Chapter 1

Types of Apparatus Equipped with a Pump

The main purpose of a fire department pumper is to provide adequate water pressure for effective fire streams.

NFPA® 1901, Standard for Automotive Fire Apparatus, contains the requirements of pumper design.

The standard specifies a minimum pump capacity of 750 gpm (3 000 L/min) and a water tank with a capacity of at least 300 gal-lons (1 200 L).

Pump capacities larger than 750 gpm (3 000 L/min) increase in increments of 250 gpm (1 000 L/min) with most municipal fire departments operating pumpers of 2,000 gpm (8 000 L/min) or less.

Rescue Pumper — Specially designed apparatus that combines the functions of both a rescue vehicle and a fire department pumper. These vehicles are designed with more compartment space than a standard fire department pumper. In addition to standard engine company equipment, rescue pumpers carry medical, rescue, and extrication equipment.

Initial Attack Fire Apparatus — Fire apparatus whose primary purpose is to initiate a fire attack on structural and wildland fires and support associated fire department actions. Also known as Midi-Pumper or Mini-Pumper.

- **Mini-Pumper** — Small fire apparatus mounted on a pickup-truck-sized chassis, usually with a pump having a rated capacity less than 500 gpm (2 000 L/min). Its primary advantage is speed and mobility, which enables it to respond to fires more rapidly than larger apparatus. Known as brush trucks, brush breakers, or booster apparatus
- **Midi-Pumper** — Apparatus sized between a mini-pumper and a full-sized fire department pumper, usually with a gross vehicle weight of 12,000 pounds (6 000 kg) or greater. The midi-pumper has a fire pump with a rated capacity generally not greater than 1,000 gpm (4 000 L/ min).

Elevating Water Devices. Some fire departments operate pumpers equipped with various types of elevating devices to apply fire streams. The articulating or telescoping devices most commonly combined with pumpers generally range in height from 50 to 75 feet

Water Tenders or Tankers- The capacity of mobile water supply apparatus operating in a particular jurisdiction is based on a variety of factors including:

- **Terrain** — The apparatus must be capable of traversing roads in the area, including hills and winding, narrow roads (Figure 1.7, p. 18).
- **Bridge and weight limits** — Bridges in a response area must be capable of supporting the weight of water supply apparatus. If the apparatus is over- weight for some older bridges, alternate routes should be preplanned.
- **Monetary-constraints**— Local jurisdictions may not have enough funding to purchase and operate a large mobile water supply apparatus.
- **Interoperability**—Thecapabilityofnearbyjurisdictionsshouldbeconsid- ered before making a purchase. Water shuttles may operate more efficiently with apparatus of similar capacity.

Mobile water supply apparatus, as stated in NFPA® 1901, Chapter 7, are equipped with a tank capacity of at least 1,000 gallons. State, federal, and gross vehicle weight limits may regulate weight distribution and load requirements of the chassis. Mobile water supply apparatus have **two basic functions** on the fireground. The water tender may be **used in a mobile shuttle operation**. In this operation, the water tender arrives at the designated dump site and either pumps off or uses the quick dump valve to off-load its water supply into folding portable water tanks (Figure 1.8). Once it is off-loaded, the water tender returns to the fill site to reload and the process is repeated. The apparatus may also **be used as a stationary reservoir or "nurse tender,"** which can be useful in certain situations. In this operation, the apparatus is parked in close proximity to the fire scene. The pumpers connect to the water tender and use its supply during suppression operations.

Foam Capability: Many fire departments including **municipal, airport, wildland, and those serving industrial facilities** operate pumpers capable of discharging foam on Class A (ordinary combustible) and/or Class B (flammable and combustible liquid and gas) fires. Many industrial pumpers, while capable of flowing plain water on Class A fires, are also large capacity foam pumpers. These types of apparatus, built based upon the requirements in Chapters 11, 16, and 20 of NFPA® 1901, are operated by members of the facility's industrial fire brigade or department. Some industrial fire brigades and airport fire departments also operate mini-pumpers that have smaller pumping and tank capacity of the full-sized apparatus. Both municipal and industrial foam pumpers may be equipped with any of the following:

- Around-the-pump, direct injection, balanced pressure foam proportioning systems
- Compressed air foam systems (CAFS) (combined with or in addition to another proportioning system)
- Balanced pressure proportioning system (provide reliability of foam proportioning at larger flows)
- Fire pumps ranging in capacity from 750 to 3,000 gpm (3 000 L/min to 12 000 L/min) or greater

- Large onboard tank of foam concentrate (usually found on industrial pump-ers) (Figure 1.4, p. 16) often contain 500 gallons (2 000 L) or more of foam concentrate
- Large fixed foam/water turret capable of flowing the entire capacity of the fire pump NOTE: Some apparatus may have foam proportioning systems that exceed the capacity of the apparatus and may be supported by other pumpers.

Compressed Air Foam Systems (CAFS) — Generic term used to describe a high-energy foam-generation system consisting of a water pump, a foam proportioning system, and an air compressor (or other air source) that injects air into the foam solution before it enters a hoseline.

Foam proportioning systems on municipal fire pumpers

The foam proportioning systems commonly found on municipal fire pumpers are scaled down versions of those used for industrial fire pumpers. Likewise, the foam tanks are correspondingly smaller, usually ranging from 20 to 100 gallons (80 L to 400 L). These tanks are often designed to be refilled directly from 5 gallon (20 L) containers.

Aircraft rescue and fire fighting (ARFF) apparatus are used to provide immediate suppression of flammable liquid fires and suppression of vapors from fuel spills. Airport apparatus sometimes respond off of airport property to assist municipal fire departments with large scale flammable liquid incidents.

Functions of modern **fireboats** include ice and water rescue, emergency medical services, fire fighting, and relay pumping to land-based apparatus. Some fireboats have capacities as high as 50,000 gpm (200 000 L/min). Individual master stream devices on these vessels may discharge large volumes of water sometimes in excess of 10,000 gpm (40 000 L/min

Quint — Apparatus that serves as an engine and as a ladder truck; equipped with a fire pump, water tank, ground ladders, hose bed, and aerial device. According to the NFPA® 1901, Standard for Automotive Fire Apparatus, the vehicle must be equipped with a pump rated at a minimum of 1,000 gpm (4 000 L/min) and a water tank of at least 300 gallons

Rescue Apparatus Equipped with Fire Pumps Rescue vehicles in some jurisdictions may be equipped with small fire pumps and tanks in order to extinguish small fires and provide protective hoselines at extrication and other incidents.

Trailer-Mounted Fire Pumps Although not common in most municipal fire departments, trailer-mounted fire pumps may serve certain fire service applications. Long-term pumping operations, such as those involving fires at petroleum storage facilities or landfills, may be suitable for the de-ployment of trailer-mounted pumps in order to release standard fire department pumpers for response to other incidents

Inverter — Step-up transformer that converts a vehicle's 12- or 24-volt DC current into 110- or 220-volt AC current.

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Portable generators are highly useful when electric power is needed remote from the position of a fire apparatus. Portable generators are available with a variety of power capacities; 5,000 watts is typically the largest capacity.

vehicle-mounted generators have a larger capacity than portable units. In many systems, the vehicle-mounted generator provides power for the apparatus floodlights as well as any portable electrically operated equipment. These generators may be equipped as follows:

• Powered by gasoline, diesel, power-take-off, or hydraulic systems • Have 110 and 220 volt capabilities • Have capacities up to 12,000 watts

Chapter 2

Apparatus Inspection & Maintenance

NFPA® 1002 also requires that driver/operators be skilled in the performance of certain maintenance tasks.

Maintenance refers to keeping apparatus in a state of usefulness or readiness while repair means to restore that which has become inoperable

Every fire department should develop standard operating procedures (SOPs) that provide for a systematic apparatus maintenance program that complies with applicable NFPA® standards. These procedures should specify maintenance procedures, when they are performed, and who is responsible for conducting the maintenance. The procedures should also specify a method for reporting, correcting, and documenting all activities

Maintenance — Keeping equipment or apparatus in a state of usefulness or readiness.
Repair — To restore or put together something that has become inoperable or out of place.

Documentation, Reporting, and Follow-Up Each jurisdiction should establish an inspection and maintenance policy that details how the results of an inspection are documented and transmitted to the appropriate person in the administrative system

Keeping the apparatus body clean also helps promote a longer vehicle life. In cold weather climates where road salt is used during inclement weather, a corrosive effect on steel body components may occur. Frequent washing to remove these chemicals will reduce the likelihood of body and component damage.

Proper inspection of apparatus and equipment components is made much easier when parts are free of dirt and grime. A clean engine permits proper inspection for leaks and their source.

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During the first six months after an apparatus is received, while the paint and protective coating are new and unseasoned, the vehicle should be washed frequently using cold water to harden the paint and keep it from spotting

- Use a garden hose without a nozzle to apply water to the apparatus. High pressures can drive dirt and debris into the finish (Figure 2.3).
- Rinse as much loose dirt as possible from the vehicle before applying soap. This will lessen the amount of grit that may be scratched into the finish. Never remove dirt by dry rubbing.
- Wash the apparatus before dirt, grit, and road salt can dry on the surface. Use only cleaning products that have been specifically designed for use on automotive paint.
- Do not wash with extremely hot water or while the surface of the vehicle is hot.
- Begin washing from the top of the vehicle and work downward. • Dry the apparatus with a clean chamois that is rinsed frequently in clean water, or use a rubber squeegee. Failure to dry the vehicle thoroughly may encourage corrosion.

Glass Care To clean automotive glass, use warm soapy water or commercial glass cleaner. These liquids may be used in conjunction with paper towels or clean cloth rags. Shop towels are generally not acceptable because even after being laundered, they may have metal shavings embedded in the cloth. Avoid using dry towels or cloths because they may grind grit or dirt into the glass surface. Do not use putty knives, steel wool, or any abrasive tool to remove deposits from the glass.

• Wait until the apparatus is six months old to apply wax/polish products, if necessary.

Commercial Drivers' License (CDL) — A driver's license that is issued to individuals who demonstrate competence in inspecting and driving vehicles with a Gross Vehicle Rating of 26,001 pounds or more.

Circle or Walk-Around Method — An inspection method in which the driver or inspector starts at one point of the apparatus and continues in either a clockwise or counterclockwise direction inspecting the entire apparatus.

Two types of inspections are actually conducted during a walk-around inspection: the operational readiness in- spection (required by NFPA® standards and the authority having jurisdiction) and the vehicle pretrip road worthiness inspection.

- **Operational Readiness Inspection —** Inspecting an apparatus and equipment on the apparatus to ensure that all equipment is in place, clean, and ready for service.
- **Pretrip Road Worthiness Inspection** — A visual inspection of an apparatus to ensure the major components of the chassis are present and in proper working condition.

The driver/operator begins the walk-around inspection at the driver's door on the cab and works around the apparatus in a clockwise pattern (Figure 2.8). Check each important area as you circle the vehicle. Get in the cab, start the apparatus, and perform a functional check on apparatus systems.

Functional Check — An inspection where a certain system or component of an apparatus is operated to ensure that it is functioning properly.

When approaching a vehicle to be inspected, driver/operators should observe:

- Any problems that may be readily apparent from a distance such as body damage or a severe lean to one side.
- The terrain on which the vehicle is parking. Fire station apparatus floors, driveways, or parking areas may have sloped surfaces.
- Vehiclefluidleaks,suchaswater,coolant,oil,hydraulicfluid,ortransmis- sion fluid, which may indicate a serious mechanical problem (Figure 2.9).

Tire Types and Condition Driver/operators should make certain that tire types match. It is never acceptable to mix radial tires with bias-ply tires.

The correct tire for any commercial vehicle is determined after the vehicle's specifications are final. Tire selections for fire apparatus are based on gross axle weight ratings for the apparatus. Too much or too little pressure will damage tires and cause poor road-handling characteristics, as well as exces- sive fuel consumption

Gross Axle Weight Rating — The maximum amount of weight that an axle system can safely carry.

NFPA® 1911 requires that all tires be replaced every seven years, regardless of their condition.

Tire Pressure. The maximum tire pressure imprinted on the exterior of each tire is not the recommended operating tire pressure. Set and maintain the tire pressure at the tire manufacturer's pressure recommendations for the correct tire size, type, load range (ply rating), and measured in-service axle loads. Each tire manufacturer will have published charts so you can customize the pressures to the actual axle weights.

Load Management System — An electrical monitoring system that will shed electrical load in a predetermined order if the chassis voltage begins to drop below a predetermined level.

Overload — Operation of equipment or a conductor in excess of its rated ampacity; continuous overload may result in overheating that damages the equipment.

Load Sequencer — Device in an electrical system that turns lights on at specified intervals, so that the start-up load for all of the devices does not occur at the same time.

Load Monitor — Device that "watches" an electrical system for added loads that may threaten to overload the system

Load Shedding — When an overload condition occurs, the load monitor will shut down less important electrical equipment to prevent the overload.

steering wheel play should be no more than approximately 10 degrees in either direction (Figure 2.15). On a 20-inch (500 mm) diameter steering wheel, the play may be about 2 inches (50 mm) in either direction. Play that exceeds these parameters could indicate a serious problem that may result in loss of vehicle control during routine and emergency driving conditions.

Free Play — Amount of travel the clutch has before it begins to disengage the engine from the transmission.

Throw-Out Bearing — The component used to push on the internal clutch fingers connected to the clutch pedal and when activated, disengages the clutch from the engine.

Curb weight is the weight of an empty fire apparatus fresh off the assembly line with no tools, water, equipment, or passengers.

Before placing any apparatus in service, load all compartments with the intended in-service equipment, hose, water, and crew. Weigh each axle and compare the results to the Gross Axle Weight Ratings (GAWR) placard. If the measured weights are higher than the GAWRs, remove or redistribute equip-ment until a safe loading is achieved.

Per NFPA® 1901 and 1911, a side-to-side variance in weight should not exceed seven percent.

Federal, state, and provincial laws may dictate how and when brakes are tested.

Smaller apparatus, as well as some older vehicles, may be equipped with hydraulic braking systems. Most commercial and private vehicles built since 1990 are equipped with antilock braking systems.

Hydraulic Braking Systems — A braking system that uses a fluid in a closed system to pressurize wheel cylinders when activated.

Antilock Braking Systems— An electronic system that monitors wheel spin. When braking and a wheel are sensed to begin locking up, the brake on that wheel is temporarily released to prevent skidding.

Air Brakes

Most large, modern fire department pumping apparatus are equipped with air-actuated braking systems (air brakes). The NFPA® and other sources have developed recommendations for air brake use. On apparatus equipped with air brakes, the air pressures must build up to a sufficient level within a defined period of time after starting the engine.

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Air-Actuated Braking Systems — A braking system that uses compressed air to hold off a spring brake (parking brake) and applies air pressure to a service brake for vehicle stopping.

Apparatus with air brakes are to be equipped with an air pressure protec-tion valve that prevents air horns or other nonessential devices from being operated when the pressure in the air reservoir drops below 80 psi (560 kPa). Any deficiencies in this system must be reported and repaired by a certified mechanic.

ABS Brake Systems Antilock braking systems (ABS) reduce the possibility of an apparatus going into a slide, jackknife, or spin during heavy braking. ABS brakes also assist the driver/operator in keeping the apparatus in a straight trajectory during heavy or emergency braking. ABS technology does not necessarily provide a faster stop, but it greatly enhances a controlled stop. Driver/operators must know the type of braking system used on their apparatus and be familiar with its operation. Procedures for using different types of braking systems are dis-cussed in Chapter 3 of this manual.

Apparatus brakes should be thoroughly tested at least annually using the methods outlined in NFPA® 1911, Standard for the Inspection, Maintenance, Testing, and Retirement of In-Service Automotive Fire Apparatus.

If the slack adjusters are not operating within manufacturer's specifications, the vehicle should not be driven until a certified mechanic has made repairs.

Air Brake Test — A series of tests used to ensure the serviceability of an air braking system. Tests include air loss, air compressor buildup, air warning, and emergency parking brake activation.

Slack Adjusters — Devices used in an air brake system that connect between the activation pads and the brake pads that compensate for brake pad wear.

Tilt Cab — A truck that uses a cab that lowers over the power train.

Exhaust systems on newer apparatus, depending on their date of manufacture, may be equipped with systems to provide for cleaner emissions from diesel engines. Diesel particulate filters (DPF) trap much of the particulate matter in exhaust emissions. However, these systems must periodically conduct a process of regeneration in which the exhaust temperature is raised in order to burn off particulate matter accumulated in the filter. In automatic regeneration mode, the vehicle may be operated normally. If the vehicle is driven without automatic regeneration and the filter becomes too contaminated, the vehicle will experience reduced power and driving capability until a regeneration cycle is complete. This condition will prevent use for emergency response.

In addition to a DPF system, engines produced after **January 1, 2010**, may be equipped with an exhaust after-treatment system called Selective Catalyst Reductant (SCR). An SCR system uses Diesel Exhaust Fluid (DEF) to help further reduce emissions. DEF is stored in a tank downstream of the DPF and is injected into the gas in order to reduce the nitrogen oxide (NOx) emissions from diesel engines. The DEF levels in the DEF tank on apparatus that use this system should be checked during apparatus inspections.

The manufacturer's manual will recommend the Society of Automotive Engineers (SAE) numbers for engine oil. The SAE number indicates only the viscosity of the oil. Some other essential characteristics of oil are corrosion protection, foaming, sludging, and carbon accumulation. These characteristics may be controlled by the refiner. Driver/operators should consult the opera-tor's manual for the type of oil and location of fill ports and grease fittings.

Batteries can also give off hydrogen gas, which is highly explosive and a mere spark can ignite it. In some jurisdictions, driver/operators may be responsible for charging vehicle batteries.

Fire pumps are tested at regularly scheduled intervals to compare actual performance to specific standards. In addition to this testing, fire depart-ments should require regular inspections to detect deficiencies or failure of the fire pump and other fire suppression equipment.

Post-Maintenance/Repair Inspection — A specific inspection to an area of a chassis or apparatus to ensure that the unit is operating properly in accordance with the manufacturer's initial design.

Chapter 3

Apparatus Safety and Operating Emergency Vehicles

NFPA® 1002, Standard for Fire Apparatus Driver/Operator Professional Qualifications, has established minimum qualifications for apparatus driver/ operators.

NFPA® 1001, Standard for Fire Fighter Professional Qualifications.

Regardless of the selec- tion process used for a candidate to become a driver/operator, a balance of experience, knowledge, maturity, sense of responsibility, and mental aptitude are necessary to safely and efficiently complete the many tasks which a driver/ operator may be assigned.

Federal laws, state or provincial motor vehicle codes, city ordinances, NFPA® standards, and department policies all regulate driver/operators in their duties.

Most driving regulations pertain to dry, clear roads during daylight conditions.

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Reckless Disregard — An act of proceeding to do something with a conscious awareness of danger, while ignoring any potential consequences of so doing. Reckless disregard, while not necessarily suggesting intent to cause harm, is a harsher condition than ordinary negligence.

Negligence — Breach of duty in which a person or organization fails to perform at the standard required by law, or that would be expected by a reasonable person under similar circumstances

Gross Negligence — Willful and wanton disregard.

Due Regard — Driver/ operators drive with "due regard" for the safety of others using the highways. State vehicle codes provide and give special privileges to the operators or emergency vehicles; however, this does not relieve the operator from the duty and responsibility to drive with "due regard" for the safety of others.

apparatus may be backed into the station or during hose loading operations. Backing accidents generally account for a significant percentage of all damage repair costs

Brake Fade — Loss of braking function which occurs due to excessive use of the brakes.

Only effective handling and braking techniques can ensure maximum braking efficiency.

Inability to recognize a dangerous situation. In a study conducted by the **Society of Automotive Engineers (SAE)**, it was determined that in 42 percent of all collisions, the driver/operator was not aware of a problem until it was too late to correct.

Considering a pumper with a 1,000 gallon (4 000 L) tank, the difference in weight between a full and empty tank is over 8,000 pounds (4 000 kg

Poor maintenance of apparatus, especially braking systems, can lead to failures that result in collisions

"**Homebuilt"** apparatus that have been built by members of the fire department or local mechanics and custom-built, overloaded vehicles are more likely to have design problems

Driver/Operator Personal Readiness The driver/operator must be prepared to report to duty without any compromise of physical or mental ability Any firefighter, regardless of rank, should advise a driver/operator who may be mentally or physically impaired to seek appropriate assistance

It is SOP in most fire departments to don their protective gear be-fore getting into the apparatus, with the exception of their helmets per NFPA® 1500 (Figure 3.8). One possible exception to this is the driver/operator. Some driver/operators are not comfortable driving the apparatus wearing rubber fire boots or bulky protective clothing.

The driver/operator may wish to don protective clothing after arriving at the scene.

NFPA® 1500, Standard on Fire Department Occupational Safety and Health Program, NFPA® 1901, Standard for Automotive Fire Apparatus

Assign at least one member, other than the driver/operator and the firefighters actually loading the hose, as a safety observer to the operation. The observer must have constant visual contact with the hose-loading operation, as well as visual and voice communication (usually via a portable radio) with the driver/operator (

Close the area in which the hose loading is being performed to other vehicular traffic.

Drive the apparatus only in a **forward direction, straddling or to one side of the hose**, and at a **speed no greater than 5 mph** (10 km/h).

Do not allow members to stand on any portion of the apparatus while the vehicle is in motion.

Allowing a diesel engine to idle unnecessarily will waste fuel and may lead to the buildup of carbon in injectors, valves, and pistons and may cause damage to internal engine components and emission systems.

High Exhaust System Temperature (HEST) indicator — Lights when the exhaust system is very hot, usually due to an active regeneration in process.

DPF indicator—Lights to indicate that the DPF is loading up with soot. See the owner's manual for details.

Manual(parked) regeneration switch—Allows driver/operator to manually initiate an active regeneration to burn off the DPF soot load.

Regeneration inhibit switch—Allows the driver/operator to keep the engine from initiating an active regeneration process. Used in limited circumstances if the apparatus is parked on dry grass or over other combustible material where there is a risk that high exhaust temperatures may start a fire.

The DPF collects particulates (soot) from the exhaust stream and burns them more completely

Active regeneration can occur in two manners, in automatic mode or in manual (parked) mode

. Parked regeneration cannot be initiated during pumping operations

Diesel Exhaust Fluid Tanks

An apparatus equipped with Selective Catalyst Reductant (SCR) will have a tank in addition to the fuel tank that must be filled with Diesel Exhaust Fluid (DEF).

Failing to keep the DEF tank full may derate (reduce its torque output) the apparatus engine, or limit the vehicle speed. After a driver/opera-tor continues to ignore an empty DEF tank, the apparatus may be limited in speed to 5 mph (10 km/h) and will need service from the dealer. Top off the DEF tank every time the apparatus is fueled and carry a spare jug of DEF on the apparatus just in case.

A hot engine should cool to the normal operating temperature. Usually an idling time of three to five minutes is sufficient

Torque —

- Force that tends to create a rotational or twisting motion.
- Measurement of engine shaft output.
- Force that produces or tends to produce a twisting or rotational action

A hot engine should cool to the normal operating temperature. Usually an idling time of three to five minutes is sufficient. Shutting down an engine without sufficient cool down may result in the following:

- Immediate increase of engine temperature from lack of coolant circulation
- Oil film "burning" on hot surfaces
- Damage to heads and exhaust manifolds
- Damage to the turbocharger that can result in seizure

Since most apparatus are shared by multiple driver/operators, it is essential that mirror adjustment take place at the start of each shift, or any time the driving responsibility changes from one individual to another

NOTE: Some jurisdictions may recommend manually shift- ing an apparatus equipped with an automatic transmission as a way to slow the vehicle in preparation for a stop

Angle of approach — Angle formed by level ground and a line from the point where the front tires touch the ground to the lowest projection at the front of the apparatus.

Angle of departure — Angle formed by level ground and a line from the point where the rear tires touch the ground to the lowest projection at the rear of the apparatus.

Breakover angle—Angle formed by level ground and a line from the point where the rear tires touch the ground to the bottom of the frame at the wheelbase midpoint.

Weight transfer follows the law of inertia which states that "objects in motion tend to remain in motion; objects at rest tend to remain at rest unless acted upon by an outside force Whenever a vehicle undergoes a change in speed or direction, weight transfer takes place relative to the rate and degree of change

Axle Weight Distribution

The driver/operator should ensure that the apparatus is properly loaded at all times. Poor weight distribution can make vehicle handling unsafe, such as the following:

- Too much weight on the steering axle can cause hard steering and can damage the steering axle and tires.

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- Under-loaded front axles (caused by shifting weight too far to the rear) can make the steering axle weight too light to steer safely.
- Too little weight on the driving axles can cause poor traction.
- The drive wheels may spin easily.

During bad weather, the truck may not be able to keep going. Weigh the ap-paratus after loading it with all equipment and personnel to ensure that the axle loading is balanced within 7 percent from side to side and within the axle weight ratings front-to-back.

Driving Downhill

Use the service brake and auxiliary brake as well as manually shifting to lower gears to limit speed. To prevent engine damage, limit downhill speed to lower than maximum rpm. The engine governor cannot control engine speed down-hill: The wheels turn the engine and driveshaft as gravity pulls the vehicle down the hill. Engine speed faster than the rated rpm can result in engine damage. It is unsafe and may be illegal to allow the apparatus to coast out of gear or "freewheel" while driving downhill. Failure to use alternate methods to slow the vehicle may result in brake failure, resulting in vehicle runaway.

NOTE: Some jurisdictions may recommend using the transmission to slow the vehicle and maintain a safe speed on the descent. Local policy may specify this practice as a measure to extend the life of service brakes.

Engine lugging occurs when the throttle is applied when a manual transmis- sion is in too high a gear for the demand on the engine

When this over throttling occurs with a diesel engine, more fuel is injected than can be burned. This results in an excessive amount of carbon particles in the exhaust, oil dilution, and additional fuel consumption

Aerial apparatus may be much longer than other commercial vehicles. This poses a hazard in areas where railroad crossings are located just before a controlled intersection. Drivers who cross the railroad tracks must ensure that there will be room between the tracks and the stop light to fit the apparatus while the light is still red. There are 19,824 locations in the U.S. where there is less than 100 feet (30 m) following the railroad tracks. These sites account for an average of 122 accidents annually

It may take 3 to 15 times greater distance for a vehicle to come to a complete stop on snow and ice than it does on dry pavement.

Audible Warning Devices

At speeds above 50 mph (80 km/h), an emergency vehicle may outrun the effective range of its audible warning device

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In some instances, increasing the speed of an apparatus by 20 mph (30 km/h) can decrease the audible distance by 250 feet (75 m) or more

When more than one emergency vehicle is responding along the same route, they should travel at least 300 to 500 feet (90 to 150 m) apart.

Visual Warning Devices

Do not drive with the high beam headlights constantly on as they may obscure other warning lights

In addition to dimming headlights and spotlights at an incident scene, driver/ operators must be aware that warning lights and scene floodlights may reduce the effectiveness of the reflective trim on firefighters PPE

NOTE: Studies have shown that vehicles traveling with low beam head- lights on during daylight hours have fewer accidents.

Strobe Light Activated Devices- Some systems use strobe lights (emitters) mounted on the apparatus to activate sensors in the traffic lights (Figure 3.15). The emitter generates an optical signal that is received by the traffic light as the apparatus approaches

Traffic Signal Preemption Devices- Some traffic control systems may be activated by the vehicle's siren as it approaches an intersection

Intersections equipped with this device will have 3-inch (77 mm) white and blue lights, mounted near the regular traffic light, facing each direction of travel.

GPS Based Traffic Signal Preemtion-These devices are capable of determining location, speed, and status of the apparatus turn signal, as well as maintaining a recorded database of unit identification information for a historical record of signal use.

NFPA® 1500 require fire apparatus to come to a full stop and account for vehicles in all lanes of traffic before proceeding through the intersection.

Passing Other Vehicles

Generally, it is best to avoid passing vehicles that do not pull over to yield to fire apparatus. In some instances, the driver/operator will need to pass. Be prepared to do this in the safest manner possible. Use the following guidelines to ensure safety:

- Always travel on the inner most lane (fast lane) on multilane roads. Wait for vehicles in front of the apparatus to move to the right before passing.
- Avoid passing vehicles on the right side because drivers normally move to the right upon the approach of emergency vehicles.
- Becertainthatopposinglanesoftrafficareclearbeforecrossingthecenter line.
- Avoid passing other emergency vehicles if at all possible.

Braking Distance — Distance the vehicle travels from the time the brakes are applied until it comes to a complete stop.

Total Stopping Distance — Sum of the driver reaction distance and the vehicle braking distance.

Reaction Distance — Distance a vehicle travels while a driver transfers a foot from the accelerator to the brake pedal after perceiving the need for stopping.

Other factors affect the driver/operator's ability to stop the apparatus in- including:

- Road conditions (wet, dry, snow, ice) and slope of driving surface
- Speed of apparatus
- Weight of the vehicle
- Type and condition of the vehicle's tires and braking system

Acceleration Skid — Accelerated skids usually occur when the gas pedal is applied too quickly.

Locked Wheel Skid — This type of skid is usually caused by braking too hard at a high rate of speed and locking the wheels. The vehicle will skid no matter which way the steering wheel is turned.

Driver/operators must balance the service brakes, transmission gear se-lection, and retarding device in order to maintain control when descending grades during icy conditions. Some of the most common causes involving driver error include the following:

- Driving too fast for road conditions
- Failing to anticipate obstacles (including other vehicles, debris, or pedes-trians in the road)
- Improper use of auxiliary braking devices
- Improper maintenance of tire air pressure and adequate tread depth

Antilock Braking System (ABS) Most new fire apparatus are equipped with an all-wheel, antilock braking system (ABS). ABS systems minimize the chance of the vehicle skidding when the brakes are applied forcefully as follows:

- Using an onboard computer that monitors each wheel and controls pressure to the brakes, maintaining optimal braking ability.
- Using a sensing device to monitor the speed of each wheel, sending a signal to the onboard computer.
- Receiving information from the computer when a wheel begins to lock up. The computer compares it to the information received from the other wheels to determine if this particular wheel should still be turning. Steering is maintained as long as the wheels do not lock.
- Reducing the brake pressure and allowing the wheel to continue to turn. Once it turns, it is braked again.

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Apparatus Not Equipped with ABS: A driver/operator driving an apparatus NOT equipped with ABS that enters into a skid should release the brakes and allow the wheels to rotate freely. You should turn the steering wheel in the direction the vehicle should be traveling. If you oversteer, you will lose control of the vehicle

Auxiliary Braking Systems: NFPA® 1901 requires that all apparatus with a GVWR of 36,000 lb (18 000 kg) or greater be equipped with an auxiliary braking system

- Exhaust brake
- Transmission output retarder
- Engine compression brake
- Electromagnetic retarder

The amount of retardation force available from any auxiliary braking system is a complex function of vehicle speed, engine speed, temperature, and control strategy.

Exhaust Brakes The exhaust brake is the least capable of the four auxiliary brake devices. An exhaust brake uses a valve to restrict the flow of the exhaust, which creates back pressure that adds to the engine's inherent braking ability.

Engine Compression Brake— An engine compression brake device is any device that uses the engine and transmission to impede the forward motion of the motor vehicle by compression of the engine.

Electromagnetic Retarders; An electromagnetic retarder is either mounted in the driveline, or supplied as an integral part of the rear axle

Transmission Retarders: A transmission output retarder uses the viscous property of the automatic transmission fluid to retard the driveline.

Automatic Traction Control Systems: ineffective in snow deeper than 3 to 6 inches (75 to 150 mm) depending on consistency of the snow, or when the vehicle is moving at very slow speeds, or in reverse.

Automatic Traction Control (ATC): Many vehicles that are equipped with ABS are also equipped with automatic traction control (ATC). This feature automatically reduces en- gine torque and applies the brakes to wheels that have lost traction and begin to spin. This transfers torque to the wheels that still have traction, which helps improve overall traction on slippery roads.

Driver Controlled Differential Lock: Some aerial apparatus may be equipped with Driver Controlled Differential Lock (DCDL). The purpose of this equipment is to improve traction and han- dling by locking the differential during off-road and wet weather conditions, such as snow or ice. Disengage the DCDL feature when road conditions improve to prevent drive line damage, tire wear, and maximize vehicle control.

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NOTE: Manufacturers recommend that the differential lock be disengaged while traveling and turning downhill. A dangerous condition can occur whereby the driver/operator loses positive steering control due to the differential lock not allowing differential rear wheel rotation.

Interaxle Differential Lock: The interaxle differential allows for speed differences between the rear driving axles.

To reduce load on the drive train and avoid equipment damage:

- Ease up on the throttle pedal when shifting into or out of the locked condi- tion.
- Do not activate this switch while one or more of the wheels are actually slipping or spinning.
- Do not spin the wheels with the inter-axle differential locked.

Roll Stability Control

Roll Stability Control (RSC) is integrated into the ABS system

Electronic Stability Control (ESC), also referred to as Electronic Stability Pro- gram (ESP), is a more capable system than RSC. Where RSC merely slows the vehicle down, ESC applies the brakes independently to aim the vehicle in the direction that the operator positions the steering wheel.

Backing…

Use hand signals that are agreed upon and understood by the spotter and driver/operator.

Use portable radios, if feasible.

Sound two short blasts of the vehicle's horn immediately before backing the apparatus.

When preparing to back the apparatus, the spotter should be positioned in the vision of the driver/operator, preferably in the left (driver's side) mirror, approximately 8 to 10 feet (2.5 to 3 m) behind and slightly to the left of the apparatus

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See backing spotter hand signals Pg. 115

Tiller Operators

The tiller operator must be qualified to operate the aerial ladder and be familiar with the duties assigned to all truck company personnel. The tiller operator's driving assignments include:

- Straight-line driving
- Turning and backing

- Proper placement of the trailer at fires

Officers and instructors should stress the importance of the following:

- Using good signal practices
- Trailing in-line on a straightaway always
- Bringing the trailer quickly into line again as soon as a turn is completed
- Observing the trailer overhang on turns

Aerial Apparatus Hose Chutes: Maintain vehicle speed of 5 mph (10 km/h) or less. At 5 mph (10 km/h), 7 feet (2 m) of hose is pulled out each second. Travelling more than 5 mph (10 km/h) is likely to cause a hose jam in the hose chute.

Chapter 4

Positioning Apparatus

Pre-incident Planning — Act of preparing to manage an incident at a particular location or a particular type of incident before an incident occurs.

Incident scene size-upsupport operations. Courtesy of Ron Jeffers. determines the most advantageous position for the attack pumper.

Size-Up — Ongoing evaluation of influential factors at the scene of an incident.

local operating guidelines and orders from the Incident Commander (IC), will set the scene for later-arriving apparatus to support.

Pull the apparatus past the front of the building, if feasible, when arriving at an incident where no fire is evident (investigation mode).

Apparatus and personnel should maintain a **collapse zone** of at least **one and a half times the height** of any building determined likely to collapse

The corners of a structure are generally considered the safest position should a collapse occur.

Positioning: . If a building is less than five floors tall, the attack pumper(s) is (are) positioned on the side of the street closest to the building and aerial apparatus are placed outboard of the pumper(s). In cases where the fire building is greater than five floors, the attack pumper(s) take(s) the outside position to allow the aerial apparatus maximum reach to the building. Driver/operators should position pumpers providing water supply for elevated stream operations as closely to the aerial apparatus as practical.

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Fire Department Connection (FDC) — Point at which the fire department can connect into a sprinkler or standpipe system to boost the water pressure and flow in the system. This connection consists of a clappered siamese with two or more 21⁄2-inch (65 mm) intakes or one large-diameter (4-inch [100 mm] or larger) intake.

Relay — To shuttle water between a source and an emergency scene using mobile water supply apparatus.

Drafting —Process of acquiring water from a static source and transferring it into a pump that is above the source's level; atmospheric pressure on the water surface forces the water into the pump where a partial vacuum was created.

Drafting on dry Hydrant — Permanently installed pipe that has pumper suction connections installed at static water sources to speed drafting operations. A dry hydrant consists of an intake hose connection on the shore and a length of pipe extended into the water with a strainer on the end

A good way to minimize the chance of the intake hose kinking is to put a counterclockwise twist in the hose when making the connection between the hydrant and pumper.

Dual Pumping — Operation where a strong hydrant is used to supply two pumpers by connecting the pumpers intake-to-intake. The second pumper receives the excess water not being pumped by the first pumper, which is directly connected to the water supply source

Dual Pumping Operations With dual pumping, one strong hydrant is used to supply two pumpers. Generally, the pumpers are in close proximity to each other as both of them are being used as attack pumpers at the same incident

Tandem Pumping — Short relay operation in which the pumper taking water from the supply source pumps into the intake of the second pumper; the second pumper then boosts the pressure

of the water even higher. This method is used when pressures higher than the capability of a single pump are required. Tandem pumping may be needed when pressures higher than a single engine is capable of supplying are required

Tandem pumping operations may also be used in situations where the attack pumper is located a relatively short distance from the water source, but a great distance from the fire.

In tandem pumping operations apparatus may be located up to 300 feet (90 m) apart

NFPA® 1962, Standard for the Inspection, Care, and Use of Fire Hose, Couplings, Nozzles, and the Service Testing of Fire Hose, contains test pressures for various types of fire hose.

Wildland/Urban Interface— Line, area, or zone where an undeveloped wildland area meets a human development area.

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Once the apparatus arrives at the structure it is assigned to protect, position it according to the following guidelines for safety and efficiency:

- Park the apparatus off the roadway (if conditions permit) to avoid blocking other apparatus or evacuating civilians.
- Clear away any nearby brush that may serve as fuel for a fire.
- Position the apparatus on the leeward side of the structure to minimize
- exposure to heat and blowing embers.
- Placetheapparatusatanearbybutsafedistancefromthestructureinorder to keep hoselines short.
- Keep doors and windows closed to keep out burning material.
- Place the vehicles air conditioning on recirculation mode to avoid drawing in smoke from the outside.
- Do not position apparatus in close proximity to power lines, large trees, LPG tanks or other pressure vessels, and exposed structures

Anchor Point — Point from which a fire line is begun; usually a natural or man-made barrier that prevents fire spread and the possibility of the crew being "flanked" while constructing the fire line. Examples include lakes, ponds, streams, roads, earlier burns, rockslides, and cliffs.

Fording — Ability of an apparatus to traverse a body of standing water. Apparatus specifications should list the specific water depths through which trucks must be able to drive. Driver/op-erators should not attempt to ford streams with a vehicle unless it has been specifically designed to operate in such conditions.

Mop-Up — (1) Overhaul of a fire or hazardous material scene. (2) In wildland fire fighting, the act of making a fire safe after it is controlled by extinguishing or removing burning material along or near the control line, felling dead trees (snags), and trenching logs to prevent rolling.

For apparatus capable of mounting mobile fire attack, during these operations hoselines should be kept short in order to facilitate movement.

Level I Staging — Used on all multiple-company emergency responses. The first-arriving vehicles of each type proceed directly to the scene, and the others stand by a block or two from the scene and await orders. Units usually stage at the last intersection on their route of travel before reaching the reported incident location.

Level II Staging — Used on large-scale incidents where a larger number of fire and emergency services companies are responding; these companies are sent to a specified remote location to await assignment.

Staging Area Manager — Company officer of the first-arriving company at the staging who takes command of the area and is responsible for communicating available resources and resource needs to the operations section chief.

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Hazard-Control Zones — System of barriers surrounding designated areas at emergency scenes, intended to limit the number of persons exposed to a hazard and to facilitate its mitigation. A major incident has three zones:Restricted (Hot) Zone, Limited Access (Warm) Zone, and Support (Cold) Zone.

Hot Zone — Potentially hazardous area immediately surrounding the incident site; requires appropriate protective clothing and equipment and other safety precautions for entry. Typically limited to technician-level personnel.

Warm Zone — Area between the hot and cold zones that usually contains the decontamination corridor; typically requires a lesser degree of personal protective equipment than the hot zone.

Cold Zone — Safe area outside of the warm zone where equipment and personnel are not expected to become contaminated and special protective clothing is not required; the Incident Command Post and other support functions are typically located in this zone

Because it is not always possible to stop the flow of trains on a track during emergency operations and it may require one to two miles (1.5 to 3 km) for a fully loaded train to make a complete stop. Use the following guide- lines when operating near a railroad:

- Take care not to position the apparatus close enough to a track where a passing train may contact the vehicle.
- Cross railroad tracks only at designated crossing points in order to avoid the possibility of becoming stuck on the tracks due to the ground clearance of the apparatus and the height of the track bed.
- Parkonthesamesideofthetrackastheincidentinordertoavoidstretching hoselines across the track and to keep firefighters from making repeated crossings of the track.
- Notify the rail company to confirm that rail traffic has been halted along the section in question if stretching a hoseline across a track is absolutely necessary. If this is not possible, the hose may be run underneath the rails or an aerial apparatus may be used to provide access for a hoseline over the top of a track location.
- Use consideration for railroads that operate using high voltage overhead wires

Connect LDH to hydrant and lay hose to street, folding approx 3 feet (1 m) back onto itself (place two full counterclockwise twists in the hose if sexless couplings are not used).

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Chapter 5

Principals of Water

Principles of water

plain water remains the most common weapon in the firefighter's arsenal.

Water (H_2O) is a compound (molecule) of hydrogen and oxygen formed when two hydrogen atoms (H_2) combine with one oxygen atom (O). Below 32°F (0°C) (the freezing point of water), it converts to a solid state of matter, called ice. Above 212°F (100°C) (the boiling point of water), it converts to a gas, water vapor, or steam.

Water is considered to be virtually incompressible, and its weight varies at different temperatures. Water's density, or its weight per unit of volume, is measured in pounds per cubic foot (kg/m^3). For fire protection purposes, ordinary fresh water is considered to weigh 62.4 lb/ft^3 (1 000 kg/m^3) or 8.3 lb/ gal (1 kg/L).

Water has the ability to extinguish fire in several ways. It can cool or absorb heat from the fire, as well as smother (exclude oxygen from) fires. Water may also be used to smother fires in combustible liquids whose specific gravity is higher than 1 (heavier than water) (Figure 5.2). Smothering may also occur when water converts to steam within a closed space.

Advantages of water:

- Water has a greater heat-absorbing capacity than other common extinguishing agents
- A large amount of heat is required to change water to steam, allowing more heat to be absorbed from the fire.
- The greater the surface area of water exposed, the more rapidly heat is absorbed. The amount of surface area can be increased with the use of a fog stream or deflection of a solid stream off an object.
- At 212°F (100°C), water converted to steam occupies approximately 1,700 times its original volume, helping to dissipate heat in a well-vented room (Figure 5.3). The expansion ratio is even greater at higher temperatures.
- Although some areas experience water shortages, generally it is an inex- pensive and readily available commodity.
- Water has a high surface tension that makes it somewhat difficult to soak into dense materials.
- Wetting agents may be mixed with water to reduce its surface tension and increase its penetrating ability. Water may be reactive with certain fuels, combustible metals, sodium metal, and triethyl aluminum. Due to low levels of opacity and reflectivity, radiant heat easily passes through water, rendering water curtains ineffective.

- In cold weather climates, the 32°F (0°C) freezing temperature of water may create operational problems such as frozen pumps and hoselines. Safety hazards such as ice dams and slippery surfaces occur in below-freezing temperatures (Figure 5.4, p. 170).

Some Disadvantages of water:

- Water has a high surface tension that makes it somewhat difficult to soak into dense materials.
- Wetting agents may be mixed with water to reduce its surface tension and increase its penetrating ability. Water may be reactive with certain fuels, combustible metals, sodium metal, and triethyl aluminum. Due to low levels of opacity and reflectivity, radiant heat easily passes through water, rendering water curtains ineffective.
- In cold weather climates, the 32°F (0°C) freezing temperature of water may create operational problems such as frozen pumps and hoselines. Safety hazards such as ice dams and slippery surfaces occur in below-freezing temperatures (Figure 5.4, p. 170).
- Water is a good conductor of electricity. This characteristic may pose a danger to firefighters using water near energized electrical equipment.
- At 8.3 pounds per gallon (1 kg/L), water is a relatively heavy agent. Accu- mulations of water within a structure can lead to an increased potential for structural collapse

Pressure — Force per unit area exerted by a liquid or gas measured in pounds per square inch (psi) or foot (psf), pounds per square inch (psi), or kilopascals (kPa). kilopascals (kPa).

Force — Simple measure of weight, usually expressed in pounds or kilograms.

1 cubic foot of water and weighing 62.4 pounds. Each container exerts a force of about 62.4 pounds per square foot with a total of about 187.2 pounds of force over a 3 square foot area. If the containers are stacked on top of each other, the total force exerted – 187.2 pounds – remains the same, but the area of contact is reduced to 1 square foot. The pressure then becomes 187.2 pounds per square foot

A 1-inch square column of water 1 foot high therefore exerts a pressure at its base of 0.434 psi.

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Principles of Pressure

The speed at which a fluid travels through a hose or pipe is determined by the pressure upon that fluid as well as the size of the orifice through which it is flowing. This speed is often called velocity.

- **First Principle** Fluid pressure is *perpendicular* to any surface on which it acts.
- **Second Principle** Fluid pressure at a point in fluid *at rest is the same intensity in all directions*.
- **Third Principle** *Pressure applied* to a confined fluid is transmitted equally in all directions.
- **Fourth Principle** The pressure of a liquid in an open vessel is *proportional to its depth*.
- **Fifth Principle** The pressure of a liquid in an open vessel is *proportional to the density* of the liquid.
- **Sixth Principle** The pressure of a liquid at the bottom of a *vessel is independent of the shape* of the vessel.

Atmospheric pressure at sea level is 14.7 psi (100 kPa), which is considered standard atmospheric pressure

At sea level, the column of mercury is 2.04 x 14.7, or 29.9 inches (759 mm) tall

For the purposes of this text, psi means psig (pounds per square inch gauge). A gauge reading 10 psi (70 kPa) at sea level means that it is actually 10 psig plus the atmospheric pres- sure of 14.7 psi.

To convert head in feet to head pressure, you must divide the number of feet by 2.304 (the number of feet that 1 psi will raise a one square inch column of water

Vacuum — In the fire and emergency services, a pressure that is somewhat less than atmospheric pressure; a vacuum is needed to facilitate drafting of water from a static source.

Head — Alternate term for pressure, especially pressure due to elevation. For every 1-foot increase in elevation, 0.434 psi is gained (for every 1-meter increase in elevation, 9.82 kPa is gained). Also known as Head Pressure.

Head Pressure: To convert head in feet to head pressure, you must divide the number of feet by 2.304 (the number of feet that 1 psi will raise a one square inch column of water

Residual Pressure — Pressure at the test hydrant while water is flowing; represents the pressure remaining in the water supply system while the test water is flowing and is that part of the total pressure that is not used to overcome friction or gravity while forcing water through fire hose, pipe, fittings, and adapters.

Elevation — Height of a point above sea level or some other reference point.

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Altitude — Geographic position of a location or object in relation to sea level. The location may be either above, below, or at sea level.

Elevation Pressure — Gain or loss of pressure in a hoseline due to a change in elevation. Also known as Elevation Loss.

Altitude impacts the production of fire streams because atmospheric pres- sure drops as height above sea level increases. This drop is of little consequence between sea level and approximately 2,000 feet (600 m). Above this height, the lessening of atmospheric pressure means fire department pumpers must work increasingly harder to produce the pressures required for effective fire streams.

Above sea level, atmospheric pressure decreases approximately 0.5 psi (3.5 kPa) for every 1,000 feet (300 m).

Friction Loss

The following causes friction loss in a fire hose: • Movement of water molecules against each other • Linings of fire hose/delaminating hose • Couplings • Sharp bends/kinks • Change in hose size or orifice by adapters • Improper gasket size

The friction loss in older hose may be as much as 50 percent greater than that of new hose.

Principles Of Friction Loss

- **First Principle** If all other conditions are the same, friction loss varies directly with the length of the hose or pipe.
- **Second Principle** When hoses are the same size, friction loss varies approximately with the square of the increase in the velocity of the flow. This principle illustrates that friction loss develops much faster than the increase in velocity. NOTE: Velocity is proportional to flow. For example, a length of 3-inch (77 mm) hose flowing 200 gpm (800 L/ min) has a friction loss of 3.2 psi (22 kPa). As the flow doubles from 200 to 400 gpm
- **Third Principle** For the same discharge, friction loss varies inversely as the fifth power of the diameter of the hose.
- **Fourth Principle** For a given velocity, friction loss is approximately the same, regardless of the pressure on the water.

Applying Friction Loss principles

the same volume of water supplied into a fire hose under pressure at one end will be discharged at the other end.

The smaller the hose, the greater the velocity needed to deliver the same volume

Friction loss in a water system increases as the length of hose or piping increases.

This agitation causes a degree of turbulence known as critical velocity. For this reason, hoselines of various diameters have a specific hose length at which the reduction in flow makes their use undesirable. Beyond this point, it is necessary to use parallel hose- lines or siamese lines to increase flow and reduce friction.

Means of Moving Water There are three methods of moving water in a system

• **Direct pumping system** — Uses one or more pumps that takes water from the primary source and discharges it through the filtration and treatment processes. From there, a series of pumps force the water into the distribution system. If purification of the water is not needed, the water can be pumped directly into the distribution system from the primary source. Duplicating these pumping units and providing a secondary power source provides redundancy against failures in supply lines or pumps.
• **Gravity system** — Uses a primary water source located at a higher elevation than the distribution system. The gravity flow from the higher elevation provides the water pressure. This pressure is usually only sufficient when the primary water source is located at least several hundred feet (meters) higher than the highest point in the water distribution system. The most common examples include a reservoir at a higher elevation that supplies water to a city below or a system of elevated tanks in a city itself.
• **Combination system** — Most communities use a combination of the direct pumping and gravity systems. In most cases, elevated storage tanks sup-ply the gravity flow. These tanks serve as emergency storage and provide adequate pressure through the use of gravity. When the system pressure is high during periods of low consumption, automatic valves open and allows the elevated storage tanks to fill. When the pressure drops during periods
Water

Water Processing or Treatment Facilities: The fire department's main concern regarding treatment facilities are that a maintenance failure, a natural disaster, the loss of power supply, or a fire could disable the pumping station(s) or severely hamper the purification process

Water Distribution System

A fire hydrant that receives water from only one direction is known as a dead-end hydrant. When a fire hydrant receives water from two or more directions, it is said to have circulating feed or a looped line. A distribution system that provides circulating feed from

- **Primary feeders** — Large pipes (mains), with relatively widespread spac-ing, that convey large quantities of water to various points of the system for local distribution to the smaller mains
- **Secondary feeders** — Network of intermediate-sized pipes that reinforce the grid within the various loops of the primary feeder system and aid the concentration of the required fire flow at any point

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• **Distributors** — Grid arrangement of smaller mains serving individual fire hydrants and blocks of consumers Water

Water Main Valves:

- **Indicating valves.** An indicating valve visually shows whether the gate or valve seat is open, closed, or partially closed
- **Non-indicating valves.** These are the most common type of valves used on most public water distribution systems. In a water distribution system, these are normally installed in valve boxes or manholes.
- **Non-rising-stem** gate valves should be marked with a number indicating the number of turns necessary to completely close the valve.

Water pipe that is used underground is generally made of cast iron, ductile iron, asbestos cement, steel, plastic, or concrete

Water System Capacity

• The **average daily consumption (ADC) is** the average amount of water used per day based on the total amount of water used in a water distribution system over the period of one year.
• The **maximum daily consumption (MDC)** is the maximum total amount of water that was used during any 24-hour interval within a 3-year period. Unusual situations, such as refilling a reservoir after cleaning, should not be considered in determining the maximum daily consumption.
• The **peak hourly consumption (PHC)** is the maximum amount of water used in any 1-hour interval over the course of a day.
Private

Chapter 6

Hose Nozzles and Flow Rates

Solid stream nozzles on handlines should generally be operated at a maximum of 50 psi (350 kPa) nozzle pressure, while master stream appliances should be operated at a maximum 80 psi

Fog Stream — Water stream of finely divided particles used for fire control.

Periphery-deflected streams are produced by deflecting water around an inside circular stem in the nozzle. The water is then deflected by the exterior barrel of the nozzle. The position of the stem relative to the barrel will determine the shape of the fog stream

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Impinging stream nozzles break water into fine, evenly divided particles by driving several jets of water together at an angle.

The reach of the fog stream is directly related to its width, the size of the water particles (droplets), the wind, and the volume of water flowing.

Constant Flow Fog Nozzles

A constant flow nozzle is designed to flow a specific vol- ume of water on all stream patterns at a specific nozzle discharge pressure

Most constant flow nozzles are designed to operate at a nozzle pressure of 100 psi (700 kPa). However, some nozzles may operate at 50 (350 kPa) or 75 psi

Selectable Gallonage Nozzles Some nozzles may be designed for adjustable gallonage settings.

Automatic Fog Nozzles Automatic nozzles are a type of variable flow nozzle with the ability to change patterns while maintaining the same nozzle pressure (Figure 6.7). If the gallonage supplied to the nozzle changes, the automatic nozzle adjusts to maintain virtually the same pressure and consistency of pattern. This

Within the limitation of its design, an automatic nozzle maintains its constant operating pressure even if the pump discharge pressure rises above this level.

High Pressure Fog Nozzles Operating at a pressure of up to 800 psi (5 600 kPa), high pressure fog nozzles produce a stream with significant forward velocity, but a relatively low volume of water delivery.

These nozzles are best suited for wildland fires and are not recommended for structural fire fighting due to their low water flow of only 8 to 15 gpm

Selecting Nozzles:

Handline: Generally, 350 gpm (1 400 L/min) is the maximum flow for a handline.

Master Stream Appliances

- **Fixed monitors** — Commonly called deck guns and permanently mounted on the apparatus.
- **Combination monitors —** May be used in a mount on the apparatus or removed and used remotely from the vehicle. Combination monitors often have flow limitations when they are removed from the apparatus and placed on the ground.

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- **Portable monitors** — Stored on the apparatus for deployment to the loca-tion where they are to be used.

Elevated Master Stream: Pre-piped waterways generally feature a master stream that may be remotely controlled from the apparatus turntable and is generally able to move both up and down and side to side.

Jurisdictions may have unique needs that are best met by special nozzles not required as part of the NFPA® 1901 standard list of pumping apparatus equipment.

Cellar nozzles (some varieties are referred to as distributors) are most often lowered through holes or other openings to the cellar of an occupancy

Piercing Nozzles: An impinging jet nozzle capable of flowing approximately 125 gpm (500 L/min) at 100 psi (700 kPa) is part of the hardened tip. Piercing Nozzle — Nozzle with an angled, case- hardened steel tip that can be driven through a wall, roof, or ceiling to extinguish hidden fire. Also known as Piercing Applicator Nozzle, Puncture Nozzle, or Penetrating Nozzle.

Chimney Nozzle: Flowing only 1.5 to 3 gpm (6 to 12 L/min) at a nozzle

Nozzle Reaction — Counterforce directed against a person holding a nozzle or a device holding a nozzle by the velocity of water being discharged. NR = 1.57 x d2 x NP

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