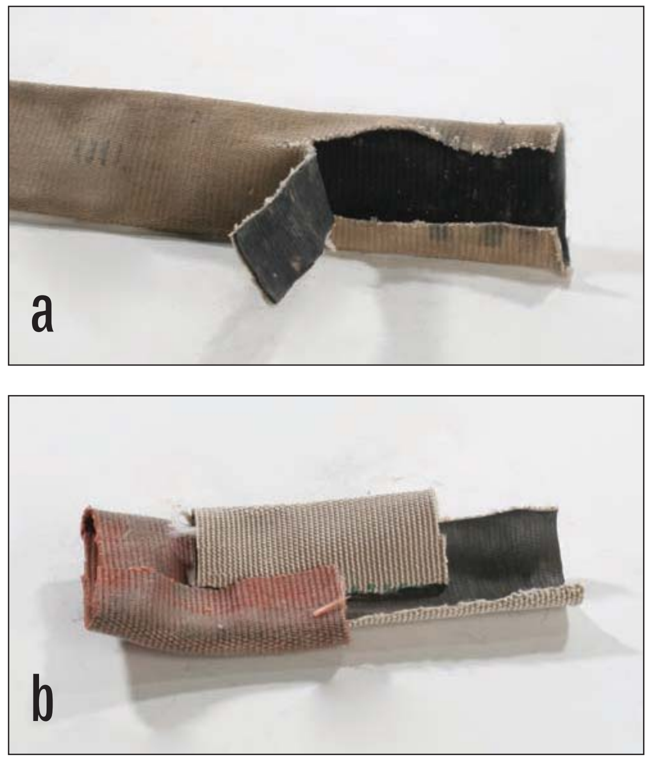


Fig. 15–24 a, b. Top: 1½-in. (38-mm) SJ cotton rubber hose; Bottom: 1¾,-in. (45-mm) DJ nylon structure hose. Both have rubber liners. (Courtesy of Adam Weidenbach)

Two other types of hose the fire service uses are drafting hose and booster hose. *Drafting hose*, also called *hard suction hose*, needs to maintain a waterway under a vacuum (i.e., negative pressure, at or below 0 psi). Suction hose was traditionally made out of a wired frame wrapped with rubber belting and coated in rubber. This made a hard semiflexible black hose that was very heavy and rigid. Drafting hose is now frequently either made out of an EPDM rubber liner with outer nylon and wire reinforcement or a durable, flexible, lightweight polyvinyl chloride (PVC) plastic. Drafting hose allows pumps to acquire water from static water sources by providing a waterway in which a vacuum can be created and maintained. Once a good vacuum is attained, water from the static source simply flows up the hose under atmospheric pressure into the pump. This is the same principle that is at work when you use a straw to drink a glass of soda. The straw is basically a drafting hose made of plastic tubing. Typically, drafting hose is made in 10-ft (3-m) lengths, and engines carry two lengths of it. Fire engines carry only 20 ft (6 m) of drafting hose because the laws of physics dictate that the practical limit in the fire service for drafting vertically is around 20 ft (6 m). Drafting hose is manufactured in a variety of diameters; large pumps need large drafting hose. A 1,500-gpm (5,678 L/min) pump requires 6-in. (15 cm) diameter hard suction hose to reach capacity at a 10-ft (3-m) draft.

Even though the lion's share of all attack and supply hose is either single jacketed or double jacketed, there are other options. One type of uniquely constructed hose being offered by hose manufactures is an **extruded hose** made out of nitrile rubber or polyurethane with a weaved matrix providing the backbone of the hose (fig. 15–25). In essence, it is a jacketless hose designed with a nitrile rubber or polyurethane material composing both the waterway and jacket, and the embedded, woven fabric matrix providing the required strength. Extruded hose is offered both in supply and attack hose diameters. Its main advantage is that it is lightweight while still providing the majority of all required aspects of fire service hose. However, extruded hose is notorious for its tendency to kink.

Fig. 15–25. Extruded 1½-in. structure fire hose. (Courtesy of Adam Weidenbach)

The main use of extruded hose is for large water supply operations and is usually ordered in 4-in. (100-mm) diameters and larger, although it is also found in smaller-diameter hand lines. It is now even purchased in diameters of 6, 8, 10, and 12 in. (152, 203, 254, and 305 mm). These diameters are referred to **ultra-large-diameter hose (ULDH)**. This is an exciting new type of hose, which is providing solutions in governmental and big industrial applications. ULDH hose is uniquely suited for large-scale disasters where flows of up to 10,000 gpm (37,854 L/min) through a single hose are required. The Department of Homeland Security funded a ULDH system in New Jersey, and even cities as small as Berkeley, California (population ca. 100,000) are investing in this technology. Berkeley is purchasing a ULDH system to combat large-scale water main failures that are predicted by the water district serving their community following a major earthquake on the Hayward Fault. ULDH systems with portable pumping capabilities are becoming more and more common and can act as a buffer to overcome the inevitable large-scale water problems during catastrophic events.

Size and type of hose and common flows

FFI 5.3.10 In this section, we will look at different diameters, flows, and standard lengths of various fire hose. The nice thing about fire service hydraulics is that it is based in math and physics. There is always one manufacturer or another trying to say that their hose flows the best or claiming that their 2-in. (51-mm) hose is as hydraulically efficient as a competitor's 2½-in. (65-mm) hose. Do not fall into this trap. Technological advances are usually applied to all similar types of hose at the same time, no matter who the manufacturer is. The simple fact is that the larger the diameter of the hose, the more water it will flow.

Take, for example, a flow of 200 gpm (757 L/min) in a 1¾-in. (45-mm) DJ attack hand line hose. A 200-gpm (757 L/min) flow in 1¾-in. (45-mm) attack hose will require 62 psig (434 kPa) per 100 ft (30 m) of hose just to overcome the friction loss. On the other hand, that same 200-gpm (757-L/min) flow in 3½-in (90-mm) DJ medium-diameter supply hose (MDH) only loses 4 psi (28 kPa) per 100 ft (30 m) due to friction loss. This example clearly demonstrates the need for different hose sizes for different jobs in the fire service. Note that in table 15–2 the largest attack hand line hose is 2½ in. (64 mm). This is because a 2½-in. (65-mm) diameter fire hose can reasonably move the maximum recognized hand line flow of 325 gpm (1,230 L/min). There is no need for a larger-diameter hand line hose in most circumstances. This is discussed in more detail in chapter 16, Fire Streams. The other type of hose used in supply situations is commonly referred to as **large-diameter hose (LDH)**. Look at table 15–2 to get an idea of the size and type and common flows of these types of hose, attack/hand line, MDH, and LDH. The table includes the dry weight of 100 ft of hose as well as the same

Table 15–2. Size and type of hose and common flows, based on nylon double-jacketed structure fire hose construction

Size	Typical flows, gpm (L/min)	Type	Weight per 100 ft (30 m) empty, lb (kg)	Weight per 100 ft (30 m) full, lb (kg)	Typical length, ft (m)
1½ in. (38 mm)	60–150 (227–567)	Attack/hand line	30 (13.6)	107 (48.5)	50 (15)
1¾ in. (45 mm)	95–200 (960–757)	Attack/hand line	32 (14.5)	152 (68.9)	50 (15)
2 in. (51 mm)	150–250 (568–946)	Attack/hand line	40 (18.1)	176 (79.8)	50 (15)
2½ in. (65 mm)	200–325 (757–1,230)	Attack/hand line	52 (23.6)	264 (119.7)	50 (15)
3 in. (75 mm)	0–500 (0–1,893)	MDH/supply	68 (30.8)	375 (170.1)	50 (15)
3½ in. (90 mm)	0–800 (0–3,028)	MDH/supply	78 (35.4)	493 (223.6)	50 (15)
4 in. (100 mm)	0–1,200 (0–4,542)	LDH/supply	88 (39.9)	631 (286.2)	50 or 100 (15 or 30)
4½ in. (115 mm)	0–1,500 (0–5,678)	LDH/supply	100 (45.4)	787 (357)	50 or 100 (15 or 30)
5 in. (125 mm)	0–2,000 (0–7,571)	LDH/supply	110 (19.9)	958 (434.5)	50 or 100 (15 or 30)

100 ft (30 m) of hose when charged with water. Notice again in the attack hose section the dramatic difference in weight between 2½-in. (65-mm) attack hose and 3-in. (75-mm) MDH.

The fire service fights more than just structure fires. So far, the hose we have discussed is mainly used to supply and attack fires related to buildings, and thus is commonly referred to in the broadest sense as structure fire hose. Most common structure fire hose is double jacketed in design. If you look again at table 15–2, you will notice that it states that all information is based on nylon double-jacketed structure fire hose construction.

Beyond structure fires, the fire service is responsible for extinguishing all types of fires. One specialized facet of the fire service, wildland firefighting, has its own type of hose, called single-jacketed (SJ) wildland hose. Wildland SJ hose was developed strictly for wildland firefighting and is usually either 1 in. or 1½ in. (25 or 38 mm) in diameter. It is designed to be lightweight and to withstand higher pressures than DJ structure fire hose. In contrast to a standard DJ structure fire hose with couplings every 50 ft (15 m), wildland hose generally comes in standard 100-ft (30-m) lengths, thus eliminating a full coupling every 100 ft (30 m), which reduces its overall weight. This same goal of weight reduction was applied when the outer jacket was removed from the specification of wildland hose. The main reason for this reduced weight is that wildland SJ hose is usually carried long distances, commonly on foot while hiking. Wildland SJ hose can also commonly be used to form very long continuous progressive hose lays where pressures can become high, based both on distance and terrain. There is even a special lightweight ¾-in. (20-mm) wildland hose. Flows during suppression of wildland fires from a single line rarely are more than 70 gpm (265 L/min) in 1½-in. (38-mm). SJ wildland hose and 30 gpm (114 L/min) in 1-in. (25-mm) SJ wildland hose. These low flows can be complicated by high pressures due to hilly terrain and portable, low-volume capacity high-pressure pumps. These are some of the reasons why there is a special hose developed specifically to combat wildland fires.

As far as booster hose and reel lines are concerned, they typically flow between 30 and 60 gpm (114 and 227 L/min). They are used in both urban and wildland environments. The booster hose is stored on motorized reel line. When the booster hose is in use, you pull out only the required amount. When finished, you can take it up quickly onto the reel. Booster hose should only be used in situations where required and expected flows will not exceed their limited capability, and *never for building or vehicle fires*. Booster line hose is made in

100-ft (30-m) lengths in both ¾-in. (20-mm) and 1-in. (25-mm) diameters. Booster hose is stored on reel lines in coupled lengths of up to 300 ft (91 m). In an urban environment, booster hose is commonly used at small outside trash fires or during overhaul. In the wildland environment, booster hose is commonly used on small grass fires: the vehicle it is attached to slowly moves while firefighters extinguish the burning grass. This type of wildland fire attack is called a mobile attack. These reel lines with booster hose are severely limited to low flows of 60 gpm (227 L/min) and less and have a fixed length usually not exceeding 200 ft (60 m). Some highly urbanized departments do not even use them; the Los Angeles Fire Department (LAFD) is good example of this. Other departments have stopped using booster lines because they are frequently misused due to their ease of deployment. One must recognize that speed is no excuse for bringing the wrong tool for the job. Hoses are tools used to move water. It is imperative that the right size of hose and flow is selected for the job at hand. There will be further instruction on selecting hose in the fire stream and fire attack chapters.

Couplings

SKILL DRILL

Couplings are a key component in making fire hose versatile. The coupling makes it possible to join two pieces of hose together or break apart two joined pieces of hose in a rapid manner. The two most common types of couplings in use today in the U.S. fire service are the threaded coupling (made up of individual male and a female couplings) with NST or a type of sexless coupling called **Storz**. Both types of couplings allow good, strong, watertight connections to be made in a rapid manner. Modern couplings can handle great pressures and stresses developed inside the hose during pumping operations.

Today, couplings are typically made out of hardened aluminum. In the past, brass was a very commonly used material. Some fire hose may still be in service with brass couplings today. However, the vast majority of all fire hose now has hardened aluminum couplings. Hardened aluminum couplings resist all of the following areas of concern regarding fire hose: corrosion, abrasive forces, compressive forces, and expansive forces. This durability makes hardened aluminum ideal for the fire service.

Hose lengths are individually marked for identification purposes. A unique number is stenciled on the hose jacket. Alternatively, a special steel numbering die is used to number a hose coupling on a length of hose when it is received new; for example, the first 2½-in. (65-mm) hose length purchased in the year 2009 is marked 2009-1, the next is designated 2009-2, and so on. Records are kept of each hose length so that the age of a hose can be tracked when it is tested (described later). In addition, in large departments the engine company that receives the new hose may have the couplings painted with a specific combination of colors or provided with another numerical designation in order to return the hose to the proper company after a large fire.

The common features of male and female coupling design are shown in fig. 15–26.

Fig. 15–26. Male and female set of hardened aluminum coupling with brass expansion rings. (Courtesy of Adam Weidenbach)

Male and female couplings are one of the most commonly used hose couplings in the fire service. They are attached usually at the factory to lengths of fire hose typically in 50- or 100-ft (15.2- or 30-m) lengths. Hose commonly comes from the factory standard, with a female coupling on one end and a male coupling on the opposite end. The couplings in fig. 15–26 are a male/female set designed for use on DJ 3-in. (75-mm) hose. One way to attach a coupling to a piece of hose is by using what is called a brass expansion ring system. On the right in fig. 15–26, the male coupling has a brass expansion ring sitting in its bowl or shank. Notice that this male coupling has **rocker lugs** extending the full length of the bowl. A lug is a raised part of a coupling that allows a **spanner wrench** to grab onto it. On the left in fig. 15–26, the female coupling has rocker lugs only on the swiveling part of the female coupling and its bowl is smooth in nature. Also notice the female coupling has a gasket inside the female threaded area to allow for watertight connections. Both of these couplings are threaded with, 2½-in. (65 mm)

NHT. These couplings are designed to attach to one another with or without the use of spanner wrenches.

Shown in fig. 15–27a is a 2½-in. (65-mm) NH female coupling designed with a bowl for 3-in. (75-mm) DJ hose sitting on top of a machine called a hose expander. This removed bowl gasket sits on top of the machine, and the expansion ring is visible on the draw bar. The draw bar is the part of the machine that will eventually expand the brass expansion ring inside the hose. To get a watertight seal, the brass expansion ring is inserted into a cut piece of 3-in. (75-mm) DJ hose, and then the hose with the expander ring in it is pushed into the bowl of the proper sized coupling. In the bowl, the expansion ring makes contact with a rubber bowl gasket located inside at the end or bottom of the bowl. The assembled hose, expansion ring, and coupling are then pushed as a unit onto the expander (fig. 15–27b). The expansion ring is then hydraulically expanded under tremendous force by the expanding machine. This particular application for 3-in. (75-mm) DJ hose with 2½-in. (65-mm) couplings requires about 1,300 psi (9,100 kPa) of expansive force. The brass expansion ring ends up sandwiching the hose and the tail gasket against the inside of the coupling's bowl, which is ribbed to help the hose remain in place when pumped under high pressures. In this case, you end up with a 2½-in. (65-mm) female coupling joined to a length of 3-in. (75-mm) DJ hose. This is a very strong, mechanically pressed attachment.

In fig. 15–28, you can see four different hose sizes, all with male and female couplings. The top example (4½-in. [115-mm] red supply hose) has extended lugs on the female swivel. The next hose down is a 3-in. (75-mm) tan DJ MDH, which has a coupling design to allow for a 2½-in. (65-mm) threaded connection. The blue hose is 2½-in. (65-mm) DJ hand line hose, with 2½-in. (65-mm) threaded couplings. The last example is 1¾-in. (45-mm) DJ hand line hose with 1½-in. (38-mm) couplings. All the hose in fig. 15–21 is of DJ construction with hardened aluminum couplings that were attached to the hose using brass expansion rings.

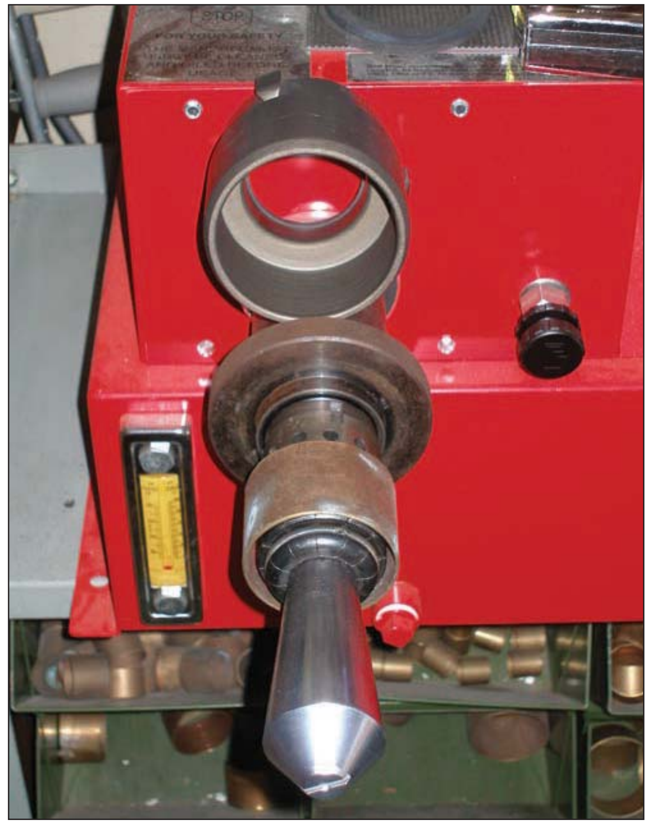


Fig. 15–27a. Coupling expander

Fig. 15–27b. Hose mounted with coupling expander

Fig. 15–28. Different hose sizes with male and female couplings

Coupling fire hose. We will now discuss techniques of joining two hoses together using male and female couplings. Anyone who has screwed together a nut and bolt or joined two garden hoses together can understand the basic principles of coupling and uncoupling threaded fire hose. Firefighting is a team endeavor, but there are times when one must do a certain operation alone. This applies to coupling and uncoupling lengths of fire hose. There are various methods that can be used if you are by yourself. Some of the methods are the "foot-tilt method" and the "knee press method." If there is an additional firefighter, both of them can assist in coupling or uncoupling the hose (fig. 15–29). One common method is called a "stiff-arm method." For each of these methods it is important for the firefighter to make use of a thread design incorporated in the male thread of a fire hose coupling, called a "higbee cut." This allows for an easier connection of male and female connections. The "higbee cut" can be located by finding the "**higbee indicator,**" usually located on the coupling lugs. Most times, fire hose can be coupled and uncoupled by hand-tightening the coupling. If they are too tight to be uncoupled in this manner, a spanner-wrench can be used, but only to uncouple, not to couple, as this can damage the gaskets in the female couplings.

The other common coupling that has gained widespread use in the United States is the Storz sexless coupling. It is manufactured for use on all sizes of hose. However, the most common sizes are 4-in. and 5-in. (100 and 125 mm) Storz couplings. These unisex couplings have some advantages over a male/female design. The most obvious is the fact that one does not need any **double male** or **female adaptor fittings**, which are needed when you find yourself in a situation where you are trying to join two hoses together with the same sex threaded coupling. No matter which side of the hose you grab, it will automatically be able to attach to another Storz fitting of the same size. Storz couplings are also fast to connect, needing just a quarter turn to lock together. This can lead to problems if the hose has twisted during operation, because they have been known to uncouple themselves in older hoses without a locking mechanism. (See fig. 15–30 for nonlocking 5-in. [125-mm] Storz coupling.) Modern Storz fittings have a locking mechanism that has solved the uncoupling issue.

Fig. 15–29. Firefighters utilize various techniques to aid in coupling and uncoupling hose.

Fig. 15–30. Nonlocking 5-in. (125-mm) Storz coupling

Coupling and uncoupling a Storz fitting is basically the same as working with threaded hose. They also tighten to the right or clockwise and loosen to the left or counterclockwise. The same coupling techniques discussed previously—both the single-firefighter and two-firefighter coupling methods—can be applied to Storz couplings. The notable difference is that it only takes a little more than half a turn to completely couple and uncouple a Storz fitting. It is therefore necessary to ensure that when completing a coupling, both locks are secure and the lugs are lined up. This will ensure that the Storz coupling will stay together under pressure. If you work in a fire department still using nonlocking Storz, it is critical to make sure the Storz lugs are lined up and excessive twists are not in the uncharged hose. Not doing so can lead to catastrophic self-uncoupling of nonlocking Storz hose when charged.

The 5-in. (125-mm) Storz coupling in fig. 15–31 does not use an expansion ring attachment to join it to the hose. Instead of a bowl, there is a tail piece and an attached external collar or retaining ring. The hose is simply cut and pushed over the tail piece, usually with a **hose gasket** of some sort (fig. 15–32). Then the retaining ring goes over the hose and the tail piece. The retaining ring is then mechanically fastened to the hose with (in this case) four heavy-duty bolts. The retaining ring design also makes a strong watertight connection between the hose and the coupling.

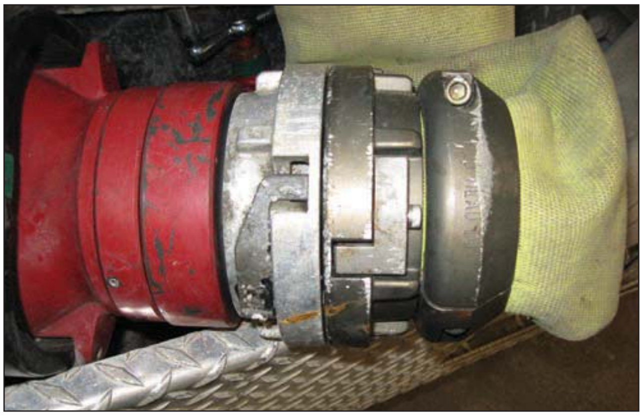


Fig. 15–31. Locking Storz coupling

Fig. 15–32. It is important to check hose gaskets for wear and tear, on a regular basis.

Per NFPA 1962, *Standard for the Inspection, Care, and Use of Fire Hose, Couplings, and Nozzles and the Service Testing of Fire Hose,* couplings should be visually inspected after each use for the following problems: damaged threads, corrosion, slippage on the hose, out of round, swivel not rotating freely, missing lugs, loose external collar or internal gasket, and other defects that could impair operation.

When inspecting couplings for damage, the best tools you have are your eyes and hands. First, look for abrasion damage to the shanks and excessive wear from use. If they are excessively worn from dragging, they should be put out of service. Corrosion is not common because the hardened aluminum is very resistant to corrosive forces. Hold the coupling and pull on the hose, and there should be no movement. Any sign or feeling of movement of the hose from the shank is a failure, and the hose and coupling should be put out of service. Any collar-type coupling should have all of its collar bolts, and there should be no signs of collar slippage or looseness. Any collar problems should cause the coupling and hose to be put out of service. Any female swivel should be checked by freely spinning it. If stiff in motion, the female swivel can be washed in hot soapy water and lubricated with silicone lubricant.

One specific item that is often overlooked, but is easy to address, is the female swivel gasket in the common threaded coupling. If it looks old, worn out, cracked, nonpliable, or smashed, just pull it out and check it. The gasket simply sits in a groove, and it is easily removed by pinching the gasket with a thumb and index finger and pulling it out of the groove (fig. 15–32). If it fails inspection because it is cracked or no longer elastic, just replace it. Once again, pinch it, place it back in its groove in the female coupling, and make sure it is seated all the way. It is good practice to join the hose to another male couple after replacing a gasket to ensure proper working condition. This also guarantees that proper installation has been achieved.

It is obvious that great care must be taken to ensure that couplings work in a flawless manner. This takes discipline in inspection and care of fire hose. Without a properly coupled hose, you do not have a means of moving water efficiently, and without that, you cannot successfully use water to mount an effective fire attack. Couplings are a keystone item found on all fire hose, and they are vital to fire hose function.

Earlier in this chapter, it was mentioned that there was specialty hose called ultra-large-diameter hose, or ULDH. This type of hose can be coupled in many ways, and fig. 15–33a shows an example of a two **Victaulic couplings** joined together with a retaining ring and gasket. Victaulic couplings (mechanical couplings) are designed to be field repairable and are used on very large hose (up to 18 in. [457 mm] in diameter). Figure 15–33b shows a 12-in. (305-mm) coupling with no hose on it. This ULDH special hose is simply cut and pushed onto the tail piece. Then, a series of metal bands are tightened over the hose in the grooves located on the coupling's tail piece to make a watertight connection. This is not a fast method of coupling hose, but when using ULDH in a major emergency, the ULDH hose may be in place for months. Having couplings every 100 ft (30 m) is just not an option, given that the hose lay may be miles long. There are, of course, many other ways to couple hose used in all types of industry. In the United Kingdom, the fire service uses British Instantaneous Hose couplings.

Japan has a new sexless coupling system as well. The point is that as a professional firefighter, you must know what your agency uses and also understand that there are other types of coupling systems that may be used in your mutual aid response areas.

Fig. 15–33 a, b. There are various specialty couplings that are utilized in the field, such as those used in ULDH.

Fittings, appliances, and hose tools

SKILL DRILL

Now that we have a general understanding of what fire hose is—a conduit for flowing water—a question comes to mind: How do we get all these different types of hose to work together? How do we join two different sizes of hose together or two different couplings designs together? How do we get a hose to divide into two hoses or combine into one hose? This is where hose fittings, appliances, and hose tools come into play.

First, let's take a look at **hose fittings**. They used to be made out of brass, but today they are made from the same hardened aluminum that couplings are made out of. When looking at a fitting, it is always good to take a systematic approach. One must have a common way of identifying a fitting, so that when you need a fitting, it is easy to describe. It is always proper to start with the female side when describing a fitting. However, if the fitting has a Storz side, start naming with it. Other items that need to be identified are the sizes of both sides of the fitting. After you have addressed those two main steps in naming a fitting, do not forget to identify anything else that is special about it. For example, it could have different types of thread, swivels, or extended lugs. If you do not name a thread type, it is assumed that the fitting is NHT. Take a look at the fittings and naming examples in fig. 15–35. All the fittings are named from left to right. Notice that some of these fittings are still made of brass. In the past, all fittings were generically called *brass*.

All the reducing fittings in fig. 15–34 do exactly what their names imply: They go from larger to smaller. Most of the time, reducing fittings are just called **reducers**.

Fig. 15–34. Reducers. (Courtesy of Adam Weidenbach)

1. 4½-in. (115-mm) female to 2½-in. (65-mm) male reducer
2. 3-in. (75-mm) female to 2½-in. (65-mm) male reducer
3. 2½-in. (65-mm) female to 1½-in. (38-mm) male reducer
4. 2½-in. (65-mm) female to 1½-in. (38-mm) male bell reducer. (Bell component keeps it from hanging up on corners or objects.)

The couplings in fig. 15–35 are all increasing fittings; they simply make it possible to go from small to larger. Most of the time increasing fittings are just called **increasers**.

Fig. 15–35. Increasers. (Courtesy of Adam Weidenbach)

1. 3-in. (75-mm) female swivel to 4½-in. (115-mm) male pin lug increaser. (Notice that the swivel end and also the pin lugs were mentioned.)
2. 2½-in. (65-mm) female to 3-in. (75-mm) male increaser
3. 1½-in. (38-mm) female to 2½-in. (65-mm) female increaser

Figure 15–36 shows all double female fittings. They make it possible to join two males together. These are the most common type, as they join males of the same diameter together. Most double female fittings swivel on both sides. It is assumed they do, so if you have a specialty double female that is ridged on one side, you must state it.

Fig. 15–36. Double female. (Courtesy of Adam Weidenbach)

1. 4½-in. (115-mm) double female (DF)
2. 2½-in. (65-mm) DF
3. 1½-in. (38-mm) DF

Fig. 15–37 shows all double male fittings. They make it possible to join two females couplings together. These are the most common type, as they join females of the same diameter together.

Fig. 15–37. Double males. (Courtesy of Adam Weidenbach)

1. 4½-in. (115-mm) double male (DM)
2. 2½-in. (65-mm) DM
3. 1½-in. (38-mm) DM

Figure 15–38 shows a common type of adaptor fitting used in the fire service. This is the first adapter we have looked at that changes thread type. These types of adapters are often needed because many departments use Storz fittings on their large-diameter supply hose. The two Storz adapters in fig. 15–38 are identical and have a locking feature on the Storz side. This safety feature is now required with Storz fittings. Since Storz fittings only require about a half turn to couple, they also only take about a half turn to uncouple. This half turn feature does make coupling Storz fittings easy, but also makes them susceptible to self-uncoupling if the hose twists too violently during operation. This is why modern Storz fittings have locking mechanisms. Storz fittings with locking mechanisms should be able to be coupled and uncoupled by hand without wrenches. Figures 15–38 and 15–39 both show 5-in. (125-mm) Storz adapters, but another common Storz size is 4 in. (115 mm). Remember the naming rules: If there is a Storz side, you start by naming it first.

Fig. 15–38. Storz adapter: 5-in. (125-mm) Storz locking to 4½-in. (115-mm) female swivel, extended lug. (Courtesy of Adam Weidenbach)

Fig. 15–39. Storz adapter: 5-in. (125-mm) Storz nonlocking to 4½-in. (115-mm) male. (Courtesy of Adam Weidenbach)

The fittings in fig. 15–40 are examples of fittings that change thread types. In older cities, some existing buildings predate the standardization of thread **pitch** and

count of the standard NST. Other times, you many need a thread adapter to be able to connect to other types of common thread design used in construction. For example, you may need an adapter such as a 3-in. (75-mm) pipe thread (a common thread used to join pipes) female to a 2½-in. (65-mm) NH male. This adapter would be very useful if you needed to connect fire hose to an industrial pump that had a 3-in. (75-mm) male pipe threaded outlet. Figure 15–40 shows some examples.

Fig. 15–40. Thread adapters. (Courtesy of Adam Weidenbach)

1. 2½-in. (65-mm) Female National hose thread to ¾-in. (20-mm) male garden hose thread (GHT)
2. 1½-in. (38-mm) Female Pacific Coast thread (PAC) to 1½-in. (38-mm) male National hose
3. 1½-in. (38-mm) Female National hose thread to 1½-in. (38-mm) male Pacific Coast thread (PAC)

Notice that the fittings are clearly stamped with their thread designators. The two Pacific Coast (PAC) thread adapters are reverse of each other. Look at their male end and you can see that PAC has a finer thread than the NHT.

The fittings in fig. 15–41 are elbow fittings. Elbows are sometimes called drop fittings. Their main purpose is to allow a hard bend from a ridged outlet, so that hose connected to it will not flex or kink. You commonly see them on pump panel discharges, and some departments carry them in standpipe kits to overcome poorly designed standpipe outlets. They can be very useful.

Fig. 15–41. Elbow fittings. (Courtesy of Adam Weidenbach)

1. 5-in. Storz locking to 4½-in. (115-mm) female swivel, 30° elbow
2. 2½-in. (65-mm) female swivel to 2½-in. (65-mm) male, 60° elbow

Figure 15–42 shows a simple cap and plug. A cap covers a male outlet, and a plug fills a female inlet. Most caps and plugs have some sort of chain attached to them. This is so that when the plugs are removed from their male outlet or female inlet, they will be hanging nearby, so they can be reinstalled after use and are not easily lost.

Fig. 15–42. Cap and plug. (Courtesy of Adam Weidenbach)

1. 2½-in. (65-mm) cap
2. 2½-in. (65-mm) plug

Appliances. Now that we have looked at some common fittings, there is another set of equipment that is used when working with water and fire hose. This general category is called **appliances**. Simply put, an appliance in a piece of equipment that water flows through that is portable in nature. Appliances include gate valves, wyes, siameses, water thieves, water distributors, portable hydrants, and hydrant valves. Water appliances allow water flow to be manipulated in different ways. As you have probably noticed, the fire service names many of its tools based on function and appearance, and appliances follow this same basic principle. Again, we call it as we see it. When talking about an appliance, generally they are described based on the direction of water flow through the appliance. Figures 15–43 to 15–46 demonstrate this commonsense naming practice.

Fig. 15–43 a, b. Wyes. (Courtesy of Adam Weidenbach)

Figure 15–43 (a and b) shows examples of **wye** appliances, commonly just called wyes. A wye is a device in which water enters through a single female inlet and then leaves through two male outlets. For this reason, when naming them, it is just a given regarding the sexes of the one female inlet and the two male outlets. When asking for a wye, it is critical to include the sizes of inlets and outlets, and whether you need a gated wye (a wye with individual control valves for each outlet) or not.

1. 2½-in. (50-mm) straight wye. You need only to name the size since all inlets and outlets are the same; **straight** refers to the fact that there are no valves to control the flow of water.
2. 2½-in. to 1½-in. (65-mm to 38-mm) gated wye. This wye changes size as water flows through it, and it also has quarter turn ball valves. The valves allow the water to each outlet to be controlled individually. The inline handle on the left is an open outlet, and the perpendicular handle on the right is closed outlet.

Figure 15–44 (a and b) shows two appliances called **Siamese**. A Siamese is the opposite of a wye. A Siamese takes two female inlets and turns them into one male outlet. For this reason, when naming a Siamese, it is a given regarding the sexes of the two inlets and one outlets. When requesting a Siamese, it is necessary to include whether or not it is straight or **clappered**.

1. 2 ½-in. (65-mm) straight Siamese.
2. 2 ½-in. (65-mm) clappered Siamese. The clappers, or sometimes a single, swinging clapper, prevents water from flowing out the other female inlet if only one of inlet is being supplied water under pressure.

Appliances are made for all sorts of special purposes. There are pressure reducers, hydrant valves, portable hydrants, ladder pipe assemblies, and ground monitors. Technically, nozzles are considered appliances, but we will not discuss them here because they are covered in great detail in the chapter 16, Fire Streams. Appliances are much like fittings. There are just too many variations to cover them all. Fire departments stock the fittings they use and need, and the same holds true for appliances. Figure 15–45 has one such example: a 5-in. (125-mm) Storz to three 3-in. (75-mm) gated wye with a built-in pressure relief valve. Many appliances that are used with LDH have a built-in pressure relief device to help reduce the chance of water hammer damage. These pressure relief devices have become mandatory in many applications regarding LDH and large flows of water. Before we move on to hose tools, look at some of the Web sties maintained by fitting and appliances manufactures. You will see that the options out there are amazingly diverse, and many special appliances and fittings exist for firefighting.

Fig. 15–44 a, b. Siamese. (Courtesy of Adam Weidenbach)

Fig. 15–45. 5-in. (125-mm) Storz to three 3-in. (75-mm) gated wye. (Courtesy of Adam Weidenbach)

Hose tools. Hose tools aid firefighters in the use of fire hose. Some examples of **hose tools** are spanner wrenches, hose rollers, hose edge rollers, hose jackets, hose clamps, chafing blocks, and hose bridges. Figure 15–46 shows a variety of spanners. Starting at the top of fig. 15–46 is a large spanner with one end for use on couplings between 2½ and 3½ in. (65 and 90 mm) and the other end for 3½ and 5 in. (90 and 125 mm). This large, stamped, aluminum spanner is good to use with Storz fittings as well. Remember that when using a spanner it is always good to grab a set of spanners. If you have two identical spanners, then it is easy to hold both the male and female sides of the hose when you are trying to couple or uncouple the hose. Typically, you can couple hose by hand, but many times when uncoupling hose after use, you many need to use two spanners because the connection has become very tight. The second spanner down in fig. 15–46 is a smaller pocket spanner. It is an old design, made to be used on pinhead coupling lugs and fittings. The third spanner down in fig. 15–46 is another pocket spanner. Firefighters should have a small pocket spanner on hand at all times. This particular pocket spanner is the Oakland (California) Fire Department's (OFD's) version. If you look at the end, you will see that it can be used with either pin lugs or the more modern rocker lug. It also has a hydrant pentagon and a smaller striking surface. The bottom spanner is the smallest of the four. You can see a small protruding pin at the end of it. This small pin is for recessed designed couplings, which are found on booster lines. This is because booster hose is stored on a reel, and smooth couplings without raised lugs prevent the booster hose from damaging itself when reeled in on top of itself.

Fig. 15–46. Spanners. (Courtesy of Adam Weidenbach)

Hydrant spanners are included in the hose tools section. Hydrant spanners are also sometimes called hydrant wrenches. A hydrant spanner is just a wrench designed to open and close hydrant, as well as take off hydrant caps. The most standard type of hydrant spanner is the one on the top in fig. 15–47. This standard type hydrant spanner, as you can see upon closer examination, is fully adjustable by screwing the handle in and out to make the pentagon opening larger or smaller, and it can also be used to couple and uncouple hose. The standard hydrant spanner is shown with a 2½-in. (65-mm) regular hydrant outlet cap. Notice the pentagon protrusion, which is usually the same size as the operating nut on the hydrant it is attached to. On the bottom in fig. 15–47 is one type of specialty locking cap hydrant spanner, which is becoming more common because the illegal use and vandalism of hydrants has become common in some areas of the country. Drinking water is very valuable and open hydrants waste a lot of water. For example, a flow of 1,000 gpm (3,785 L/min) in just 1 hour equals 60,000 gallons (227,125 L) of water, enough to fill about three average residual swimming pools. Locking caps, like the one shown with the locking cap hydrant spanner, make it more difficult to illegally turn on a hydrant or gain access to the water. Notice that the hydrant operating nut pentagon is not adjustable, and also the locking cap spanner has no built-in lug grabber for use with hose; this one is truly a specialty tool. The locking hydrant outlet cap is designed to be tamper-proof and requires a special hydrant spanner to remove it. As a firefighter, you should become familiar with all types of hydrants and locking mechanisms used in your jurisdiction, including the types of failures and troubles these systems have. Access to water in a rapid fashion by using the proper tools, such as hydrant spanners, is one of the most basic tasks assigned to a firefighter at a fire.

Hose clamps are not used today as much as they were years ago. This is mainly attributable to the more common use of LDH for supply operation. Basically, a hose clamp is just a clamp that can be screwed down in design, has lever action, or is even hydraulic. They were commonly used on fire hose before charging. This allowed water to flow into the hose until it arrived at the clamped section. Firefighters working beyond the clamped section then had time to make the necessary connections and hose lays. They would then return to the closed clamp that had stopping water from continuing down the fire hose and carefully open it to allow water to continue to its destination. Hose clamps were primarily used on 2½-in. (65-mm) (when it was still considered a supply line), 3-in. (75-mm), and 3½-in. (90-mm) supply line.

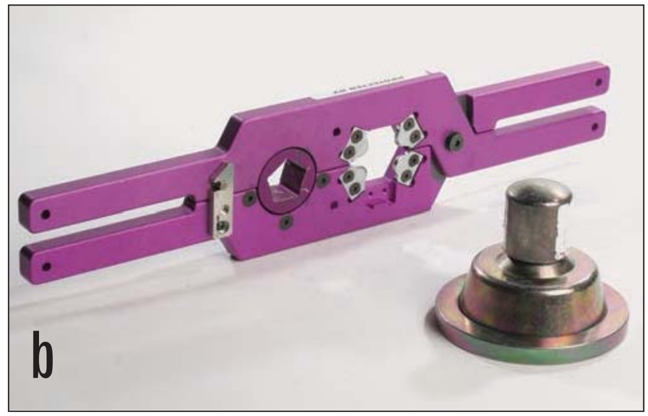


Fig. 15–47. (a) Standard hydrant wrench/spanner (b) Locking cap hydrant spanner. (Courtesy of Adam Weidenbach)

Figure 15–48 shows a common screw-down hose clamp on a length of 3-in. (75-mm) MDH. Notice that it has stopped the water from the hydrant just before the rear hosebed. This is because it was placed by an engineer who called for water before he or she broke the supply line. This maneuver allowed the hydrant firefighter to charge the hydrant and come up to do other tasks. This technique of using a hose clamp to free the hydrant firefighter from the hydrant was once common practice in fire departments that used MDH as supply line. Releasing clamps or applying hose clamps to charged hoseline must be done in full personal protective equipment (PPE) including gloves and helmets. Hose clamps are under a tremendous amount of force and have been known to break spontaneously and/or rapidly come undone. One should never partly unscrew a screw-down hose clamp that is holding back water and then just kick the latch open. This is a dangerous practice.

Fig. 15–48. Screw-down hose clamp

Figure 15–49 shows a press-down type hose clamp, which achieves its mechanical advantage from a level type action instead of a screw. Press-down hose clamps are used the same way as screw-down types; however, they are more effective at stopping flowing water because they can be more smoothly and quickly applied. The screwing action of a screw type hose clamp is a cumbersome endeavor when used against an already charged line.

Using a hose clamp to stop the flow of water to replace a burst section of hose is a difficult and dangerous task, and this task is much easier to accomplish by simply closing the proper valve at the pump panel.

Fig. 15–49. Press-down hose clamp

Some departments still use hose clamp, especially departments that use 3-in. (75-mm) supply line; however, it is usually not part of their standard operating procedures (SOPs). Many times these clamps are carried on the apparatus but not regularly used. One place hose clamps are still used regularly is for a wildland hand line evolution call or a progressive hose lay. Figure 15–50 shows a wildland hose clamp designed to be used on 1-in. or 1½-in. (25 or 38 mm) SJ wildland. It has a simple clamping design and is handheld.

Fig. 15–50. Wildland hose clamp

One other technique that should be mentioned is the simple field hose clamp. This action does not require any special tools, just good technique and strength. Also, it is not effective in hose size above 2½ in. (65 mm). Basically, a simple field hose clamp is just a simple double bend in the hose that is then just pressed down on itself. This creates two kinks in the hose in close proximity to each other. The goal is not to stop the flow of water completely, but merely to slow it enough to allow a burst length to be replaced or (usually) to add an extra length of hose. The firefighters in fig. 15–51 are performing the field hose clamp maneuver.

Fig. 15–51. Field hose clamp maneuver

Hose jackets are another hose tool that are not in regular use anymore. A hose jacket is a hose tool that is put around a hose that has sprung a leak. They were mainly designed for use on fire hose sizes between 1½ and 3½. in. (38 and 90 mm). While no longer commonly used, they can serve an important function if a department still has one. Some hose jackets were made of a metal clam-type clamp design with a hose orifice in the middle and a rubber seal at each end. This clam-type clamp hose jacket was simply placed over the leak and then clamped into position. Another type of hose jacket was simply made out of leather, straps, and buckles. The use of a leather-type hose jacket is self-explanatory in nature. All hose jackets mainly just slowed a flowing leak and did not function well above 150 psi (1,050 kPa). You can still order them or make them; however, they are not used frequently anywhere. Figure 15–52 shows a metal clam-type clamp hose jacket on a 3-in. (75-mm) MDH. This type of design works on 2½-in. (65-mm) to 3-in. (75-mm) fire hose, partly because of modern hose construction, in which the outer jacket of fire hose is designed in a ripstop fashion so that small leaks usually do not become bigger ones rapidly. Hose jackets also have proven to be ineffective on LDH, mainly due to the difficulty of maneuvering LDH because of its heavy charged weight.

Fig. 15–52. Metal clam-type clamp hose jacket. (Courtesy of Tim Olk)

Hose rope tools serve a very useful purpose. They help firefighters move and secure hose. Some hose rope tools are designed with a cast hook that also serves as a handle with an attached piece of webbing or rope that forms a loop. These types of hose rope tools are used by the fire department to secure fire hose to aerial ladders during ladder pipe operations and to secure hose to ground ladders, fire escapes, and window ledges. Figure 15–53 shows a traditional cast metal hook and rope hose tool, known as a **hose strap**. Notice that the metal hook also has a opening for your hand. One could just loop the rope around the hose and pass the hook through. This creates a **lark's foot** around the hose, which acts like a hand of rope. The cast hook part could then be hung on a ladder fire escape or grand ladder or just used as a handle to help manipulate the charge hoseline. This was particularly useful for large hoseline like 3-in. MDH.

Fig. 15–53. Hose strap

Hose rope tools do not have to be custom-designed, as discussed previously. Some fire departments require firefighters to carry a length of 1-in. (25-mm) tubular webbing tied into a loop with two overhand bend knots. This inexpensive hose tool usually forms at least a 4-ft (1.2-m) loop that can be used not only on fire hose but also on victims and injured firefighters as a rescue aid. This loop of webbing is very strong and can easily be wrapped around the hose and passed through itself, forming a lark's foot knot around a charged hoseline. In this fashion, it can be used as a handle to pull on a large hose or help move it around. Figure 15–54 shows just such a piece of looped webbing lark's foot around an uncharged hose. This 1-in. (25-mm) tubular webbing hose rope tool can also be lark's footed around a charged vertical hoseline below a coupling and then clove-hitched to a banister or railing to prevent the charged hoseline from slipping backward under the force of gravity. The lark's foot and clove hitch (a simple knot covered in chapter 8) are easily tied with gloves on.

The final hose tools that will be covered are **hose bridges** and **chafing blocks**. These two items are not used enough in today's fire service. Many departments have stopped their use all together. Both of these tools are used to prevent hose damage. As has been mentioned previously, fire hose has come a long way since the time of simple, single-cotton-jacketed, rubber-lined construction. This has led to some complacency because of the durability of current specification of fire hose. The item in fig. 15–55a is a chafing block. This chafing block has an obvious channel for fire hose and straps to attach it to the hose. Chafing blocks should be used especially on supply hose that bends up from street level to a pump inlet connection. This is a point where supply hose is exposed to a lot of vibrations, which cause the hose jacket to wear as it rubs back and forth against the pavement. One of the reasons supply hose is mentioned is that much of it is still of SJ design.

Fire hose should never be driven over, whether the hose is charged or uncharged. If it is necessary to drive where there is fire hose, the hose should be protected using a hose bridge.[8] This commonsense rule is often broken. Although fire hose is very durable, it is not intended to be driven over. In fig. 15–55b, the hose tool is a hose bridge used for 3-in. (75-mm) fire hose. The hose bridge in this case is two pieces of triangular shaped wood jointed by two nylon straps. To use it, you simply lift up the 3-in. (75-mm) fire hose and place the hose in the valley formed between the two pieces of wood. This hose bridge is only around 20 in. (508 mm) in length, so you need two hose bridges to make a spot where vehicles can safely drive over. All types of hose bridges are available for fire hose up to sizes of 12 in. (305 mm) in diameter. However, as fire departments have begun using more and more LDH, it has become difficult to find space for efficient storage and easy deployment of hose bridges stored on fire apparatus. The lack of hose bridges on apparatus has led to some poor practices, like running over hose that is not properly bridged.

Fig. 15–54. Rope hose tool with lark's foot. (Courtesy of Adam Weidenbach)

Fig. 15–55. (a) Chafing block and (b) hose bridge. (Courtesy of Adam Weidenbach)

Basic hose maintenance and testing

Cleaning. FFI 5.5.2 Fire hose must be properly cared for. The vast majority of fire departments load hose back onto the apparatus at the scene. Before loading hose back onto a fire apparatus after use, one should wash the dirty used lengths with clean water. This can be accomplished by spraying water from a reel line or another type of charged hoseline and a stiff, long-handled broom kept on the engine. Once sufficiently clean, the hose can be loaded back onto the apparatus. Remember that if the fire hose is cotton jacketed, it should be thoroughly dried before being loading onto the apparatus, using a **hose dryer** or **hose tower**. This is done to prevent the growth of mold and mildew. In the case of cotton jacketed hose, just roll it up and thoroughly clean and dry it back at the station.

When loading hose onto a fire apparatus, make an attempt to reload the hose in a different order than the way it deployed. To avoid permanent folds, try to pack the hose in such a manner that the folds are in different locations than before. Fire hose that has been used must be checked for serviceability, because it could have incurred serious damage during use. One should check for obvious damage to couplings and the outer jacket. It is good practice to check for leaks in attack and supply lines after use by simply inspecting them while they are still charged. Many leaks and other damage to fire hose are found this way; take those particular lengths of hose out of service. This practice prevents damaged or leaking hose from making its way back onto the engine in service at fire scenes. Simple actions such as these can really help prolong the life of hose and also prevent premature failure of fire hose. They also help prevent unexpected fire hose failure at emergencies.

Some fire departments have to deal with extremely cold temperatures. In these cases, fire departments that have this type of severe weather problem usually take wet, used hose back to the station where they can then clean the hose properly and dry it. Sometimes hose used in freezing temperatures has to be thawed. It is best to never let hose freeze completely, especially with water in it. Hose that has frozen completely with water in it needs to be thawed and then be subjected to an in-service hose test before being placed back into service. Dealing with freezing temperatures is one of the toughest weather conditions for firefighters. Some agencies that have to contend with cold weather on regular basis have specialized equipment like mechanical hose washers and dryers. Many of these departments store many extra lengths of hose, sometimes up to entire second hose complement, back at the station.

When cleaning fire hose, it is also necessary to check the couplings for damage to the male threads or to the female swivel. Ensure that there is a pliable rubber gasket in each female coupling. Female couplings that are sticking and not swiveling freely can be dunked in warm water with a mild detergent. Once dry, apply some silicone lubricant to the swivel. Mild detergent can also be used on the fire hose if necessary, for example, if the hose was exposed to some oil. It is not necessary for fire hose to be scrubbed completely clean or beaten into a germ-free state suitable for eating off of it. It is only necessary to keep the hose free of large pieces of dirt and debris that can be easily scrubbed or washed away.

Fire hose is susceptible to gaining a **memory** at the folds. In other words, if fire hose is left for a long enough time, a heavy crease will develop where it is folded. This memory at the folded areas can lead to hose failure caused by damage to the liner. To prevent this failure, "hose shall be removed from the apparatus and reloaded so that the folds occur at different positions with sufficient frequency to prevent damage and the setting of permanent folds in the rubber lining."[9] This is called exercising the hose. All hose should be removed from the apparatus at least four times a year. One of these times will be for the annual in-service hose test. At each of these times, hose should be inspected and then loaded back on the apparatus, using care to make sure the hose is loaded in such a way that the folds end up in different locations.

Fire hose testing

SKILL DRILL

FFII 6.5.5 NFPA 1962, the *Standard for the Inspection, Care, and Use of Fire Hose, Couplings and Nozzles and Service Testing of Fire Hose*, is really the definitive resource for fire hose testing and maintenance. This standard has become more complex over the years as fire hose has become increasingly diverse. Standards like recommended pressures for service testing hose have changed a lot over the years as new hose has become more resistant to high pressure. It has gotten to the point where testing companies exist strictly to test fire hose to the NFPA in-service test standard. Some fire agencies now hire testing companies to complete the annual in-service hose test and help meet some of or all of the requirements of NFPA 1962. These testing companies have specially built hose-testing rigs that test thousands of feet of fire hose at a time. Test procedures will be discussed in the following paragraphs.

In addition to the previously mentioned general hose care, fire hose has to be hydrostatically tested once a year. The annual in-service hydrostatic test is defined in NFPA 1962, chapter 7, Service Testing. Before we discuss the details of the annual service test, it is important to understand that when testing hose, all fire hose is described based on its ability to withstand pressure. For example, a 5-in. (125-mm) LDH marked as "supply hose" by the manufacturer has a maximum operating pressure of 185 psi. However, similarly sized 5-in. (125-mm) LDH marked "attack hose" by the manufacturer has a 270 psi maximum operating pressure. Obviously the 5-in. (125-mm) LDH "attack hose" cannot be used as a hand line. The stenciled "attack line" on this particular 5-in. (125-mm) LDH is referring to its ability to withstand high pressures that are used to supply hand lines, standpipe, and sprinkler systems.

Figure 15–56 shows a 3-in. (75-mm) DJ 50-ft (15-m) length of fire hose. Earlier in this chapter, 3-in. (75-mm) fire hose was described with respect to its use as medium diameter hose (MDH), mainly for supply operations and sometimes as a hand line. We discussed how 3-in. (75-mm) hose is too large to function properly as a hand line and slightly too small to act efficiently as supply line based on modern fire flows. However, pump-supplied 3-in. (75-mm) hose can still move a lot of water. The 3-in. (75-mm) DJ hose shown in fig. 15–56 is stenciled by the manufacturer as "Attack Hose" and also "Service Test to 400 psi PER NFPA 1962."

Fig. 15–56. 3-in. DJ Hose

Using the 3-in. (75-mm) DJ hose in fig. 15–56, we will define the following terms: **service test pressure**, **proof/acceptance test pressure**, **burst pressure**, and **operating/working pressure**. All of these pressures are defined using the service test pressure as a guide. The service test pressure is required to be stenciled on all new fire hose. It is the pressure used to determine if fire hose is still suitable for use, and it is the pressure the hose is tested to during the annual service test by the user. In fig. 15–57, the service test pressure is 400 psi (2,800 kPa). The proof/acceptance test pressure is the pressure the hose is subjected to by the manufacturer at the factory prior to shipment. The proof/acceptance test pressure is to be no less than twice the service pressure, and in this case that would mean a minimum of 800 psi (5,600 kPa). Burst pressure is tested by the manufacturer when the hose is new, and it is at least three times the specified service test pressure, which in this case is 1,200 psi (8,400 kPa). Operating/working pressure should not exceed 90% of the service test pressure, so if the service test pressure is 400 psi (2,800 kPa), then the operating/working pressure should not exceed 360 psi (2,520 kPa). This 10% safety factor over the service test is designed to ensure that hose that passes its annual hose test will not fail during use. Most fire department pumping operations will rarely exceed operating pressures of 250 psi (1,750 kPa); however, water hammer can expose hose in use to higher pressures.

All fire hose should be kept track of using a written record. This record can be kept at the firehouse or in a central location. It is beneficial to have this information in a computerized database. If this is done, things like common failures or the need to order hose can be identified easily. Hose records should include the following for each length of hose: identification number (usually stamped or inscribed on the male coupling), size, length, type of hose, in-service date, repairs, annual service tests, and service test pressure. Some organizations record more or less information about their fire hose. The details listed here are considered the minimum acceptable practice. This hose record should be updated any time a length of hose is put into or out of service.

Testing process. Annual service testing of fire hose is a requirement of NFPA 1962. This testing should always be reflected properly in the hose records. The following will just cover the basics of the service test. NFPA 1962 should be consulted for definitive step-by-step procedures and requirements. If your department does not follow the NFPA standard, they should follow the manufacturer's recommendations.

Fire hose testing involves two parts, visual inspection of the hose and couplings and the pressure testing of the hose. Both are critical parts of hose testing. Visual inspection of the hose involves inspecting the couplings, gaskets, and the interior rubber lining of the hose. Some damaged parts, such as a gasket, may require replacement. Others, such as damaged inner lining or couplings, will require that the hose be condemned.

If the hose passes the visual inspection, it needs to be identified. Hose will have stenciling on it indicating the manufacturer, type, and size of the hose, as well as service test pressures. Testing of the hose should be in an open area where the hose can be laid out. It is recommended that all personnel wear a minimum of a helmet and gloves during the testing process. The hose can be tested by using a **hose testing machine** (fig. 15–57). If a pumper is being used, the operator should be fully qualified and certified on that particular pumper.

Fig. 15–57. Proper hose testing is important to ensure proper working equipment on the fireground.

To conduct the test, lay the hose out straight, with no bends, and coupled together up to 300 feet (90 m). Place a mark with a pencil behind each coupling to determine if slippage occurs during the test. Cap the last male coupling with a cap and bleeder or a fire service nozzle, and secure the hose to prevent it from whipping during the test. Bleed the air out of the hose while slowly filling it with water. When all the air is out of the hose, close the nozzle or bleeder and begin the test. First check for leaks, and then bring the pressure up to the recommended service test pressure and hold for 5 minutes while observing the hose visually from a distance of 15 ft (5 m). If no problems are observed, reduce the pressure in the hose and open the nozzle or bleeder valve to release the pressure, and record the results. If a problem occurs such as slippage, burst length, etc., remove the length from service, mark it as condemned, and record the results.

Proper service testing is the only way we can determine the suitability of hose for fire-suppression use. As of now, there is no recommendation for the maximum life span of hose. Committees of industry leaders and manufacturers have come up with a guideline of 10 years. It is probably more reasonable to state that hose can become unserviceable at any time based on use. Heavily used fire hose can fail an in-service hose test after just a few years. Rarely used hose may pass a service hose test 30 years after its date of manufacture. Generally, hose that passes its service-pressure hose test is suitable for use and should be retested every year to confirm this. The maximum life span issue will be more definitively addressed in the near future, but most likely it will be closer to 15–20 years. Hose has a definite cost factor associated with it, and it is very durable. It should not be discarded strictly based on age if in good serviceable condition.

Hose storage

SKILL DRILL

FFI 5.5.2 Fire hose is typically stored in one of two places, either on the apparatus or in the firehouse. We are first going to address hose stored in the firehouse. Typically, hose stored in a firehouse should be in-service hose. Hose that is out of service or marked for repair should never be stored anywhere near or next to in service hose. Hoses stored in a firehouse are typically rolled in a straight roll. Figure 15–58 is a 2½-in. (65-mm) DJ attack hose in a 50-ft (15 m) length. It is rolled in-service with male coupling at the center of the roll, which protects the NH threads.

Hose that is out of service should be clearly tagged "out of service" and then rolled into a straight roll with the male coupling out. If the firefighter placing the hose out of service knows that the hose is not repairable, both couplings should be cut off the fire hose before discarding it. This ensures that bad hose will not be used in error. In some circumstances, the removed couplings can be reused. Figure 15–59 is an out-of-service straight roll with the male coupling exposed, that is, missing a clear and complete repair tag. You will notice that just by looking at this 3-in. (75-mm) DJ hose you cannot tell what is wrong with it. The repair tag is very important!

Fig. 15–58. In-service straight roll, with male-threaded coupling protected. (Courtesy of Adam Weidenbach)

Fig. 15–59. Out-of-service straight roll, with male coupling exposed, but with no repair tag. (Courtesy of Adam Weidenbach)

Figure 15–60 shows a 3-in. (75-mm) DJ hose rolled out of service with the male coupling removed and clearly labeled with an attached repair tag. Originally, it was a 50-ft (15-m) length of 3-in. (75-mm) hose. The damaged section has been removed, and it is awaiting a new male coupling. The repaired 3-in. (75-mm) DJ will be a 25-ft (8-m) jumper and will need to be service tested after the coupling is installed. This will ensure that it is ready to go back into service as a 25-ft (8-m) jumper, sometimes called a **pony length** (often used to hook up to a hydrant close to the pumper to fill the water tank).

Fig. 15–60. Out-of-service hose, male coupling removed, with properly filled-out and attached repair tag. (Courtesy of Adam Weidenbach)

Finally, fig. 15–61 shows a returned out-of-service hose. This set of couplings is from the same length of 50-ft (15 m) DJ 1¾-in. (45-mm) attack line. The outer jacket of this hose was severely damaged at a structure fire; however, the hose did not fail. The first jacket and liner remained intact, and the engine company was able to successfully complete its fire attack. You can now see how valuable an extra outer jacket can be. This is an example where both couplings should be cut from the hose, and the hose discarded. The couplings should be inspected thoroughly and may be reused if in serviceable condition.

Figure 15–62 shows an example of clean, serviceable hose stored on a hose rack. Notice that all lengths are in-service, straight-rolled with the male coupling protected. In-service hose should be clean and dry, and it should have passed an annual in-service hose test. Hose stored in this manner should be good for a year. It is important not to hang hose in hose towers for longer than it takes to dry the hose. Excessive hanging of fire hose can lead to extreme drying of the hose liner, which can cause liner failure. Hose is best stored as shown in fig. 15–62, where it is kept in a climate-controlled area of a building. Remember, hose that sits can be damaged by passing equipment or environmental degradation, and even attacked by rodents. When a year of proper storage has passed, stored fire hose should again be subjected to an annual in-service hose test.

Fig. 15–61. Severely damaged 1¾-in. (45-mm) DJ hose. Cut the couplings off and discard hose. Do not roll. (Courtesy of Adam Weidenbach)

Fig. 15–62. In-service hose properly stored on a hose rack. (Courtesy of Adam Weidenbach)

Hose loads

SKILL DRILL

FFI 5.2.2 Hose is stored on apparatus in many ways. The most common ways are in rear hosebeds, crosslays (also known as a "Mattydale load," which was invented by the Mattydale, New York, Fire Department), reels, and compartments. Hose can be stored in different types of tactical manners, depending on how it is going to be deployed. This is one area of the fire service where there are many differing opinions. Depending on the type of district a company responds to, it may alter the design and layout of how hose is carried on apparatus. These factors include available water supply, types of buildings, types of hose used, and common overall lengths of hose stretches, to name a few. It is good for fire departments to have a standard hose complement and hose load developed for their particular district or city. This standard load should be the right mix of hose sizes and loads for their particular needs.

Fire hose is mainly carried in one of two ways on a fire apparatus: either preconnected to a discharge or suction inlet or not attached to any discharge or pump inlet. First, we will take a look at attack lines. **Preconnected** attack lines, sometimes called live lines, are generally attack hand lines not usually exceeding 300 ft (90 m) in length. They are usually made with either 1½-, 1¾-, 2-, or 2½-in. (38, 45, 50, or 65 mm) hose with the last female coupling attached to a pump discharge, and in turn, the last male coupling having a nozzle attached to it. The preconnected attack lines in fig. 15–63 are called preconnected crosslays (hose stored in a "trough" that runs from one side of the apparatus to the other). They are both made with 1¾-in. (45-mm) DJ hose. The front (left) preconnect crosslay is 150 ft (45 m), or three lengths of hose, and the rear crosslay (right) is 200 ft (6 m), or four lengths of hose. Preconnected hose does not have to be mounted in a crosslay bin. Many fire departments have preconnected attacks lines that lay off the back of the rig as opposed to a crosslay. Once deployed, a preconnected attack line must be pulled off and completely flaked out. After the deployment of all the preconnected hose, the pump operator can then open the discharge outlet that the preconnected deployed hose is already attached to. This is only done after the call for water is made by the members manning the pulled preconnected attack line.

The preconnected attack lines in fig. 15–63 are loaded in the simplest manner. Both are loaded in a simple flat-load style. The flat load is the gold standard of loading hose in today's fire service. It is simple, reliable, reasonably deployable, predictable, and easily duplicated and reloaded, even when handled by extremely fatigued members. It requires no special setup or folds; simply connect the female couplings to the proper discharge in the crosslay and then load the correct number of lengths of hose one after another. The final step is to attach a nozzle. The company in fig. 15–63 also included some **pull loops** when loading their 1¾-in. (45-mm) flat-loaded preconnects. The loops, in this case, are on both sides and appear to be roughly at every length of hose. The loops are made to help facilitate the deployment of hose as additional members join in the stretching of the selected preconnected line. Remember that, with preconnected or live lines, all of the hose must clear its bed before charging, because premature charging of a preconnected line without complete clearing of its bed leads to catastrophic tangling and delays in proper deployment.

Fig. 15–63. Preconnected attack crosslays. (Courtesy of Daryl Liggins)

There are other ways of loading preconnected lines. Two very popular methods of loading preconnected lines go by the names **minuteman load** and the **triple fold**. Both of these techniques of loading preconnects come with pros and cons. The first alternative load we will discuss is the minuteman load. Basically, this is a hose load designed for preconnected operation no longer than 200 ft (60 m) and using attack hose with a maximum diameter of 1¾-in. (45-mm). The main reason for these limitations is that all of the hose, when initially deployed, is pulled onto a single firefighter's shoulder. Overall lengths exceeding 200 ft (60 m) and hose sizes larger than 1¾ in. (45 mm) invite common failures related to tangles and loss of stability and control during deployment. It is difficult to properly deploy this much hose from a single bundle on a shoulder without practice.

The minuteman load can be a time and labor saver; however, it is best served with 1½-in. (38-mm) attack hose, preferably in a maximum length of 150 ft (45 m). The minuteman load, because of its design, is best suited for rear-facing preconnects in the hosebed. This is because the nozzle sits at the bottom of the load in the direction it must be pulled. Some departments that load their crosslays with minuteman loads have one load facing toward the officer side of the engine and the other facing toward the engineer side.

Neatness counts for this load. A messy minuteman load is almost a guaranteed tangle because you must neatly carry all of the hose for the load to properly work.

Minuteman load. A minutemen load is a method of deploying fire hose and a nozzle with minimal effort using minimum manpower. To load the minuteman on a fire apparatus for a 150-ft (45-m) stretch of hose you connect a 50-ft (15-m) length to a pump discharge and make one pass and let the rest sit to the side for later. Connect the other 50-ft (15-m) lengths together and place in the bed with a nozzle on the open male end at the bottom and the rest of the 100 ft (30 m) of hose on top. Then connect the first 50-ft (15-m) length to the 100 ft (30 m) already in the bed and you have a finished minuteman load.

To deploy the minuteman load, grab the entire bundle of hose onto your shoulder with the nozzle on the bottom. Walk away from the pumper and allow the hose to deploy off the load from the top. When you get to your destination you will have all the hose smoothly deployed and the nozzle in your hand ready to be used (fig. 15–64 a and b).

Triple fold. Another method of storing and deploying hose for fire attack is the triple fold method. The triple fold method has the hose folded in three layers and then laid in the hose bed in an S-shaped fashion with one layer on top of the other so the nozzle is placed on top. It is designed so one person can easily remove the hose pack. For this hose lay to be used, all of the hose must be removed from the hose bed before deploying the nozzle. It is typically used for 150- and 200-ft (45- and 60-m) hose stretches (fig. 15–65).

Static attack loads, sometimes called **dead loads**, are beds of attack hose usually 1½, 1¾, 2, or 2½ in. (38, 45, 50, or 65 mm), with nozzles attached to last male coupling. These static attack loads are not attached to pump discharges when loaded onto the apparatus. To use a static attack load, a firefighting team simply removes the desired amount of hose and then calls for water once properly in place. The pump operator then goes to the static attack load that has been used, breaks the hose at the next female coupling, attaches that female coupling to a pump discharge, and then supplies the deployed hose with water. Figure 15–66 shows the crosslay bin area of a Los Angeles Fire Department (LAFD) pumper. Notice the large amount of attack hose, which is all loaded in a static flat-load fashion. None of LAFD's attacks lines is preconnected to discharges.

Fig. 15–64. (a) The minuteman load and (b) deploying the minuteman load

Fig. 15–65. The triple fold load

Fig. 15–66. Static attack crosslays. (Courtesy of Daryl Liggins)

Attack hose can also be carried at the rear of the apparatus in the hosebed area, along with the supply hose. In the hosebed, attack hose can either be preconnected to a rear discharge and loaded or be loaded in a static fashion. Figure 15–67 shows two pumpers with two different static attack loads. Figure 15–67a shows a single 2½-in. (65-mm) horseshoe finish, and fig. 15–67b shows both a 2½-in. (65-mm) and a 1¾-in. (45-mm) attack line. Notice that the 1¾-in. (45-mm) attack hose line is filled out with 2½-in. (65-mm) hose on the bottom. This horseshoe finish is sometimes called a reverse horseshoe finish. It is usually just the last length of hose with the nozzle attach fed back upon itself in a U-shaped (thus horseshoe) fashion. This makes a nice 50-ft (15-m) pack of hose to grab when deploying the hose from a static bed. In that case, make sure the nozzle team has at least a 50-ft (15-m) length of working line. Notice also that the hosebed in 15–67b has vertical divider separating the beds; these are called hosebed dividers, and they are adjustable. There are other options regarding finishing static hosebeds to aid in the deployment of hose depending on fire department preferences (fig. 15-68).

Fig. 15–67 a, b. Static attack lines loaded in the hosebed. (Photos courtesy of Daryl Liggins)

Fig. 15–68. Reverse horseshoe finish

Hose bundles

SKILL DRILL

FFI 5.5.2 We have discussed attack hose loaded on the apparatus in crosslay and at the rear of the apparatus in the hosebed. In both places you can find the attack hose loaded in both a static or preconnected fashion. One other way attack hose is often carried on apparatus is in **bundles** or specialized rolls. Bundles and specialized rolls of hose are commonly kept in compartments or seat-belted onto running boards and fenders. Once again, there are many types of bundles and specialized rolls used by the fire service. Many departments choose the one they feel best suits their operations. Let's take a look at the **horseshoe bundle**. A horseshoe bundle is easy to fold, does not get tangled, and deploys in an efficient fashion. Figure 15–69 (a, b, and c) shows a series of pictures:: a completed 2½-in. (65-mm), 50-ft (15-m) horseshoe pack with a nozzle on it; a firefighter rebuilding a 2½-in. (65-mm), 50 ft (15-m) horseshoe pack using a self-contained breathing apparatus (SCBA) bottle as a guide; and two 50-ft (15-m) horseshoe packs of 1¾-in. (45-mm) joined together at the coupling and then strapped together.

Bundles of hose are necessary for many reasons. For example, if you enter a building to use a standpipe (bundles in this case are called **standpipe packs**), or walk up a hill during a wildland fire, you have an easy way to carry the hose. The bundle should be folded in such a way that it is easy to deploy and couple the hose. Figure 15–70 clearly shows the value of a hose bundle. All of these firefighters are able to climb the stairs of a building while having both hands free. Also note their front and side profiles do not increase much. This will allow them to pass by civilians or others who are attempting to exit the building easily.

In addition, the hose bundle, some specialized hose rolls need to be discussed, including the donut roll, twin donut roll, and self-locking twin donut roll. Hose rolls are used as a means of storing hose on the apparatus or in a hose rack in the fire station. There are several variations of hose rolls: the straight roll, the simple donut, and the twin or double donut. The straight roll is designed for storing hose at the fire station on a hose rack. It is made by laying the length of hose straight out and, starting with the male coupling, rolling the hose so that the male coupling is in the center and female coupling is on the outside.

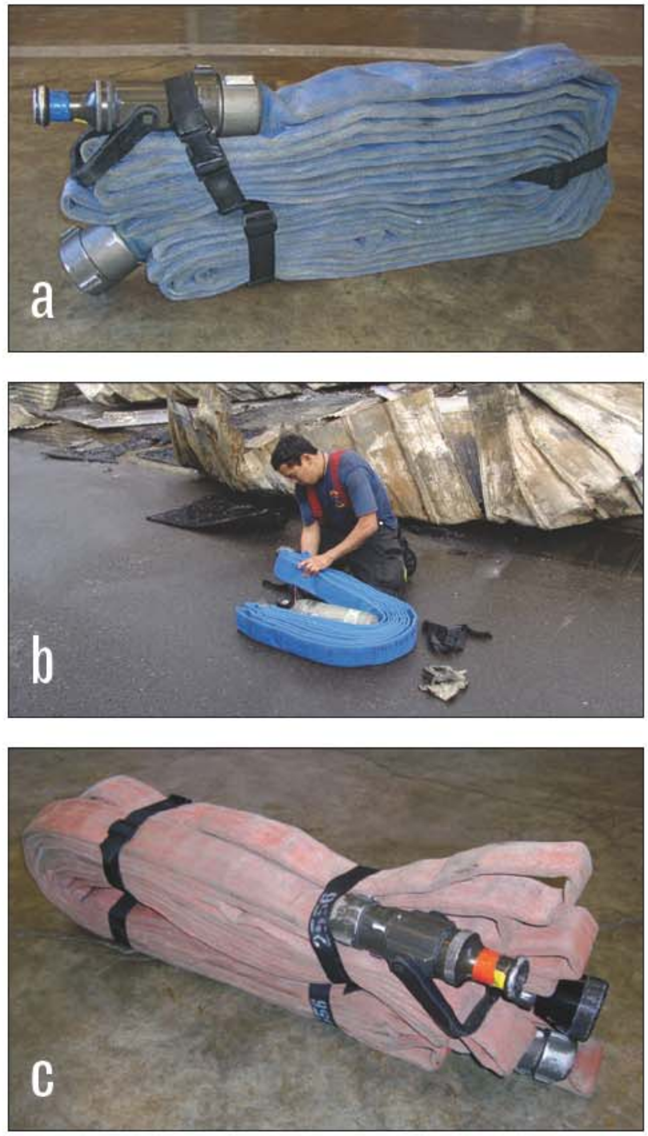


Fig. 15–69 a, b, c. Horseshoe hose bundles of 50 ft (15 m) and 100 ft (30 m). (Courtesy of Daryl Liggins)

Fig. 15–70. Firefighters ready to enter a building with 2½-in. (65-mm) hose in bundles. (Courtesy of Daryl Liggins)

Water Supply and Hose
FIREFIGHTER I
Chapter 15

Donut roll. The simple **donut** is made by folding the hose length onto itself so that the male end of the hose is about 3 feet (1 m) in from the female end. The hose is then rolled on to itself so, when completed, the male coupling is inside the roll and protected from damage (fig. 15–71).

Fig. 15–71. The donut roll

To deploy this roll, you simply grasp the two couplings and roll the hose out from where you are standing or in congested areas hold on to the two couplings and drag the hose with you while the roll deploys behind you.

The donut roll is a staple in the wildland firefighting environment. During progressive hose lays, wildland hose is easily deployed from the donut roll.

Twin donut roll. Another popular donut roll is the **twin donut roll** (fig. 15–72). The twin or double donut roll allows for a compact roll that can be stored in a smaller compartment on an apparatus or can be used for applications such as stand-pipe packs or high-rise packs. It is made by laying the length of hose out so that the two couplings are side-by-side. The hose is then rolled so that, when it is complete, both coupling are on the outside and easily accessible. This roll can be held together by using a hose strap or by a variation known as a self-locking twin donut roll. To deploy it, simply remove the hose strap that is locking it, and, by grasping the couplings, roll the hose away from you so that, when deployed, you have both couplings in you hands

The self-locking twin donut roll. This roll is particularly useful because it forms a carrying handle without the aid of hose strap or other securing devices such as hose packs (fig. 15–73).

There are additional hose bundles and hose rolls that will not be discussed here. There are several types, and they all have their pros and cons. Your department will only use a few of them. Please pay close attention when your instructors go over the bundles and hose rolls because you will be responsible for how to use them properly.

Fig. 15–72. Twin or double donut roll

Fig. 15–73. Self-locking twin donut roll

Reel line. The last type of attack hose carried on an apparatus is a form of preconnected attack hose called **booster/reel line**. Earlier in this chapter, we detailed the many downfalls of using a reel line as an attack line. It has a very limited flow and should only be used in situations such as very small outside fires. Most reel lines, even if 1 in. (25 mm) in diameter, do not flow more than 60 gpm (227 L/min). This is a very small flow and is completely inadequate for any interior building operations. As stated previously, some departments no longer spec hose reels for their apparatus. Reel lines can provide a good utility function. A reel line, like all tools, is useful only if used properly. Using a 60-gpm (227 L/min) reel line on an inappropriate fire is not the fault of the reel line, but of the person who selected it.

Water supply evolutions

SKILL DRILL

Supply line is fire hose used to supply water for fireground operations. Supply line is typically deployed in hose-laying operations where the engine is in motion, and the supply hose pays out of the hosebed as the engine is driven. These supply hose-laying operations are typically made either from a hydrant toward the fire, called a **forward lay**, or from the fire to a hydrant, called a **reverse lay**. In this section we will cover forward lays, reverse lays, and also **split lays**, as well as the basic use of hydrants. These are the most common water supply evolutions using supply hose.

Supply line is almost always loaded statically in the hosebed. An exception to this rule is short, preconnected intake jumpers, usually no longer than 35 ft (10.7 m) in length. These short lengths of supply hose are commonly preconnected to the pump's intakes to assist firefighters in making rapid connection to hydrants or already laid or deployed supply lines. LDH supply jumpers are made in various lengths: 15, 20, 25, 35, and 50 ft (4.5, 6, 7.6, 10.7, and 15 m). Supply line in the hosebed may be loaded with the female coupling out, male coupling out, or Storz couplings. Depending on which sex coupling or type of adapter with Storz is the first out of the hosebed, one can determine what tactic a department usually uses during its water supply evolutions. You have probably noticed by now that most of the figures in this book show hose loaded in a flat style. In fig. 15–74 (a, b, and c) an engine company loads 4-in. (100-mm) DJ LDH in a flat load, taking care to place the large 4½-in. (115-mm) couplings at the front of the hosebed. Placing the large couplings in carefully is a must, because they should not be allowed to flip during a hose lay operation. When loading supply hose, it is sometimes necessary to take a short fold of hose, not only to ensure that the coupling does not flip over while paying out, but also to allow placement of the coupling in a desirable location in the hosebed. This short fold of hose is commonly called a **Dutchman**. The flat load has become the standard practice for loading hose. In fact, "excessive edge wear can occur when 100% synthetic yarn-reinforced hose is loaded on the apparatus in the conventional manner (horseshoe U-load, accordion, or skid loads). To prevent this edge wear, hose manufactures recommend that if 100% synthetic yarn-reinforced hose is used, it should be loaded on the apparatus in the flat load manner."[11]

Fig. 15–74 a, b, c. Firefighters load 800 ft (244 m) of 4-in. (100-mm) hose in a flat load. This 4-in. (100-mm) NST LDH is set up for a forward lay with the female coupling out.

Fig. 15–75. The horseshoe load

Some departments may still use a **horseshoe (U-load)** or **accordion load**, both of which require the fire hose to be loaded on its edge. Let's take a brief look at a horseshoe load, as shown in fig. 15–75. You can see that the hose is loaded in a U-shaped horseshoe fashion. The original main advantages of this horseshoe load are that it promotes good air flow for cotton jacket hose, minimizes severe bends in the hose, and is very difficult to hang up on laying line. The negatives of the horseshoe load are that all the lengths, if hand-jacked or pulled, are of unequal sections due to the nature of its outside in loading technique, and it also promotes excessive edge wear of the supply hose.

The accordion load promotes good air flow for cotton jacket hose, although it can be easily packed too tightly and might hang up upon deployment. The accordion load provides easy shoulder-carrying capabilities with each layer being of the same back-and-forth distance. Firefighters can merely walk up to an accordion load, grab a few folds, and know exactly how much hose they are pulling and then easily place it on their shoulders. Figure 15–76 shows an example of a accordion load. Horseshoe and accordion loads are usually made up of 3-in. (75-mm) MDH, which can be set up in forward or reverse fashion and also in dual beds. Another reason that both the horseshoe and accordion loads have been generally phased out is that they do not work well with any type of LDH supply hose. In addition, both the accordion or horseshoe load's bottommost layer of hose is in direct contact with the metal hosebed bottom on edge. This lower layer of hose on edge is exposed to excessive wear and is not recommended, because with modern synthetic hose, it has been know to cause premature failure.

Fig. 15–76. The accordion load

However, finishing the last length or two of supply hose in a horseshoe or other edge-laid finish to aid in hose evolutions is an acceptable practice, because there is no added weight of hose above the finish, and the finished, on-edge hose is on top of the other hose and not the metal hosebed bottom. Many departments practice this tactic to aid their lead-off or hydrant person in gathering enough hose to complete a water supply evolution.

Supply line is usually no smaller than 3 in. (75 mm) MDH because of the friction loss encountered when moving large volumes of water. The NFPA states that the minimum size supply line is 3½ in. (90 mm) However, many departments still use 3-in. (75-mm) hose. With the trend toward increased hand line flows due to harsher fire conditions caused by modern fire loads, 3-in. (75-mm) MDH is beginning to be too small to appropriately act as supply hose. Some departments use dual beds of 3-in. (75-mm) MDH, which does overcome single 3-in. (75-mm) MDH supply line high-friction loss when moving a large amount of water. This is made possible by laying two supply lines from a single engine; hence the name **dual bed**. For example, the friction loss for a 1,000 gpm (3,785 L/min) in a single 3-in. (75-mm) hose lay per 100 ft (30 m) is 80 psi (560 kPa). However, if two 3-in. (75-mm) MDH supply lines are laid side by side and share the 1,000 gpm (3,785 L/min) flow by each flowing just 500 gpm (1,892 L/min), the friction loss is only 20 psi (140 kPa) per 100 ft (30 m). Laying dual 3-in. (75-mm) supply lines is the hydraulic equivalent to a single 4-in. (100-mm) LDH supply line.

Modern fire departments that continue to use a 3-in. (75-mm) MDH supply line are usually heavily urbanized cities with dual 3-in. (75-mm) MDH supply beds that also have a strong water supply infrastructure that supports its use. This infrastructure includes close hydrant spacing of no more than 300 or 500 ft (91 or 152 m) and good water pressure, as well as using the tactic of placing their pumps at hydrants to provided pumped 3-in. (75-mm) MDH supply. These characteristics and tactics allow for continued use of 3-in. (75-mm) supply line in some cities. Supply line is like any other tool in the fire service: there is a vast array of choices and selection is based on many variables, including available water supply infrastructure and tactics.

Forward lay. A forward lay is just what it sounds like. An engine spots a hydrant near the fire and then lays a supply line towards the fire building. Most fire departments that use a forward lay water supply tactic use a single bed of supply hose, usually in any of the following sizes of LDH: 3½, 4, 4½, and 5 in. (90, 100, 115, and 125 mm). Figure 15–77a shows an engine performing a forward lay evolution by laying a single supply line from a hydrant to a residential building fire. Fire departments that utilize a forward lay should load their LDH supply line with the female coupling out to provide easy connection to the male hydrant outlets/nozzles.

Forward lay tactic departments that have Storz fittings on their LDH supply line usually pre-attached a Storz to threaded swivel female adapter to speed hydrant connections; the attached adapter is usually sized to the largest common outlet on their jurisdiction hydrants. If forward laid supply hose is attached directly to the hydrant outlet, the fire department utilizing this tactic is relying on the residual pressure in the water mains to overcome the friction loss in the supply hose. This limits the practical water capacity of the hydrant. This downside to a forward lay can be overcome using a four-way hydrant valve.

Figure 15–77b, is a Akron four-way hydrant valve being used to augment pressure in an existing 3-in. (75-mm) forward lay supply line. A four-way hydrant valve appliance offers an immense advantage to departments using a forward lay tactic, because if it becomes apparent that due to water supply issues (a extremely long forward lay, for example) placing a pump at the hydrant will significantly increase water supply, one has the option of accomplishing this without interruption of water flow in existing forward laid water supply hose.

Placing a pump at the hydrant is the best way to use all the existing flow capacity in water main system. The engine in Fig. 15–77b could be called upon to supply more water; it could easily gain access to more water by stretching an LDH to the other non-used outlet on the hydrant and then supply additional water through more hose. An engine assigned to a hydrant that uses all of the hydrant's outlets and then pumps it down to only a 10-psi (70-kPa) hydrant residual pressure has effectively used all of the available water from that hydrant; this is called welling the hydrant.

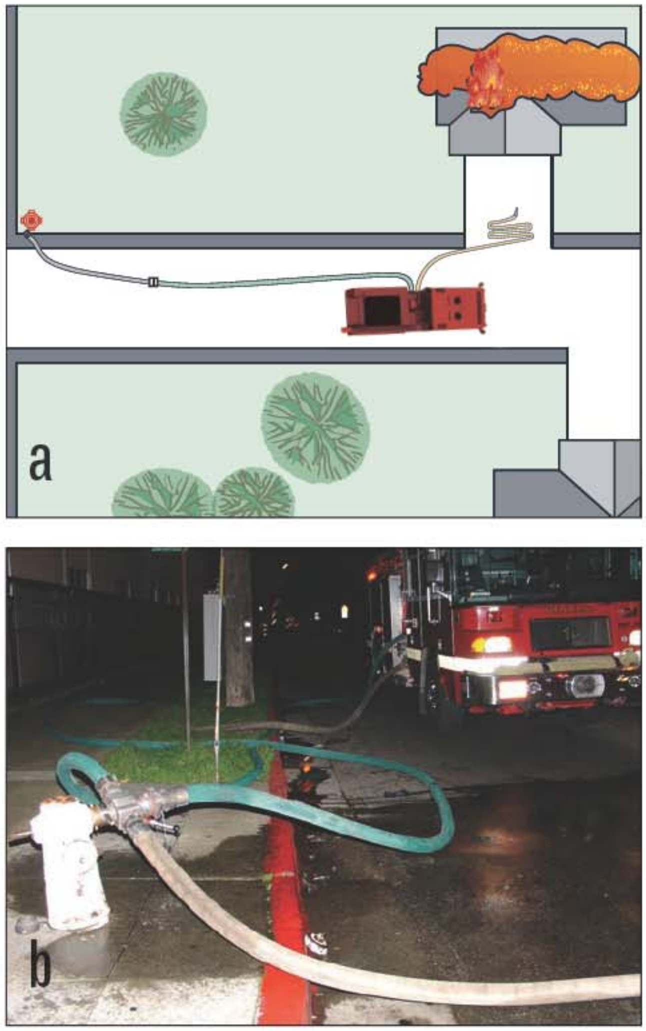


Fig. 15–77. a) Diagram of a typical forward lay. b) Engine pumps through a four-way hydrant valve.

Reverse lay. The reverse lay is simply a water supply evolution where an engine company lays supply line or attack line back to a hydrant (fig. 15–78). This means an engine performing a reverse lay stops at the fire building and then lays hose to the nearest hydrant. The reverse lay is typically used in two different ways: for water supply or fire attack. In the supply scenario there is usually an engine already on the fire scene with attack lines deployed. The attack engine either has no water supply or has an inadequate existing supply. One such example would be an engine operating off its tank. The supply engine that is performing the reverse lay to establish a water supply would pull near the attack engine either by passing it on a wide street or by backing down the street when access is an issue. Once the reverse laying supply engine is in position, the crew would pull the proper supply hose for attack pumper and then release the supply engine, whose crew would proceed to lay out to a nearby hydrant. Once at a hydrant, the engineer would then connect the pumper to the hydrant and the reverse laid supply hose to the engine's discharges. The supply engine at the hydrant must strive not to block access for arriving ladder companies.

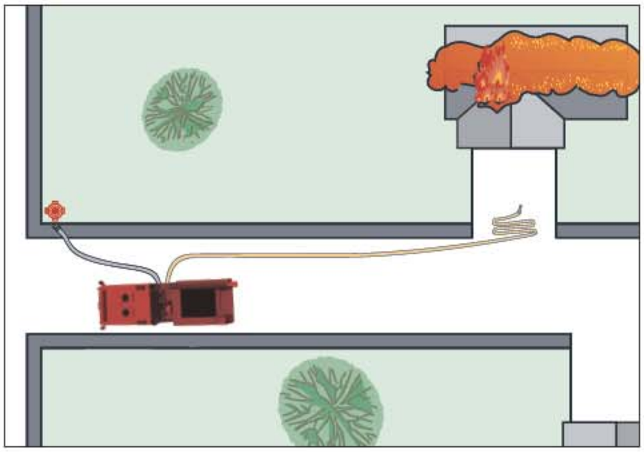


Fig. 15–78. Reverse lay

The other type of reverse lay is an attack line operation. In this case the engine pulls up to the fire building and the crew gets out. The engine crew then proceeds to make a line selection (typically either a single attack line or both an attack line and a backup line are pulled). These lines are located in the hosebed and must be static loads. The company must select the proper size of attack line and estimate how much hose is needed at the fire building to make an effective attack. At the same time, they must strip any equipment they need. Some examples of this would be SCBAs, lights, and hand tools. Sometimes a gated wye or manifold is attached to the engine's supply hose; later, the attack lines, usually removed from engines in bundle configuration, will be connected. Once all of that is accomplished, the engine is then released by the company officer, laying supply hose as it travels. The engineer then drives to the nearest hydrant, leaving the company behind at the fire scene. As the engineer makes the necessary connections to the hydrant and engine, the rest of the company at the fire building starts to flake their attack line and get into position. Once a call for water is made by the attack crew, the engineer charges the proper attack line. Reverse lays for attack hand line operations are typically done in large urbanized areas where hydrants are closely spaced. This leaves the front of the building open for extensive use of aerial devices.

Many fire departments use reverse lays as a water supply evolutions for apparatus located near the fire building. Figure 15–79 depicts the Milwaukee (Wisconsin) Fire Department's (MFD's) rear hosebed and a diagram of a supply reverse lay. Notice that they still use 3-in. (75-mm) MDH as a supply line in the two center hose bins. Both 3-in. (75-mm) MDH supply beds have the male coupling facing out to facilitate reverse lays. Each hose bin has 750 ft (230 m) of 3-in. (75-mm) hose, in 50-ft (15-m) lengths. One 3-in. (75-mm) MDH supply bed has a red hose strap, and the other 3-in. (75-mm) hosebed has a tan hose strap. The MFD can either reverse lay a single or dual 3-in. (75-mm) lay. Pumped supply of 3-in. (75-mm) MDH in this configuration can easily supply 1,000 gpm (3,785 L/min) even if the full 750 ft (230 m) is used, as long as a dual 3-in. (75-mm) hose lead is taken. This leaves a 500-gpm flow in each 3-in. (75-mm) lead at 20 psi (140 kPa) per 100 ft (30 m) of friction loss. The MFD also benefits from optimal hydrant spacing of 300 ft (90 m). Such short lays are a good match for 3-in. (75-mm) hose, especially when it is pump-supplied.

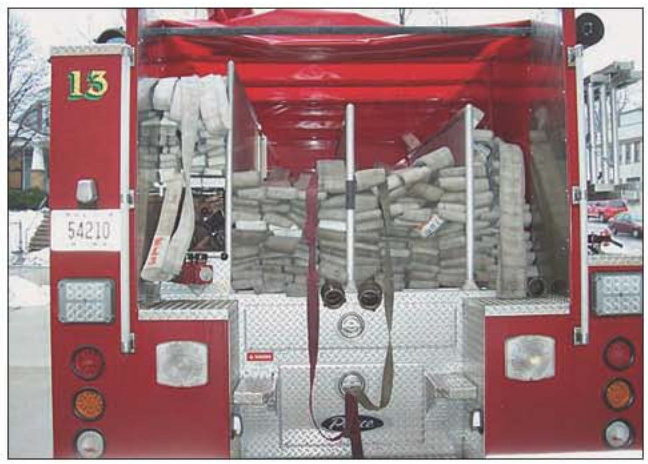


Fig. 15–79 MFD hosebed setup for reverse lays

Another example of a city that uses 3-in. (75-mm) hose is San Francisco. The SFFD benefits from both an excellent water supply system and close hydrant spacing. The SFFD also deals with a densely constructed city, predominately of multiple-story wooden structures. They use dual beds of 3-in. (75-mm) MDH, one with the male coupling out and the other with the female out. This allows them to accomplish a single 3-in. (75-mm) forward lay or a single 3-in. (75-mm) reverse lay with ease. They can also take dual reverse lays or dual forward lays by using either a double female or double male adapter. In fig. 15–80, the engine at the hydrant is pumping two 3-in. (75-mm) leads. Notice one of the leads is attached to a pump discharge by a brass 3-in. (75-mm) double female adapter. The engineer operating the engine has welled the hydrant with two suction jumpers. This engine is properly positioned, out of the way, and connected in a manner such that it will supply all the available water from the hydrant. This SFFD engine could easily be called upon to supply more lines until the hydrant flow reached the available capacity. Notice that in the background extensive aerial operations and ground ladder operations are taking place directly in front of the fire building. Although the SFFD uses 3-in. (75-mm) MDH as supply line on their engines, they also maintain a small fleet of 5-in. (125-mm) LDH hose tenders. This is a common practice for departments that use 3-in. (75-mm) MDH, given that there is truly no substitute for size of hose when called to move very large amount of water—2,000 gpm (7,571 L/min) and up. These hose tenders are usually for special calls or assigned to certain alarms.

Fig. 15–80. SFFD pumps dual 3-in. (75-mm) MDH lay at hydrant

Split lays

Now that we have discussed the water supply evolutions of both forward and reverse lays, we will describe another useful operation called a split lay. The split lay is basically where two engines are used to complete one water supply line evolution from the hydrant to the building fire. The split lay is not commonly done; however, split lays can be extremely effective in the right circumstances. For example, the first due engine arrives at an extremely long alley way or private drive with a building fire located at the end of it. This engine in fig. 15–81 came across just this circumstance. The company officer in this case decided to use a split lay by dropping a supply line at the beginning of the private drive and continued into the fire building. The first due company officer then radioed the second due engine company to pick up their dry lay. This second due company now was then tasked with finishing the water supply line. The second due company stopped and attached their supply line to the dry supply line laid by the first due company.

The second due company's engineer then drove back to the nearest hydrant. Once at the hydrant, all necessary connections were made. Then engineer ensured that the middle connection or **split connection** had been completed and the attack pumper was ready for water. Once all of this was confirmed, water was pumped from the hydrant through the now completed split laid supply line to the attack pumper.

Let's say in this case the total length of the split lay worked out to 1,000 ft (305 m) of 5-in. (125-mm) hose, and each engine in the example only carried 800 ft (245 m) of 5-in. (125-mm) LDH. This would mean that due to the long driveway and distance to the nearest hydrant, it would have been impossible for either company to have made this supply operation on their own. It is not necessary to only consider split lays if the amount of hose required is more than one company's complement. Split lays are sometimes performed for access issues alone.

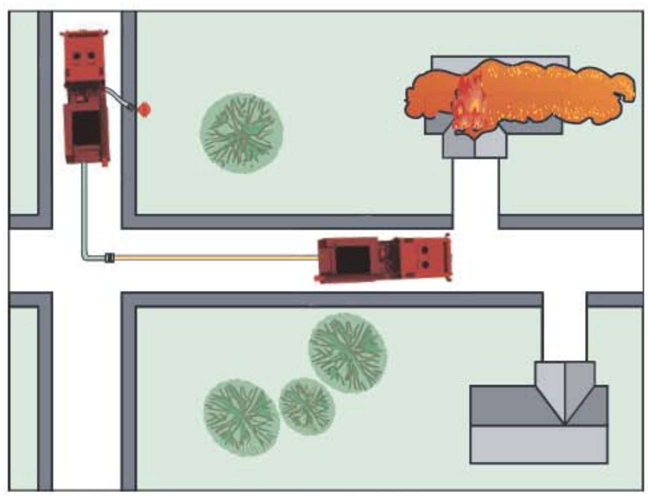


Fig. 15–81. Diagram of a typical split lay

Drafting operations

SKILL DRILL

In rural settings, drafting operations are commonplace. This may involve the use of a dry hydrant connected to a lake, a cistern, or a swimming pool, as described earlier. Perhaps the most common operation is simply the use of a rigid (hard suction) hose placed in a body of water.

Once the engine has been placed at the edge of the source of water (lake, pond, river, etc.), the two hard suction hoses are removed and connected. The strainer is then attached.

A **floating strainer** is typically a square-shaped device attached to the hard suction hose that floats on the surface of the water, maximizing its ability to avoid underwater debris and to draft from shallow water depths. It can simply be placed on the water, and the pump operator can begin to pump after establishing a vacuum (fig. 15–82).

A traditional, round strainer (a circular tube with many holes cast into it) is deployed into the water using a rope to keep it off the bottom of the lake, pond, or other body of water. The rope is then tied to the engine, and the pump operator can initiate creating a vacuum and then begin pumping operations (fig. 15–83).

Fig. 15–82. Floating strainer in operation

Fig. 15–83. Traditional barrel strainer

HYDRANT APPLIANCES

Departments across the country use different **hydrant appliances** to accomplish a variety of tasks. Figure 15–84a depicts an LDH four-way valve attached to a hydrant, which provides the option to pump at the hydrant after water flow is established through the initial supply line. Many departments use four-way hydrant valves. In fig. 15–84b, the dry barrel hydrant with two 2½-in. (65-mm) outlets has a hydrant gate valve attached to it and a single 3-in. (75-mm) MDH supply line. The gate valve allows the use of the other hydrant outlet without turning the hydrant off.

The yellow hydrant in fig. 15–84c has a 5-in. (125-mm) lead attached to it, which is using a Carlin automatic hydrant valve.

The last picture on the right in fig. 15–84d shows a large high-pressure hydrant. The water available from this hydrant is under such tremendous pressure that it is necessary to put a pressure-reducing valve on it. This type is called a Gleason valve, and it is used by SFFD on their high-pressure auxiliary water supply hydrant system. Boston is another city that has a unique hydrant system; one part is a hydrant stem system located under manholes that require a Lowry hydrant. The Boston Lowry hydrant is carried on the engine and is attached directly to a connection in the street. The City of Boston has three hydrant systems; the Lowry system is located mostly in downtown. Today, five engine companies still carry Lowry hydrants.

In summary, many fire departments use different hydrant appliances. Some of these appliances are very simple (like gate valves), and others are rarely used and complex (like the Carlin automatic hydrant valve). You must be familiar with your own fire department's operations as well as the water supply operations and capabilities of your surrounding jurisdictions. The Carlin automatic hydrant valve is used by a jurisdiction near the fire department of one of the chapter authors. Therefore we should know how it works, even though we think it is very impractical.

Basic hydrant use

SKILL DRILL

The ability to use a hydrant correctly is a critical skill that all members of the fire service should not only master but also routinely practice. Engine companies should routinely drill with fire hydrants. It is a bread-and-butter operation that needs to be second nature to all firefighters. All common problems related to hydrants in your particular jurisdiction should be preidentified, and solutions should already be in place. Very few fire departments have the luxury of hydrants that are perfectly maintained and work properly very time. Many departments face significant hydrant problems from vandalism and poor maintenance. I strongly recommend that fire departments outfit all of their engine companies with

Fig. 15–84 a, b, c, d. From left to right: a four-way hydrant valve, a gate valve, a Carlin automatic hydrant valve, and a Gleason pressure-reducing valve.

hydrant bags. A hydrant bag should have all of the necessary equipment to make a good connection to a hydrant, even when problems are encountered.

Take a look at the hydrant bag in fig. 15–85. Fire departments can encounter significant problems with their hydrants based on a variety of factors. This hydrant bag was design by a department that use wet barrel hydrants. It includes a pipe wrench for stripped spindles, a **cheater bar** to apply extra force (avoid breaking the hydrant stem connected to the operating nut by applying too much force), a 3-lb (1.4-kg) maul to knock loose rusted or stuck caps; a Hydra-Shield® locking cap spanner to deal with locking caps; a 2½-in. (65-mm) female to 4½-in. (115-mm) male increaser, in case the steamer outlet is nonfunctional; and a regular screw-type hydrant wrench. Fire departments that access water with dry barrel hydrants should consider these additional items to aid in hydrant connections: extra hydrant caps (in case one or more are missing), outlet plugs or blocks (in case of damaged outlet threads), and different hydrant gate valves.

Hydrant bags are especially useful for departments that rely on forward lay water supply evolutions. During a forward lay, the engine company leaves a firefighter at the hydrant. This firefighter has only the equipment that has been removed from the engine, to obtain a good water supply by rapid connection of the supply line to the hydrant. By placing all of the necessary equipment in a hydrant bag, the lead-off firefighter should have all of the tools required to "catch the hydrant." After checking the PPE and SCBA, one of the first things the lead-off firefighter at shift change should check is the hydrant bag. Hydrant bags are also useful for departments that use reverse lays. In case of a reverse lay, the engineer is able to grab one bag to locate all the tools necessary to make a good hydrant connection.

Let's walk through hitting a hydrant while performing a forward lay.

The forward lay is used when the water source, static or municipal, is located before the structure on fire. In a forward lay, the pumper approaches the water source— in this case a hydrant—and stops. A firefighter, sometimes known a "hydrant firefighter," gets off the pumper with the needed equipment: hydrant wrench, spanner, gates, hose traps, etc., and removes a sufficient amount of supply hose to "wrap" the hydrant. As mentioned previously, the hydrant firefighter checks the hydrant for damage and access, and then proceeds to secure the hose (wrap) around the barrel of the hydrant to anchor it safely in place. The pumper then proceeds to the fire scene. The hydrant firefighter then checks the hydrant, removes the caps and flushes the hydrant. The hose and gates are then connected to the hydrant, and the hydrant firefighter awaits a signal from the pump operator or fire officer to open or charge the hydrant.

Fig. 15–85. An example of tools in a hydrant bag

Once water is received at the pumper, then those necessary functions (fire attack, exposure control, hydraulic ventilation, etc.) can be accomplished at the fire scene to control and extinguish the fire.

Once the fire is extinguished and all overhaul functions have been accomplished, the process of shutting down the operation can begin. At this point the incident commander notifies the pump operator to begin shutting down attack lines and the hydrant firefighter is notified that they can begin closing the hydrant, as discussed in a previous section. Once the hydrant has been shut down and the pressure bleeds off the hose, the gates can be disconnected. The hydrant caps are replaced and the supply hose is drained of excess water and prepared to be repacked on the pumper.

LESSON FROM THE FIREGROUND

The fire department arrived at a well-involved two-story garden apartment fire. The fire was burning throughout a second floor dwelling unit and the fire coming from the windows had spread the fire into the combustible attic space. The buildings were situated between 1,000 and 1,200 ft (305 and 366 m) off the main road. There was a hydrant in the complex but the fire department knew this hydrant was fed by a dead end 6-in. (150-mm) water main. The first arriving pumper (1,500 gpm [5,678 L/min] with 500 gal [1,892 L] tank) stopped at the hydrant at the entrance to the complex and dropped a 5-in. (125-mm) supply line.

The volume of fire dictated the use of heavy caliber streams. A deck gun was ordered to hit the main body of fire. The pre-piped 1¾-in. (45-mm) smooth bore tip master stream was charged. A 2½-in. (65-mm) hoseline with a one and ⅛-in. (3-mm) smooth bore tip was ordered to the adjoining second floor apartment where the fire was now spreading. A second two and ½-in. (13-mm) hose line with the same nozzle was stretched to combat the fire in the attic, which was now rapidly involving the attic space over the entire building.

As the hand lines were charged, the pump operator realized the supply line was collapsing. A second supply line was called for and an additional 5-in. (125-mm) supply line was stretched from the dead end hydrant using two 100-ft (30-m) lengths of hose. Although this improved the situation slightly, there was still a problem supplying adequate water to the single deck gun and two large hand lines.

The immediate assumption was there had to be a problem with the hydrant and the public water supply. The initial static pressure was 70 psi (490 kPa) but quickly bottomed out. An examination after the fire showed that there was plenty of water. The problem was a basic pump operations flaw. There was too much friction loss created when flowing the large volume of water through the five-inch supply hose from the hydrant. The simple answer would have been to have another pumper at the hydrant to overcome the friction loss problem.

NOTES

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QUESTIONS

1. What is normal atmospheric pressure and how does it register on a standard fire service gauge?
2. Explain the effect friction loss has on flow pressure in a fire hose.
3. In the water distribution system, on what type of water main are hydrants normally found?
4. Why are dry barrel hydrants typically found in climates where the temperature can be expected to drop below freezing?
5. What items should be included in a hydrant inspection?
6. What color should the bonnet of a hydrant capable of flowing more than 1,500 gpm (5,678 L/min) be painted?
7. When setting up a water shuttle, what conditions make for a good fill site?
8. When is relay pumping typically needed?
9. How would a 2½-in. (65-mm) hoseline be classified? Why?
10. What is the advantage of double-jacketed hose when compared to single-jacketed hose?
11. Can large-diameter hose (LDH) be used to draft water from a static source? Why or why not?
12. Why are Storz connections commonly used on large-diameter supply hoses?
13. Prior to reconnecting sections of hose together, what should the couplings be inspected for?
14. What is the definition of a hose appliance?
15. Explain the difference between a gated wye when compared to a clappered Siamese.
16. Why should a fire hose not be folded or reloaded in the same order it was prior to being used?
17. What does it mean if a fire hose is stamped "400 psi service test"?
18. What advantage do attack lines stored preconnected on the pumper have over attack lines stored in a dead load?
19. Laying a supply line from the hydrant to the fire is referred to as what?
20. In what circumstances might a split lay be utilized?