Chapter 12

Relay Pumping Operations

Relay Operation — Using two or more pumpers to move water over a long distance by operating them in series; water discharged from one pumper flows through hoses to the inlet of the next pumper, and so on. Also known as Relay Pumping.

Water supply pumper — Pumper that takes water from a hydrant or static source and pumps it under pressure to the next apparatus in the relay pump-ing operation. Water supply pumpers should be the apparatus with the largest pumping capacity. Some jurisdictions refer to water supply pumpers as source pumpers.

Relay pumper — Pumper or pumpers connected within the relay that receive water from the source pumper or another relay pumper, raises the pressure, and then supplies water to the next apparatus. This pumper may be of smaller capacity due to its ability to use the acquired energy of previ-ous pumpers in the relay.

Fire attack pumper — Pumping apparatus located at the fire scene that receives water from the relay and is responsible for supplying the attack lines and appliances required for fire suppression.

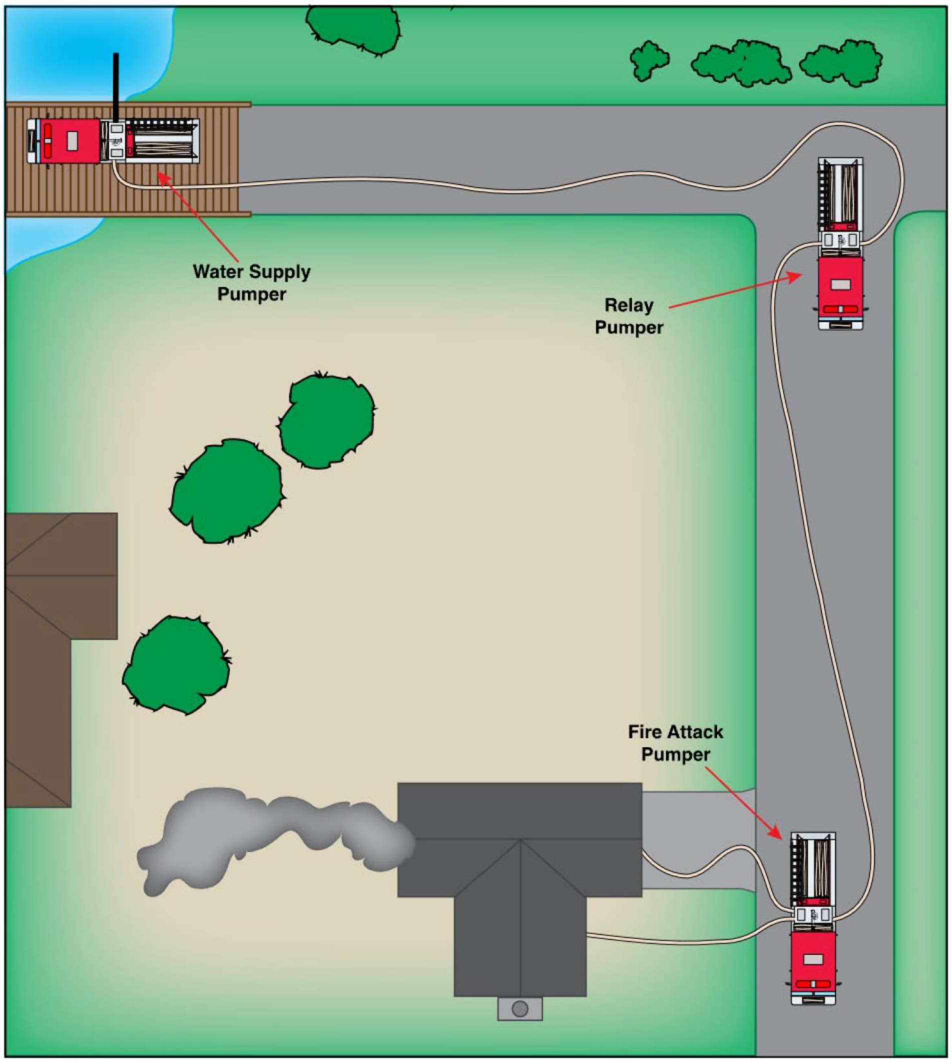


Figure 12.1 Apparatus are named based on their role within a relay pumping operation.

Tender — Term used within the Incident Command System for a mobile piece of apparatus that has the primary function of supporting another operation; examples include a water tender that supplies water to pumpers, or a fuel tender that supplies fuel to other vehicles.

Large Diameter Hose (LDH) — Relay-supply hose of 31⁄2 to 6 inches (90 mm to 150 mm) in diameter; used to move large volumes of water quickly with a minimum number of pumpers and personnel.

The distance of the relay is the second important consideration. The longer the hose lay, the more friction loss will be encountered. As explained in previous chapters, friction loss is directly affected by the amount of water being flowed, the diameter of the hose, and the distance between pumpers. If the amount of flow through a relay operation needs to be increased, depending on the size of the supply hose and fire flow requirements, at least one of three conditions must be met:

- The diameter of the supply hose or the number of hoselines must be in-creased.

- The pump discharge pressure of the pumpers involved in the relay must be increased.
- More pumpers must be added to the relay to overcome friction loss or eleva-tion.

Pumpers in the relay operation could increase their pump discharge pres-sure. However, this action will not necessarily increase the volume of water through the system. Centrifugal pumps are rated to pump at their **maximum volume capacity at 150 psi** (1 050 kPa) at draft. When pumping at pressures higher than 150 psi (1 050 kPa), the volume capability of the pump is reduced proportionately. Depending on the length of the hose lay and the volume of water flowed, a point will be reached where increased pressure will not increase the volume.

It is advisable for driver/operators to maintain an intake pres-sure of **20 to 30 psi** (140 to 210 kPa) as a relay pumper. Once the pump discharge pressure on the relay pumper has reached the desired pressure, with water being discharged, no further adjust-ments should be required. Follow the same procedure for each successive relay pumper in the operation. The first relay pumper opens the discharge valve supplying the relay or attack pumper on a coordinated basis. Conduct this process while observing the intake pres-sure gauge to maintain intake pressure within the desired range of 20 to 30 psi (140 to 210 kPa) residual pressure. The next relay pumper follows the same initial actions as the first. Following this process, long relay operations may be completed efficiently with a minimum of delay.

Shutting Down the Relay When the need for relay pumping has ended, the operation should be dis-continued from the fire scene first. If done in reverse with relay pumpers still operating, they may run their pumps dry in a high rpm condition and risk cavitation. Beginning with the attack pumper and coordinating with the other pumpers in the relay, each driver/operator should slowly decrease the throttle, open the dump line valve, and then disengage the pump. Close all valves slowly to prevent water hammer at any point in the system. This method provides for the refilling of onboard water tanks of the apparatus involved in the relay.

Open Relay Method During relay pumping operations, the open relay method may be employed to provide an alternate water supply system. This method consists of deploying portable folding drop tanks at each intake for pumpers in the relay operation.

Closed Relay Method Each fire department, as well as neighboring departments that conduct joint operations, should have a standard policy for the use of relay pumping. These operations should be practiced within the department and jointly between mutual aid partners on a regular basis.

Chapter 13

Water Shuttle Operations

Water shuttle operations are used to provide water supply to incident scenes where relay pumping is not a viable option. In a water shuttle operation, mobile water supply apparatus (tenders or tankers depending on local vocabulary) deliver their load of water to the incident scene, dump it into portable tanks, travel to a fill site, reload, and then return to the incident scene to dump an-other load of water

Fill Site — Location at which tankers/tenders will be loaded during a water shuttle operation.
Dump Site — Location approved for water shuttle apparatus to discharge their water for other apparatus to draw during incident operations.

Water Shuttle Apparatus (pumpers & water tenders)

Pumpers With the exception of operations that feature a vacuum tanker (described later in the chapter) or the use of a hydrant, most water shuttles require at least two pumpers for water supply. A pumper located at the water source (fill site) is generally referred to as the fill site pumper and has the responsibility of filling water tenders (Figure 13.2). For large-scale operations, this function may require two or more fill site pumpers to maintain an adequate supply to the fire scene.

Water Tenders Each department must choose the appropriate capacity of their tender(s) based on local water supply availability, road conditions, and bridge height and weight restrictions. Vehicle weight restrictions generally limit single rear axle apparatus to a maximum capacity of 2,000 gallons (8 000 L). However, the single axle apparatus carrying this load must be designed to carry the weight. For apparatus with a capacity greater than 2,000 gallons (8 000 L), tandem rear axles, tri-axles, or semi-trailers are required. Many jurisdictions employ tenders of significant capacity to fulfill their water supply requirements.

NOTE: In order to be considered a tender under NIMS typing, an onboard or portable fire pump is required.

When designing or purchasing water tenders for shuttle operations, the filling and dumping capabilities are of prime importance. Apparatus that use medium diameter supply hose for filling should have at least two external fill connections piped directly to the tank (Figure 13.6). If LDH is used, one fill connection is generally sufficient

In addition to the vacuum tenders mentioned earlier in the chapter, there are two primary types of large tank discharges in use on water tenders: gravity and jet-assisted dumps.

Jet-assisted dumps use a small diameter in-line discharge inserted into the piping of the large tank discharge. The in-line discharge is supplied by the fire pump on the water tender and creates a Venturi effect that increases the water flow through the large tank discharge. Some fire departments have chosen to install larger gravity dumps on their water tenders to limit cost and address the following operational issues concerning jet-assisted dumps:

- Apparatus must be equipped with a fire pump.

- The fire pump must be engaged before dumping. This adds time to the dumping operation.
- Although water can be discharged without engaging the pump, it will be at a lower rate than if a gravity dump valve were installed.
- High velocity of water discharge may miss the portable tank and strike people or other apparatus.
- The mechanism may freeze between dumping operations in cold weather climates.

When using a circular travel route, consider the direction of travel if there is a substantial grade on a portion of the route. Fully loaded tenders should travel down grade and empty tenders should make the return trip traveling uphill.

When a Water Supply Group is established, the person in charge is known as the Water Supply Group Supervisor (Figure 13.18). Only this Supervisor will report directly up the chain of command to the Operations Section Chief or Incident Commander. If an incident escalates beyond the span of control for a Group Supervisor, the IC may establish a Water Supply Branch under the supervision of a Branch Director

NOTE: Direct pumping is generally performed only when a minimal volume of water is required.

Nurse Tender Operations Another dump site method of delivery involves positioning a large water tender immediately adjacent to the attack pumper, serving the same role as a portable tank

Portable Water Tank Operations Using one or more portable water tanks located near the incident scene to eliminate the need for backing or turning around is an efficient way to manage dump site water supply

Open Butt — End of a charged hoseline that is flowing water without a nozzle or valve to control the flow.

Baffle — Intermediate partial bulkhead that reduces the surge effect in a partially loaded liquid tank.

For operations that require more than three tanks and jet siphons and flows over 500 gpm (2 000 L/min), parallel jet siphons should be used to transfer water to the tank supplying the attack pumper. A second pumper may be used to draft from the tanks solely to supply the jet siphons, to relieve some of the work of the dump site pumper's driver/operator.

There are two basic methods for calculating a flow rate for a specific tender. See page 465 for details

Chapter 14
Foam Equipment and Systems

Principles of Foam Mechanical foams are the most common foams in use. These products must be proportioned (mixed with water) and aerated (mixed with air) before use. To produce fire fighting foam,

foam concentrate, water, and air must be educted or injected in the correct ratios. If any element is removed or incorrectly ap-plied, the result will be poor quality foam, or no foam production. Before describing types of foams and the foam-making process, it is impor-tant to understand the following terms (Figure 14.1):

- Foam concentrate — Raw foam liquid in its storage container before being combined with water and air.
- Foam proportioner — Device that injects the correct amount of foam concentrate into the water stream to make the foam solution.
- Foam solution — Mixture of foam concentrate and water before the intro-duction of air.
- Foam — Completed product after air is introduced into the foam solution (also known as finished foam). Proper aeration should produce a blanket of uniform-sized bubbles that will maintain an effective cover over Class A or Class B fuels for the required period of time. Specifically formulated foams should be used on each class of fire.

Class B fuels are divided into two categories: hydrocarbons and polar solvents.

Polar solvent fuels, such as alcohol, acetone, ketones, and esters, are known as miscible liquids because they mix with water. Special alcohol-resistant (polymeric) formulations of fire fighting foam must be used when these flam-mable liquids are encountered.

Hydrocarbon Fuel — A petroleum-based organic compound that contains only hydrogen and carbon.

Polar Solvents — Liquid having a molecule where the positive and negative charges are permanently separated, resulting in their ability to ionize in solution and create electrical conductivity. Water, alcohol, and sulfuric acid are examples of polar solvents.

Miscible — Materials that are capable of being mixed in all proportions.

Class B foams are designed solely for use on hydrocarbon fuels and are not effective on polar solvent products regardless of the concentration that is applied. However, some foams intended for use on polar solvents may be used on hydrocarbon fuel products, but only under the direction of the manufacturer.

How Foam Works

Foam extinguishes and/or suppresses vapors by the following methods (Figure 14.2, p. 482):

- Separating — Creates a barrier between the fuel and the fire
- Cooling — Lowers the temperature of the fuel and adjacent surfaces
- Suppressing or smothering — Prevents the release of flammable vapors, reducing the possibility of ignition or reignition

Fire fighting foam creates a film or blanket on the burning or exposed fuel. This blanket excludes oxygen making ignition difficult and stops the burning process on fuel that has been ignited. As the foam begins to break down, water is released, providing a cooling effect on the fuel suppressing the process of heat producing oxidation. The water being released may also runoff, carrying the product with it.

Most fire fighting foam concentrates are formulated to mix with 94 to 99.9 percent water. For example, when a 3 percent foam concentrate is used, the finished foam solution consists of 97 parts water mixed with 3 parts foam concentrate. The result is 100 parts foam solution

Class A foams are formulated to be proportioned within certain limits established by the manufacturer to achieve specific objectives. These per-centages may range from a little as 0.1 percent to 1 percent.

Foam is proportioned using one of four basic methods:

- Induction
- Injection
- Batch mixing
- Premixing
- Batch mixing
- Premixing

Induction- The induction method of proportioning foam uses the pressure of a water stream to induct (draft) foam concentrate into the fire stream. This is achieved by passing the stream of water through a Venturi device called an **eductor** (Figure 14.4). A **pickup tube** connected to the eductor is inserted into the foam concentrate container. The pressure differential created by the water passing through the Venturi causes a reduction in pressure in the device that allows atmospheric pressure to force foam concentrate into the water stream. In-line eductors and foam nozzle eductors are examples of foam proportioners that work by this method.

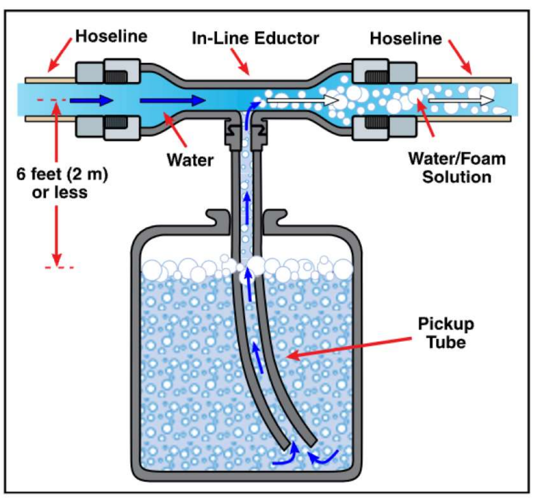


Figure 14.4 An eductor picks up foam concentrate and mixes it with water.

Injection- The injection method of proportioning foam uses an external pump to force foam concentrate into the fire stream at the proper ratio in comparison to the flow. These systems are most commonly employed in apparatus mounted or fixed fire protection systems.

Batch Mixing -A simple but potentially inaccurate method of mixing foam concentrate and water, batch mixing occurs when an appropriate amount of foam concentrate is poured directly into a tank of water

Premixing- Premixing is a common method of proportioning in which premeasured por-tions of water and foam concentrate are mixed in a container. Typically, this method is used with portable and wheeled extinguishers, skid-mounted twin-agent units, and apparatus-mounted tank systems

How Foam Is Stored

- Pails
- Totes
- Barrels
- Apparatus Tanks

Pails- Five-gallon (20 L) plastic pails are commonly used containers in many mu-nicipal fire departments

Barrels- Foam concentrate is also available in 55-gallon (220 L) plastic or plastic-lined barrels. Some fire departments use these for bulk storage, but they are more common in industrial applications

Totes- When bulk storage of foam concentrates is required, some fire departments or industrial facilities may specify 275 gallon (1 100 L) containers, called totes. Under conditions that may require large quantities of foam, such as aircraft rescue fire fighting (ARFF), wildland, or industrial facilities, this method of storage may be prudent

Apparatus Tanks- Fire apparatus equipped with onboard foam proportioning systems usu-ally have foam concentrate tanks piped directly to the delivery system. This eliminates using pails or barrels to supply a foam eductor. Foam concentrate tanks may be found on many municipal fire pumpers as well as industrial foam tenders and ARFF apparatus. Foam concentrate tanks on municipal fire apparatus generally range from 20 to 200 gallons (80 to 800 L) while foam pumper or tenders may carry 8,000 gallons (32 000 L) or more of concentrate

Class A Foam

The formula of Class A foam includes hydrocarbon **surfactants** that reduce the surface tension of water in the foam solution. This reduced surface ten-sion allows for better penetration and increased effectiveness. When used in conjunction with compressed air foam systems (CAFS), Class A foam provides excellent insulation qualities

Surfactant — Chemical that lowers the surface tension of a liquid; allows water to spread more rapidly over the surface of Class A fuels and penetrate organic fuels.

The shelf life of properly stored foam solution can be as long as 20 years making it an economical choice to purchase in bulk quantities

Class A foam concentrates may be mixed with percentages as little as **0.1 to 1.0 percent**.

using percentages greater than 0.5 percent with a standard fog nozzle may not increase fire fighting performance

- Fire attack and overhaul with standard fog nozzles — 0.2 to 0.5 percent concentrate
- Exposure protection with standard fog nozzles — 0.5 to 1.0 percent concen-trate

- Any application with air aspirating foam nozzles — 0.3 to 0.7 percent con-centrate
- Any application with compressed air foam systems (CAFS) — 0.2 to 0.5 percent concentrate

Application Rate — Minimum amount of foam solution that must be applied to an unignited fire, spill, or spill fire to either control vapor emission or extinguish the fire; measured per minute per square foot (or square meter) of area to be covered.

Application of Class A Foam

- Areas that require maximum penetration. Wet foam is very fluid and will easily penetrate Class A fuels
- Vertical surfaces. Dry foam forms a rigid coating that adheres well. It is slow to drain, allowing the foam to cling to a vertical surface for extended periods. Dry foam, which often resembles shaving cream, has very low water content and high air content.
- Surface of a fuel. Foam must have the ability to cling and penetrate the surface of a fuel. Medium foam is able to penetrate a fuel while maintaining a sufficient blanket of protection.

Class B Foam

Class B foam is applied to suppress fires involving flammable and combustible liquids. It is also used to suppress vapors from unignited spills involving these liquids.

These foam concentrates consist of a synthetic or protein base. While syn-thetic foam is made from a mixture of fluorosurfactants, protein based foam is derived from animal protein.

Class B foam concentrates should be stored in cool areas to maximize shelf life: approximately 10 years for protein based foams and 20 to 25 years for synthetic foam. Generally, different brands of foam concentrates should not be mixed together for storage in apparatus tanks as they may be chemically incompatible. However, when ready for immediate use during emergency operations, similar type concentrates such as AFFF and fluoroprotein may be mixed together immediately before application. Foam concentrates of the same type, which are manufactured to U.S. Military specifications (Mil-Spec concentrates), may be mixed at any time with no adverse effects.

The chemical properties of Class B foam concentrates and their impact on the environment may vary depending on the product and manufacturer. Generally protein based products are considered safer for the environment. However, consult the safety data sheets (SDSs) provided by the manufacturer for specific safety information.

Military Specifications (Mil-Specs) — Specifications developed by the U.S. Department of Defense (DoD) for the purchase of materials and equipment.

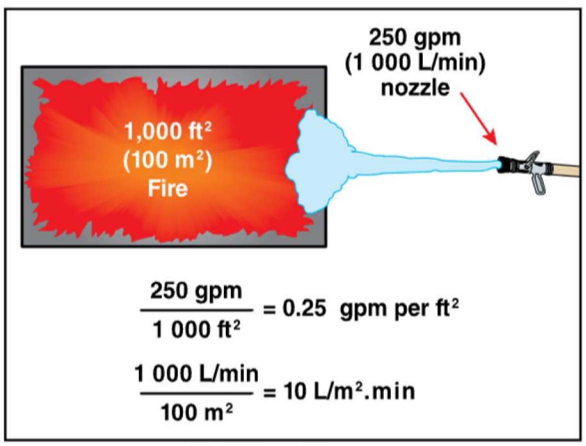
Safety Data Sheet (SDS) — Form provided by the manufacturer and blender of chemicals that contains information about chemical composition, physical and chemical properties, health and safety hazards, emergency response procedures, and waste disposal procedures of a specified material. Formerly known as Material Safety Data Sheet (MSDS).

Class B foams are mixed in proportions from **one to six percent**.

Foam expansion is generally described as being low, medium, or high. NFPA® 11 states that low expansion foam contains an air/solution ratio of up to 20 parts finished foam for every part of foam solution, a 20:1 ratio. Medium expansion foam is commonly used at a rate of 20:1 up to 200:1 through hydrau-lically operated nozzle type delivery devices. When high expansion foam is used the expansion rate is from 200:1 to 1000:1.

Rates of Application The rate at which foam is applied depends on several variables, in-cluding
• The type of concentrate used
• Whether or not the fuel is on fire
• Type of fuel involved (hydrocarbon vs. po-lar solvent)
• Whether the fuel is contained or uncontained The

In order to calculate the application rate available from a specific nozzle, divide the flow rate by the area of the fire. For example, a 250 gpm (1 000 L) nozzle on a 1,000 square foot (100 m2 [m2.min]) (Figure 14.14).



Regular Protein Foams -Protein foams derived from animal protein sources such as hooves, horns, or feather meal. These sources are hydrolyzed in the presence of lime and converted to a protein hydrolysate that is neutralized. Stabilizers, corrosion inhibitors, and antimicrobial agents, as well as additives to inhibit freezing are also contained in the formula. Regular protein foam generally has good heat stability and burnback resistance.

Fluoroprotein Foam- Fluoroprotein foam, a combination of protein-based foam and synthetic foam, contains protein concentrate to which fluorochemical surfactants are added. The addition of these chemicals provides fluoroprotein foam with the ability to flow more readily than ordinary protein foam. This type of foam also provides longer lasting vapor suppression that may be critical during incidents involv-ing unignited spills. Fluoroprotein foam continues to be a favored option by some municipal and industrial fire departments.

Fluoroprotein foam may be made alcohol resistant with the addition of ammonia salts suspended in organic solvents. The alcohol-resistive properties will be effective for approximately 15 minutes, offering high-water retention and resistance to heat.

Film Forming Fluoroprotein Foam (FFFP)- Film forming fluoroprotein foam (FFFP) concentrate is based on the tech-nology of fluoroprotein foam for long lasting heat resistance and the capabili-ties of aqueous film forming foam (AFFF) for quick knockdown. FFFP is also available in an alcohol-resistant formulation.

Aqueous Film Forming Foam (AFFF)- Aqueous film forming foam (AFFF), or commonly called A triple F, is currently the most commonly used synthetic foam concentrate. Its formula consists of fluorochemical and hydrocarbon surfactants combined with solvents to cre-ate a high boiling point. The fluorochemical surfactants reduce the surface tension of the water in the foam solution to a degree that a thin aqueous film is spread across a fuel product as the foam solution is applied.

When AFFF or FFFP foam is applied to a fire involving a hydrocarbon fuel product, several actions will occur:

- An air/vapor excluding film is released ahead of the foam blanket.
- A fast moving blanket of foam spreads across the surface of the fuel sur-rounding objects and providing insulation.
- As the aerated foam blanket drains its water, more film is released giving the foam an ability to recover, or “heal” areas where the foam blanket is disturbed.

Protein Foam Concentrate — Foam concentrate that consists of a protein hydrolysate plus additives to prevent the concentrate from freezing, prevent corrosion equipment and containers, prevent bacterial decomposition of the concentrate during storage, and control viscosity.

Hydrolyze — To cause or undergo a chemical process of decomposition involving the splitting of a bond and the addition of the element of water.

Burnback Resistance — Ability of a foam blanket to resist direct flame impingement such as would be evident in a partially extinguished petroleum fire.

Film Forming Fluoroprotein Foam (FFFP) — Foam concentrate that combines the qualities of fluoroprotein foam with those of aqueous film forming foam. See Foam Concentrate.

Aqueous Film Forming Foam (AFFF) — Synthetic foam concentrate that, when combined with water, can form a complete vapor barrier over fuel spills and fires and is a highly effective extinguishing and blanketing agent on hydrocarbon fuels. Also known as light water.

Alcohol resistant AFFF concentrate- is commonly available for use on polar solvents. This concentrate is generally used at a concentration of three or six percent, based on manufacturer's recommendations (Figure 14.17). Alcohol-resistant AFFF may also be used on hydrocarbon fuels at one to six percent proportion based on the manufacturer's guidelines.

When AR-AFFF foam is applied to polar solvent fuels, a membrane is created over the fuel. This membrane separates the water in the foam blanket from the ef-fects of the solvent. The blanket acts in much the same way as ordinary AFFF. Alcohol resistant AFFF should be applied gently to a fuel product in order to allow the membrane to form. Aspirating nozzles are generally best for preserving the membrane that forms on the surface of these products.

High-Expansion Foams High-expansion foam contains a detergent base and low water content. The low water content provides less runoff and minimizes water damage. Several common applications for high-expansion foam include:

- Concealed space fire such as cellars and coal mines or subterranean spaces such as utility tunnels and sewers
- Fixed extinguishing systems for specific industrial hazards
- Class A fire application

Low Energy Foam Proportioning Systems

In-Line Foam Eductor — Type of foam delivery device that is located in the water supply line near the nozzle. The foam concentrate is drawn into the water line using the Venturi method.
See Pg. 494 for more information

The pressure at the discharge side of the eductor must not exceed 70 percent of the eductor inlet pressure. This back pressure is determined by adding the nozzle pressure, friction loss in the hose between the eductor and the nozzle, and the elevation pressure. Excessive back pressure may result in no foam concentrate being inducted into the water.

The concentration of foam solution will only blend accurately if the inlet pressure at the eductor is correct (usually 150-200 psi

The foam concentrate inlet to the eductor should be no more than six feet (2 m) above the liquid surface of the foam concentrate

Foam Nozzle Eductors- A foam nozzle eductor operates under the same principle as an in-line educ-tor. The eductor is built into the self-educting nozzle rather than attached to the hoseline. This system requires that foam concentrate be available at the point where the nozzle is operated. This often becomes a logistical problem

Self-Educting Master Stream Foam Nozzle — Large-capacity nozzle with built-in foam eductor.

A **jet ratio controller (JRC)** is a type of in-line eductor that may be used to supply foam concentrate to a self-educting master stream. It allows the foam concentrate supply to be located as far as 3,000 feet (900 m) away from a self-educting master stream nozzle. This distance allows firefighters charged with operating the fire pump and maintaining the foam concentrate supply to do so from a considerable distance, as well as an elevation change of up to 50 feet

Apparatus Mounted Foam Proportioning Systems

Installed In-Line Eductor Systems

An installed in-line eductor system operates under the same principles as portable in-line eductors (Figure 14.21). The standard precautions regarding hose lengths, matching the nozzle and eductor flow capability, as well as inlet pressures apply to both apparatus mounted and portable systems. The only difference in the systems is the fixed-position mounting on the apparatus. When operating the installed system, foam concentrate may be supplied from a pickup tube into a drum or pail, or by using a tank permanently in-stalled on the apparatus.

In some installations a bypass proportioner is installed to reduce the friction loss across the eductor (Figure 14.22, p. 498). In the bypass mode, a valve directs the water through a second chamber of the eductor that contains no orifice or restrictions. This mode is used when no foam is desired, and the discharge function is to supply a plain water hoseline. When a foam line is required, a valve is directed to divert water through the eductor/orifice chamber. A metering valve is present at this point to accommodate various foam concentrates. Installed in-line eductors are most commonly used to proportion Class B foam. Installed in-line foam eductors are generally not effective for proportioning the very low concentrations used in Class A foam operations.

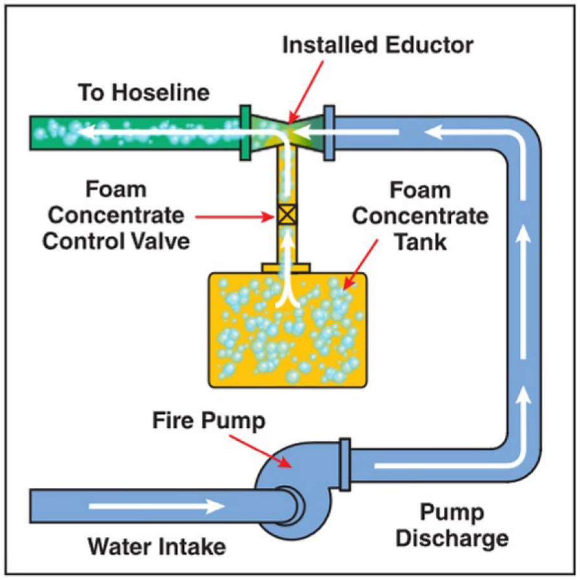
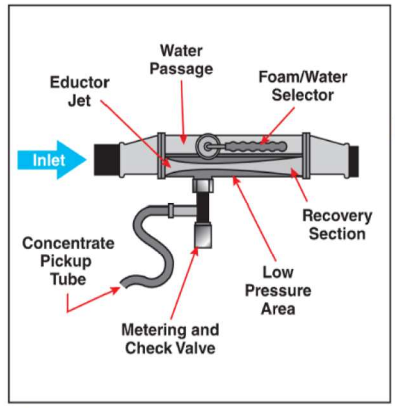


Figure 14.21 Some pumping apparatus are equipped with an installed in-line eductor.

Figure 14.22 The pump will discharge plain water when the proportioner is in bypass mode.



Around-the-Pump Proportioners Around-the-pump proportioners are one of the most common t ypes of ins t a l led proportioners used in modern fire apparatus. This system consists of a small return (bypass) water line connected from the discharge side of the pump back to the intake side of the pump (Figure 14.23). An in-line eductor is installed in this line with a valve controlling the flow of water passing through it. In the open position the valve allows approximately 10 to 40 gpm (40 to 160 L/min) to flow through the piping. This flow passes through the eductor, creating a Venturi effect that draws foam from the onboard concentrate tank. The foam solution that is created is pumped through the bypass piping to the intake side of the fire pump where it is pumped to a discharge and into a hoseline. Around-the-pump proportioners should generally be used at the specific flow for which they are rated.

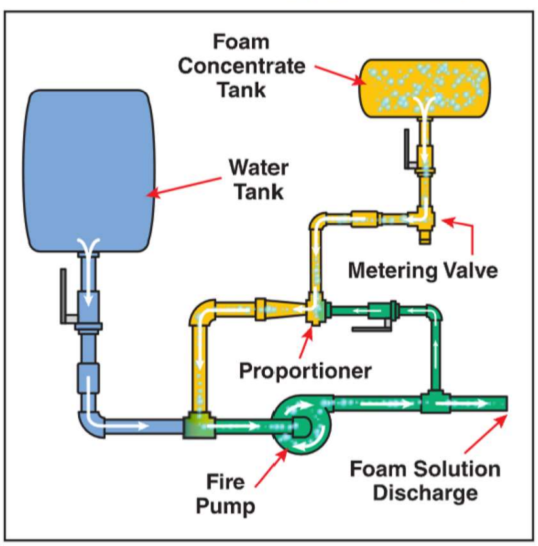


Figure 14.23 Around-the-pump foam proportioners are

Bypass-Type Balanced Pressure Proportioners- The bypass-type balanced pressure proportioner, used on large mobile apparatus installations, such as ARFF vehicles, is one of the most accurate methods of foam proportioning. This system features the ability to monitor the demand for foam concentrate and adjust the amount of concentrate supplied. In addition the bypass type balanced proportioner has the ability to allow foam discharge from some outlets, and plain water from others simultaneously.

Apparatus with a bypass-type balanced pressure proportioner feature a foam concentrate line supplied by a separate foam concentrate pump con-nected to each discharge outlet (Figure 14.24). The concentrate, drawn from an onboard tank, is supplied at the same pressure as the water supplied by the main fire pump. The pressure of the concentrate and water are monitored by a hydraulic pressure control valve that ensures a proper balance.

The orifice of the foam concentrate line is adjustable at the point where it connects to the discharge line. The orifice is set to reflect the percent desired for a particular application. Because the water and foam concentrate are sup-plied at the same pressure and the sizes of the discharges are proportional, the foam is proportioned correctly.

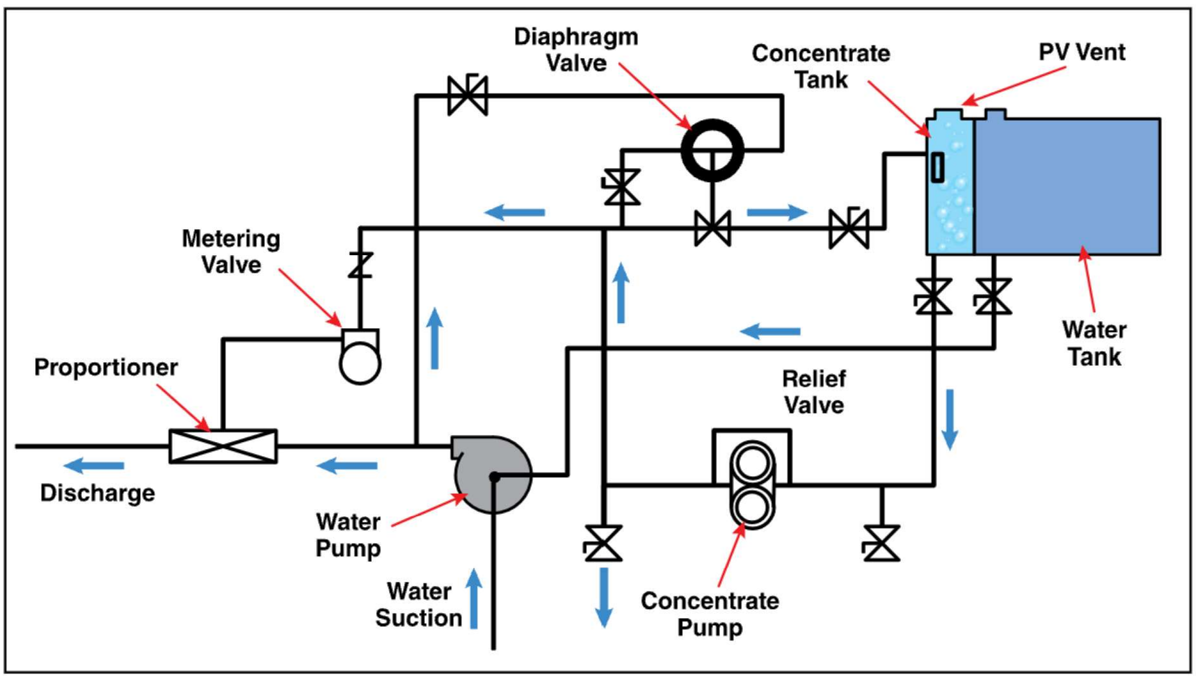


Figure 14.24 A bypass-type balanced pressure foam proportioning system.

Variable-Flow Variable-Rate Direct Injection Systems- Variable-flow variable-rate direct injection proportioners generally oper-ate off power supplied by the apparatus electrical system, although some larger units may use a combination of electric and hydraulic power. The foam concentrate ratio is controlled by the speed of a positive displacement foam concentrate pump that injects foam concentrate into the water flow. No flow restricting devices are equipped in the proportioning system because the water flow governs the foam concentrate injection, enabling full flow through the fire pump.

Variable-Flow Demand-Type Balanced Pressure Proportioners- A variable-flow demand-type balanced pressure proportioning system, also known as a pumped/demand system, consists of a variable speed mechanism driven electrically or hydraulically, that operates a foam concentrate pump. The foam concentrate pump supplies a Venturi-type proportioning device attached to a water line. During operation, the foam concentrate pump is monitored so that its flow is appropriate for the flow of water, producing an effective foam solution.

Batch mixing or the dump in method is the simplest method of proportioning foam.

In addition, when refilling the water tank, the foam residue leftover on the interior surface may cause frothing. This foam solution acts as a cleansing agent that removes lubricants from pump seals. To avoid this, driver/operators should thoroughly flush out the tank and pump to remove all foam. Afterward, the driver/operator should check the seals for proper lubrication. Failure to do so may result in difficulty priming, pump cavitation, as well as inaccurate measurements of some gauges.

High Energy Foam Generating Systems/CAFS

Compressed air foam offers several tactical advantages, including:

- The reach of the fire stream is considerably longer than those of low energy systems.
- A CAFS system produces small uniform air bubbles that are very durable. • Foam produced by a CAFS adheres to a fuel surface and resists heat longer than low energy foam.
- Hoselines containing high energy foam solution weigh less than those containing plain water, or low energy foam solution.
- CAFS may provide a safer fire attack that allows effective reach from a greater distance. However, CAFS does have a number of limiting factors, including:
- A CAFS increases the purchase price and maintenance costs of new apparatus.
- Hose reaction may be erratic if the foam solution is not supplied to the hoseline in sufficient quantities.
- In the event of a hose burst, the compressed air will intensify the reaction of the hoseline.
- Additional training is required for personnel who will operate and conduct fire attack operations using CAFS equipment.

CAFS apparatus use a standard centrifugal pump with an automatic dis-charge side proportioning system. Due to the low eduction rates, a variable flow rate sensing proportioner is required to supply the fire stream at the rate of 0.1 to 1.0 percent.

Handlines

Smooth Bore Nozzles- The use of smooth bore nozzles is limited to the applica-tion of Class A foam from a CAFS (Figure 14.26). Smooth bore nozzles provide an effective stream with excellent reach capabilities using this system. This is an exception to the standard rule that dictates the discharge orifice be no greater than half the diameter of the hose.

Fog Nozzles- Firefighters may operate fixed flow, selective flow, or automatic fog nozzles when applying a low expansion, short duration foam blanket. These nozzles break the foam solution into droplets while using the agitation of water droplets moving through air to achieving the foam-ing action (Figure 14.27).

Expansion ratios for most fog nozzles are in the 2:1 up to 4:1 range. Their most efficient usage is during application of regular AFFF and Class A foam. However, they may also be used with alcohol resistant AFFF on hydrocarbon fires. Fog nozzles are not an acceptable choice for delivery of fluoroprotein foams as insufficient aspiration is created. Likewise, they should not be employed for incidents involving polar solvents. Many nozzle manufacturers have designed foam aera-tion attachments that may be added to the end of a fog nozzle to increase aspiration of the foam solution.
Figure

Air-Aspirating Foam Nozzle- Air-aspirating foam nozzles induct air into the foam solution by a Venturi action. These nozzles can be used with Class A foam in wildland fire fighting applications, and are the only nozzles that should be used with protein and fluoroprotein concentrates. They provide maximum expansion of the agent, but since most of the stream's energy is used to introduce air, it is not able to reach as far as a standard fog nozzle

Master Stream Foam Nozzles

Large-scale flammable and combustible liquid fires often require the deliv-ery of an amount of foam that is beyond the capability of the handlines. Like handline nozzles, fixed flow or automatic fog master stream appliances may be used to deliver foam. They perform in a similar manner to the handline nozzles discussed in the preceding section. Industrial foam pumpers and ARFF apparatus are often equipped with aerating foam master stream nozzles.

Medium-and High-Expansion Foam Generating Devices- There are two basic types of medium-and high-expansion foam generators: water aspirating and mechanical blower. They both produce foam contain-ing high air content. The air content of medium expansion foam ranges from 20:1 to 200:1. For high expansion foam, the ratio ranges from 200:1 to 1000:1.

Water aspirating devices for medium-and high-expansion foam are similar to other foam producing nozzles, except that they are considerably larger and longer. The back portion of the nozzle is open for airflow (Figure 14.29). Foam solution is pumped through the nozzle as a fine spray, mixing with air to form a moderate expansion. The end of the nozzle features a screen, or series of screens, that break up the foam and mix it with additional air. These nozzles typically generate a lower air volume foam product than mechanical blowers.

Mechanical blowers look very similar to an ordinary smoke
ejector. They operate on the same principle as the water aspirating nozzle, except that air is forced through the foam solution by the fan instead of being pulled by water movement. The mechanical blower produces foam containing a very high air content that is well suited for incidents requiring total flooding. Its use is limited to high-expansion applications.

Assembling a Foam Fire Stream- Placing a foam line into operation using an in-line proportioner is a basic method of achieving foam delivery. Driver/operators must be proficient in the steps required to complete this operation.

The following information provides the causes for the production of poor quality foam or the lack of foam production:

- Incorrect match between eductor and nozzle flow, resulting in no pickup of foam concentrate.
- Air leaks at fittings may cause a loss of suction.
- Clogged proportioning equipment.
- Partially closed nozzle will result in a flow rate that will not al-low the creation of a Venturi effect capable of picking up foam concentrate.
- Too long of an attack line on the discharge side of the eductor.
- Kinked hose.
- Nozzle placed too far above the eductor, resulting in excessive elevation pressure.
- Different manufacturers foam concentrates should not be mixed together (except for mil-spec concentrates) as they may be chemically incompatible.
- Different classes of foam should not be mixed as they may produce an inef-fective foam product or prevent any foam delivery.

The driver/operator must be aware of the specific manufacturer's recom-mendations for the foam concentrate and foam proportioning equipment in use. This information combined with department policy should provide working guidelines for operational use.

Foam Application Techniques

Under certain circumstances driver/operators may be required to operate a handline or master stream during an incident at which foam lines are used. In order to maintain maximum effectiveness and scene safety, correct tech-niques must be used for application. The techniques for applying foam to a fire or spill include:

- Direct-application method
- Roll-on method
- Bank-down method
- Rain-down method

Direct Application- The direct application method of fire attack with Class A foam consists of applying finished foam directly onto the burning material. This technique follows the same procedure as direct attack using plain water, yet is usually more effective due to Class A foam's enhanced extinguishing capabilities.

Roll-On Method- A method for Class B foam application, the roll-on method involves directing a foam fire stream on the ground near the front edge of a burning liquid spill. The foam will then roll across the surface of the fuel. Application of the foam should continue until it spreads across the entire surface of the fuel and the fire is completely extinguished, or the vapors are suppressed. Firefighters may need to re-position the stream to different areas to ensure the entire surface of the spill is adequately covered. This method is effective for use only on a pool of liquid fuel on the open ground

Bank-Down Method- Another method employed with Class B foam when a vertical surface is near or within a pool of ignitable liquid is the bank-down method. Using this type of application foam is directed onto the vertical surface and allowed to run down and spread across the pooled fuel product

Rain-Down Method- When the first two methods are impractical due to the elevation of the fuel above grade, the rain-down method of application may be employed. This is the most common method of application for aboveground storage tank fires. It involves the direction of a Class B foam fire stream into the air above the fire, allowing the foam to gently rain down on the surface of the fuel (Figure 14.32, p. 508). The firefighters operating the attack line must position within reach and sweep the stream back and forth across the surface of the fuel until it is completely covered and the fire is extinguished.

Environmental Impact- The primary concern regarding the environmental impact of foam is the ef-fect of finished foam after application to a fire or spill. The severity of impact may vary based on the concentrate and type of Class A or B solution. Bio-degradability of these products is determined by the rate at which natural bacteria can degrade the foam. The process of decomposition results in the consumption of oxygen. When foam solution makes its way to a natural water source this reduction of oxygen may result in the destruction of vegetation and aquatic life. Studies by the U.S. Forest Service have shown that release of Class A foam into bodies of water can be lethal to fish. No foam concentrates, solutions, or finished foam should be discharged into any body of water. Foam manufacturers safety data sheets (SDSs) as well as NFPA® 1150 Standard on Foam Chemicals for Fire in Class A Fuels will provide additional information regarding this topic.

Although used in the same manner as Class A foam, these durable agents are structurally and chemically quite different. Chemically these products are water absorbent polymers as opposed to hydrocarbon based surfactants like Class A foam. When mixed with water, durable agents form small bubbles filled with water, unlike Class A foam in which bubbles are filled with air. These products are nontoxic and biodegradable and pose no adverse environmental impact. However once applied, surfaces coated with these products become very slippery for walking or driving. Durable agents are also considerably more expensive than Class A foam.

These products are usually siphoned from a container with an eductor, but may be batch mixed in a tank if necessary. Durable agents are applied for extinguishment, fire line construction, or structure protection through any standard handline nozzle or master stream device. They may also be air dropped via tanker or helicopter.

When used as an extinguishing agent, the standard application ratio is 1:100 (one percent solution in water). When used on a fire line, durable agents are often applied at 11⁄2 to 2 percent. For structure protection, the application ratio is 2 to 3 percent. With this application, durable agents will adhere to vertical structural surfaces for up to 24 hours. In addition, the products may be rehydrated by using a fine water mist, thus extending protection for up to several days.

Durable Agents- Other additives are currently available for use as extinguishing agents as well as pre-treatment of structures threatened by fire spread. Generally known as durable or gelling agents, fire blocking gels, or aqueous fire fighting gels, these products retain their fire retarding properties longer then Class A foam.

Biodegradable — Capable of being broken down into innocuous products by the actions of living things, such as microorganisms.

Decomposition — Chemical change in which a substance breaks down into two or more simpler substances. Result of oxygen acting on a material that results in a change in the material's composition; oxidation occurs slowly, sometimes resulting in the rusting of metals.

Gelling Agents — Superabsorbent liquid polymers capable of absorbing hundreds of times their own weight in water. These gels can be used as fire suppressants and fire retardants. Gels function by entrapping water in their structure rather than air, as is the case with fire fighting foams. Also known as Durable Agents.

Air Drop — Process of dropping water, short-term fire retardant, or long-term fire retardant from an air tanker or helicopter onto a wildland fire.

Chapter 15

Apparatus Testing

Road Tests — Preservice apparatus maneuverability tests designed to determine the road-worthiness of a new vehicle.

The apparatus being tested must meet the following minimum standards:

- The apparatus must accelerate to 35 mph (55 km/h) from a standing start within 25 seconds. This test is conducted in two runs in opposite directions over the same course.
- The apparatus must achieve at least a top speed of 50 mph (80 km/h). This requirement may be waived for vehicles not designed for use on public roadways.
- The apparatus must come to a full stop from 20 mph (30 km/h) within 35 feet (10.5 m).
- The parking brake installed on the vehicle must conform to the specifications listed by its manufacturer.

Performance Requirements — Written list of expected capabilities for new apparatus. The list is produced by the purchaser and presented to the manufacturer as a guide for what is expected.

Hydrostatic Test- A hydrostatic test is performed to ensure that the pump and associated pip-ing are capable of withstanding high pressure pumping demands. The pump body as well as the entire intake and discharge piping system, with the exception of the tank fill and tank-to-pump lines on the tank side of the valves, are subjected to a minimum hydrostatic test pressure of 500 psi (3 500 kPa) for a minimum of 10 minutes.

Pump Certification Tests- Pump certification tests are performed by an independent testing organization such as Underwriters Laboratories, and are designed to ensure that the fire pump will operate as designed on the completed apparatus. These tests are performed at the manufacturing plant before final acceptance of the vehicle. The results of the tests are stamped on a plate affixed to the pump panel of the apparatus. Certification testing requirements should be part of the apparatus bid specifications. Commonly, fire departments reference the requirements of NFPA® 1901 Standard for Automotive Fire Apparatus. The NFPA® 1901 standard requires the following certification tests be conducted for apparatus equipped with a fire pump of 750 gpm (3 000 L/min) up to 3,000 gpm (12 000 L/min):

- Engine speed check
- Pumping test
- Pumping engine overload test
- Pressure control system test
- Priming system test
- Vacuum test
- Water tank-to-pump test
- Engine speed interlock test
- Gauge and flowmeter test
- Manufacturer's predelivery test For

Fire Flow Testing — Procedure used to determine the rate of water flow available for fire fighting at various points within the distribution system.

Acceptance testing is conducted to demonstrate to the purchaser that the apparatus conforms to all bid specifications at the time of delivery. Testing is conducted at the jurisdiction to which the apparatus has been sold with representatives from the purchasing agency and the manufacturer available to review the procedures. Acceptance testing should feature a pump test in addition to the pump certification test that was previously performed at the factory. This process should be adequate to prove the validity of the pump certification.

Acceptance Testing — Preservice tests on fire apparatus or equipment, performed at the factory or after delivery, to assure the purchaser that the apparatus or equipment meets bid specifications.

In jurisdictions that are higher than 2,000 feet (600 m) above sea level, a pumping engine overload test should be performed as part of acceptance test-ing. This will ensure that the engine develops the necessary power to operate in the conditions of higher altitudes.

Performance Testing of Fire Pumps (Pumper Performance Tests)

The following sections feature information on minimum performance test-ing as required in NFPA® 1911. These tests include:

- Engine speed check

- Pump shift indicator
- Pump engine control interlock
- Priming system test
- Vacuum test
- Pumping test for fire pumps
- Overload test
- Pressure control test for fire pumps
- Intake relief valve system test
- Gauge test flowmeter test
- Tank-to-pump flow rate

Site Considerations for Pumper Performance Tests- Although the NFPA® 1911 standard allows performance testing to be conducted using a hydrant or static water supply, many jurisdictions prefer a static water source because it will provide easier evaluation for pump performance (Figure 15.2). The water level of the static source must be at least 4 feet (1.2 m) deep, with the strainer submerged at least 2 feet (600 mm) below the surface. The distance of the centerline of the pumper intake above the surface of the water is based on its capacity. For pumps rated at 1,500 gpm (6 000 L/min) or less, 10 feet (3 m) is the maximum distance, while 2,000 gpm (8 000 L/min) pumps use a 6 foot (2 m) maximum lift.

Correcting Net Pump Discharge Pressure for Testing Net pump discharge pressure is the difference between the intake pressure and the discharge pressure. Performance tests are conducted at 150 psi (1 050 kPa), 165 psi (1 150 kPa), 200 psi (1 400 kPa), and 250 psi (1 750 kPa) net pump discharge pressure. When operating at draft, the net pump discharge pressure is more than the pressure displayed on the discharge gauge. When tests are conducted, the friction loss in the intake hose and the height of the lift must be considered. NFPA® 1911 provides information on friction loss allowances for various sizes of intake hose that may be used during pump testing.

Equipment Required for Performance Tests NFPA® 1911 specifies that all gauges used for service testing must be calibrated within 60 days of the testing. The following equipment is required for performance tests on fire department pumpers:

- A gauge to determine intake pressure. The gauge should be calibrated to a range of 30 in Hg to zero (-100 to 0 kPa) for a vacuum gauge, or 30 in Hg (-100 kPa) vacuum to 150 psi (1 050 kPa) for a compound gauge (Figure 15.4, p. 522).
- A gauge with a range of 0 to at least 400 psi (2 800 kPa) (with + or - 5 % accuracy) to determine pump discharge.
- A pitot tube with knife edge and air chamber rated from 0 to at least 160 psi (1 100 kPa) is required if a flowmeter is not used (Figure 15.5).
- Smooth bore nozzles of the appropriate size to provide the volumes pumped for the required tests. (If a flowmeter is used, fog nozzles may be substituted, providing they are rated for the required flows).
- A means to secure the nozzles (rope, chain, or test stand).
- A hand tachometer (if applicable).

- Appropriate means to record the test results (written form or computer program). The following additional equipment may serve to make the testing process
easier and more efficient:
- Two 6-foot (2 m) lengths of 1⁄4-inch (6 mm) diameter, 300 psi (2 100 kPa) hose with screw fittings and gauges. These gauges are connected to fittings at the pump panel.
- Clamp to hold the pitot tube to the test nozzle.
- Test stand to hold the gauges.
- Stopwatch.

Flowmeters- A flowmeter, which indicates flow in gallons (or liters) per minute, within plus or minus five percent of accuracy, offers increased efficiency over a pitot gauge when determining flow from nozzles during a pump test.

Safety During Service Testing- To perform fire pump service testing safely, personnel should:

- Wear protective head gear, eyewear, gloves, and hearing protection if noise levels have the potential to reach or exceed 90 decibels (dB)
- Open and close valves and nozzles slowly to prevent water hammer.
- Operate the engine throttle slowly to prevent sudden pressure changes that may damage equipment or injure personnel.
- Secure test nozzles and observe hose from a safe distance.
- Ensure that no people or obstructions are in the path of a hose stream.
- Be sure that personnel are protected from any open manholes if using a test pit.
- Chock apparatus wheels.
- Monitor air quality for the presence of carbon monoxide.

Manhole — (1) Hole through which a person may go to gain access to an underground or enclosed structure. (2) Opening usually equipped with a removable, lockable cover, that is large enough to admit a person into a tank trailer or dry bulk trailer. Also known as Manway.

Engine Speed Check- An engine speed check should be conducted under no-load conditions after ensuring all fluid levels are within manufacturer's recommendations. Skill Sheet 15-1 provides the steps to determine if the engine is running at the same governed speed at which it was rated when the apparatus was new. If it is not running at the correct speed (plus or minus 50 rpm), the apparatus should be evaluated by a qualified mechanic before any further tests are performed. Engine speed may be determined by the engine tachometer and/or a properly calibrated handheld tachometer.

Tachometer — Instrument that indicates the rotational speed of a shaft in revolutions per minute (rpm); usually used to indicate engine speed.

Vacuum Test- A vacuum test evaluates the priming device, pump, and intake hose for air leaks. Many fire departments perform this test first, as it will be difficult to proceed if the pump will not hold the necessary vacuum. See Skill Sheet 15-2 for the steps to perform a vacuum test. If the pump fails to reach

22 inches of mercury (-75 kPa), remove the ap-paratus from service until repairs can be made. Check the internal condition of the suction hose and refer to Chapter 2.

Priming System Test- When the driver/operator has the apparatus prepared for the pumping test, operate the priming system until the pump achieves prime and is discharging water. According to NFPA® 1911, fire pumps of 1,250 gpm (5 000 L/min) capac-ity must achieve prime in 30 seconds or less, and those rated at 1,500 gpm (6 000 L/min) must be primed within 45 seconds. Additional specifications offer increased time based on the size of intake piping.

Pumping Test- The pumping test evaluates the overall operation of the engine and fire pump. In order to achieve the correct engine and nozzle pressures for the pump capacity, the testing of a series of adjustments will be required. Any pressure changes should be made slowly to avoid damage to the pump and other equipment, as well as to ensure the safety of personnel conducting the test.

Pressure Control Test- Pressure control devices installed on the fire pump must be tested to ensure they operate as designed, maintaining a safe level of pressure on the pump when valves are closed at a range of discharge pressures.

Discharge Pressure Gauge and Flowmeter Operational Tests- The discharge pressure gauges and flowmeter (if so equipped) must be tested to ensure that the driver/operator has accurate information on which to base decisions on pump operation. Gauges that are not properly calibrated may cause the driver/operator to unintentionally supply dangerously low or high pressures to firefighters operating attack lines.

Tank-to-Pump Flow Test- A tank-to-pump flow test must be conducted on any apparatus with an on-board water tank. This test verifies that the piping between the onboard tank and pump is sufficient to supply the minimum amount of water specified by NFPA® 1901 and the design of the manufacturer. Pumpers with an onboard tank capacity of 500 gallons (2 000 L) or less must be capable of flowing 250 gpm (1 000 L/min) from their onboard tank. Pumpers with a capacity of greater than 500 gallons (2 000 L) must be capable of flowing at least 500 gpm (2 000 L/min). Some jurisdictions may specify higher flows based on local require-ments. If an apparatus with specifications greater than the NFPA® minimum is being tested, it is recommended that the specified capacity be achieved during testing. Use the following procedures in Skill Sheet 15-5 to check the operation of the tank-to-pump line.

Internal Intake Pressure Relief Valve Test- The operation of the internal intake pressure relief valve as well as intake relief valves on any other appliances used on the apparatus should be tested. The steps required to test this valve are as follows:

- A discharge hoseline from a second pumper is connected to the intake of the apparatus being tested.
- The discharge pressure from the supply pumper should be increased until the internal intake relief valve on the test pumper opens.
- The pressure at which the internal intake relief valve actuated is recorded.
- The recorded pressure should be compared to past test results as well as operating procedures used by the jurisdiction where the pumper is in ser-vice. If necessary the valve may be adjusted

to the desired setting.

Foam Proportioning Equipment Testing Foam proportioning equipment installed on an apparatus must also be tested for proper operation before being placed in service, and periodically thereafter. This equipment is generally checked by one of two methods:

- Testing the foam-to-water concentration that the system and associated equipment are able to produce
- Testing the rate at which foam concentrate is consumed in proportion to a known flow of water through the system

The accuracy of an apparatus foam system must be tested prior to delivery per NFPA® 1901. However, the standard does not require the system to be tested on a yearly basis. IFSTA recommends that driver/operators have the ability to perform the four basic testing methods specified in NFPA 1901® so that the operability of the foam system may be verified periodically during the service life of the apparatus. The methods for testing a foam proportioning system for calibration accuracy are:

- Foam concentrate displacement method
- Foam concentrate pump discharge volume method
- Foam solution refractivity testing
- Foam solution conductivity testing

Foam Concentrate Displacement Method- This method checks the volume of foam concentrate that is drawn through the system to determine the accuracy of the proportioning equipment. The foam system is operated at a predetermined flow using water instead of foam concentrate. The water is drawn from a calibrated tank instead of the foam concentrate tank or five gallon (20 L) pails. The volume of water drawn from the tank over a measured period of time is correlated to the actual percentage of foam concentrate that the system would have drawn.

Foam Concentrate Pump Discharge Volume Method- Certain direct injection type proportioning systems may use this method to check the volume of foam concentrate that is proportioned into a fire stream. Water may also be used as a substitute for foam concentrate during testing with this procedure. To begin the test, the foam system is operated at a predetermined flow while the discharge from the foam concentrate pump is collected in a calibrated tank for a specified period of time. The volume in the calibrated tank may then be correlated to the actual percentage of foam concentrate that the system should proportion at the test flow rate.

Foam Solution Refractivity Testing- A foam solution refractivity test ensures the quality of a foam solution after it has been created by a foam proportioning system. This test is accurate for protein and fluoroprotein based foam solutions.

The amount of foam concentrate present in the solution is measured using a refractometer. This device measures the velocity of light that travels through a medium. The refractometer compares samples of solution drawn from a system being tested to a base reading. Any deviation in the content of foam concentrate in the solution will result in a different bending of light beams through the refractometer.

The scale readings on the refractometer do not directly represent the actual foam proportioning percentage, so results must be plotted on a graph in order to be interpreted.

Refractometer — Device used to measure the amount of foam concentrate in the solution; operates on the principle of measuring the velocity of light that travels through the foam solution.

Foam Solution Conductivity Testing- Conductivity testing is used to ensure the quality of synthetic based foam produced by various foam proportioning systems and equipment. Due to the very light color of synthetic based foam, refractivity testing is not an accurate measure of the foam's quality. However, conductivity testing verifies the abil-ity of the foam product to conduct electricity.

Direct Reading Conductivity Testing- This method may be employed when a direct reading conductivity meter is available. The actual percentage of foam concentrate in a solution may be indicated on certain meters. Other meters may require that the individual con-ducting the testing develop a calibration curve. The procedure for developing a calibration curve for conductivity testing is the same as for refractivity testing

Conductivity Comparison Testing- This method is used during testing with a meter that displays units of micro-siemens per centimeter (ms/cm). Readings for plain water and foam solution produced by the proportioning system are obtained. The percentage of foam concentrate in the solution is then determined using Formula 15.1.

Percent of Concentrate in Solution = (Conductivity of Solution) – (Conductivity of Water)/ 500

Conductivity Calibration Curve Testing- Conductivity calibration testing is performed using a handheld tempera-ture compensated conductivity meter. This test procedure is similar to that described for refractivity testing. A calibration curve is developed using the same process as refractivity testing. However, the readings are obtained us-ing a conductivity meter. More detailed information concerning foam system testing, including testing compressed air foam systems (CAFS) may be found in the IFSTA Principles of Foam Fire Fighting Manual.

Fore more information, refer to TANK2PUMP.COM