General Order

Department of Fire & EMS
G.O. 7-3-26

Subject: 2026 FADO – Fire Apparatus Driver Operator Proficiency Advancement Process
Date: July 13, 2026
Authority: Chief Michael Robinson/MWR

The department is preparing to initiate the internal application process for Fire Apparatus Driver Operator.

The application period will open from July 27, 2026 – August 3, 2026. Candidates are reminded that they must submit a hard-copy paper application to Human Resources. All certification and credentialing documents must be uploaded through the Carroll County Career Center application portal. No hard-copy certification paperwork will be accepted by Human Resources.

To be eligible to participate, candidates must hold the minimum certifications outlined in policy 2.06 Employee Advancement Requirements and Procedures. The requirement to have FADO Aerial Proboard certification has been removed in Policy 2.06. Applicants must provide a transcript or letter from Assistant Chief Brothers showing successful completion of the Aerial Operators Course.

The schedule for the process is as follows:

- July 27, 2026 – Application period open
- August 3, 2026 – Application period closes at 1700 hrs.
- September 3, 2026 - Written Exam (Time & location will be sent to qualified applicants)
- September 14-16, 2026 – Practical Testing

Members on D Shift (September 3, 2026) may submit leave requests from 0700-1300hrs to take the exam. Please add to the comment section in VTI "FADO Exam".

Source material for the exam:

- IFSTA Pumping & Aerial Apparatus – **3rd Edition**
- Carroll County Fire Apparatus Driver Operator Handbook
- SOP 4.2.2 Hydrant Running Assignment
- SOP 4.2.3 Non Hydrant Running Assignment
- SOP 4.2.5 Standpipe & Sprinkler Support.
- SOP6.04 Emergency Vehicle Operations (Revision date March 19, 2025)

Carroll County Department of Fire & EMS

Fire Apparatus Driver Operator Handbook

Table of Contents

Section 1 - Apparatus Maintenance

Emergency Vehicle Inspection, Preparation, and Driving Techniques

INTRODUCTION

The intent of this portion of the manual is to provide the operator with the information needed to safely and efficiently operate emergency apparatus. This section includes, but is not limited to, vehicle knowledge and inspection, general operation and safety features of the vehicle, and proper driving techniques in normal as well as emergency operations.

OPERATORS

The operator must be completely knowledgeable in all aspects of the vehicle they intend to operate. It is important that the operator can demonstrate safe driving habits and is fully knowledgeable of the safety features inherent to the vehicle. The operator shall be able to identify the various components of the vehicle and explain their use. The operator will be able to identify any defects, make minor repairs, and understand when the vehicle is to be placed out of service due to safety reasons or major defects. In turn the operator will be able to complete the necessary documentation required by the Department.

OBJECTIVES

Upon completing this module of the Driver Training Manual, the operator will be able to correctly identify, maintain, evaluate, adjust, and operate an emergency vehicle. This will involve being able to identify major components of an emergency vehicle and being able to prepare the vehicle for an emergency response. These operations will include preventive maintenance, pre-response preparation, safety checks and adjustment. The operator will know, understand, and successfully demonstrate safe and correct handling of the vehicle in routine, emergency, and dangerous driving situations.

VEHICLE INSPECTION AND DRIVING PREPARATION

Major Motor Vehicle Components

There are many motor vehicle components to be discussed when describing any motor vehicle and some are specifically associated with emergency vehicles. The following is a list of components covered in this section:

- Vehicle characteristics – height, weight, length, and width
- Motor / engine components
- Braking systems: drum, disc, air, ABS, and engine retarders
- Exhaust systems
- Driveline
- Steering system
- Electrical system
- Suspension
- Wheels and tires

VEHICLE CHARACTERISTICS

The characteristics of an emergency vehicle affect the impact on the physical forces of the vehicle. The **height**, **weight**, **length**, and **width** of the vehicle are those items that are going to affect the action and reaction of the vehicle while it is in motion. These items limit the direction of travel of the vehicle due to weight limitations (bridges), height constraints (overpasses), and width restrictions (tunnels).

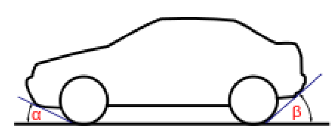
Height: It is important to know the overall height of the vehicle including all lights and other equipment mounted on the top of the vehicle. The operator should be able to recognize not only structural overhangs but also other potential problems, for example tree limbs, power and phone lines, and any other low hanging objects. It is also important to understand the vehicle height plays a role in how the vehicle is going to handle in terms of braking and turning. The taller the vehicle is, the higher the center of gravity. This is important when making turns. Because the center of gravity is higher, the potential for rollovers is higher if the vehicle is exceeding safe turning speed. This higher center of gravity changes the braking on the vehicle as well.

Weight: The gross vehicle weight rating (GVWR) is the maximum operating weight specified by the vehicle manufacturer including the vehicle itself, fluids, accessories, passengers, and cargo. The GVWR is vital to know because of posted weight limits on bridges, overpasses, roadways, and parking areas. All publicly maintained roads have a safety factor designed into the roadbed or supporting structures, however privately maintained facilities are unpredictable. Where a weight limit is posted on a public roadway it can be assumed that the actual designed weight limit is higher. Before entering an area with weight limit restrictions, consider the GVWR of your apparatus compared to the weight limit, the apparent condition of the roadway or bridge, and whether you will be simply passing across the surface or parking on it. When apparatus weight exceeds posted limits, consider another route. Knowledge of territory is key to avoiding these situations.

As with height, the weight of the vehicle influences vehicle handling. The weight of the vehicle has a direct impact on the braking system. The weight distribution between the front and rear axle must be appropriately distributed. The vehicle should have approximately 1/3 the weight over the front axle and 2/3 of the weight over the rear axle. Additionally, the weight should be distributed evenly from side to side. Personnel, equipment, and accessories must be placed on the apparatus in a way that avoids overloading components of the vehicle. When weight is distributed correctly the braking, suspension, and steering systems will work as designed.

Another term to be familiar with is “curb weight”. The curb weight of a vehicle is the weight of the vehicle with all the standard equipment and amenities, but without any passengers, cargo or any other separately loaded items in it. For fire apparatus, this is essentially the weight of the vehicle when it is brand new and leaving the manufacturing plant.

Length: The length of the vehicle is important to know in terms of turning radius (wheelbase contingent) and angle of approach and angle of departure. It is safe to assume that the longer the vehicle the wider the turning radius must be. The angle of approach and departure are important when moving across hills. These are the smallest angles made between the road surface and a line drawn from the point of ground contact and either the front or rear of the tire to any projection of the apparatus. This is important so that the front or rear bumpers or any object of the undercarriage of the vehicle does not come into contact with the road surface.



Width: The width of the vehicle comes into play when driving into diminished clearance environments. It is important that the width of the vehicle is the overall width that includes mirrors, and any piece of equipment mounted to the exterior of the vehicle. Public roadways have lanes varying from 9 to 12 feet wide.

***NOTE** Driver/Operators will verify vehicle height, width, and weight prior to proceeding through any area where clearance or weight restrictions may be questionable.*

MOTOR/ENGINE COMPONENTS

There are two types of engines, gasoline and diesel. Their components are very similar in nature. The primary concern to the operator is the type of fuel used by the engine. Care should be taken to ensure the proper fuel is used. The following is a list of the basic components in the motor compartment of the vehicle.

***NOTE** Before adding any fluid, ensure you are using the correct specified fluid for that vehicle. (i.e. Not all power steering fluid is the same from vehicle to vehicle.)*

Engine Block: The engine block is where the pistons perform the work to create the motion of the vehicle. The block becomes extremely hot during the operation of the vehicle. Oil and antifreeze pass through the block during its operation.

Radiator: The radiator contains the fluid used to keep the engine block from overheating. The cooling system is a closed system working under pressure.

***NOTE** The fluid in this system becomes extremely hot and should not be handled until cooled.*

Battery(s): The batteries are the start of the electrical system. They are used in starting the vehicle and maintain electrical components during the operation of the vehicle. The standard starting circuit contains two 12-volt batteries wired in parallel. On some vehicles there is a selector switch to opt for either or both batteries. The switch indicates which battery is being charged. It is important to note not to turn off the battery switch while the engine is running. This will cause damage to the alternator and electrical system. If the batteries need to be charged, only charge one at a time, and not both, on the selector switch. Charging both could cause one battery to receive an excessive charge, causing the contents to boil, resulting in battery damage or destruction.

*** NOTE** The battery(s) contain acid which will harm you if you come in contact with it.*

Power Steering Pump: The power steering pump maintains the fluid used to assist in steering the vehicle. The fluid in this system can be checked either while the engine is cold or hot. There are differentiating indicator marks on the dipstick for this purpose.

Brake Master Cylinder: This unit contains the fluid used to operate hydraulic braking systems.

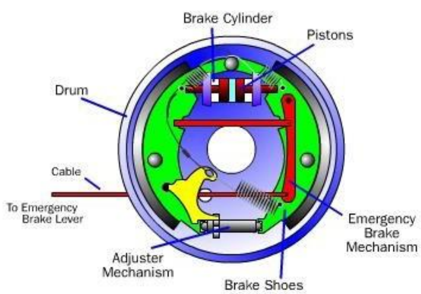
***NOTE** This is not present with air brake systems.*

Fan/Accessory Belts: Belts are used to turn the cooling fan for the radiator and provide a means of recharging the batteries through the alternator. They are attached to the power steering pump and air conditioning compressors.

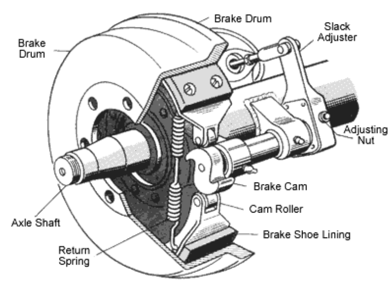
BRAKING SYSTEMS

A vehicle's braking system converts inputs from the brake pedal or parking brake controls in the cab to the friction devices (brakes) located at each vehicle wheel. Systems on CCDFEMS apparatus either use liquid or air to create the forces to engage the friction devices. Liquid systems are known as hydraulic.

There are generally two types of braking devices that can be on the vehicle, drum and/or disc brakes. Drum brakes have drums located on each end of the vehicle's axles. The wheels are bolted to the drums, and the braking mechanism is inside the drum. To stop, the brake shoes and linings are pushed against the inside of the drum. This causes friction, which slows the vehicle (and creates heat). The heat a drum can take without damage depends on how hard and how long the brakes are used. Too much heat can cause the breaks to fade (become less effective) or stop working.

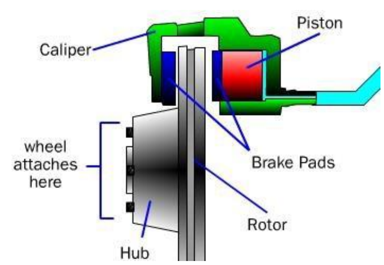


Hydraulic Drum Brake



Pneumatic Drum Brake

Disc brakes are comprised of a rotor and a caliper that squeeze the brake pads to stop or slow the vehicle. The rotor is the disc and is attached to the wheel axle. When the brake pedal is depressed, the caliper squeezes together, bringing a pair of brake shoes into contact with the rotor. The friction of the opposing brake pads as they squeeze the rotor slows the rotor rotation and causes the wheel to slow and stop.



Disk Brake

Pneumatic (air) brake systems are the most commonly used in fire service apparatus and commercial motor vehicles in general. Air brakes use compressed air to make the brakes work. An air brake system typically has three functions each having distinct features: service brake, parking brake, and emergency brake systems.

- The service brake system applies and releases the brakes when you depress the brake pedal during normal driving operations.
- The parking brake system applies and releases the parking brakes when you use the parking brake control.

- The emergency brake system uses parts of the service and the parking brake systems to stop the vehicle in the event of a brake system failure.

The main operating components of an air brake system are:

Air Compressor: The air compressor pumps air into the air storage tanks. The compressor receives power from the vehicle motor through gears or a V-line belt. The compressor may be air or oil cooled.

Air Compressor Governor: The governor automatically engages and disengages the compressor to maintain preset levels in the air storage tanks. When the air tank pressure rises to a preset level (around 125 psi) the governor stops the compressor. When the tank pressure falls below a preset level (around 100 psi) the governor allows the compressor to start pumping again.

Air Storage Tank: Air storage tanks are used to hold the compressed air. The number and the size of the tank(s) depend on the size of the vehicle and any auxiliary functions that draw air from the system. The tanks hold enough air for the service brakes to be used several times even if the compressor fails to automatically replenish the air. All air has a certain level of humidity which means that there is always water vapor in the atmosphere. Air is heated as it's compressed, and it cools as it travels through the discharge line to the air storage tank. This cooling results in condensation creating pools of water in the bottom of the air tanks. Oil from the compressor and any contaminants that made it through the compressor’s air filter can also be in the water. This moisture can lead to blockages or malfunctions if the water freezes. It can also lead to corrosion or reduce capacity in the storage tanks. Since the moisture tends to collect at the bottom of the air storage tanks each tank has a method of draining or bleeding the tank. Tanks can have either a stopcock valve that requires turning to open or a spring-loaded stopcock that is opened by pulling on a cable that is usually reachable without climbing under the vehicle.

***NOTE** It is important to remember that once the tanks have been bled, the system must be recharged prior to moving the vehicle.*

Most fire service vehicles also have an automatic air dryer installed between the air compressor and storage tanks. Their purpose is to filter out water vapor, oil vapor, and other contaminants before they can reach the air tanks and valves. This helps prevent freeze-up during the winter and extends the life of air valves. During extreme cold weather it may be necessary to manually drain air tanks after returning to the station.

Safety Valve: A safety valve is installed in the first air tank the air compressor pumps air to. This valve protects the tank and the rest of the system from being over pressurized. This valve is usually set to release at 150 psi. **NOTE** If this safety valve releases air there is a problem that a mechanic should be notified immediately.

Brake Pedal: To apply the brakes you press down on the brake pedal. Pushing the pedal down harder applies more air pressure. Letting up on the brake pedal reduces the air pressure and releases the brakes. Releasing the brakes lets some of the compressed air go out of the system, so the air pressure in the tanks is reduced. Pressing and releasing the pedal unnecessarily can let air out faster than the compressor can replace it. If the pressure gets too low the brakes lose effectiveness and at the extreme the spring brakes will apply.

Foundation: Foundation are the components at the wheels. They form the basis for the rest of the brake system, hence "foundation." The types of foundation brake systems are:

- **S-cam Brakes**: When you push the brake pedal, air is let into each brake chamber. Air pressure pushes the rod out, moving the slack adjuster, thus twisting the brake camshaft. This turns the S-cam (named because of its S design). The S-cam forces the brake shoes away from one another and presses them against the inside of the brake drum. When you release the brake pedal, the S-cam rotates back and a spring pulls the brake shoes away from the drum, letting the wheels roll freely again.

- **Wedge Brakes**: In this type of brake, the brake chamber push rod pushes a wedge directly between the ends of the two brake shoes. This shoves them apart and against the inside of the brake drum. Wedge brakes may have a single brake chamber, or two brake chambers, pushing wedges in at both ends of the brake shoes. Wedge type brakes may be self-adjusting or may require manual adjustment.

- **Disc Brakes**: In air-operated disc brakes, air pressure acts on a brake chamber and slack adjuster, like S-cam brakes. But instead of the S-cam, a "power screw" is used. The pressure of the brake chamber on the slack adjuster turns the power screw. The power screw clamps the disc or rotor between the brake lining pads of a caliper, similar to a large C-clamp.

Supply Pressure Gauge(s): All air-brake vehicles have a pressure gauge connected to the air tank. If the vehicle has a dual air brake system, there will be a gauge for each half of the system. (Or a single gauge with two needles). These gauges let you know how much pressure is in the tanks.

Low Air Pressure Warning: A low pressure warning signal is required on all vehicles with air brakes. A warning signal you can see must come on before the air pressure in the air tanks falls below 60 psi. The warning is usually a red light and on some vehicles a warning buzzer sounds as well.

Brake Light Switch: Drivers behind you must be warned when you put your brakes on. The air brake system does this with an electric switch that works by air pressure. The switch turns on the brake lights when you are applying the brakes.

Spring Brakes: All vehicles must be equipped with emergency brakes and parking brakes. They must be held on by mechanical force (because air pressure may leak out). Spring brakes are used to meet these needs. When driving, powerful springs are held back by air pressure. If the air pressure is lost during a catastrophic failure or overuse of the service brakes, the springs automatically apply the brakes. The air pressure is also released by the driver using a control on the dashboard to apply the brakes for parking.

Parking Brake Controls: In most vehicles, you apply the parking brakes using a diamond-shaped, yellow, pull-push control knob. You pull the knob out to put the parking brakes on (spring brakes), and you push it in to release them.

***NOTE** Avoid pushing the brake pedal down when the spring brakes are on. The combined forces of the springs and the air pressure could damage the brakes. Most systems are designed to prevent damage; however, the best practice is to not simultaneously engage the service and parking brakes.*

Apparatus equipped with air brakes use two methods for parking brakes. First is a driveline brake, which is an actual disc or drum that attaches to the drive shaft and is operated by cables or levers. The second type is a spring-activated brake atop a service brake chamber that automatically applies the brake when the air pressure drops below a preset pressure.

It is important to define what a Dual Air Brake System is. Most new vehicles use a dual air brake system for safety reasons. A dual air brake system has two separate air brake systems that use a single set of brake controls. Each system has its own tanks, hoses, and lines, etc. One system typically operates the regular brakes on the rear axle(s). The other system operates the regular brakes on the front axle. The first system is called the primary and the other is called the secondary system. Some apparatus may have additional air tanks to supply additional or auxiliary accessories.

Many vehicles are equipped with Antilock Braking Systems (ABS). The purpose of the ABS is to permit the driver of the vehicle to stop the vehicle in the shortest possible distance while maintaining full control. By preventing the wheels from locking, ABS helps to improve control and stability. ABS allows steering during braking applications, and in most instances, reduces stopping distances, especially on wet, icy, or loose gravel surfaces. ABS use sensors at each of the wheels to send wheel speed information to a central computer. When the computer senses that a wheel is about to lock up, it automatically “pumps” the brakes on that wheel.

Due to the size and weight of today’s apparatus, secondary or auxiliary braking systems have been added to increase the braking capabilities of the vehicles. Essentially there are three (3) types of auxiliary braking systems:

- Engine Brake
- Automatic Transmission Retarder
- Driveline Retarder

The engine brake is known as a compression brake, or by the trade name “Jake Brake”. The brake mechanism uses the “compression” that the engine creates to slow the vehicle down. Essentially the system is allowing more new air into the cylinders of the engine causing it to work or bear down harder creating less horsepower and a force. The engine brake customarily comes with a selection switch allowing the driver to decide on the amount of work the braking system should do (2 cyl, 4 cyl, 6 cyl) or high or low. It should be noted that engine brakes on vehicles with automatic transmission are typically not effective below 20 miles per hour (mph) due to the low rpms of the engine while operating at low speeds.

***NOTE** Most manufacturers recommend the engine brake be turned off or placed in a lower mode during inclement weather or slippery road conditions.*

The automatic transmission retarder is attached to the transmission at either end of the transmission. The input retarder operates on the input end and the output retarder, which is the most prevalent on fire service apparatus, is attached to the output end of the transmission. The retarder system is self-contained and consists of a vaned rotor, which rotates in a vaned cavity. The rotor is splined to and driven by the output shaft. An external accumulator holds transmission fluid until the retarder is activated. When activated, the fluid in the accumulator is pressurized and directed into the retarder cavity. The interaction of fluid with the rotating and stationary vanes causes the retarder rotor speed, and hence the output shaft, to decrease and slow the vehicle.

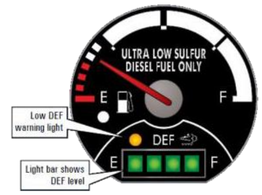
***NOTE** Most manufacturers recommend the retarder be turned off during inclement weather or slippery road conditions.*

The driveline retarder can be divided into 2 types, hydraulic and electromagnetic. Both types are attached to the driveshaft between the transmission and the rear axle. The hydraulic type absorbs energy by pumping oil around the driveshaft slowing the vehicle down. The electromagnetic retarder sets up a magnetic field that grabs the driveline. The absorbed energy is transferred to the surrounding atmosphere as heat.

***NOTE** Most manufacturers recommend the retarder be turned off during inclement weather or slippery road conditions.*

EXHAUST SYSTEMS

Vehicle exhaust systems have grown increasingly complicated as emission control standards have increased. Since 2007 most diesel engines have been equipped with "after-treatment" systems integral to the exhaust system. For the apparatus operator, there are two primary areas of concern that impact vehicles equipped with these systems: the Diesel Exhaust Fluid (DEF) and the Diesel Particulate Filter (DPF). Both the DEF and DPF are included in the instrument panel light cluster to alert the driver to the system status.



DEF is a non-hazardous solution of 32.5% urea, and 67.5% de-ionized water used in post-2009 diesel vehicles. DEF is sprayed into the exhaust stream of diesel vehicles to break down nitrogen oxide emissions into nitrogen and water. DEF is **not a fuel additive** and never comes into contact with diesel. It is stored in a separate tank, typically with a blue filler cap.

Note** If a unit is filled with the wrong type of fluid (Gas in a diesel tank, DEF in a diesel tank, Diesel in a gas tank, DEF in a Gas tank, etc.,)* ***do not start the engine, immediate damage to the motor will occur. *Place the unit out of service, it will need to be towed to the appropriate shop.*

The DEF tank is separate from the diesel fuel tank and should be refilled only when it reaches half. There is no need to continuously top off the DEF tank. The DEF level indicator is generally located immediately adjacent to the diesel fuel level indicator on the dashboard. DO NOT allow the DEF tank to reach empty or the vehicle will automatically reduce power.

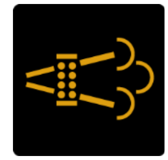
***Note** DEF tanks should be refilled between ½ and ¼ tank.*

DEF crystallizes when stored for prolonged periods as the water evaporates. Do not use DEF that shows signs of crystallization and always completely use a container to avoid storing open containers. Do not allow vehicle DEF systems to become empty, this will create crystallization in the lines and tanks.

Use the filler tube supplied with the case to avoid spills or splashes. Spills can be safely washed down with water. DEF is not corrosive to human skin; however, it is corrosive to aluminum and paint. Do not allow it to remain on the diamond tread or paint. Spills MUST be washed down with water.

The freezing point of DEF is 12°F, however vehicles are equipped to thaw the DEF, and this should not restrict use of the vehicle.

Personal protective equipment is not necessary when handling DEF, however it will stain clothes.



The DPF indicator illuminates when sufficient particulate has accumulated in the system to require regeneration. Regeneration occurs in one of two modes; automatically when the vehicle is at highway speeds for more than 20 minutes or while parked. Parked regeneration is most likely the mode required simply due to the type of driving done by fire apparatus. Personnel must refer to manufacturer for specific instructions on conducting regeneration.

HEST – High Exhaust System Temperature light (HEST) illuminates to indicate that high exhaust temperatures may exist due to DPF / Regen activity. Do not use station plymovent systems when this light is on. High exhaust temperatures may melt or ignite items close by.

Beyond the emissions control features, the exhaust system is basic and is comprised of a muffler or mufflers, exhaust pipes, tail pipes, and/or vertical stacks. It is important to note that a faulty exhaust system affects the performance of the motor and can emit poisonous fumes into the crew area causing serious illness.

DRIVELINE

The driveline consists of the transmission, front universal joint, driveshaft, rear universal joint, differential, and the rear axle. The transmission is a system of gears that allows change in the ratio of the number of engine revolutions to the number of wheel revolutions. The drive shaft connects to the rear of the transmission and is powered to turn the differential. The differential is a component of the rear axle that the rear wheels are attached to and allows wheels on the same axle to turn at different speeds when making turns. The entire system works in unison to power the rear wheels.

Locking Differential: Vehicles may be equipped with a locking differential that is engaged by a switch on the dashboard. A locking differential temporarily divides torque from the driveline to be delivered equally to all wheels sharing an axle, regardless of their traction. The drive wheels will act like they are rotating on a common shaft. One wheel that finds good traction will keep the truck moving. Without a locking differential, the wheels without traction may continue to spin with little torque being sent to the wheels with traction.

- Never engage the differential lock above 25 mph or while the wheels are spinning
- When engaged, steering radius will increase dramatically
- Disengage once the vehicle is freely moving—do not drive on dry pavement with the lock engaged or damage may occur to tires or axle components
- When tire chains are installed, do not attempt to turn the vehicle with the lock engaged.

Inter-Axle Differential Lock (tandem axle chassis): The inter-axle differential in a tandem axle chassis provides necessary differential action between the axles. This allows the wheels of either axle to revolve faster or slower than the wheels of the other axle to compensate for cornering, uneven road surfaces, and slightly different tire sizes. When encountering soft or slippery road conditions, the inter-axle differential can be locked out, eliminating any differential action between the axles.

- Engage the IAD lock only when stopped or moving at slow speed. NEVER lock the IAD lock with the rear wheels spinning.
- Disengage once the vehicle is freely moving—do not drive on dry pavement with the lock engaged.

***Note** Tandem axle vehicles may be equipped with both an inter-axle differential lock AND a locking differential.*

***Note** Turning should be limited with both inter-axle differential locks AND locking differentials.*

TRANSMISSIONS

There are two types of transmissions: standard and automatic. The standard or manual transmission uses a clutch assembly to shift the transmission gears depending on the RPMs of the motor and the desired speed requested. Computer modules control the automatic transmissions. The modules signal and influence the engines RPMs during transitional shifting.

STEERING SYSTEM

The steering wheel and column connect to steer the vehicle. They connect to a gear and linkage mechanism that changes the direction of the front wheels. In most vehicles this either “power assist” or “power steering” to ease the turning of the steering wheel. These are both hydraulic (fluid) driven systems.

ELECTRICAL SYSTEMS

The electrical system supplies power for primary and auxiliary functions. The primary functions of the electrical system include power the generator and storage battery, generator/alternator, and voltage regulators; power distribution (via engine wiring); timing (distributor); and spark generation if equipped. Auxiliary functions include inside/outside lighting (headlights; amber, red signaling or warning lights; turn signals; instrument panel lights; etc.); and horn, siren, and public address system.

SUSPENSION

This system is comprised of leaf springs, shock absorbers/coils, air rides, and wheels and tires that enable the driver to maintain control on rough terrain and sharp curves.

WHEELS & TIRES

As mentioned before, the wheels and tires are a part of the suspension system; however, it's important to define them a bit more. Both wheels and tires must have a weight rating which will accommodate the weight distributed through the axle and springs. The condition of the tires is based on inflation, tread design, and tread wear. All of these have a major impact on vehicle handling. Each tire has only about 40 square inches of contact with the road. It is imperative that both the inflation pressure and tread be in good condition to provide maximum safety. When tire tread depth reaches 6/32" appropriate notifications shall be made. The minimum allowable depth of the tread should be 4/32" on steering axles and 2/32" on non-steering axles.

Automatic Traction Control: To aid the tires in maintaining traction, apparatus may be equipped with an automatic traction control function. This system monitors wheel speeds and automatically applies braking to a drive wheel that is spinning. In extreme situations, engine speed may also be decreased until traction is achieved, leaving the driver unable to accelerate. If it is desirable to rock the vehicle when stuck and the automatic traction control is cutting the throttle, engage the "mud and snow" switch or other override control provided by the chassis manufacturer.

EMERGENCY VEHICLE PRE-RESPONSE PREVENTIVE INSPECTIONS

Emergency vehicles of all types should be inspected prior to each shift and whenever an event or incident occurs that may cause damage to the vehicle. Emergency vehicle accidents caused by the lack of maintenance or vehicle malfunction are preventable. Regardless of who performs the actual maintenance on the vehicle, it is the driver's responsibility to confirm the vehicle is ready for use. The responsibility for the mechanical safety of the vehicle is that of the driver. **IF IT ISN'T RIGHT, DO NOT DRIVE IT**. The preventive maintenance inspection not only identifies problems but often permits repairing them at least temporarily.

Inspections, maintenance, and repairs must be recorded by the Department. The records must include the date and description of all maintenance, repairs, and inspections performed.

Inspections can be broken into nine core areas to expedite the inspection process:

1. Check prior maintenance records
2. Conduct a vehicle overview
3. Conduct an engine compartment check

4. Conduct an interior cab check
5. Conduct a vehicle walk around check
6. Conduct a compartment and equipment check
7. Conduct an undercarriage check
8. Conduct a moving and driving test
9. Complete inspection process

The following is a breakdown of the nine categories listed above:

Check PM Records: Each day the records of the previous days should be reviewed for defects and repairs.

Vehicle Overview: Conduct a vehicle overview including inspecting for body damage and cleanliness; and leveling of the vehicle (indicates suspension problems).

Engine Compartment: Conduct an engine compartment check with the engine off. You should check the following:

- Oil levels
- Coolant levels
- Power steering fluid level
- Transmission fluid level
- Air compression belts
- Hydraulic reservoir
- Brake fluid level
- Battery fluids both left and right
- Windshield washer fluid levels
- Belts and wiring harnesses
- Steering box not leaking
- Safety devices including hood latches and safety bars for tilt cabs

Interior Cab: Conduct an interior cab check by first properly preparing for the vehicle inspection:

- Engage the parking brake, chock the wheels, turn the batteries on, turn on the ignition master, place the transmission in neutral, and start the engine.
- Check the instrument/dash gauges for operating voltages, temperatures, pressures, and levels.

- Check the accelerator pedal tread, in place and not loose.
- Conduct brake test and listen for obvious leaks, and/or blown diaphragms.
- Check steering wheel and column for centering, excessive play (greater than 10 degrees), and abnormal movement.
- Check electric/air horns for equal tone quality from each horn.
- Check electronic and mechanical sirens for excessive draw on ammeter and voltage fluctuations and electrical system problems.
- Check windshield wipers and washers as well as heating and defrosting systems.
- Check radio equipment including fixed, portable, public address system, and cellular phone if equipped.
- Check for the onboard documents (vehicle registration, insurance card, etc.)
- Interior lighting systems should be checked to ensure they are working properly.
- Mechanisms for seat adjustment, both mechanical and pneumatic, should be checked to ensure they are working properly.
- Check seatbelt (occupant restraints) systems.
- Check the interaxle differential locking systems, both dual and tandem axle.
- Check visual and audible chassis warning systems, including oil, water, and transmission fluid level and temperature and open-door compartment warning lights.
- Ensure outside mirrors, both manual and mechanical, can be adjusted and the wiring for the heating system is intact and operational.
- There should be appropriate maps and accountability rings/systems on board.
- Internal communication devices and equipment (FireCom) should be checked.
- Check the fast idle RPMs to ensure that it can maintain the electrical system.
- Check the warning lights.

Vehicle Walk Around: Conduct a vehicle walk around and operate and/or check the following:

- Windshield and windows for any cracks that may necessitate taking the vehicle out of service. If damage to the windshield obscures or distorts your vision the windshield requires repair.
- Check headlights, both low and high beams and four-way flashers.
- Visualize the condition and operations of the emergency warning lights.
- Check DOT marker lights and reflectors.
- Check turn signal function.

- With assistance, check to make sure all the brake lights are operational.
- Check the generator and/or auxiliary power devices and attached appliances or lights.
- Check levers, switches, and knobs on all exterior panels.
- On the tires and wheels, check for obvious gouges, slashes, cuts, bubbles, or any other damage. Look for indications of rust or peeling paint on non-aluminum rims. Check the condition of the lug nuts and wheel hubs. Check for any hub oil leaks. Inspect the rims for damage and missing weights. Check condition, inflation, and tread depth on tires. The depth of the tread should be 4/32” on steering axles and 2/32” on non-steering axles.
- Check the automatic snow chains for condition, position, and operation.
- The undercarriage and ground should be checked for any obvious fluid leaks (note the color of the fluid leaking).

Compartment Check: Conduct the compartment and equipment check:

- Make sure the compartment latching mechanisms work properly.
- Ensure the portable power equipment on board is working properly and fueled.
- Ensure the inventory is complete and in its proper place.
- Check the circuit breakers for onboard generators.
- Ensure the DOT required traffic warning devices such as cones, flares, and reflective triangles are on board.
- Ensure at least one dry chemical fire extinguisher is on board and charged.
- Crew equipment should include SCBA, hand lights, AED, EMS bag, and radios, should be checked to ensure they are in working order.
- Ensure all other equipment (hazard lights, etc.) is working properly.

Undercarriage: Conduct an undercarriage check:

- Bleed the moisture from the air tanks as required. Check the color of the fluid being emitted – light gray sludge indicates a bad compressor
  - ***NOTE** Moisture should be bled from tanks frequently during inclement* weather and temperature fluctuations.
- The brake lines should be checked for cracks, fraying, dry rot, pulling or distortion, or wear marks.
  - **NOTE** Check slack adjusters for excessive movement, not more than 1 inch, and whether they are frozen in place. Do not attempt to make adjustments; trained personnel should conduct the adjustments.

- The driveline (engine to differential/rear axle) should be properly greased, make sure there is no excessive movement in the joints, and the dust covers are intact.
- Check the exhaust system for soot stains that mark leaks, clamps and hangers securing the exhaust, and any deterioration of the components.
- On the suspension system, mechanical or pneumatic, check the leaf springs for cracks and breaks, shackles and hangers, shock towers, and leaks and air leaks (shocks or bags).

- Make sure the automatic snow chains are securely attached and lined up properly.
- Look for obvious damage, such as rust, loose parts, shiny spots from rubbing, asymmetrical parts (out of alignment), any cracks in the frame rails, and shifting or damaged body mounts.
- The inner sides of wheels and tires/ sidewalls on the tires should be checked for excessive dusting, fluid leaks, bad seals, and cracked brake drums and shoes.
- All wiring harnesses should be checked for frayed or cut wires.
- Check the fuel tank for obvious leaks or weeping, straps and grounding pad are intact, fuel lines are ok, and the overflow is not kinked.
- Check the transmission, rear end, plugs, vents, and axle for leaks or signs of weeping.

Brake Test/Air Brakes: Conducting a DOT Air Brake Test. Note: this test is ONLY to be used on apparatus with air brakes. Use the acronym “COLA” to remember the key points of a test:

C = Cut In Pressure - approximately 100 psi. Any compressor that does not cut in before 95 psi must be reported immediately.

O = Cut Out Pressure - between 120-140 psi. Any higher than 140 psi must be reported immediately.

L = Low Pressure Warning - The low air warning devices (buzzer and light) should activate before air pressure drops below 55 psi or level specified by the manufacturer.

A = Air Leakage - with foot on or off the brake pedal, air leakage should be less than 3 psi per minute (4 psi per minute for a Tiller Truck).

Complete Inspection Process: Document the inspection and compare it to the previous report. Follow-up on discrepancies noted. If discrepancies are noted that impact function, operational/directional ability, and/or safety, place the unit out-of-service and consult with station contact for maintenance before placing the unit back in service.

ROUTINE MAINTENANCE ON EMERGENCY VEHICLES

Properly maintained vehicles are safer and more reliable to operate. In fire service vehicles, safety and reliability are key to successful service delivery. Routine maintenance of the vehicle is the responsibility of the driver. Deficiencies should be repaired or reported in writing to oncoming shifts and maintenance personnel. The role of the emergency driver as it pertains to preventive and routine maintenance is defined in NFPA Standard 1002, Fire Department Vehicle Driver/Operator Professional Standards. Applicable, with minor adjustments, to all emergency vehicles, the standards states:

> *"… Prior to operating fire department vehicles, the fire apparatus operator shall meet the job performance requirements as defined in …"*

As this relates to the preventive maintenance function, it specifically states that the driver shall be able to "perform routine tests, inspections, and servicing functions on the specified systems and components and ... so that the operational status of the vehicle is verified."

The systems and components identified in NFPA 1002 are listed here. Items for consideration under each are identified as reference:

Batteries:

- Connections of the cables are clean and tight
- Battery (ies) box/compartment is clean and secure

Braking System:

- Air Brakes
  - Pressure prior to starting the engine (air) should be approximately 125 psi;
  - Build-up time, if appropriate (air), when the engine is operating at normal RPMs, the pressure should build from 85 psi to 100 psi within 45 seconds in dual air systems. In single air systems, pressure should build up from 50 to 90 psi within 3 minutes when operating at normal RPMs.
  - Moisture in system/drain air tanks, in tanks with manual bleed valves, turn the valve ¼ turn to drain air, moisture, and dirt from system. Return valve to closed position to build up air in system again
- Hydraulic Brakes
- Proper fluid level in the master cylinder
- No signs of leaks or damaged lines
- ABS verification (dash light)

- Braking Operation (during runs as well as at inspection time)
- Brake pedal (proper range of motion)

Coolant System:

- Correct level (generally approximately 2 inches below the top of the radiator, check with local requirements)
- Hose and/or connections wear/leaks

Electrical System:

- Ensure all lights and audio equipment are operational, if bulbs need to be replaced make sure the correct bulb size and style is used and replace faulty fuse in audio system if needed.
- Voltmeter should be reading between 12 and 14 volts

Fuel:

- Correct level, if not, fill tank with proper type of fuel. Rule of thumb is to fill units at ¾ or below
- Check any power equipment levels and fill as needed with the proper fuel for that equipment
- If a unit is filled with the wrong type of fluid (Gas in a diesel tank, DEF in a diesel tank, Diesel in a gas tank, DEF in a Gas tank, etc.,) **do not start the engine, immediate damage to the motor will occur.** Place the unit out of service, it will need to be towed to the appropriate shop.

Hydraulic Fluids:

- Check for leaks on the floor under the vehicle and areas around connections of the hoses
- Ensure proper levels and add (if permissible) with the appropriate type of fluid

Oil (Engine):

- Leaks on the floor under the vehicle
- Check levels using the dipstick in the engine compartment
    - Checked when the engine is cool or cold
    - Engine is warm or hot and the oil is dispersed throughout the engine

- o Allow 20 to 30 minutes for oil to settle back into the oil pan after the motor is run
- The color and texture of the oil on the dipstick should be noted. If the oil is frothy (bubbly) or a color other than dark brown or black, there may be water or fuel infiltrating the oil that is indicative of a motor problem.

Tires:

- Condition (sidewalls, rims, tread)
- Correct inflation pressure, fill as needed to the recommended pressure.
  - o The recommended pressure is set by the vehicle body manufacturer and may differ from the chassis manufacturer
- Tread depth (2/32nd or 4/32nd dependent upon the axle)

Steering System:

- Ease of operation (power OK and no extra play)
- Correct fluid level, this may be checked while the engine is hot or cold and the fluid level should correspond to that recommended on the dipstick

SAFETY CHECKS AND ADJUSTMENTS MADE BEFORE DRIVING

There are certain items that should be checked by the driver prior to moving the vehicle:

Occupant Restraint Systems: Restraints reduce the likelihood of serious injury or death in the event of an accident. The law and CCDFEMS policy require that there be a restraint for all riders and that they be used all times the vehicle is in motion. In addition to a collision, the restraints keep the driver in position behind the wheel and in front of the controls during sharp turns, over excessive maneuvers, roll overs, and yaw skidding or spins.

Adjustable Head Restraints: Head restraints help prevent cervical spine and other injuries from hyperextension and hyperflexion, i.e.. forces resulting from rear end collisions. The proper adjustment for the head restraints is to have the center of the restraint at the center of the skull not at the base of the neck. If the restraint is too low, the neck could be broken if the force of impact is great.

Seat Position: When the seat is properly adjusted, the brake and accelerator can be applied fully without fully extending the leg. The steering can be held with only a slight bend at the elbows. The seat should be fully locked into position. If the seat was to move during operation, it could cause the driver to lose control.

Mirrors: The side-view mirrors should be adjusted to view the edge of the vehicle and out to the adjoining lanes. Convex mirrors need to be adjusted to view the blind spots that the side-view mirrors do not cover. In large vehicles convex mirrors are invaluable for managing lane position and expanding your view around the vehicle.

PRECAUTIONS BEFORE MOVING

The driver controls the movement of the vehicle; therefore, the driver must verify when passengers are ready. Prior to moving the vehicle audible or visual communication is necessary with all crew members confirming that they are belted and ready. Prior to moving, ensure the bay door is fully opened and/or the wheel chock is stowed, all compartments and cab doors are closed, and there are no obstacles in the path of the vehicle. If you are dispatched to a call during training or daily checkout, it is especially important to ensure the crew, equipment, and apparatus are all ready for departure. In this situation you should conduct a circle check to ensure all equipment is stowed and you are ready to respond. Do not sacrifice a quick check of the apparatus for the sake of speed.

OPERATING AN EMERGENCY VEHICLE

It is important to remember that the most common causes of a vehicle collision are reckless driving, improper backing and excessive speed.

Purpose of Emergency Vehicle Signaling Equipment

Lights and sirens (Emergency Vehicle Signaling Devices) are used to request the right of way from traffic, both vehicle and pedestrian. Warning and signaling equipment assist the responders with arriving at an incident expeditiously. Due regard MUST always be exercised, regardless of the perceived severity of the emergency.

Local Law (Maryland)

To request the right-of-way and enact the exemptions provided to emergency vehicles, Maryland law requires an emergency vehicle operator to use both audible and visual emergency warning devices while responding to an emergency. You may not be protected from consequences should you choose to run “silent” with only warning lights engaged. It is important to remember that use of signaling equipment by the operator **DOES NOT** guarantee other drivers will yield or even see you, nor does it free the driver from the possibility of civil or criminal liability if a collision does occur.

To better understand the liability and responsibility of the driver, it is important for drivers to know some key terms:

- **True Emergency**: is defined as a situation in which there is a high probability of death or serious injury to an individual or significant property loss.

- **Due Regard**: for the safety of others means that a reasonably careful person performing similar duties under similar circumstances would act in the same manner. Like the “standard of care” concept for EMT.
- **Negligence:** A legal deficiency or wrong that results whenever a person fails to exercise that degree of care that a prudent person would exercise under similar circumstances. It indicates a lack of “due regard.”
- **Gross Negligence:** Is the reckless disregard of the consequences of an act to another person. It occurs when a person’s actions (or lack of) result in failure to exercise even a slight degree of care.
- **Willful and Wanton**: Intentional or with careless indifference (considered the most serious form of negligence). Another assessment is that “you did it, you have done it before, and you would do it again.”
- **Vicarious Liability**: The legal liability placed on one person for the acts committed by another person. This concept extends liability to supervisors and instructors for acts of personnel they manage or teach.

Usually, a court will judge the actions of an emergency vehicle driver based on two primary considerations:

1. Was the emergency vehicle responding to a true emergency?
2. Did the emergency vehicle driver exercise due regard for the safety of others?

If the answer to both questions is yes, the emergency driver has demonstrated a responsible and professional attitude through his/her subsequent action(s).

Using Emergency Vehicle Signaling Equipment

An emergency vehicle driver must use all signaling devices when responding. Remember that most emergency vehicles are taller than the average automobile on the road. As you approach another vehicle from behind there are fewer warning lights visible to that driver in their mirrors. Your unit can be so close that only a couple of lights on the grill of your unit are in position to gain their attention. This is another reason to leave a space cushion between you and the vehicles ahead.

Another good practice is to leave the cab windows cracked open to aid with hearing other responding apparatus, trains, and traffic.

BASIC EMERGENCY VEHICLE CONTROL TASKS

Steering, accelerating, and braking accomplish directional and speed control. A competent emergency vehicle driver understands, chooses, and applies each of the basic driving maneuvers in the right combination and intensity at the right moments to effectively and safely operate their apparatus.

Steering: Steering an emergency vehicle, whether driving non-emergency, responding to an emergency, or making an evasive maneuver, requires certain habits. These include:

- Use both hands on the steering wheel as much as possible. Obviously one hand is occasionally required to operate other vehicle functions, such as the windshield wipers, lights, and transmission.

- Maintain hands in the “9 and 3” or “10 and 2” position on the steering wheel for maximum control and turning without repositioning your grip.

Braking and Stopping: Effective braking is essential to the safe operation of an emergency vehicle. Braking must be applied in a timely fashion with the correct intensity to maintain control. Prior to anti-lock braking systems becoming nearly universal, vehicles with hydraulic brakes required firmly pumping the brake pedal during hard stops to avoid the locking of the wheels into a skid. Air brakes do not react well to repeated pumping of the pedal and instead require just enough firm and steady pressure to slow the vehicle without locking the wheels. This was referred to as “threshold” braking because the driver was seeking the threshold between braking and skidding.

Anti-lock braking systems (ABS) change the dynamic of applying pressure to the pedal on both hydraulic and air brake systems. The following guidance applies:

- Do not pump the brake pedal. This only creates confusion for the monitoring system that manages the ABS. Steady pressure to the pedal signals the system that you want to slow down, and the system manages the foundation brakes to carry out that action.
- Even vehicles with ABS can skid. If the vehicle’s wheels lock, immediately release the brake pedal and steer with the skid. Reapply the brakes to attempt to establish traction.

In areas where there is a high probability of braking, i.e. passing through an intersection or traveling against traffic; the driver should “cover” the brake by hovering their foot over the brake pedal without applying pressure. This action will reduce the reaction time if braking is required.

The single most important aspect of braking safely is allowing enough space around your vehicle to identify the need to brake and then applying the brakes in a controlled manner. In heavy apparatus when you expand your look ahead distance sufficiently you can often slow and almost stop without even needing to engage the service brakes.

Backing – Backing collisions account for a large portion of preventable emergency vehicle incidents. Since speed is usually low, most backing incidents are relatively minor unless they involve a pedestrian. Regardless of severity, any collision makes the unit unavailable for service for a period of time varying from an hour or even days. It also results in consequences for the driver and potentially a bad public image for the

CCDFEMS.

Backing apparatus safely is accomplished by adhering to some basic principles:

- Position to minimize the need for backing - If thought is given to the next move or destination for a vehicle, a simple adjustment in the approach can minimize or even eliminate the need for backing.
    - Conduct an approach assessment – When approaching the place to back up the driver must complete a size-up of the entire area for obstacles that effect their planned path.
- This can only be done if the driver slows down so they can view the area before pulling past to position for backing. Even when spotters are deployed there are times when the driver should dismount to see the area themselves before backing. Spotters do not absolve the driver of responsibility for avoiding a collision.
- Be predictable – The spotter(s) must know where the driver is going to properly assist. Drivers must communicate their planned path before the spotter(s) dismounts the apparatus. If confusion develops the apparatus must stop and a conversation needs to occur.
- Give audible notice – Most apparatus is equipped with a backup alarm of some type. When shifting the vehicle into reverse pause before backing to allow the alarm to engage and provide some warning to pedestrians around the vehicle. Recognize that high levels of ambient noise around the vehicle, such as an active fire scene, may disguise or overwhelm the sound of the backup alarm. Personnel can also become desensitized to the audible warning, so never assume the alarm is heard.
- Use a spotter – The first spotter should normally position at the driver side rear about 10 to 20 feet behind the tailboard. Additional spotters can be helpful in complex situations and should be positioned to watch the passenger side corners to supplement the primary spotter. Spotters need to allow themselves some space cushion to the apparatus and the ability to escape should be vehicle unexpectedly continue backing toward them. The driver and the spotter must make acknowledged eye contact. If the spotter disappears from sight, the driver must stop immediately or risk running over their co-worker. ***IF*** a spotter is unavailable, conduct a walk around the vehicle before backing.
- Drivers must remove their headset and roll down their window prior to backing – The sense of sound is needed to augment the visual information being gathered in the mirrors. The exception is when you have wireless headsets, and the spotters are wearing them also. Many collisions have occurred despite the presence of a spotter because the driver momentarily looked away from the spotter and failed to hear the spotter yelling to stop.
- Understand hand and audible signals – Ensure that the driver and spotter have the same understanding of what the signals mean. If confusion occurs the driver needs to stop and establish clearer communications. Spotters need to give clear

guidance. The best spotter is often someone who is themselves an apparatus operator.

- Use mirrors – Drivers need to be well versed at using the mirrors. Hanging out the window or physically turning their body around to see to the rear are not acceptable practices and should only be done in odd circumstances. Just like while driving forward, the driver needs to scan all mirrors and avoid fixating on just the driver side mirror.
- Beware of the front corners of the vehicle – When backing the front end of the vehicle can swing into blind spots and strike fixed objects that are not visible to the spotter. Landscaping rocks, low retaining walls, fire hydrants, and protective bollards are all examples of objects that could be out of the view of the driver when backing. These types of obstacles need to be identified on the approach assessment. A second spotter positioned at the front of the vehicle will help to identify these hazards.
- Maintain speed control – Backing should be done at an extremely slow speed. It is reckless and unnecessary to back vehicles more quickly than a spotter can casually walk.

Parking & Positioning – Emergency vehicles are parked under a wide variety of conditions and time constraints. Nearly every emergency response will require the driver to decisively park the apparatus in a spot selected quickly to best support operations. It requires skill and experience to do it fast and without mishap. Where experience is lacking, it must be replaced with a slower pace. New drivers need to learn to slow down upon approach to the scene. Some factors to consider when positioning an emergency vehicle are as follows:

- Identify existing hazards on the scene and potential hazards as the incident escalates. Recognize overhead wires may fall, flammable liquids flow downhill, and flammable vapors may accumulate in low areas. Traffic is ALWAYS a hazard on every incident scene.
- Know policies and techniques that address positioning on specific incident types.
- Consider the location of your vehicle's exhaust outlet when responding to outdoor emergencies, such as vehicle crashes or medical emergencies. Avoid positioning your exhaust where it blows into the work area.
- Most emergency vehicles are not designed for off-road use. Before "beaching" an apparatus the driver needs to consider the terrain, the apparatus, the weather, and the legitimate incident needs.
- When operating an ambulance or arriving on a scene later in the incident, sometimes it is best to park with consideration to future positioning or departure of the vehicle. There are times when it is important to not commit too deeply into a scene and limit positioning options. Listening to scene reports, knowing arrival order, and seeking guidance from the incident commander are all sources of information regarding positioning.

- Operators should consider exhaust outlet locations, as high exhaust temperatures during diesel particulate filter (DPF) regeneration may ignite dry vegetation and cause brush fires.

URBAN DRIVING SKILLS

Even in normal, non-emergency conditions, operating an emergency vehicle in urban areas requires a high degree of skill. Older communities with narrow streets to commercial areas with streets lined with midrise buildings to newer town center mixed use developments all share common hazards for fire apparatus. Westminster, Mount Airy, Sykesville, Taneytown and numerous other areas of Carroll County pose unique challenges for apparatus operators. Land values and a constantly increasing population inevitably lead to densely populated areas throughout the County as a transition from rural to urban occurs.

Emergency vehicles are typically larger and heavier than the traffic around them. Even command or staff vehicles are loaded down with equipment not normally found in a typical passenger vehicle. Urban areas naturally develop limited sight distances and limited space cushions created by gridlocked traffic, narrow travel lanes, raised medians, street parking, and very short setbacks on buildings. These factors are further complicated by pedestrians, alleys, parking lots, landscaping trees, and crosswalks.

Speeds more than a posted limit are rarely justified. Excess speed should only be used if the road conditions permit it. Reasonable speed is one of the few factors under the direct control of the emergency vehicle operator that allows more time to react and more opportunity to control the vehicle if an evasive action is required.

Recognize that urban environments diminish the effectiveness of warning lights and sirens. An expected reaction to an approaching emergency vehicle is to pull to the side and slow down or stop. In an urban environment, other traffic may not have any space to do this or may choose to do undesirable things. Some of the possibilities are stopping in the middle of a lane, trying to race ahead of the responding vehicle, or beat the emergency vehicle through an intersection. In extreme cases, aggressive drivers may intentionally interfere with an emergency vehicle they perceive to be delaying their travel.

In other cases, motorists may not react at all and just keep traveling. Modern vehicles have a great deal of sound deadening or insulation to increase occupant comfort. The volume of the radio or other entertainment systems, air conditioner noise, phone conversations, and/or poor driving habits of the driver can all be factors leading to a failure to yield to an emergency vehicle.

Emergency vehicle drivers must avoid the temptation to become aggressive when they encounter vehicles failing to yield. Overly aggressive or emotional reactions to civilian motorists will eventually lead to a collision. While seeming counterintuitive, backing off the siren, maintaining following distance, and giving the other driver a chance to think and react is often the best way to handle confused or oblivious motorists. Beware of startling an unsuspecting motorist. They could respond by slamming on their brakes or causing a collision with other vehicles. Vary the siren pitch and duration; use headlights, horn, siren, or spotlight to get their attention. Be patient and keep signaling. Be very cautious about passing until you are sure the other driver sees you. If you attempt to pass an unaware driver there is a risk, they'll identify you just as you are beside them and panic at a moment where you have no space cushion to react defensively.

Likewise avoid actions that could cause other drivers to enter intersections against the traffic light or crossing into oncoming traffic. To yield where medians and curbs leave no room, another driver may move forward into cross traffic. Urban environments frequently make the use of opposing lanes appear to be a desirable option. Use of opposing lanes of traffic to pass other vehicles must be done with extreme caution as it multiplies the hazards to the emergency vehicle.

Apparatus drivers should learn the typical traffic patterns for their response area. Traffic blockages are common during the morning and evening commutes. Drivers may need to develop different routes for different times of day or days of the week. Construction zones or special events may further enhance the need to identify alternate routes.

When approaching gridlocked areas, slow down before reaching the blockage. This allows you time to identify the path of least resistance if one exists. Do not plow through the middle of stopped traffic when a right turn lane is wide open. The emergency vehicle driver can communicate their intention to other motorists through early lane positioning. Even where a lane is open as you approach, beware of motorists who panic and switch lanes unexpectedly. This can be especially true of right turn lanes or shoulders. Allow the traffic to make a path and avoid trapping your vehicle in a sea of surrounding traffic. Thinking in football terms – the best running backs sometimes let the play develop in front of them before they pick a path to run. If traffic is unable to move, moderate the use of your siren and/or horn as they may only increase confusion or anxiety. Patience will improve your safety and effectiveness.

NEGOTIATING INTERSECTIONS

Intersections are the most dangerous areas for emergency vehicles. Most people consider an intersection the meeting of two streets, however intersections come in many forms. An intersection is anywhere that other vehicles may cross your path, i.e. parking lot exits, alleys, driveways, trails, or railroad crossings.

There are two types of intersections: an *uncontrolled intersection* is any intersection that does not offer a control device (stop sign, yield sign, traffic signals, or railroad gates) in the direction of travel of the emergency vehicle. A *controlled intersection* is defined as any intersection that has a control device that regulates the flow of traffic, including stop signs and traffic signals.

Every intersection is a danger to the emergency vehicle operator until the cross traffic is confirmed to be controlled or absent. When approaching any intersection, consider the following:

- Scan the entire intersection for possible hazards (including vehicles turning right turn on red, pedestrians, vehicles not yielding). Observe conditions beyond the roadway.
- Slow down and cover the brake pedal with your foot.
- Change the siren cadence not less than 200 feet from the intersection.
- Do not assume warning devices are seen or heard unless the actions of other drivers is confirmed.

- Identify a primary path through the intersection as early as possible. Have contingency paths if unexpected obstructions are encountered.
- Be prepared to stop. This means adjusting speed and covering the brake until the reaction of other drivers becomes obvious.
- Establish eye contact with other vehicle drivers.
- Utilize crew resource management when available. The officer and other crew members may assist in identifying the status of oncoming traffic, but this does not relieve the driver of the ultimate responsibility for avoiding a collision.

When crossing intersections with multiple lanes of cross traffic proceed one lane of traffic at a time. Treat each lane of traffic as a separate intersection. Be very cautious of intersecting lanes that are not controlled by stopped traffic. Impatient motorists see the open lanes as an opportunity to race past the other stopped traffic.

Before exposing the apparatus to an intersection, the vehicle operator must make sure there is an adequate gap in traffic and/or traffic is yielding. The vehicle operator should at the very least:

1. <u>look left</u> – this traffic is usually the closest and immediate hazard
2. <u>look right</u> – once the left seems ready, check the next set of approaching lanes
3. <u>look left again</u> – ensure the nearest lanes remain safe to cross
4. <u>look straight across</u> – check that opposite traffic isn't turning in front of you
5. <u>check the mirrors</u> – ensure impatient motorists have not pulled up beside you before making a turn

When making a right turn at an intersection from a stop it takes about six seconds to turn right and accelerate to a speed of 30 mph. This time increases with the size of the vehicle. Do not turn in front of other motorists assuming they see your apparatus. Other drivers must have time to react to your sudden appearance ahead of them.

An observation skill that needs to be developed by emergency vehicle drivers is reading the "body language" of other traffic. Some characteristics that can often be observed that help the emergency vehicle operator anticipate the actions of surrounding traffic are:

- Are the other cars changing speed?
- Does the driver appear to be scanning around them?
- Are they glancing at their mirrors?
- Are the turn signals or hazard flashers activated to try and signal a yielding action?
- Does the driver appear to be talking on a cell phone; either handheld or hands-free?

- Is the other vehicle showing any signs of yielding or changing their position; sometimes other drivers are simply indecisive?

Emergency vehicle operators can help other drivers by remaining predictable and signaling their intentions. Use all means of signaling – lights, sirens, turn signals, lane position, and eye contact or hand signals. As you approach stopped traffic, try to select your lane in advance and position the apparatus accordingly. Be decisive. Avoid weaving back and forth behind stopped traffic as this only increases the chance a civilian motorist will inadvertently switch lanes in front of your approach. Signal the emergency vehicles intent <u>at least</u> one block in advance of an urban intersection and five seconds in rural areas.

Intersections require drivers to constantly scan the roadway, the median, the shoulders, the cross streets, and the mirrors to identify obstacles. Be constantly aware of other responding apparatus, including police units. As you get closer to the incident scene the more likely you are to meet other units at an intersection. This situation can be especially confusing to motorists as they are now faced with yielding to vehicles from multiple directions. Do not forget to scan for bad road surfaces, bicyclists or pedestrians, animals, and diminished clearances (road signs overhanging the road, parked vehicle mirrors or accessories).

Ultimately, emergency vehicle operators must be prepared to some degree to stop at every intersection they encounter. Controlled intersections with stop or yield signals working against the travel route of the apparatus mandate the ability to stop in a controlled manner, however apparatus drivers must constantly search for conditions that could require yielding the right-of-way to avoid a collision.

TURNING VEHICLES AROUND

Any type of turnabout within open travel lanes exposes the apparatus to a collision. Be extremely cautious about passing through parking lots to turn around as they often have limited space, congested traffic lanes, and lots of pedestrians. Residential driveways can also be problematic as they are rarely constructed to hold the weight of heavy apparatus. Choosing a safe location to turnabout is important; choose an area with good visibility. You should have a clear view of the entire path of travel and all traffic lanes. Avoid hills, curves, and blind intersections where motorists may approach your apparatus with almost no warning.

Operators must become familiar with the turning radius of their apparatus to judge what type of turn around maneuver is appropriate or feasible. The types of turnabouts include the U-turn and the three-point turn.

- The *U-turn* is advantageous as it allows the apparatus to avoid backing. It requires a wide roadway and good visibility. Drivers must also remain aware of road signs or other unanticipated obstacles that hinder the turn. Beware of civilian vehicles entering blind spots when swinging wide for a U-turn; most drivers are not anticipating your maneuver. Look for other vehicles approaching from the driver side rear before you begin to turn. Highway median U-turns should only be used during emergency response.
- The *three-point turn* should only be used when the road is too narrow for a U-turn and other efficient options are not available. Three-point turns in open travel lanes need to be avoided as they tend to be done in a hurry and often a spotter is either not used or becomes exposed to uncontrolled traffic. Impatient or unaware motorists may strike the apparatus broadside or end up behind the apparatus during backing. The opportunity for a negative outcome is significant.

SAFE FOLLOWING DISTANCES

Emergency vehicles need a safe following distance during travel to provide the operator time to react to conditions. A safe following distance allows the apparatus to stop or change lanes in a controlled manner without hitting the vehicle ahead should they stop or slow unexpectedly. Rear-end collisions are almost always avoidable when drivers pay attention and maintain good distances. If the proper distance is observed, left and right lateral evasive and other abrupt anti-collision maneuvering is minimized and unnecessary. Emergency vehicle operators must respect that their apparatus is considerably larger in dimension and weight than passenger vehicles. These differences create much larger forces working acting upon the vehicle and thus larger forces to stop the vehicle. The larger forces translate into longer stopping distances.

Drivers must recognize that a safe following distance accounts for their perception time, reaction time, and braking time/distance. Before any braking can occur, the driver must *perceive* a need to brake. This requires the driver to be alert and scanning ahead. *Reaction time* is the period between recognition of a hazard to the time brake application begins. Average drivers require about ¾ second. Air brake systems lengthen reaction time by ½ to 1 second due to lag within the system. The driver's ability to perform under stress and the drivers' experience are also factors that influence reaction time. Before the brakes even engage as much as 2 ½ seconds may elapse, which equates to nearly 150 feet of travel distance at 40mph.

Braking distance is the distance traveled from the first braking action until the vehicle comes to a full stop. Braking distance varies nearly infinitely due to the factors involved. Vehicle speed, weight, mechanical condition, and tire condition are all factors. Road surfaces, weather, and the driver are also factors that affect braking distance.

An appropriate following distance will allow enough time to come to a full stop if the vehicle ahead of you comes to a sudden stop. One way to estimate a safe following distance for an emergency vehicle is the “four second rule”. The four second rule maintains a separation of at least four seconds between the emergency vehicle and the vehicle ahead up to speeds of 40mph. For each additional 10mph another 1 second is added to increase the separation. In adverse weather conditions, add another 1 second per 10mph.

The four second rule is simple to apply. When the vehicle traveling ahead passes a fixed object, begin counting the seconds. Stop counting when your vehicle passes that same fixed object. Compare this time to the recommended time established by the four second rule to reasonably approximate your safe following distance.

Under routine operations when stopped at an intersection leave enough space between you and the vehicle in front of you. This allows you the ability to go around vehicles when responding to a new call.

Policy and rules cannot replace sound judgment by the driver. Time and spacing requirements are affected by too many variables to be addressed by more than guidelines. Traffic density or volume, road surface conditions, hazards, roadway design, and speed limits influence the following and stopping distances. When conditions get bad, add more distance.

PASSING ANOTHER VEHICLE

Emergency vehicles are constantly overtaking other vehicles during routine and emergency driving. In this section, the term “passing” references situations where the emergency vehicles must change lanes or make another maneuver to go around another vehicle. Some considerations to address before passing include:

- Is it necessary to pass?
- Is there a pressing need to “get around” the vehicles ahead, or is it related to driver impatience?
- Will vehicle traffic ahead move out of your lane in response to your audible/visual warning devices, negating the need for passing?
- Is there sufficient space and sight distance to change lanes?

- Does the emergency vehicle have enough acceleration ability to complete the maneuver, or will you simply find yourself trapped beside the other vehicle?

Roadway features can aid when making the decision to pass. Pay attention to:

- Highway signs - No Passing, Intersection Ahead, etc.
- Pavement markings - solid centerline, broken centerline, etc.
- Road configuration - hills, curves, intersecting roads, etc.

If "No Passing" is advised, the transportation engineers have identified features that could create an unacceptable level of risk for a collision. Often "no passing" areas are established as the result of prior collision history on that road. Never blindly pass a stopped car or line of cars without knowing why they are stopped. Fire department vehicles are not exempt from stopping for school buses loading or unloading passengers. In any situation avoiding mishaps is optimal. The following are some good tips to avoid mishaps when passing:

- Pass assertively. Do not hesitate as conditions change rapidly.
- Stay in the passing lane the shortest time possible.
- Constantly scan the roadway for unmarked, intersecting roadways.
- Mentally note the location of each vehicle you pass so you can identify in the mirror when you've cleared the final vehicle. Visualize their location in relation to the side of the apparatus.
- In non-emergency situations it is often better to decelerate and merge behind other vehicles than to attempt to accelerate past.

EXPRESSWAY OPERATIONS

The term expressway includes interstates, freeways, turnpikes, or any other type of limited access multi-lane high speed roadway. Entering and exiting expressways require the operator to make quick and accurate decisions in rapid succession. Expressway traffic is often driving more than posted speeds and exposes emergency vehicles to traffic that is much more agile.

Entering and exiting expressways is generally accomplished via ramps with varying lengths of acceleration or deceleration lanes. These ramps can be some of the most difficult areas to navigate in larger vehicles as one group of vehicles is slowing down to exit while another set is accelerating to enter. When entering or exiting the expressway, you must monitor the road ahead while simultaneously checking your mirrors. Key points to remember while merging on an expressway:

- Use your mirrors to keep track of adjacent lanes.

- Always be prepared to stop suddenly.
- Look well in advance of your current position.
    - o **Note** vehicles that are approaching the merge area and identify gaps for your merge.*
- Adhere to ramp speed limits. Beware of signage indicating roll-over hazards or sharp curves.

Beware that warning devices may startle other motorists as your apparatus approaches from a ramp. Other vehicles may stop suddenly or change lanes in panic. The curve of a ramp and presence of overpasses or sound walls makes visual and audible warning devices less effective. Expect to merge into the flow of traffic as normal, assess traffic flow, and then decide your best lane or approach. Remain predictable to other drivers and avoid weaving from one lane to another.

DRIVING AT HIGH SPEEDS

Driving at highway speeds or in excess of the posted speed limits presents significant hazards to emergency vehicles. Exceeding a posted speed limit is a privilege granted only during emergency response and should only be done with due regard for the safety of other motorists and the emergency apparatus. In all cases, consider the following:

- Posted speeds are based upon the roadway characteristics in good weather conditions.
- Gain and lose speed in straight lines, not in curves.
- Recognize when stopping distance exceeds sight distance. Sight distance is not under the driver's control, but stopping distance is controlled by speed.
- Driving at higher speeds increases the potential for heavy or excessive braking action that may lead to brake fade.
- Higher speeds result in higher momentum and shift in the center of gravity for a large vehicle.

A moving vehicle naturally wants to stay in a straight line. As a vehicle enters a turn inertia results in centrifugal force that pushes the vehicle in a straight line rather than turning. This centrifugal force increases exponentially with speed. When the centrifugal force becomes too high, the vehicle will either slide or roll over. For every curve or turn, there is a maximum speed for traveling through the curve safely. The tighter the curve, the higher the potential centrifugal force, therefore the slower the vehicle must travel. Roadways are sometimes built with a slight side grade to the inside of the curve that aids in countering the centrifugal forces working against the vehicle. If the road is graded toward the outside of the curve this will work against the vehicle and require even slower speeds. In addition to the grade of the surface, the type and condition of the road surface plays an important role in maintaining sufficient traction in turns.

Due to land availability or restrictions, designers often lay out curves in a decreasing radius pattern. This is a design by which the turns start out with a relatively large radius (curve) that tightens as the vehicle passes through the curve. On decrease radius curves, the maximum entry speed is too fast for the later (tighter) portion of the curve. If the speed is too high for the tighter portion of the curve, physics will cause the vehicle to slide or roll over. Drivers must recognize when a ramp or curve is decreasing in radius.

To better define the safe mechanics of transitioning a curve, the following is a breakdown of a curve and proper techniques to pass through it.

Entry: Brake or decelerate to the proper entry speed *before* entering the curve. Enter the curve as far to the outside as possible. Entering on the outside of the curve effectively increases the radius of the track for the vehicle. The greater the radius, the faster the turn can be safely negotiated. Begin the turn as early as possible.

Transition: If the maximum safe speed to maintain control passing through a curve has been attained, the emergency vehicle operator experiences full control of the vehicle. The maximum "safe" speed is not the maximum "possible" speed that conditions will allow. When approaching maximum possible speeds, it will feel as though the suspension is straining. Do not apply aggressive braking. Allow natural friction of the engine and compression to slow the vehicle down. If you are traveling at near maximum speed in a curve, a relatively small event (e.g. some sand or gravel on the road) can cause complete loss of control. Once in the curve, it is best to coast at speed to maintain maximum traction. Attempting to accelerate while in turn can result in loss of steering control and traction at the rear wheels.

Exiting: Exiting curves requires the vehicle operator to keep the vehicle's speed steady. Maintain position on the inner surface of the curve. Gently accelerate out of the curve after the apex has been reached and the vehicle is on a straight path.

Stopping at higher speeds requires more stopping distance and is harder on the braking systems. Things to consider when braking at high speeds include:

- Braking creates friction that results in heat.
- Overheating in the brake system reduces braking effectiveness.
- Reduce the stress on brake systems by engaging auxiliary braking systems and downshifting the transmission.
- Drum brakes typically fade more quickly than disc brakes due to differences in heat dissipation capability.

HANDLING UNUSUAL AND DANGEROUS DRIVING SITUATIONS

Driving In Adverse Conditions

Emergency vehicle operators cannot choose to avoid driving in weather conditions that would normally stop civilian drivers. Adverse conditions can be categorized as follows:

- Traction Implications
- Environmental Hazards
- Vision Implications

Emergency vehicle drivers must adjust their driving techniques for all adverse conditions as well as adjust the auxiliary braking systems that may be on their unit. The driver's primary responsibility is the safety of the passengers and arriving safely at the incident. Slow down and drive at a speed reasonable and appropriate for the conditions. Increase following distances and drive smoothly with any vehicle to avoid sudden and dramatic maneuvering.

Traction Implications: Traction can be adversely affected by a variety of conditions. Any materials or changes in the road surface will alter the friction between the road and the tires.

- Rain: In addition to oil buildup, water forms a layer that builds between the tires and the road surface. As little as 1/16th of water can cause hydroplaning of a vehicle. Standing water may also impact steering, braking, and general vehicle operation.
- Chemicals: Road surfaces may have any number of chemicals, but the most common are oil, grease, and fuel. Chemicals can be particularly problematic early in the onset of wet weather before the rain washes away the residue.
- Snow and Ice: Snow, slush, and ice create variable road conditions resulting in reduced traction for vehicle tires. Certain roadway features such as bridges or shady areas may accumulate snow or ice prior to other parts of the travel way.
- Leaves: Leaves or other vegetation debris can create slippery conditions when allowed to accumulate on the road surface.

Whenever conditions have caused a reduction in traction, the driver must reduce speed: and, steer, accelerate, or brake smoothly and evenly. The required stopping distances multiply depending on the condition of the road surface.

Environmental Hazards: Adverse handling could be caused by natural conditions such as high winds, vegetation, and the contour of the terrain. Road construction and design are examples of manmade conditions.

Vision Implications: Conditions that affect visibility include low-light driving, precipitation, vehicle construction, and the condition of the driver.

- Low-light Driving: Low-light conditions create various challenges: hidden hazards; increased difficulty in judging the speed of other vehicles, and distance; limited highway lighting; and glare from roadside lights. Even with these limitations and possibly impaired vision, a few simple rules can help the driver compensate.
- Dim dash and cab lights at night.
- Reduce speed.
- Keep headlights and windshield clean.
- Recognize the blind spots created by the vehicle characteristics.
- Look beyond the headlights.
- Keep your eyes moving and scan continuously.
- Precipitation: Rain, fog, and snow reduce visibility. In addition, rain and fog increase glare both during the day and at night especially with the use of emergency lights. During the day when the sun is out, the snow on the ground creates a considerable glare as well. Poor visibility conditions require the operator to:
    1. Drive slowly but keep moving.
    2. Turn headlights (low beams only) and wipers on.
    3. Use four-way flashers if traveling 15 mph or more below the posted speed limit.
    4. Watch for cars ahead that are moving very slowly.
    5. Avoid decelerating suddenly.
    6. If you must pull off the road, use four-way flashers and warning lights.
    7. Use the defroster or air conditioning to minimize fogging on the inside of the windows.

CONTINGENCY SITUATIONS – CAUSES AND PREVENTION

Contingency situations can arise at any time. A contingency situation is described as a possible future event, condition, or an unforeseen occurrence that may necessitate special measures. When they arise, normal traffic flow may be suddenly interrupted and the safety of all people in the general area is diminished. Emergency vehicle operators must be familiar with contingency situations that occur most often, and to understand the actions that can be taken to minimize to reduce their impact. Five common contingency situations are:

1. ***Vehicle malfunction or component failure**:* Thorough pre-trip inspections are the key to reducing roadside emergencies. Inspect the vehicle at the beginning of every shift and note any deficiencies. Correct any deficiencies that are easily fixed

in the station.

2. ***Change or deterioration in the road**:* The key to managing changing road conditions is to expand your look ahead distance to recognize approaching hazards. Remain alert, scan well ahead, and look for clues like construction signs or skid marks on the road. Operators must also remain aware of projects or existing conditions in their response district so they can anticipate poor conditions.

3. ***Obstacle in the roadway**:* Be prepared for an appearance of obstacles in the road (e.g. pedestrians, other vehicles, animals, etc.). In congested urban areas anticipate hazards appearing from side streets, alleys, parking garage exits, or between parked vehicles. Rural roads present more opportunities for animals or debris to enter the roadway.
4. ***Weather change**:* The DC Metro area presents widely varying and sometimes unpredictable weather conditions. Cold weather brings ice or snow. Summer storms bring the threat of hydroplaning and debris from high winds.
5. ***Driver error, inattention, and inexperience**:* Fatigue is a significant factor for drivers operating on shift work. Operators must determine for themselves when they are too tired, too sick, too stressed, or otherwise physically or psychologically unprepared to operate an emergency vehicle.

HANDLING CONTINGENCY SITUATIONS

Emergency vehicle operators must be prepared to encounter unusual situations or conditions. The nature of vehicles combined with the environment offer endless variables that impact safe operations.

Evasive steering and skidding often occur when avoiding pedestrians, animals, vehicles, or other obstacles. These reactions usually occur because the driver either failed to recognize an impending hazard or the hazard appeared so suddenly that it was unavoidable. A driver in this situation needs to weigh the risk versus reward of their action. Is it worth risking loss of control of the vehicle to avoid a collision with a small animal?

The vehicle driver must constantly scan ahead and to the sides of their vehicle to identify escape routes in the event that braking is not going to avoid a collision. Beware that the crest of a hill, curves, and intersections limit your ability to identify escape routes and therefore reduce your options.

When braking will not avoid a collision, evasive steering may be employed to avoid or minimize the impact of a collision. Operators need to become accustomed to maintaining their hands at the 9 and 3 o'clock position on the steering wheel. This will allow the largest possible turn without moving the hands. The 10 and 2 o'clock positions are more comfortable, but the 9 and 3 o'clock position allows maximal directional control. Evasive steering occurs in two phases; to avoid a collision, turn the steering wheel sharply in the direction of the escape route and then counter steer as soon as the vehicle is clear of the obstacle. If a collision is unavoidable, choose an object with which to collide. When facing such a choice, the operator must rapidly decide which course and object(s) will result in the least severe collision. Head-on collisions are the most damaging collisions because the entire force of the striking vehicle is applied to the fixed object. A side swiping or indirect collision allows the energy of the collision to dissipate over a long distance since the vehicle remains in motion. Impact absorbing objects are better to choose than large immobile items that will not "give". Some examples of impact absorbing objects are parked cars, bushes and shrubs, guardrails, and small signs. Examples of nonimpact- absorbing objects include bridge abutments, retaining walls, buildings, large trees, and utility poles.

In addition to evasive steering, there are two other forms of maneuvering to avoid collisions – *emergency braking and evasive acceleration.*

- ***Emergency braking****:* The goal for emergency braking is to produce the shortest possible stopping distance without locking the wheels or losing control. The threshold braking method for accomplishing this is hard pressure to the brake pedal without locking the wheels. Modulate the pressure on the pedal. Apply steady pressure to the point of locking and then release pressure slightly to get rolling traction. If the wheels lock, **release the brake pedal.** A vehicle with ABS does not require threshold braking because the computer will not allow the brakes to lock up; a steady pressure should be maintained on the pedal. Remember that a rapid stop could cause a rear-end collision; however, this is preferable than hitting a pedestrian. Remember the action vs. outcome formula.
- ***Evasive acceleration****:* Evasive acceleration means a quick burst of speed. It can be used to avoid collision with side approaching or merging vehicles. When a vehicle is approaching from the side or merging, increasing speed can often avoid a side impact collision.

HANDLING SKIDS

While weather or road conditions may increase the possibility of skidding, skids are generally caused by one or a combination of these factors:

- Sudden change of speed or direction
- Change of speed or direction under conditions of poor traction
- Weight shift in the vehicle
- Poor tire condition
- Improper tire inflation
- Failure to identify a hazard through inattention
- Improper application of the brakes

To help regain control no matter what type of skid is occurring, ***STAY OFF THE BRAKE; STAY OFF THE ACCELERATOR; AND COUNTERSTEER!*** Steer in the direction that the vehicle's rear end is skidding.

There are two key elements to effective counter steering:

1. The steering wheel does not have to be turned violently to correct a skid. This a common "panic" reaction, and further trouble arises because the rear tends to skid back and forth (fishtailing).
2. After the initial effort to counter steer, it may be necessary to immediately steer in the other direction to help recover.

Skids can be generalized into four categories:

- **Braking skids:** This skid occurs when sudden, hard brake pressure is applied causing one or more of the vehicles to lock. Regardless of how many wheels lock, some control of the vehicle will be lost. If all wheels lock evenly or if just the front wheels lock, the vehicle will continue in a straight line on its prior trajectory unless influenced by some other force (e.g. a dip in the road). If just the rear wheels lock, the vehicle will tend to spin around and end up facing the opposite direction. If a braking skid occurs:
    - Release the brakes immediately in an attempt to regain traction; this will return the ability to steer and attempt further braking.
    - If braking is still necessary, use less pressure to avoid the wheels locking again.
- **Power skid:** The power skid occurs due to sudden, hard acceleration. Since fire apparatus is typically rear wheel driven, sudden acceleration can cause the rear wheels to lose traction. The back of the vehicle may skid to one side, trying to overtake the front end. The tendency for the rear end to slide will be greatest if the front wheels are turned. The vehicle may even spin all the way around. If a power skid occurs:
    - Release the accelerator.
    - Steer in the same direction as the rear end is skidding.
    - Counter steer to straighten the vehicle.
- **Cornering Skids:** Cornering skids (also called yaw skids) occur when speed is too great, or traction is insufficient to keep the vehicle on the intended track around a curve. While the name "cornering" implies travel through an intersection, these skids can also occur on highway ramps or any area where the roadway changes direction. A vehicle naturally wants to follow a straight line and must be forced to follow the intended path around the curve through traction with the road surface. Much like a braking skid, a cornering skid may involve one or more wheels with the vehicle reacting accordingly. If a cornering skid occurs:

  - Release the accelerator.
  - Avoid the temptation to abruptly apply the brakes as this may further reduce traction; it is best to allow natural forces to slow the vehicle.
  - Light application of the brakes may be necessary, but needs to be done cautiously to avoid full loss of control
  - Counter steer as necessary to regain the desired trajectory.
- **Hydroplane Skids:** Hydroplane skids occur when the tire is moving too fast for the water on the road to escape into the tire tread and permit direct contact between the rubber and the road. A small wedge of water builds up in front of the tire and lifts it off the road surface. The water then effectively forms a barrier between the tire and the road surface. Hydroplaning can occur on minimally wet surfaces at speeds of 25 mph. Vehicle reaction during a hydroplane skid is hard to predict. As in all skids, there are varying degrees of brake and/or steering control. A hydroplane skid may not even be perceived by the driver unless the driver attempts to brake or steer. If a hydroplane skid occurs:
  - Release brake and/or accelerator.
  - Allow the vehicle to slow naturally. The vehicle will drop through the water barrier and regain contact with the road surface.

OTHER VEHICLE EMERGENCIES

There are a number of other emergencies that can occur while in transit. The following are some possible emergencies and ways to control them:

- **Rapid Tire Deflation:** Rapid tire deflation is most hazardous when it occurs on the steering axle. The vehicle can violently pull to the side of the blowout or deflated tire. The vehicle will pull to the side of the deflated tire because the flat tire grips the road with more rubber (and more friction) an acts as a pivot. As soon as deflation is detected, the driver should begin to slow the vehicle gradually while seeking a safe area to stop. Anticipate difficult steering and be prepared to make firm movements with the steering wheel. Avoid aggressive braking as they may further disrupt vehicle control.
- **Brake Failure (non-ABS hydraulic brakes):** Brake failure in hydraulic brake systems generally results from neglect or deterioration of the system. For systems that are not ABS, pumping the brake pedal rapidly during a failure may build up enough pressure (fluid) in the system to provide minimal braking action. Leave any auxiliary braking systems engaged and down shift to allow the transmission to slow the vehicle. As a last resort once the vehicle has slowed, rub the tires against a curb for additional friction. For vehicles equipped with hydraulic service brakes, but an air parking brake another last resort is to apply the parking brake. Beware that applying the parking brake can lock up the wheels abruptly and cause the vehicle to skid.

- **Brake Failure (ABS hydraulic brakes):** Anti-lock braking systems (ABS) have similar characteristics to non-ABS except they are controlled by a computer system. In the event of a computer failure in the ABS, they are designed to simply behave like a conventional braking system and will continue to stop the vehicle. If a mechanical failure occurs in an ABS equipped vehicle apply steady firm pressure to the brake pedal. Pumping the brakes on an ABS equipped vehicle may actually lengthen stopping distance. Leave any auxiliary braking systems engaged and down shift to allow the transmission to slow the vehicle. As a last resort once the vehicle has slowed, rub the tires against a curb for additional friction. For vehicles equipped with hydraulic service brakes, but an air parking brake another last resort is to apply the parking brake. Beware that applying the parking brake can lock up the wheels abruptly and cause the vehicle to skid.
- **Brake Failure (Air brakes):** Failure of air brake systems can be the result of loss of air, contamination in the air system, or overheating of components. A catastrophic loss of air will result in the spring (parking) brake applying abruptly and potentially locking up the rear wheels. A partial system failure is more common and causes poor brake performance. Contamination of the air system may result in decreased performance of parts of the system if air lines become clogged or air capacity is reduced. Overheating of the brake pads or shoes occurs when the system is stressed by repeated heavy braking, such as an emergency response through traffic or in long downhill runs. Overheated brakes have a unique odor that most heavy apparatus operators recognize. Overheating results in brake “fade” and the vehicle will not slow down as efficiently because the friction applied by the pads or shoes is reduced. In severe cases, braking ability is essentially lost and the pads or shoes can be permanently damaged. If an air brake system is experiencing a failure, use similar approaches as for an ABS equipped hydraulic brake vehicle. Do not pump air brake systems; this will only reduce the air supply. Leave any auxiliary braking systems engaged and down shift to allow the transmission to slow the vehicle. As a last resort once the vehicle has slowed, rub the tires against a curb for additional friction.
- **Transmission Malfunctions:** Complete transmission failures are rare unless the driver shifts between reverse and forward gears without allowing the vehicle to stop first. Most electronic transmissions have built-in features to prevent such damage. Vehicle operators need to recognize and address early indications of trouble in the transmission (e.g. slipping, thrusting etc.).
- **Steering Malfunctions / Failures:** The most common failure in a steering system involves the hydraulic power steering assist. A power steering failure occurs when the engine stalls, fluid in the system is low, or when the belt that drives the system flips or brakes. In a power steering failure, the mechanical steering remains functional, however turning the steering wheel will require considerably more effort. Sudden mechanical failure of steering system components seldom occurs when proper pre- trip checks are conducted. If a failure occurs in the steering, slow the vehicle and stop as quickly and smoothly as possible.
- **Accelerator Sticks:** If the accelerator sticks, the driver should attempt to release

the pedal by tapping on it with their foot. The next move is to pull the pedal up with their foot. Do not attempt to reach down and pull the pedal as this is likely to result in loss of control of the steering. If the pedal cannot be reset, shift the transmission to neutral and slow the vehicle to a stop. Avoid shutting the motor down until the vehicle is stopped as braking and steering will be more difficult.

- **Wheels off the Road:** Numerous roadways within the County do not have curb and gutter, therefore the pavement transitions to a soft shoulder of gravel or dirt. The shoulder may be immediately adjacent to the white line, or the pavement may extend to offer a hard shoulder beyond the white line. Roadways with no hard shoulder pose a significant hazard to large vehicles. Many roll-over crashes involving fire apparatus are the result of over-correction after a set of wheels has dropped off the paved portion of the road and onto a soft shoulder. When the wheels have left the road, the vehicle will tend to pull toward the shoulder. The driver must hold the steering wheel firmly and avoid the temptation to counter steer in panic. The driver should release the accelerator and attempt to bring the wheels back onto the pavement through small steering inputs. These inputs would be similar to those used for a gradual lane change. A large steering input could cause the vehicle to lose control and enter a sideways skid.
- **Dashboard Warnings:** Apparatus operators must be familiar with the various warning lights and messaging screens associated with vehicle monitoring systems. In general, amber or solidly displayed dashboard warnings are advisory while red or flashing dashboard warnings require immediate action. Consult the manuals for your specific apparatus for detailed instructions. Operators should also know what normal operating ranges apply to the gauges and recognize when a vehicle is displaying abnormal “vital signs”.

PARKING PRECAUTIONS

Position of an emergency vehicle on an emergency incident is crucial. While apparatus is often positioned based upon function and assignment the operator must also consider traffic hazards. Utilize onboard cones and flares to enhance the work zone around the apparatus. Park the apparatus to serve as a barrier between oncoming traffic and dismounted personnel. EMS and smaller units should be protected by heavy apparatus whenever possible. When parking on a shoulder or a curb lane, even slightly angling the apparatus helps to keep the crew from opening their doors into open traffic lanes.

When apparatus is exposed to an open lane of traffic or while on an incident, all warning lights should be illuminated per standard procedures. When a unit is parked during a non-incident situation, drivers must exercise good judgement when selecting a parking spot and attempt to adhere to all applicable traffic laws. Apparatus operators need to avoid blocking travel lanes or reducing sight distances near intersections with their parked unit. Parking lots are typically very difficult for apparatus to navigate. If using parking lots, consider staying on the outer fringes of the traffic area to reduce exposure to confined areas and higher levels of vehicle traffic. Do not park in fire lanes or other areas that expose the apparatus to civilian vehicles backing out of parking spaces.

When positioning apparatus, some additional considerations must be considered:

- Reduced sight distances due to terrain, vegetation, buildings, vehicles, road configuration may require additional cones or other apparatus to position ahead of the scene.
- Control all avenues of approach around the apparatus. Recognize where intersections or driveways allow civilian vehicles to approach from multiple directions.

- Angle the blocking engine in a way that naturally diverts traffic to the open lane.
- Beware of blinding oncoming drivers with apparatus headlights or scene lights.
- Use a mix of traffic cones and flares as necessary to keep civilian vehicles out of the scene. Flares help illuminate adjacent cones at night but also can serve as effective barriers during daylight hours.

Safety Reminder – When operating outside the protective shadow of a blocking unit you greatly increase your risk of being struck by a vehicle. **Never** turn your back on approaching traffic. Always face traffic when setting up and removing traffic control devices.

Out of Service Criteria

CLASSES OF FLUID LEAKAGE

Class 1: seepage of fluid; not enough to form drops

Class 2: leakage great enough to form drops; drops do not drip

Class 3: leakage great enough for drops to drip

ENGINE COMPARTMENT

- Air filter restriction indicator that shows maximum restriction after resetting
- Engine system that has significant leakage of oil
- Oil that contains coolant
- Oil that is diluted with fuel
- A fuel system component that has Class 2 leakage of fuel
- Cooling system component that has Class 3 leakage
- Coolant that contains oil
- Radiator that is loose
- Cooling fan that is loose or cracked
- Transmission fluid that contains engine coolant

INTERIOR CAB

- Defective or damaged driver's or officer's seatbelt
    - Must be enough functioning belts for each crew member
- Cracked or broken windshield that obstructs the driver's/operator's view
- Missing or broken mirrors that obstruct the driver's/operator's view
- Windshield wipers that is missing or inoperable
- Steering wheel that has a deficiency affecting the drivability of the vehicle
- Door latches that are defective
- Defrosters that are inoperable
- Accelerator that is inoperable or defective

- Oil pressure, engine, and/or transmission temperatures that cannot be monitored or verified
- Engine or Transmission that is overheating
- “Stop-engine” warning light that remains illuminated after engine is started
- Speedometer that is inoperable
- Automatic transmission that has a “Do not shift” light on
- Charging system that fails to maintain 12 volts
- Air gauge or audio low air warning device that has failed or is inoperable when air pressure < 60psi (vehicles with air brakes)
- ABS warning indicator that is activated. (The warning indicator generally indicates that ABS is inoperable and the vehicle should be driven as such.)
- Brake warning light that is activated or brake pedal that falls away or drifts toward the flooring when brake pressure is applied
- No operable audible DOT warning devices (at least either the electric horn or the air horn, if so equipped, must be operable)
- No operable audible emergency warning devices (at least the electronic siren, or the mechanical siren, if so equipped, must be operable)

VEHICLE WALK AROUND

- Door latches that are defective
- Tires that have cuts in the sidewall that penetrate to the cord
- Tires that have a tread depth of 4/32” or less on any steering axle at any two adjacent major tread grooves anywhere on the tire
- Tires that have a tread depth of 2/32” or less on any non-steering axle at any two adjacent major tread grooves anywhere on the tire
- Any tire that is flat or has a detectable or audible leak
- On dual wheel tires: tires that are touching sidewall to sidewall when properly inflated
- Wheel studs missing or loose wheel lugs
- Wheels that are cracked, bent, and/or broken that affect drivability
- An axle with a hub seal that has any Class 3 leakage or an empty reservoir
- Fuel cap is missing or does not seal to prevent spillage

UNDERCARRIAGE

- Defective body or cab mounts
- Defective suspension components
- Steering components that are defective affecting the vehicle handling
- A steering component that has a Class 3 leakage
- Driveline components that are defective
- Axle flanges that have Class 3 leakage
- Exhaust components that are broken or hanging
- Exhaust components that are leaking causing exhaust fumes to enter the cab or patient compartment
- Tires that have cuts in the sidewall that penetrate to the cord
- Any tire that is flat or has a detectable or audible leak
- On dual wheel tires: tires that are touching sidewall to sidewall when properly inflated
- Wheels that are cracked, bent, and/or broken that affect drivability
- Fuel tank, mountings, or straps that is defective
- Transmission components that have Class 3 leakage of transmission oil
- Braking system components that are defective
- Brake system components that have Class 2 leakage of brake fluid
- Friction surfaces, brake shoes, or disc brake pads that have grease or oil on them

OPERATIONAL CHECK

- Braking operation that is ineffective
- Parking brake operation that is ineffective
- Insufficient DOT lighting to clearly mark the vehicle
- Insufficient warning lighting to clearly indicate emergency response
- Turn-signal is inoperable
- Air compressor that fails to build or maintain air pressure.

Winter Weather Driving

The Carroll County area presents several challenges during cold weather that can impact emergency vehicle operations. The area most often experiences winter precipitation that changes form throughout a storm, i.e. starting as rain changing to snow or ice. There is also frequently a freeze-thaw cycle following storms that cause roadways to clear and then become slippery again. Personnel must also recognize that the geography of Carroll County makes it possible to have widely differing road conditions from one side of the County to the other. Apparatus operators need to be ready and able to manage winter weather operations, so service delivery is not impacted.

DRIVING IN WINTER WEATHER

- SLOW DOWN, SLOW DOWN, SLOW DOWN. Increase your following distance. You need more time to see, more time to stop, and more time to maneuver.
- Turn off the jake brake or retarder during ice and snow conditions to prevent wheel spin.
- Avoid sudden or sharp steering, acceleration, or braking by knowing where you are going, slowing down, and expanding your look ahead distance.
- Snow reduces traction; however, ice may eliminate it. Ice often accompany or follows snow in the area.
- Especially where ice is present, apparatus will slide when parked. If parking on a grade that is coated with ice or snow is necessary, operators need to take precautions such as placing the tires against a curb, placing wheel chocks on the downhill side of tires, and even placing a tire or two off the pavement to an area of increased traction.
- When an especially treacherous area is identified that impacts a response, such as the street in front of a residence is iced over, communicate to other incoming units to avoid committing to it. This is particularly helpful in areas with lots of hills or valleys that can trap units.
- Deep snow and plow rows can create enough lift beneath a vehicle to cause the tires to lose traction. During extreme conditions consider remaining on main or plowed roadways and using alternate methods, i.e. walking, to reach a scene.
- If the vehicle becomes stuck, some things to try:
    - Quickly assess if your situation will have a negative effect on other apparatus or an incident and provide a Conditions-Actions-Needs report to the Incident Command via radio; do other units need to find another route?
    - Back out or alternate forward and backward movement to try and “rock” the vehicle to better traction
    - Use integral vehicle systems to assist with traction, i.e. differential locks,

disable traction control, inter-axle locks

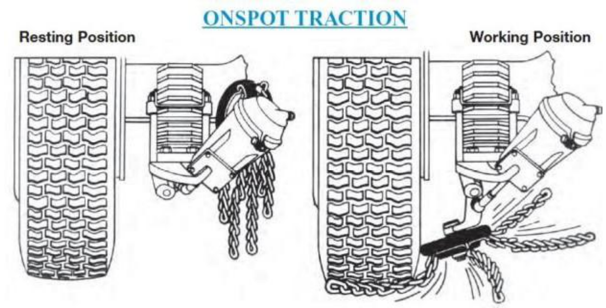
  - Stop, get out, and shovel under and around the apparatus
  - If the vehicle is equipped with standard tire chains avoid repeatedly and rapidly spinning the tires; this will destroy the chains
  - If the vehicle is equipped with automatic tire chains spinning the tires is required to put the chains below the tires
  - Remain patient and assess the need for assistance based upon the situation; frustration leads to poor decisions

- Roadways may appear wet when they're ice. If there is doubt about the surface conditions approach with the assumption of the worst-case scenario.
- Snow piles created by plowing are typically very dense and freeze solid. Striking a snow pile will be like striking a landscape boulder.
- Use the mirror heaters to keep the mirror from fogging when transitioning from the bay to the outdoors, and to evaporate ice or water from the face of the mirror.
- Keep the dashboard clear so the defroster can work. Do not block the vents with helmets, gloves, hoods, clipboards, traffic vests, towels, or any other items.
- Know how the climate controls work in the apparatus and engage the defroster before departing the firehouse. Attempting to find the defroster controls while traveling down the road leads to distractions and confusion in the cab.
- Pulling down the sun visor helps trap the warm air from the defroster near the top of the windshield. This is especially useful when driving in active precipitation.
- Keep the interior of the cab windows clean for quicker de-fogging.
- Top off your windshield washer fluid reservoir. The washer fluid not only keeps your windshield clean, but it can also work as a de-icer for your wipers and the glass.
- Refresh on the functions specific to your apparatus that may be needed in poor traction such as; all-wheel drive, automatic chains, inter-axle locks, differential locks, and automatic traction control.
- Carry a window scraper on the apparatus in case clearing the windows becomes necessary during a prolonged incident.
- Carry a scoop or snow shovel on the apparatus to assist if the apparatus becomes stuck.
- Roadway safety is always important for personnel working outside of apparatus; however, winter driving conditions amplify the dangers. Approaching vehicles may identify personnel in the roadway, however, they may not be able to avoid them. Do not position personnel where they are exposed to approaching traffic and establish shadow areas to work.

SNOW CHAINS OR CABLES

An important tool available for winter driving are tire chains. CCDFEMS apparatus have two general types of snow chains available: Automatic and Standard.

"On-Spot" or Automatic: Permanently mounted automatic chains, or "On-Spot" chains, consist of short lengths of snow chain attached to a small drive wheel that, when activated, contacts the sidewall of inside tire of the rear dual wheels. These devices rely on centrifugal force to throw the lengths of chain under the tire; therefore, the tire must be rotating for the system to aid traction.



A primary benefit of this chain system is that the driver may engage and disengage it as roadway conditions change without leaving or stopping the apparatus. An electric switch mounted in the cab provides 12 volts to an air solenoid mounted on the vehicle's frame rail. Compressed air to the solenoid is supplied from either the vehicle's onboard air system or a 12-volt compressed air kit.

When the dashboard switch is activated, the solenoid opens allowing compressed air to enter the air chamber and lower the chainwheel, so it contacts the inside of the tire. The friction between the tire and the rubber-covered chainwheel causes the chainwheel to rotate, creating enough centrifugal force to flail the chains out in front of the tire. (The principle of the system is similar to a small generator driven by a bicycle tire to operate a headlight.)

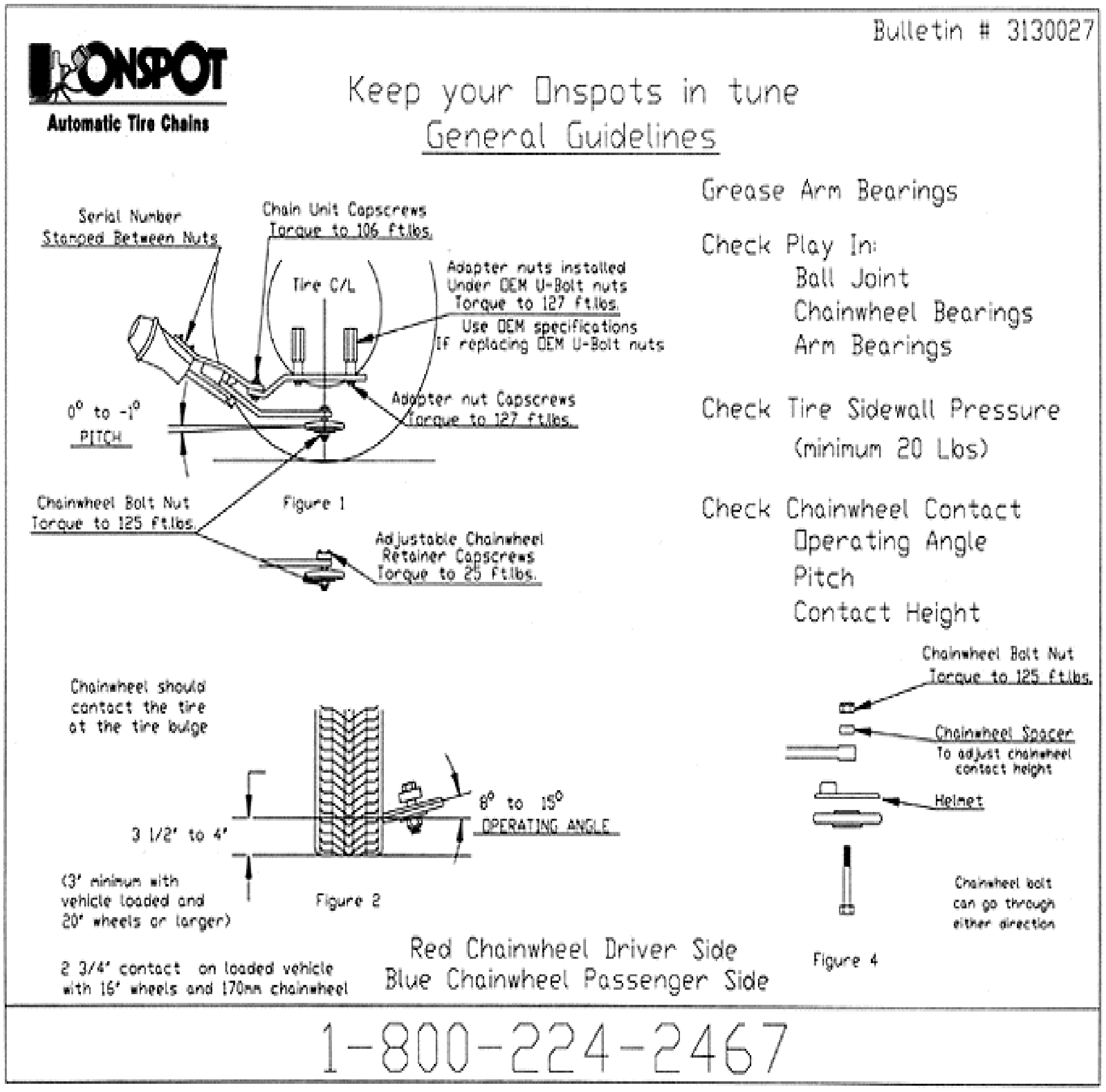
Six lengths of chain spaced at 60-degree intervals on the chainwheel ensure that there are always two (2) chains between the tire and road surface whether you are accelerating, braking or in a wheel lockup condition. The traction from the chainwheel is obtained in forward OR reverse.

When the dashboard switch is turned off, the solenoid exhausts the air provided to the chain units and return springs in the air chambers bring the chainwheels back to their resting position.

For best operation these chains **should be engaged while the unit is moving**. Automatic chains work best when the apparatus can maintain slow but steady speeds, such as in shallow snow or on intermittently clear or covered roadways.

These chains will not work well in deep snow or when conditions bring the apparatus to a crawl.

DO NOT drive faster than 25 mph when you are using "On-Spot" chains! RAISE the chains anytime that they are not absolutely necessary. Driving at higher speeds for prolonged periods will damage or destroy the "On-Spot" assembly and **will cause tire damage that may lead to failure**.



Standard Chains: Removable standard tire chains or snow chains are applied manually to the outside tire of the rear dual wheels. Standard tire chains offer better performance than "On-Spots" in deep snow, heavily rutted snow, and on ice.

On tandem axle apparatus they should be applied to the drive axle wheels however a standard rule is that we do not chain tandem axle vehicles.

Tire "chains" may also be in the form of cables which are somewhat easier to install, however offer a bit less aggressive traction in severe conditions.

Standard chains must be applied so that they are well distributed around the tire and fit snuggly. Most require some form of spring or rubber band tensioner that is added once the chains are fastened around the tire. Hanger wire or heavy-duty zip ties may be helpful to secure tire chains to the wheels.

DO NOT drive faster than 25 mph on clear pavement for any reason. Generally, units running with standard tire chains should not be on the Interstate Highways. Driving at 25 mph on the Interstate produces one hazard, while driving at higher speeds with the chains on produces another. This rule can also impact patient transport practices. Officers may consider using a chained vehicle to access patients and remove them to cleared roads where they can be transferred to an unchained unit for transport.

***Note** Do not attempt to make sharp turns with the rear differential locked while operating with tire chains. Turning can destroy the crosslinks by dragging them beneath the tire. Repeatedly spinning the tires will also destroy the crosslinks, so if the vehicle becomes stuck avoid aggressively spinning the tires if progress is not being made.*

Simultaneous use of automatic and standard chains is possible because they affect different tires, however it should be an exception and not routine. Simultaneous use should be considered if standard chains are not providing sufficient traction for the situation, such as on ice or when stuck.

Leave the windows slightly down and constantly listen for the sound of broken chains. If a crosslink breaks, stop as soon as safely possible to avoid damage to the apparatus and park in a safe location. Notify the Emergency Communications Center that you are out of service until you can repair or remove the chain.
Units should carry lengths of coat hanger wire or mechanic's wire to secure latches and broken chain sections while out of quarters.

If severe conditions dictate chains for 4x4 vehicles to safely operate most manufacturers and off-road forums recommend installing chains on front AND rear axles. We do not currently stock chains for all four tires on our 4-wheel drive vehicles. This is just for informational purposes and to expand the knowledge of our drivers. The vehicle manufacturer's guidelines should be followed in all circumstances and should be consulted BEFORE the winter season arrives to determine the suitability of tire chains and types of chains recommended. In addition to the vehicle manufacturer, the tire manufacturer should also be consulted to ensure the tires are compatible with snow chains.

In September, before the winter season, personnel should ensure the chains for their apparatus are available and they know how to install them. Improperly applied snow chains have caused significant damage to apparatus and delayed the response of units. In preparation for a winter season or predicted storm, consider these questions:

- Do you have the correct chains for each vehicle assigned to your station?
- Do you have the correct tensioners for each chain set to hold the chains tightly on the tires?

Chain Applications

The following guidelines should be followed for chain usage:

- **Less than 6 inches of snow on the ground or predicted**: Use the apparatus mounted "On-Spot" chains. Be sure to raise the chains on cleared pavement or when they are not needed for traction. Monitor the weather for changes that might produce more than 6 inches of snow and be ready to apply standard tire chains if conditions worsen.
- **6 inches of snow on the ground with more falling or forecasted**: The Shift Commander will make the recommendation and Volunteer Station Chiefs will make the order to apply the standard tire chains and **disengage** the "On- Spots".
- **Blizzard Conditions**: The Shift Commander will issue the recommendation and Volunteer Station Chiefs will make the order to apply the standard tire chains. **Do not use the "On-Spot" chains unless you are stuck and have a tire that is spinning**. Disengage the "On-Spots" as soon as you regain traction.
- **Ice**: Apply the standard tire chains and **use them in conjunction with the "On-Spots"**. Recognize that ice is by far the most dangerous road surface encountered. Allow several times your normal stopping distance and reduce speeds dramatically prior to entering turns. Carry sand, absorbent, or ice melt to improve traction in small work areas and to aid you if you get stuck. **Recognize that other vehicles moving in your proximity may not have full control**.

Section 2 – Pumping Operations

Pumping Operations

TANK WATER & EXTERNAL WATER SUPPLY

Purpose: To establish a procedure to supply an attack line from tank water, transition to an external water supply, increase flow to multiple attack lines, and set pressure control devices.

Background: It is recommended by MFRI Pump Operators course not to run more than one attack line off tank water. One exception to this rule would be in the event of a change on the fireground that effects life safety or the initial attack line becomes disabled. Until water supply is established, the water is needed for the 1st attack line. Additional lines may be deployed from the initial Engine but should not be charged until an external water supply is achieved. A hoseline supporting the Rapid Intervention Crew (RIC) can be charged, but do not flow water unless this line is used in RIC duties to rescue crews inside a fire. Non-Hydrants box alarms utilize the attack tanker set up. When the attack tanker is in place multiple lines can be charged.

Operations: One attack line transition to external water supply

1. Lay a line from a hydrant to the fire ground.
2. Place the pump in gear and open the tank-to-pump valve.
3. Pull Attack line, clear the bed, and charge off tank water upon signal from the crew.
4. Set throttle and pressure control device to manage pump pressure.
5. Connect supply line to an intake and announce to 2nd arriving that the unit is ready for water.
6. Once the supply line is charged, open intake, close tank-to-pump valve, and monitor pump panel gauges.
7. Place additional lines in service as needed and water supply will support. Adjust throttle and pressure control device as needed.
8. As water consumption allows, refill tank water.
9. Monitor pump panel, pump and engine compartment gauges.

Key Operational Considerations

- Never charge more than one line off tank water to use for fire attack. Crews inside have will have an idea how much sustained water flow they have off the tank water for one line. Life Safety and RIC are the exceptions.
- Fill tank water as soon as possible after transitioning to an external water supply to provide redundancy in the event the external supply fails.

CLASS B FOAM ATTACK LINES

Purpose: To establish a procedure for pumping foam attack lines used for fuel spill fires. Place in service a foam attack line from an in-line eductor to attack a fuel spill fire. Select appropriate type of foam concentrate and rate of flow for the type of fuel spill.

Operations:

1. Position Engine in a location uphill and upwind from the spill or fire, but within reach of handlines.
2. Identify the type of fuel spill or fire and 5 gallon pails of Universal Green foam concentrate.
3. Connect eductor directly to or near a pump discharge.
4. Connect 200’ of 1 ¾” from the eductor to a compatible fog nozzle equipped with an aerator.
5. Select the 3% foam concentrate percentage and on selector knob on the foam eductor.
6. Insert the eductor pickup tube in the foam concentrate or attach to the onboard foam cell discharge.
7. Open discharge and increase pump discharge pressure to create 200psi at the eductor.
8. After use, remove pick up tube from foam concentrate in place in fresh water for one minute. Reduce pressure to 100psi and flush the hose and appliances with plain water to remove foam residue.

Key Operational Considerations:

- Place apparatus to protect crew and apparatus from running fuel fires.
- Clean all foam equipment and hose after foam usage. Class B Foam concentrate is slightly corrosive.
- Refer to Manufacturer’s recommendations for each type foam eductor.
- Note the necessary pressures and flow from each. The nozzle must be compatible with the eductor to generate good quality foam.
- Note the maximum allowable back pressure allowed. Back pressure is the sum of the nozzle pressure and the friction loss in the hose between the eductor and the nozzle.

ELEVATED MASTER STREAMS

Purpose: To establish a procedure to supply water to an elevated master stream device on an Aerial Ladder or Aerial Tower.

Background: There are three types of elevated master stream devices you may encounter either in CCDFEMS or through mutual aid: Aerial Tower Platforms, Aerial Ladders with pre-piped water ways, and Aerial Ladders without a pre-piped water way. Each apparatus is unique and the manufacturer's recommendations should always be followed for proper pressures and maximum flow rates for each aerial master stream device.

Operations:

1. Establish a water supply from a sufficient source.
2. Position the Engine within 200' of the aerial apparatus to be supplied.
3. Connect supply lines from large diameter discharges to the gated siamese provided by the aerial apparatus operator. Ensure the gates are closed.
4. Determine what tip is used on the master stream appliance and the elevation. Determine from the aerial apparatus operator if there is a pressure recommended for any pre-piped waterway.
5. Open discharges one at a time and fill hoselines with water up to the gated siamese. Do NOT open gates on the siamese without coordination with the Aerial Apparatus Operator or crew.
6. Adjust throttle to desired pump discharge pressure based upon calculated friction loss or pre-determined pressure for the waterway.
7. Monitor intake pressure for adequate water supply and prepare to expand upon water supply if necessary.

Key Operational Considerations:

- Due to the high flows involved when supplying elevated master stream devices, apparatus should be parked as close as possible to the aerial apparatus they are supplying. This also facilitates direct communication between the pump operator and the aerial operator.
- MFRI Pump Operators Course recommends counting the ladder pipe and the siamese both as devices. +10psi for each for a total of 20psi for devices.
- Aerial devices have load ratings based upon pre-determined flows and waterway pressures. Follow recommendations of the manufacturer for maximum flow and required pressure. Aerial Apparatus Operators should be consulted for their specific apparatus.

PORTABLE MASTER STREAMS

Purpose: To establish a procedure to supply water to a portable master stream device

Background: Master streams are defined by IFSTA as large volume fire streams flowing more than 350gpm. There are several portable master stream devices used in Carroll County. Manufacturers' recommendations should always be followed for proper pressures and maximum flow rates. Most manufacturers label the device with the pertinent information, however if the information is absent or illegible personnel should consult owner's manuals or websites.

Operations:

1. Establish a water supply from a sufficient source.

2. Position portable master stream device and secure per manufacturer's recommendations.
3. Attach supply lines from the discharges at the pump panel to the intake(s) on the portable master stream device.
    a. Note the length and size of hose lines used.

    b. If dual lines are used, they should be of the same diameter for ease of pump calculations.
    c. It is good practice to place loops in the hose directly behind the appliance to aid with stability of the appliance.

4. Determine the tip size/flow. Note that some portable master stream devices have limitations on acceptable flows to maintain safe nozzle reaction levels.
5. Determine if the appliance is equipped with a shutoff.
    a. For appliances without a shutoff, the lines must not be charged without coordination with the crew and officer staffing the appliance.
    b. For appliances with a shutoff, ensure the gates are closed and begin filling the supply lines one at a time and fill hoselines with water up to the appliance. The crew can then control the gates at the appliance.
6. Adjust the pump discharge pressure to the desired level to support flow.
7. Monitor intake pressure throughout and prepare to expand upon water supply if necessary.

Key Operational Considerations:

- Operators must be prepared to shut down in the event the master stream appliance becomes unstable. Some appliances have built-in shutoffs if they over-turn. If auto shut off is activated due to sudden pressure changes or overturned device, line must be shut down and bled off before the auto shut off can be reset and normal operations can be restored.

- When equipped with a detachable base, ensure parts are securely assembled prior to charging. Specifically, locking pins must be fully engaged and tips tightened.
- Deck guns that are convertible to portable master streams are usually equipped with safety stops that restrict lowering the tip below a certain angle. This is done to direct reaction forces downward rather than backward. When the appliance is mounted to the fire apparatus the elevation angle is generally not restricted, and the safety stop can be bypassed to lower the tip further.

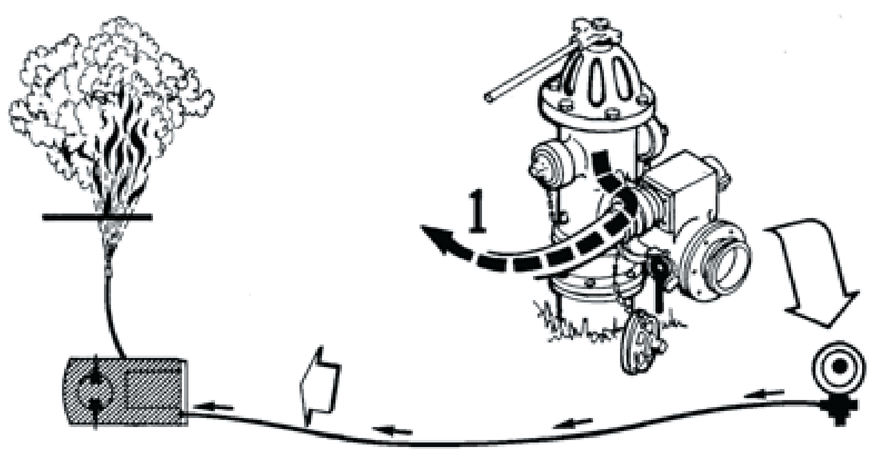
SUPPLY ENGINE - HUMAT VALVE

Purpose: To establish a procedure to provide a rapid, expandable, efficient, and uninterrupted supply of water from a municipal hydrant to an Attack Engine.

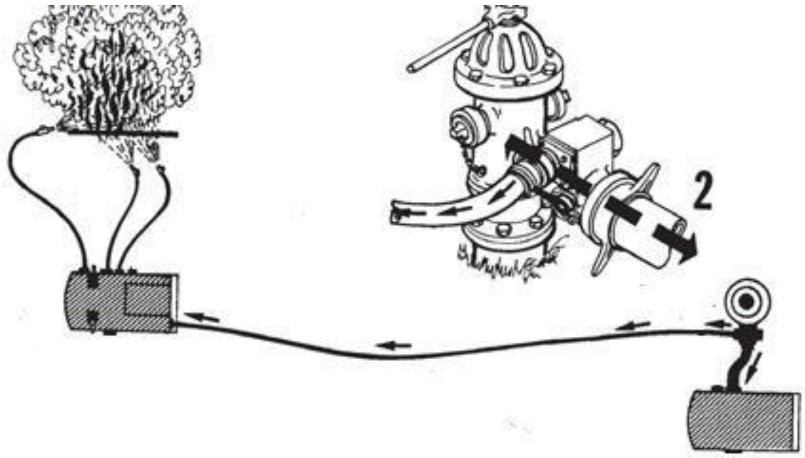
Background: The inclusion of a four-way hydrant valve allows an initial water supply directly from a hydrant to an Attack Engine prior to the arrival of a Supply Engine. A four-way hydrant valve used by CCDFEMS is the Humat Valve. The Humat Valve is connected to the steamer outlet on the hydrant immediately and charged after the Attack Engine lays a supply line from the hydrant to the fire scene. The Humat Valve permits the Supply Engine to boost supply pressure to the Attack Engine without interrupting the water supply.

Operations:

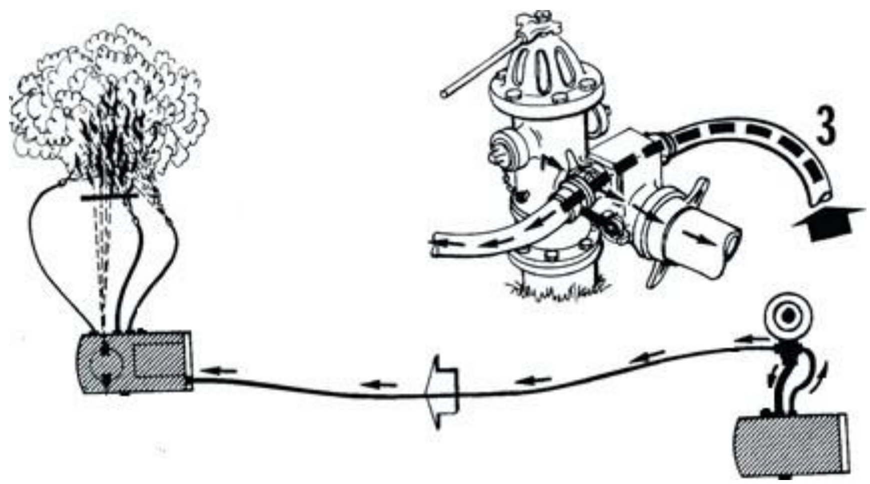
1. If not completed prior to arrival, "dress" the hydrant.
    a. Attach Humat Valve to the steamer outlet
    b. Attach gate valve(s) to the 2½" outlet(s) on the hydrant
    c. Ensure the bypass valve on the Humat Valve is closed. This directs water to the supply line and not out of the face of the Humat Valve.



2. After ensuring the Attack Engine is ready for water, charge the hydrant to get an initial water supply to the Attack Engine.
3. Connect the soft sleeve or supply line from the Supply Engine to the 4½" male connection on the front of the Humat Valve.



4. Connect a supply line from a discharge on the Supply Engine to the intake side of the Humat Valve.
5. Open the butterfly valve on the Humat Valve and fill the soft sleeve.
6. Open the appropriate intake on the Supply Engine to receive water from the Humat Valve.
7. Charge the supply line attached to the intake side of the Humat Valve.



8. Once pressure from incoming supply line exceeds the hydrant pressure an internal clapper valve in the Humat Valve will close.
   a. All of the hydrant water is directed to the Supply Engine
   b. Attack Engine is now receiving water from the Supply Engine and not the hydrant
9. Adjust pump discharge pressure based upon the amount of supply line, diameter of supply line, and fireground flow to maintain 20 to 50psi of intake pressure at the Attack Engine.

Key Operational Considerations:

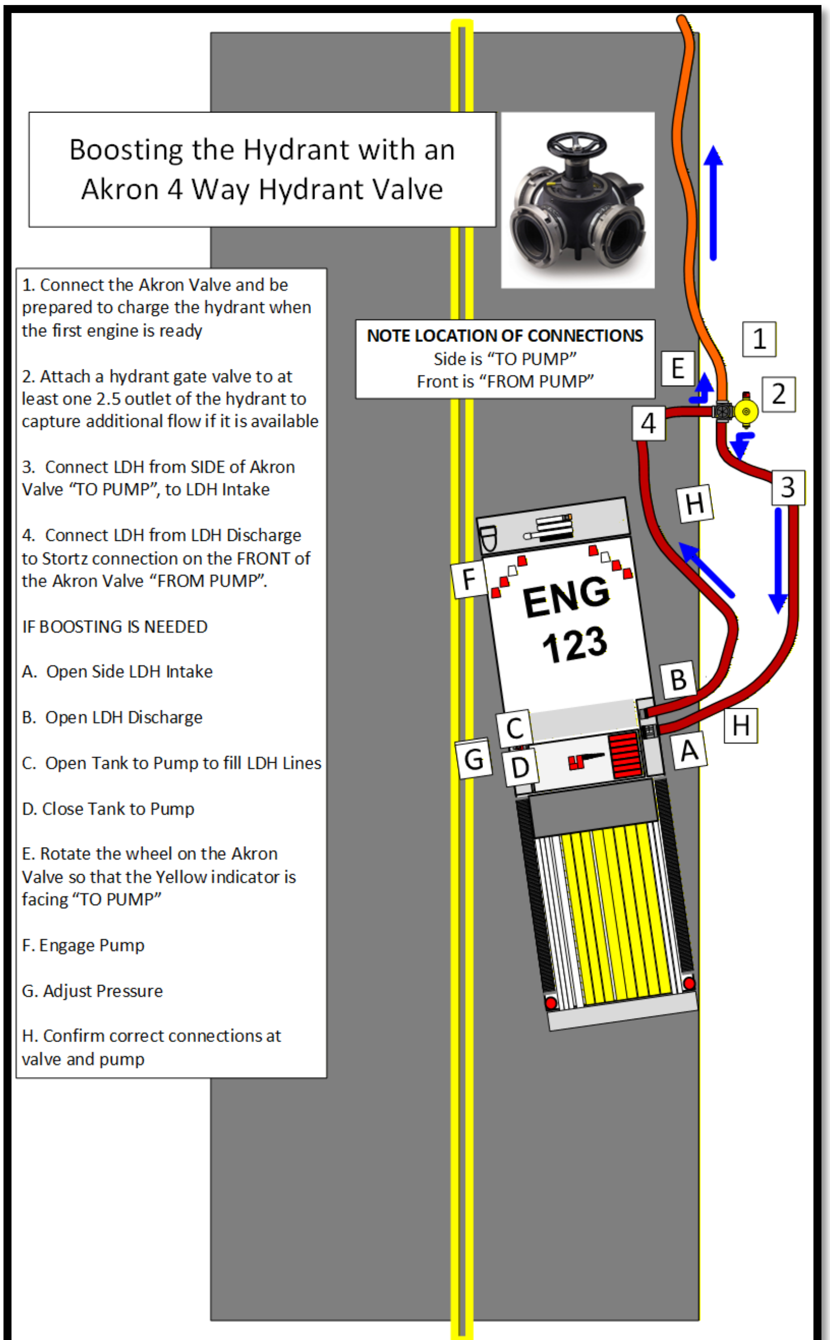
- Best practice is to charge the Humat Valve before connecting any of the hoselines from the Supply Engine. This identifies that the hydrant will provide water and provides the Attack Engine an initial supply.
- In the event the initial hydrant is OOS, the Humat Valve can be left connected to the hydrant with the Attack Engine's supply line attached to the discharge port. The Supply Engine can then split lay to another hydrant leaving their supply line connected to the intake port of the Humat Valve. Once the Supply Engine locates a new hydrant and charges their supply line, the water will flow through the Humat Valve into the supply line of the Attack Engine essentially bypassing the original hydrant.
- Clear communication between the operators of the Attack and Supply Engines is critical to ensure the supply line is not prematurely charged. The Attack Engine must be ready to receive the water or the operation and personnel can be endangered. Supply lines must never be blindly charged without coordination.
- Fully "dressing" a hydrant with gate valves on the 2½"outlet provides several advantages:

    - Provides immediate options in the event the soft sleeve MIV fails.
    - Allows a rapid expansion of the water supply without interrupting the initial water supply.
    - Permits a "heavy water hookup" without delaying the initial water supply.
    - Maximizes the flow available from the hydrant by using all available outlets.
- There are advantages and disadvantages to an Attack Engine securing their own water supply at a hydrant near the scene.
    - Taking the hydrant allows the Attack Engine to be self-reliant and truly maximize the water available from a hydrant. There is no water "wasted" in a long supply line or limited by the number of supply lines laid.
    - Taking the hydrant requires the Attack Engine operator to complete more tasks to secure a water supply and may distract them from the pump panel or water tank levels.
    - When the Attack Engine identifies that they will take their own water prior to arrival they can avoid laying LDH that can inhibit the approach of other apparatus.
    - When taking their own water, the Attack Engine reduces their flexibility in positioning on the scene and must still consider other apparatus. They are essentially "tethered" to the hydrant they have chosen.
    - A Supply Engine at a hydrant serves as a backup to the Attack Engine in the event of a mechanical failure. They can increase discharge pressure and pump through an Attack Engine to allow an orderly withdrawal or

support existing attack lines.

- When Attack Engines have their own water supply, Supply Engines should ensure and expand upon the water supply of the Attack Engine by reverse laying from the Attack Engine to another hydrant. The Supply Engine operator should assist the Attack Engine operator as necessary to ensure water supply is established in a timely manner.

Some stations utilize a hydrant valve other than the HUMAT, the below image is how to properly boost the pressure of the Akron 4-way valve found in Sykesville



RELAY OPERATIONS

Purpose: To provide a procedure for engines to create and maintain water supply at a rate of 500gpm in a constant Engine relay.

Background: CCDFEMS Non-Hydrant policy identifies relays as a secondary water supply option when the supply is within 3,000 feet of the attack. A rule of thumb is to position relay Engines at 1,000-foot intervals within the relay. A maximum length relay would require three Relay Engines, one Supply Engine at water source, and one Attack Engine. The minimum desired flow in a relay is 500gpm. For distances over 3,000 feet, a tanker shuttle operation should be considered.

Operations:

1. Once a relay operation is identified as an option to support the initial Rural Water Supply effort, engines assigned to the relay will lay up to 1,000 feet of supply line(s) each to maintain an interval of 1,000 feet or less between pumps. The supply line may be forward laid from the source toward the fireground or reverse laid from the fireground toward the source depending on apparatus approaches and access to the scene.
2. Operators connect all supply lines to large diameter intakes and discharges to maximize flow.
3. Supply line is filled with water at low pressure starting at the source, progressing through each Relay Engine, and reaching the fireground.
4. Once water has reached the fireground, pump discharge pressures should be established to maintain an intake pressure of 50psi for each engine within the relay operation.
5. Operator should expect some fluctuation of intake pressures caused by attack lines opening and closing.
6. Operators must also adjust the pressure relief devices as needed.
7. When ordered to shut down, the relay should be shut down sequentially from engine to engine starting at the fireground working back to the source.

Pumping Considerations:

- Engines can only discharge rated capacity when the net pump pressure does not exceed 150psi. Higher discharge pressures will reduce the capacity of the pump per the UL certification. It is best to utilize the largest (highest rated) pumps to complete a relay.
- The maximum working pressure of the fire hose used in a relay may also limit the amount of water that can be moved. The CCDFEMS recommends that pump pressures be limited to 250psi in 3-inch supply line, and 200psi for 4-inch and 5-inch supply line. The service test pressures for supply hose are typically 300 to 400psi.

- To initiate a relay with three or more pumpers, the following information is needed:
  - Needed fire flow (500-gpm unless otherwise directed)
  - Distance to the fire from the water source
  - Difference in ground elevation
  - Pump capacity of the responding Engines
  - Diameter of the supply hose line(s)

Key Operational Considerations:

- Relay operations are usually coordinated by a Water Supply Officer.
- Relay operations are only as good as the lowest rated pump. If a smaller capacity pump must be used in a relay, then the distance between pumps must be smaller to maximize the available capacity.
- Visualize the water within the relay as one solid column that runs through the entire relay. Any change in any participating Engine's discharge pressure will cause changes throughout the relay. Do not make throttle changes for residual intake pressures between pressures of 10psi and 100psi.
- Moving large quantities of water over great distances through several pumps is a complicated evolution that must be understood and practiced.
- When the relay is operating, keep pressure adjustments to a minimum.
- Always monitor intake pressure. Make sure intake pressures do not drop low enough to cause the line to shake and or collapse.
- Pressure management devices must be set to avoid extreme spikes in discharge pressures.
- Water takes approximately one minute to move through 1,000 feet of fire hose and 1,000 feet of 4" hose contains approximately 650 gallons of water.

Hydraulics References

The hydraulics review module is intended to provide the operator a summary of hydraulics and formulas that are most common to the fire service.

THE "Q" FORMULA

Hand Lines		Supply Lines	
Hose size	**Friction Loss Formula**	**Hose size**	**Friction Loss Formula**
1 ¾"	$13Q^2$	3" Hose	Q^2
2 ½"	$2Q^2$	4" Hose	$Q^2 \div 5$
¾" Booster	$1100Q^2$	5" Hose	$Q^2 \div 15$
1" Booster	$150Q^2$		

THE "Q" FORMULA FOR MODERN MERCEDES HOSE

Advances in technology and variations between brands require adaptation of traditionally accepted Q-formulas to more accurately reflect current coefficients of friction. The formula most accurate for Mercedes hose is:

Mercedes Hose with Elkhart Nozzles	
Hose size	**Friction Loss Formula**
1 ½	$14Q^2$
1 ¾	$8Q^2$

ESTIMATING SQUARES

For the purposes of pump calculations, the square of any number that includes "½" can be estimated by multiplying the first whole number by the next higher whole number. For example:

(1.5)2 = 1 x 2 = 2 (actually = 2.25)
(2.5)2 = 2 x 3 = 6 (actually = 6.25)

MFRI Friction Loss for Attack Lines
30 psi Friction Loss per 100-foot Section

Size of Hose	Maximum Flow
1-3/4"	150 gpm
2 ½"	250 gpm

CCDFEMS ACCEPTED FRICTION LOSS PER 100' HOSE

PSI's in black are for legacy hose.
PSI's in red are for modern Mercedes hose.

	1 ½" Hose	1 ¾" Hose	2 1/2" Hose
100 GPM	14 psi	10 psi 8 psi	5 psi 2 psi
150 GPM	31 psi	30 psi 18 psi	15 psi 4 psi
200 GPM		50 psi 32 psi	25 psi 7 psi
250 GPM			40 psi 10 psi

GENERAL NOZZLE PRESSURES

Chief XD 1 ¾ Nozzle	50 psi or 75 psi	Smooth Bore Handline	50psi
Fog Master Stream	100psi	Smooth Bore Master Stream	80psi
Metro 2 ½ Fog	50 psi		

FORMULAS

EP = NP + FL + Appl. ± EL
Engine Pressure = Nozzle Pressure + Friction Loss + Appliance ± Elevation

NR = 1.57 x D^2 x NP (Smooth Bore Nozzle)
Nozzle Reaction = 1.57 x (Diameter of Nozzle Tip)^2 x Nozzle Pressure

NR = 0.0505 x Q x √NP (Fog Nozzle)

GPM = 29.7 x D^2 x √NP (Smooth Bore Nozzle)
Gallons per minute = 29.7 x (diameter)^2 x √ nozzle pressure

RULE OF EIGHTS FOR SMOOTH BORE MASTER STREAMS

This formula uses the diameter of the tip size in eighths of an inch plus a factor of 2 to rough calculate the gallons per minute flow from a smooth bore nozzle on a master stream device with nozzle pressure of 80psi.

Example: 1⅜” Tip = 3 + 2 = 500 GPM (A 1⅜” tip has 3 eighths associated with it so it is 3 eighths plus 2 to equal 500 gallons per minute flow at 80psi)

1 ⅜”	Tip = 3/8 + 2	3 + 2 = 500 GPM
1 ½”	Tip = 4/8 + 2	4 + 2 = 600 GPM
1 ⅝”	Tip = 5/8 + 2	5 + 2 = 700 GPM
1 ¾”	Tip = 6/8 + 2	6 + 2 = 800 GPM
1 ⅞”	Tip = 7/8 + 2	7 + 2 = 900 GPM
2”	Tip = 8/8 + 2	8 + 2 = 1000 GPM

SITUATIONAL CONSIDERATIONS

Elevation Loss/Gain: Changes in elevation add or reduce pressure in the hoseline. ±5psi per 10 feet of elevation change or per floor when fire is inside a building.

FDC - Standpipe and Sprinkler Systems: Commercial/Apartment sprinkler/standpipe system - 150psi (unless the pressure is noted on the FDC sign, in which case supply the system at that pressure).

FDC – Residential Sprinkler Systems: 100 PSI to the FDC.

Master Stream Devices: Nozzle Pressure + 10 PSI for the device. Older devices with multiple intakes and stream straightener Nozzle Pressure + 20 PSI.

Non-pre-piped Aerial Apparatus: Calculate friction loss for the flow in hose in ladder bed 3” or 3 ½” and 100 feet long + 10 PSI for the Siamese appliance
+ 10 PSI for nozzle appliance + nozzle pressure + elevation loss.

Pre-piped Aerial Ladders and Aerial Towers: Pump per the specifications of the apparatus.

Relay or Pressurized Water Source Residual Pressure:
50 PSI for 3” Hose
20 PSI for 4” and 5” Hose

Drafting: Maximum theoretical lift is 33.9 feet at sea level. The actual lift capacity varies based upon pump condition, elevation, barometric pressure and primer function.

Bresnan Cellar Nozzles:
Elkhart 2½” Nine Outlet (3-9/16”; 3-5/8”; 3-1/2”)– 480gpm at 100psi or 340gpm at 50psi
Elkhart 2 ½” Six Outlet (3-9/16”; 3-5/8”) – 385gpm at 100psi or 275gpm at 50psi Akron 2 ½” Nine Outlet (3-1/4”; 6-13/32”) – 250gpm at 100psi
Akron 1 ½” Six Outlet (3-1/4”; 3-5/16”) – 95gpm at 50psi

ESTIMATING HYDRANT CAPACITY

Static – Residual x 100 = % drop Static

<10% drop: 2x water available
<25% drop: 1x water available
>25% drop: less than 1x water available

CALCULATING VOLUME

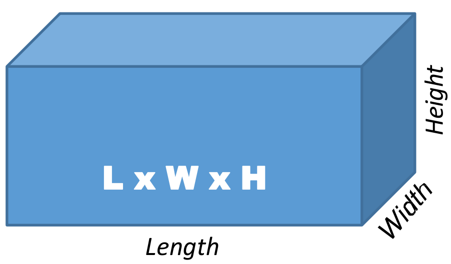
There are approximately 7.5 gallons of water per cubic foot or 1728 cubic inches. Volume is determined by multiplying length by width by height of the container. For a cylindrical container volume is determined by multiplying length by the radius squared by pi (π).

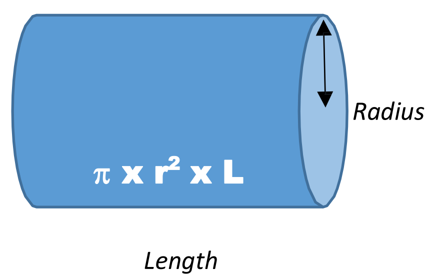
Example for a folding tank:

13’ x 13’ x 2.5’ tank = 422.5 cubic feet
422.5 cubic feet x 7.5 = 3168 gallons

Example for 100’ of 4” hose:

1200 x 22x 3.14 = 15,072 cubic inches
15072 □ 1728 = 8.7 cubic feet
8.7 x 7.5 = 65.25 gallons





CCDFEMS NOZZLES

Note: This chart may not include all nozzle variants found on CCDFEMS apparatus. Personnel must become familiar with the appliances specific to their apparatus.

Nozzle	Flow and Nozzle Pressure
Chief XD-Breakaway 	This nozzle has a break away tip, sometimes with an integrated smoothbore slug. Multiple variations of PSI's and GPMS Station 1 — 160 GPM — 50 PSI Station 3 — 150 GPM — 75 PSI Station 4 — 175 GPM — 75 PSI Station 7 — 175 GPM — 75 PSI Station 8 — 150 GPM — 75 PSI Station 9 — 150 GPM — 50 PSI Station 12 — 150 GPM — 75 PSI Station 14 — 150 GPM — 75 PSI
Original Chief-Breakaway 	Station 5 — 175 GPM — 50 PSI Station 12 — 150 GPM — 75 PSI Station 13 — 150 GPM — 75 PSI

TaskForce Tips Metro 	Station 10	150 GPM	75 PSI
TaskForce Tips Mid-Matic Automatic 	Station 6	70-200 GPM	75 PSI

Akron Model 1763 	Station 2	200 GPM	75 PSI
Elkhart R.A.M Nozzle 		500 GPM	75 PSI

TaskForce Tips Blitzfire  	500 GPM 75 PSI

Rural Water Supply & Drafting Operations

PURPOSE: To establish procedures to provide water supply from a static source at a fill site or dump site to support required minimum fire flow of 500gpm at the scene of a fire.

BACKGROUND: Water supply is a tactical operation, not a support operation. The deployment of at least three hand lines on working fires is to be expected: primary, back-up, and rapid intervention lines. Assuming that the typical CCDFEMS hand line flows at least 150gpm, then a minimum 500gpm water supply is needed to safely support an offensive fire attack. In non-hydrant areas, drafting operations will be needed to help deliver that water supply. Drafting operations may be used at the fireground, in conjunction with a relay operation, or during tanker shuttle operations.

ATTACK TANKER

The initial rural water supply tactic for rural water supply operations is referred to as Attack Tanker Operations. This tactic requires the first or preferably the second due engine to initiate a water supply by laying a supply line attached to a clappered Siamese into the scene. The first due engine, second due engine and first due tanker (attack tanker) then co-locate to initiate operations with all their combined water resources. All subsequent water carrying apparatus must pump the siamese or appliance to support fire attack. This deployment allows sufficient water for support of initial search operations and fire attack.

Attack tanker operations are limited to a 500gpm fire flow. When the needed fire flow is expected to exceed 500gpm the Incident Commander should consider enhancing the water supply using either an onsite water source, dump tank operations, or relay operations.

***NOTE** Direct tank fills **<u>shall not</u>** be used by the attack tanker. Supply lines shall be connected directly to the pump of the apparatus. The tank of the attack tanker shall be filled and then isolated, except when needed to compensate for a sudden loss of water supply.*

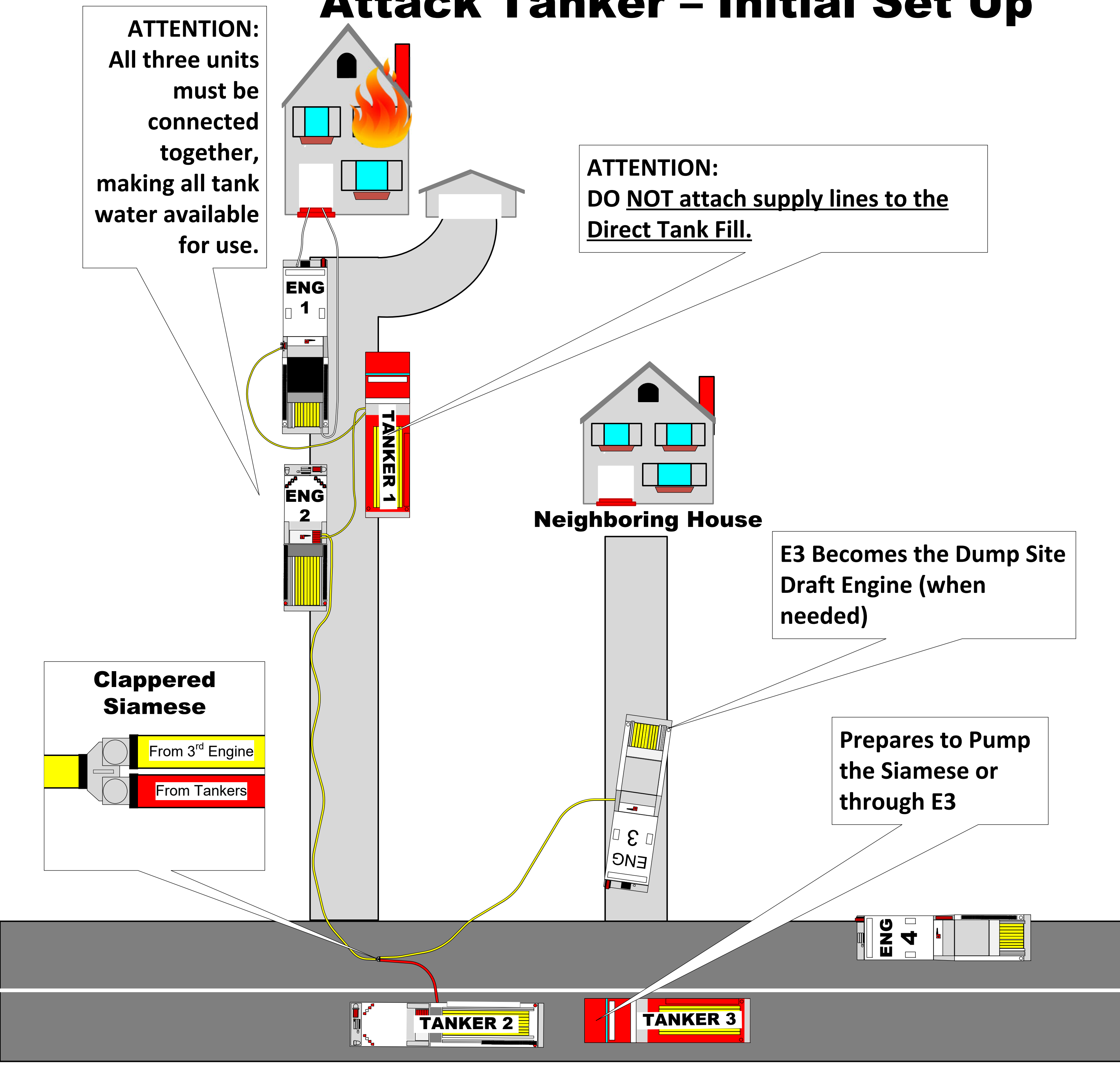
While implementation of the attack tanker concept as a water supply for non-hydrant areas reduces the initial need for drafting, operators must still be able to draft to support secondary or backup water supplies. When a tanker shuttle is implemented, it is not unusual for both the Dump Site Engine and Fill Site Engine to perform drafting operations.

Static water sources where drafting may occur include natural bodies of water (rivers, ponds, etc.), portable folding tanks, and dry hydrants connected to natural water sources or manmade cisterns.

KEY OPERATIONAL CONSIDERATIONS

- Static water supply sources should be preplanned and clearly identified on response area maps.
- When positioning the engine to draft, consider the stability of the ground surface, the vertical lift, and horizontal distance from water to pump.
- Vertical lifts over 10-feet significantly reduce pumping capacity. At a 20-foot lift, an engine's pumping capacity is reduced by 40%. Therefore, a 1500gpm engine can only pump 900gpm when drafting at a 20-foot lift.
- Horizontal distance has little effect on pumping capacity. Up to six, 10-foot sections of hard suction hose can be used horizontally with little overall effect on the pumping capacity.
- The preferred intake for drafting is always an intake closest to the impeller. For a mid- ship mounted pump, this means the driver or officer side steamer. The driver's side is preferred as it is much easier to monitor while obtaining and maintaining a prime.
- Front and rear intakes on mid-ship mounted pumps are less desirable for drafting due to the additional plumbing that must be overcome to obtain a prime
- When drafting from open top static sources, floating-style strainers are preferred over barrel-type strainers because they remain debris-free longer, do not have a depth requirement, and minimize whirlpools.
- A dump line or deck gun should be used to ensure continuous circulation of water and maintaining the prime. The discharged water should be directed back into the water source. Be cautious that the amount of water being circulated does not reduce the amount of water being sent to the fireground or fill site.
- It is important to note that water supply sites are not limited to a single clappered siamese connection. Siamese appliances may be stacked to increase capacity, and additional supply lines may be established as operational needs dictate.

Attack Tanker – Initial Set Up



DRAFTING OPERATIONS - ADVANCED CONCEPTS & ALTERNATIVE METHODS

Drafting water from static sources requires a clear understanding of pump mechanics, priming system function, and the limitations of atmospheric pressure. While modern priming systems make drafting more reliable than ever, pump operators must be prepared to identify priming issues, troubleshoot air leaks, and utilize alternative drafting methods if a primer malfunction occurs.

Operators should understand the relationship between lift, vacuum, pump RPM, and water supply, and must be capable of recognizing the signs of incomplete prime, air ingestion, or pump cavitation.

CAVITATION RECOGNITION AND PREVENTION

Cavitation occurs when insufficient water enters the pump relative to discharge demand. This produces vapor pockets that collapse inside the impeller, causing:

- Fluctuating pressure
- Reduced flow
- Metallic “gravel” noise inside the pump
- Excessive vibration
- Long-term damage to impeller vanes, wear rings, bearings, and seals

If cavitation occurs:

- **Increase** supply (reduce lift, eliminate air leaks, open strainers fully)
- **Reduce** discharge pressure or reduce RPM
- Avoid running the pump dry, as mechanical seals and clearance rings are heat-sensitive

Pump operators must immediately correct cavitation to protect equipment.

PRIMING SYSTEM OVERVIEW

Most CCDFEMS engines use one of two primer systems:

1. Rotary Vane Electric Primer
   - Electric 12V motor
   - Carbon vanes
   - Limited to ~45 seconds of continuous engagement
   - Must be exercised during daily checkout until water discharges at the pump outlet

2. Trident Air Operated Primer
   - Uses chassis air supply
   - No motor, no heat generation, no lubrication
   - Unlimited priming duration
   - Capable of overcoming imperfect drafting setups
   - Faster at low lifts (<15’)
   - Common on newer CCDFEMS units
   - Automatic systems will self-engage when discharge pressure falls below 20 PSI with pump engaged

Regardless of system type, the operator must verify:

- Pump drains are closed
- Intake screens are clear
- Hard suction couplings are tight
- Lift is minimized
- Tank-to-pump valve is closed

ALTERNATIVE DRAFTING METHODS

In the event of primer failure or difficulty establishing prime, two reliable alternative methods may be used: Burp Drafting and Purge Drafting. These methods rely on pump circulation and atmospheric pressure, not primer function. Operators must notify Water Supply immediately if either method becomes necessary.

BURP DRAFTING METHOD

The Burp Draft allows the pump to self-prime by introducing controlled amounts of air into circulating water, creating a pressure imbalance that draws water up the hard suction.

Prerequisites

- An intake valve capable of momentary, controlled operation (e.g., MIV, electrically actuated front intake valve, Keystone valve, etc.)

Procedure

1. Place pump in gear and begin circulating tank water.
2. Open tank-to-pump fully; open tank fill partially until cavitation is avoided.
3. Increase throttle to approximately 1,200 RPM (RPM mode recommended).
4. With hard suction connected, tap open the intake valve for one-second intervals.
5. When pump pressure momentarily drops, stop tapping and allow the pump to stabilize.
6. The pump will pull air through the hard suction, mixing air and water until a vacuum is established and drafting begins.

Key Points

- No primer needed.
- Best used with electronic intake valves.
- Excessive intake opening will cause the pump to lose all pressure; short pulses are critical.
- Once a solid water supply is established, transition to normal pump operations.

PURGE DRAFTING METHOD

Purge Drafting uses an external water source to push static water up the hard suction until air is expelled, achieving prime without the use of a primer.

Equipment Needed

- Intake valve
- Low-level strainer or jet siphon
- 1¾" attack line for pressurizing the appliance

Procedure

1. Connect the strainer/jet siphon to the hard suction and charge the 1¾" line.
2. Allow water from the attack line to push up the hard suction into the pump.
3. Keep the hard suction loosely threaded to the intake to allow air to escape.
4. When water flows freely from the threads with no air pockets:
5. Tighten the hard suction
6. Open the intake valve completely
7. A solid prime should be instant, with no pressure drop or surge.

Key Points

- Provides immediate prime with no pump cavitation.
- Extremely effective at long lifts or when air is trapped in the strainer.
- Must be trained regularly to ensure proficiency.

Operational and Safety Considerations

- These methods should be used only when normal priming fails.
- Notify Water Supply immediately if a primer malfunction is identified.
- Avoid running the pump dry during extended attempts to prime.
- Monitor pump temperature; heat-sensitive seals and clearance rings can be damaged quickly.
- Practice alternative drafting during training, not only during emergencies

DUMP SITES - FOLDING TANKS

Purpose: Develop and operate an efficient dump site with a sustained minimum fire flow of above 500gpm.

Operations:

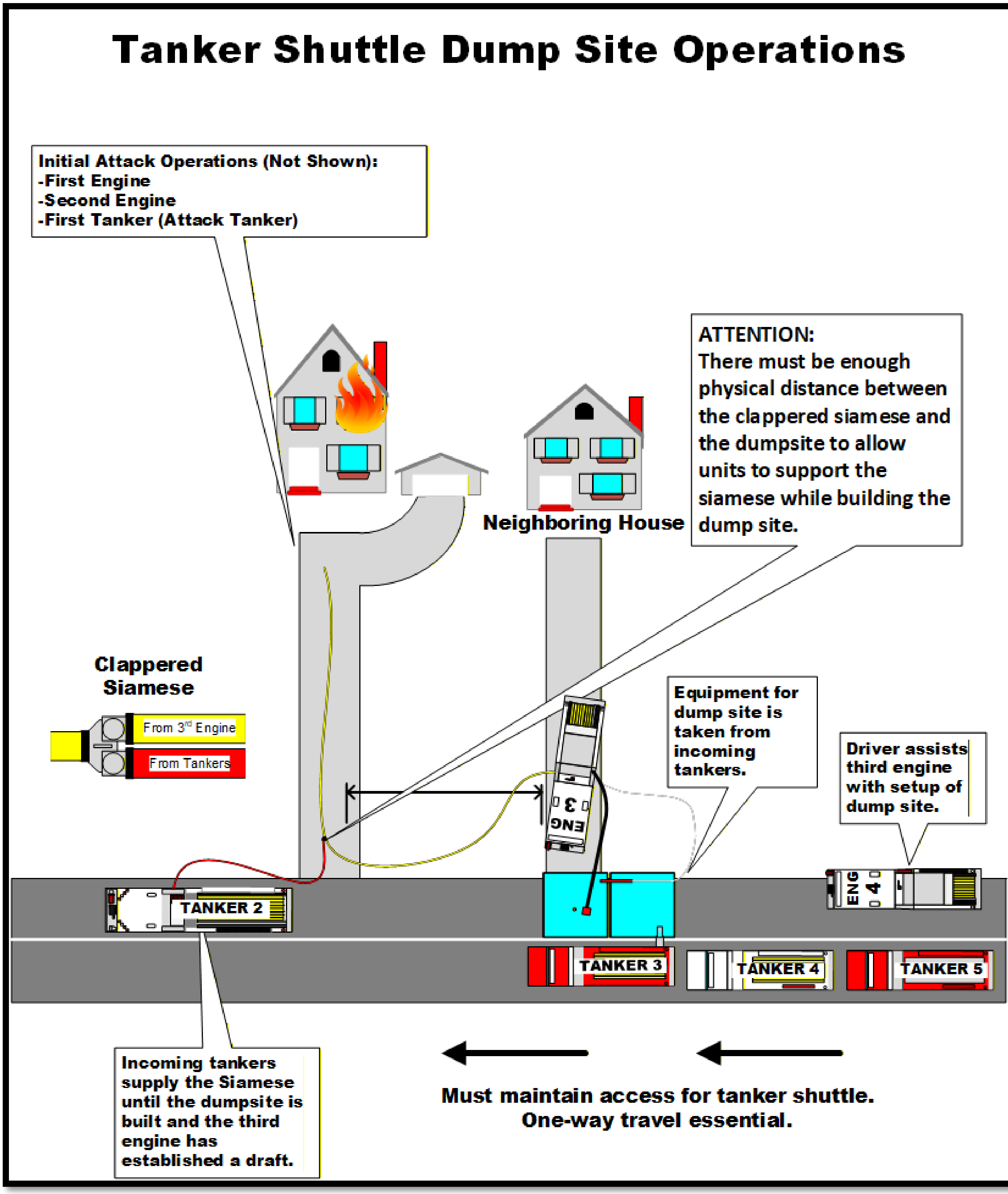
1. Select a location that permits access to the clappered Siamese or Humat Siamese placed by the 1st or 2nd due engine as well as space for the portable tanks. Tankers must be able to access the tanks to dump their load, preferably without backing.
2. Position the dump site Engine to maximize space for the portable tanks and other apparatus.
3. The initial priority of the third due engine is to deploy supply lines from the dump site Engine and 1st Due Tanker to the clappered Siamese. All hands must support his function until enough help and tankers arrive to begin setting up portable tanks (if warranted).
4. Deploy the first available portable tank at the selected site.
5. Connect hard suction hose to the chosen intake on the dump site Engine. Connect a low-level strainer to the open end of the suction hose. Place the strainer into the portable tank.

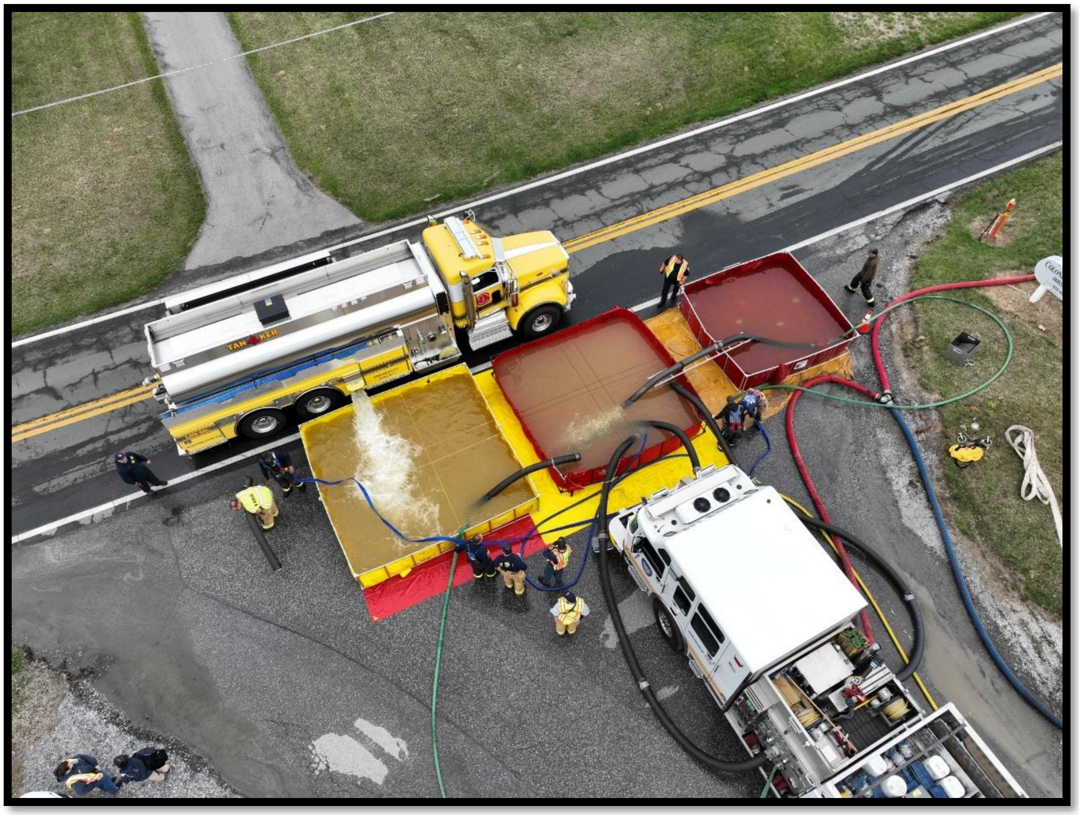
6. Fill the portable tank and ensure the dump site Engine can achieve a prime.
7. Once prime is achieved open discharge and supply clappered Siamese to the fireground (1st Tanker).
8. Use the Tanker shuttle to keep it supplied throughout the operation. The first portable tank is the primary tank.
9. As additional Tankers arrive to dump their water, deploy their portable tanks to augment the primary tank.
10. Deploy jet siphoning devices to transfer water from the additional portable tanks to the primary tank where the dump site Engine is drafting water.

Key Operational Considerations

****NOTE** Some models of the 4 inch clappered Siamese CANNOT be used upside down. Being upside down will cause the clappers to remain open.**

- The dump site is normally set up by the drivers of the 3rd due Engine and 2nd due Tanker on the assignment.
- The dump site Engine must identify the location of the Siamese supplying the fireground and that the fireground units are ready to receive water. Typically, the supply line will terminate in the 1st due Tanker (Attack Tanker) near the fireground.
- The desired dump time from a Tanker is two to three minutes.
- Smaller capacity Tankers that are holding up larger Tankers from dumping should be told to stop dumping and go directly back to the fill site. Never leave larger capacity Tankers waiting to dump.
- Jet siphoning devices move water from one folding tank to another at about 800gpm- 1,000gpm flow at approximately100psi.
- A Water Supply Group Supervisor is often established during rural water supply operations. A separate operations channel may also be assigned. The dump site Engine operator must remain situationally aware to efficiently communicate and provide situation updates as necessary.
- Tanker Drivers should not get out of their apparatus at the dump site. This slows the shuttle down considerably. Dump site personnel need to manage any adjustments or positioning within the dump site.
- Maintain only one dump site. Multiple dump sites are not recommended.


Tanker Shuttle Dump Site Operations
Initial Attack Operations (Not Shown):
-First Engine
-Second Engine
-First Tanker (Attack Tanker)
ATTENTION:
There must be enough physical distance between the clappered siamese and the dumpsite to allow units to support the siamese while building the dump site.
Neighboring House
Clappered Siamese
From 3rd Engine
From Tankers
Equipment for dump site is taken from incoming tankers.
Driver assists third engine with setup of dump site.
ENG 3
ENG 4
TANKER 2
TANKER 3
TANKER 4
TANKER 5
Incoming tankers supply the Siamese until the dumpsite is built and the third engine has established a draft.
Must maintain access for tanker shuttle.
One-way travel essential.




TANKER 7

FILL SITE ENGINE

Purpose: To establish an efficient fill site to support a minimum fire flow of 500gpm. Fill site Engine will fill Tankers at a rate of 1,000gpm.

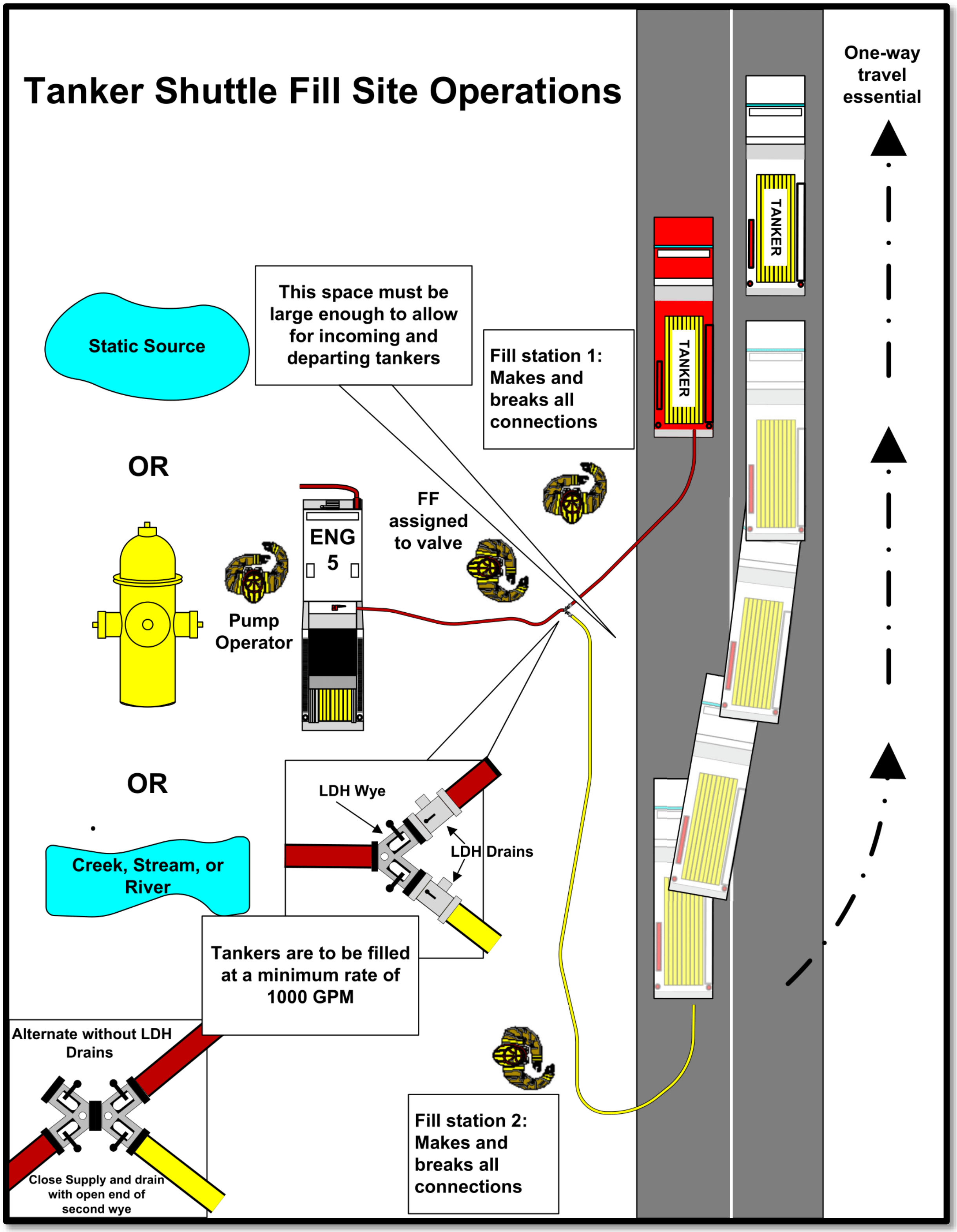
Background: The fill site needs to fill Tankers at a rate to provide the dump site with the required water to supply the fire attack at the scene. Unlike a dump site, the use of multiple fill sites is recommended when available. The desired fill rate for apparatus at the fill site is about 1,000gpm, thus filling a Tanker in 3 to 4 minutes. Ideally, Tankers should begin refilling immediately upon arrival at the fill site.

Operations:

1. Identify suitable fill site that will support 1,000gpm flow. 1st due engine should have announced the primary water location and ECC should have the fill site in the incident notes.
2. Position at the fill site to allow Tanker access to the supply hose and egress from the fill site without backing.
3. Connect hard suction hose to the chosen intake on the fill site Engine. If static water source is not a dry hydrant, select an appropriate strainer for the type of water source. For natural water sources use a floating strainer or a barrel strainer.
    i. ****Note**: some fill sites will be supplied by a hydrant connected to the municipal water system and in those situations the fill site Engine should establish a heavy water hookup for their water supply.**

4. Establish a dump line or arrange the deck gun to circulate water back to the water source.
5. Prime the pump and begin water flow.
6. Deploy supply lines from the LDH discharges on the fill site Engine to gated appliances close to the Tanker parking area. Extend supply line(s) uncharged from the appliances to facilitate filling the arriving Tankers.
    a. A fill site should have at least two fill stations and only fill one Tanker at a time while a second Tanker is connecting or disconnecting. All fill sites and stations should be set up using the same diameter hose across the incident to limit time spent at each fill site.
8. Verify an adequate draft and water supply to fill Tankers at a rate 1,000gpm.
9. Fill Tankers at a rate of 1,000gpm. Some tankers have a maximum fill pressure to avoid damaging the tank. This pressure may be noted at the direct tank fill. Fill site operators must confirm with Tanker operators if a maximum fill pressure is pertinent. If the fill pressure is unknown use 50 psi for inlet pressure.


WINFIELD
TANKER 14
3500 GALLONS
MOUNT AIRY
Direct Tank Fills
Direct Tank Fills


Tanker Shuttle Fill Site Operations
One-way travel essential
TANKER
TANKER
This space must be large enough to allow for incoming and departing tankers
Fill station 1: Makes and breaks all connections
Static Source
OR
ENG 5
FF assigned to valve
Pump Operator
OR
LDH Wye
LDH Drains
Creek, Stream, or River
Tankers are to be filled at a minimum rate of 1000 GPM
Alternate without LDH Drains
Close Supply and drain with open end of second wye
Fill station 2: Makes and breaks all connections

Key Operational Considerations:

- Tanker drivers should remain in their cabs throughout the operation. Filling operations are completed by fill site personnel.
- Establishing additional fill sites or expanding upon the initial fill site increases operational efficiency and provides more options on the fireground.
- Set up two filling stations per fill site from a reliable site capable of supplying the required flow for filling Tankers.
- A standard pump discharge pressure for filling Tankers is:
    - PDP = 50psi + FL (hose) + AL (appliance) ± EL (elevation)
- The fill site should be located as close as possible to the fireground to support greater fire flows. Longer travel times decrease available fire flow.
- Identify the route used between the fireground and fill site. Due to their size and limited maneuverability shuttle routes used by Tankers should be a loop using improved roadways whenever available.
- 5th due Engines on initial assignments are usually tasked to establish a fill site

SUPPLYING FIRE SPRINKLER AND STANDPIPE SYSTEMS SOP 4.2.5

Purpose: To provide a rapid uninterrupted water supply to support building fire protection systems via the Fire Department Connection (FDC).

Operations:

Sprinkler/standpipe systems shall be supported by initial suppression units when responding to incidents at structures and/or facilities equipped with these systems, in accordance with the following procedures.

In some occupancies where a fire pump is provided, the fire pump may be required to maintain pressures required during firefighting operations in the absence of fire apparatus support. If you are unsure if this is the case on any particular structure, support the system out of caution.

1. The first arriving engine shall address coverage of the fire department connection (FDC) supplying the sprinkler/standpipe system during their BIR based on the conditions encountered upon arrival and their familiarity with the structure and/or facility.
    a. The 1st arriving engine will either;
        i. Cover the FDC and lay to an appropriate hydrant (normally within 100') or
        ii. Direct the 2nd arriving engine to cover the FDC and lay to an appropriate hydrant.
2. The 2nd arriving engine shall cover the FDC if directed to do so.
    a. If the 1st engine is covering the FDC, then the 2nd engine shall assist the 1st engine at the hydrant while the crews of both engines accomplish their respective duties based on the applicable SOP or Incident Commander's (IC) direction.
3. Sprinkler systems must be charged immediately if they are part of the standpipe system. Otherwise, they must be charged to the required pressure when:
    a. Smoke or fire is visible.
    b. The water flow alarm sounding; or
    c. The officer in charge directs it to be done.
    d. Drivers must advise IC via radio when systems are charged.
4. All other units shall accomplish their respective duties based on the applicable SOP or ICs direction.
5. IC shall assign a crew (at least 2 personnel) from one of the responding units to locate the sprinkler room and remain in radio contact with the IC to shut and/or open the sprinkler/standpipe system at commands direction.

6. The engine supplying the FDC will support the sprinkler/standpipe system at the applicable pressure based on type of occupancy:
    a. Commercial/Apartment sprinkler/standpipe system - **150psi (unless the pressure is noted on the FDC sign, in which case supply the system at that pressure)**
    b. Residential sprinkler system - **100psi**
7. Whenever a sprinkler/standpipe system has activated due to proper function, a mechanical or electrical failure, or physical damage, the following actions shall be completed:
    a. Document the performance or non-performance of the sprinkler/standpipe system in the fire report.
    b. While on location, units will notify the State Fire Marshal's Office representative for the following instances:
        i. Malfunction or non-performance of a sprinkler/standpipe system.
        ii. A sprinkler/standpipe system not being effective when activated.
8. Fire department members shall not replace activated sprinkler heads. However, fire department members should make all efforts to return as much of the sprinkler/standpipe system to service as possible. This may include isolating the activated floor or area via shut off valves or otherwise limiting the inoperable portion of the sprinkler/standpipe system.
    a. The building owners must be advised to contact a sprinkler company to have the system inspected and certified as back in service.

Key Operational Considerations

- A forward lay places a supply engine at the hydrant in addition to the engine supplying the FDC. This offers some redundancy should a failure occur in one of the engines.
- A reverse lay may provide water to the FDC more quickly and in greater quantities as the pump is placed at the hydrant in a heavy water configuration.
- A working fire generally requires the deployment of at least three hand lines: primary, back-up, and rapid intervention lines. Assuming that the typical CCDFEMS hand line is set to flow a minimum of 150gpm, then approximately, a 500gpm water supply is needed to safely support a fire attack operation in an IDLH atmosphere.
- A single, 4-inch supply line will support 800gpm no farther than 1,000-feet without excessive friction loss and pump discharge pressures.
- A successful supply to FDC may silence the water flow alarm and the drain may stop flowing water in some sprinkler systems.
- Buildings equipped with fire pumps require the Engine operator to remain especially vigilant for pump overheating as the system may not need to accept

much water from the engine.

- When a decision must be made, supply the standpipe system first and then support the sprinkler system. Often the sprinkler system will have an adequate water supply to already be containing the fire, but the standpipe system is critical to firefighter safety.
- Poorly maintained FDC swivels may not rotate. Rather than twisting the hose repeatedly, install a double male adapter into the broken swivel and then a double female adapter to complete the connection.
- For standpipe systems, a damaged or blocked FDC may be overcome by bypassing the FDC and connecting a supply line to a riser outlet at the ground floor. Be sure to open the riser valve once the supply is charged.
- Always supply both inlets of the FDC to ensure adequate water supply and to add redundancy should a hose fail.
- For large complexes with multiple FDC multiple engine companies may be tasked with supporting the building systems.

Identifying the FDC

Buildings may have a variety of FDC and other types of connections that present the pump operator with decisions:

- Before connecting to an FDC, be sure to identify what type of system it supplies and note if a building address or identity is posted. Sprinkler and standpipe systems may be supplied by the same FDC.
- If locating an FDC becomes difficult, keep in mind that FDC are normally located within 100 feet of a hydrant. The water gong for the sprinkler system is often located directly above the FDC for the sprinkler system.
- The pump operator must know which building or set of floors are supplied by the FDC being charged.
- Parking garages often have a separate FDC from the main building.
- Some FDC may be freestanding and not on the wall of a building

Standpipe FDC

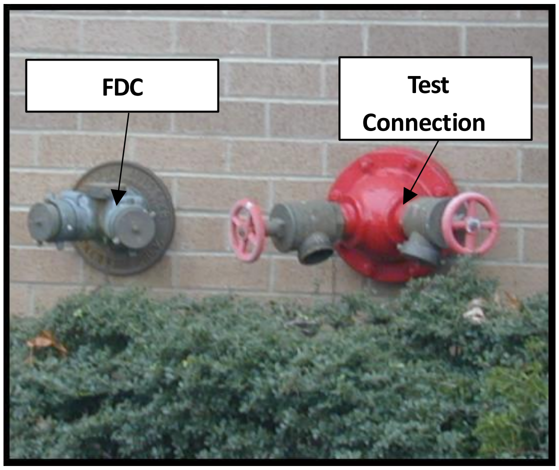
Sprinkler FDC

Adjacent, but Separate Sprinkler and Standpipe Connections

Combination FDC

FIRE PUMP TEST CONNECTION

Fire Pump Test Connections have a similar appearance to an FDC, however serve a completely different purpose in suppression systems. Fire Pump Test Connections are identifiable by the male threads on the outlets and usually have external valves. **These connections are not for fire department supply to the building systems. DO NOT connect a water supply to them**



Fire Pump Test Header

Foam Operations & Foam Systems

FOAM THEORY AND CHARACTERISTICS

In general, firefighting foam works in the following ways:

- It smothers a fire by separating the fuel from air.
- It cools the fuel and adjacent surfaces below their ignition temperature or flash point.
- It prevents flammable vapors from reaching ignition sources by encapsulating the fuel.
- It reduces the volume of flammable vapors being released that can mix with oxygen.

***NOTE** Apparatus operators should be familiar and fluent in operation of any on-board foam systems on their apparatus.*

Definitions

- Aspirate – To draw air in; aspirating nozzle attachments draw air into foam solution as it discharges to make finished foam.
- Surfactant – Wetting agents that lower the surface tension of a liquid, allowing easier spreading and penetration into solid materials.
- Emulsifier – Emulsifiers will surround an oil (or other immiscible molecule) and form a protective layer so that the oil molecules cannot "clump" together. This action helps keep the dispersed phase in small droplets and preserves the emulsion.
  - Immiscible materials are incapable of being mixed or blended together and will eventually separate into separate layers even if shaken or blended.
    - Oil and water are immiscible
- Foam Concentrate – Liquid supplied by a manufacturer which when mixed with water in the correct proportion forms a foam solution.
  - Manufacturers offer recommendations for compatibility, application, and proportioning. Consult the container or internet for manufacturer information.
- Foam Solution – A solution of water and foam concentrate after they have been mixed together in the correct proportions. There is no specific nozzle, agitation, or injection of air into the mix.
- Finished Foam – Foam solution as it exits a discharge device, having been aerated. Finished foam consists of Foam Concentrate, Water, and Air that are subjected to mechanical agitation within the pumping system and/or by the nozzle.
- Nozzle Aspirated Foam System (NAFS) –Often called “low-energy” generation systems because they rely on the energy created by a fire pump to propel the foam

stream from the nozzle, and to aspirate the foam solution at the nozzle.

- Compressed Air Foam System (CAFS) - Often called a "high-energy" foam generation system because they introduce compressed air into the foam solution before it reaches the hose and nozzle. CAFS uses a dedicated air compressor and proportioning system to create a finished foam inside the hoseline, resulting in a more uniform bubble structure, increased stream reach, improved adhesion, and greater firefighting efficiency compared to low-energy systems
- Hydrocarbons - Most hydrocarbons are byproducts of crude oil or have been extracted from vegetable fiber. Hydrocarbons have a specific gravity of less than 1.0 and therefore float on water. Examples of hydrocarbon fuels include:
    - Gasoline
    - Diesel
    - Jet propellant (JP4)
    - Kerosene
- Polar Solvents - Polar solvents are products of distillation or products that have been synthetically produced. Polar solvent fuels are miscible, that is they will mix with water. Polar fuels have a varying attraction for water. For example, acetone has a stronger affinity for water than does rubbing alcohol. Some examples of polar solvent fuels include:
    - Ketones
    - Esters
    - Ethanol
    - Amine
    - Methyl tertiary butyl ether (MTBE)
    - Acetone

Class B Foam

Class B Foams do NOT voluntarily mix with hydrocarbons, and they form a cohesive blanket on top of flammable liquids. Class B foams are "oleophobic" (Oil-Hating). This means that it produces a chemical effect that tends to prevent hydrocarbon (fuel) pickup and blanket contamination. A contaminated foam blanket is undesirable since it can "candle," the presence of small flames from the foam blanket.

As of this revision, CCDFEMS uses biodegradable National Foam Universal Green AR-F3. This concentrate is alcohol resistant (AR) fluorine free foam (F3). Universal Green is applicable for oil, gasoline, diesel fuel, or aviation fuel as well as polar solvents such as alcohol, ketones, esters and ethers. Universal Green can also be used for Class A fires. The concentrate has a freeze point of 21°F and remains usable following a freeze/thaw cycle. This foam will work with fresh, brackish and sea water. A 5-gallon pail weighs approximately 44lbs, so utilize safe lifting techniques and caution when handling.

Unlike prior generations and types of Class B foam concentrates, the proportioning of Universal Green foam concentrate is not dependent upon the type of Class B fuel encountered. The manufacturer recommends a 3% proportion rate along with an air aspirating discharge appliance as the standard for all Class B applications.

Foam supplies are maintained at stations 4, 5, 9, and 14.

Foam Expansion Tube
When greater expansion rates of foam solutions are needed, a foam aeration tube can be attached to the fog nozzle. The foam expansion tube clamps directly to compatible fog nozzles to enhance the aspiration of the finished foam.

Foam Proportioning System
Foam Proportioning Systems introduce foam concentrate into hose streams. CCDFEMS uses outboard proportioning methods to generate foam. All on board foam systems have been rendered out of service and should not be used.

In-Line Foam Eductor

The Task Force Tips (TFT) in-line foam eductor is capable of proportioning Class A or Class B foam concentrates at rates of 0.25%,0.5%, 1%, 3%, and 6%. For the eductor to function properly, a pressure of 200psi must be maintained at the appliance. The maximum back pressure is 130psi.

The eductor is often supplied by a finite amount of concentrate either stored in 5-gallon buckets or an onboard foam cell. The following provides guidance on anticipated consumption rates using the 95gpm eductor and matched nozzle:

Concentration	Time to Empty 5-gallons	Foam Consumption Rate
0.25%	20 minutes 50 seconds	0.24gpm
0.50%	10 minutes 25 seconds	0.5gpm
1%	5 minutes 16 seconds	1.0gpm
3%	**1 minute 45 seconds**	**2.9gpm**
6%	53 seconds	5.7gpm

The maximum hose lay is based on the back pressure. Pushing the foam solution thru the hose and nozzle causes back pressure on the eductor exit. If the back pressure is over 130psi the eductor will not work. Back pressure is the sum of hose line friction loss between the eductor and nozzle and the nozzle's operating pressure when flowing 95 gpm. Elevation loss adds to the back pressure when the nozzle is higher than the eductor. For each foot in vertical height there is 0.5 PSI elevation loss.

The attached foam suction hose is matched to the eductor and should not be lengthened.

If finished foam is of poor quality or not being discharged, consider the following to troubleshoot:

- Too much hose between the nozzle and the eductor
  - Eductors are most often positioned at the pump for convenience, however can be placed anywhere on the hoseline as long as 200psi is maintained at the eductor
  - The allowable length of hose from the eductor to the nozzle is not infinite and depends upon the friction loss, nozzle pressure, and elevation loss of the hose lay.
- Mismatched Nozzle
  - Eductors work with any nozzle whose gallonage is equal or larger than 95gpm
  - Larger gallonage nozzle effects both the reach of stream and the proportioning rate of the eductor
- Excessive elevation increase between the nozzle and eductor.
- Nozzles must be fully open or fully closed when using a foam eductor to create the necessary venturi effect and draw concentrate into the water stream. A partially closed nozzle creates too much back pressure.
- Excessive lift between the eductor and foam source; keep lift less than 6 feet. Normally the length of the pickup tube supplied with the eductor is what should limit the lift.
- Eductor port or pickup tube is clogged
- Eductor is on the wrong proportioning setting

Dual Pumping and Tandem Pumping

Dual Pumping and Tandem Pumping are two different water supply procedures used for two different purposes. The terms are commonly misused in the fire service. Even amongst various authors of published articles some will misuse the terms.

Dual pumping is two Engines using the same hydrant to take advantage of available water left in the hydrant after the 1st Engine is flowing its capacity or desired flow.

Tandem Pumping is a two Engine relay used to overcome friction loss in elevation.

DUAL PUMPING

Purpose: To establish a procedure using two Engines to maximize available water left in a high flow hydrant after the 1st Engine is flowing its capacity or desired flow.

Background: This procedure should be applied cautiously in areas with multiple hydrants in close proximity to each other. Water supply can often be expanded by simply positioning additional engines on other nearby hydrants.

This procedure could be implemented in an area where there are few hydrants or the secondary hydrants are too far from the scene to be used effectively. It may also be useful where railroad tracks or divided highways make laying hoselines impossible or impractical.

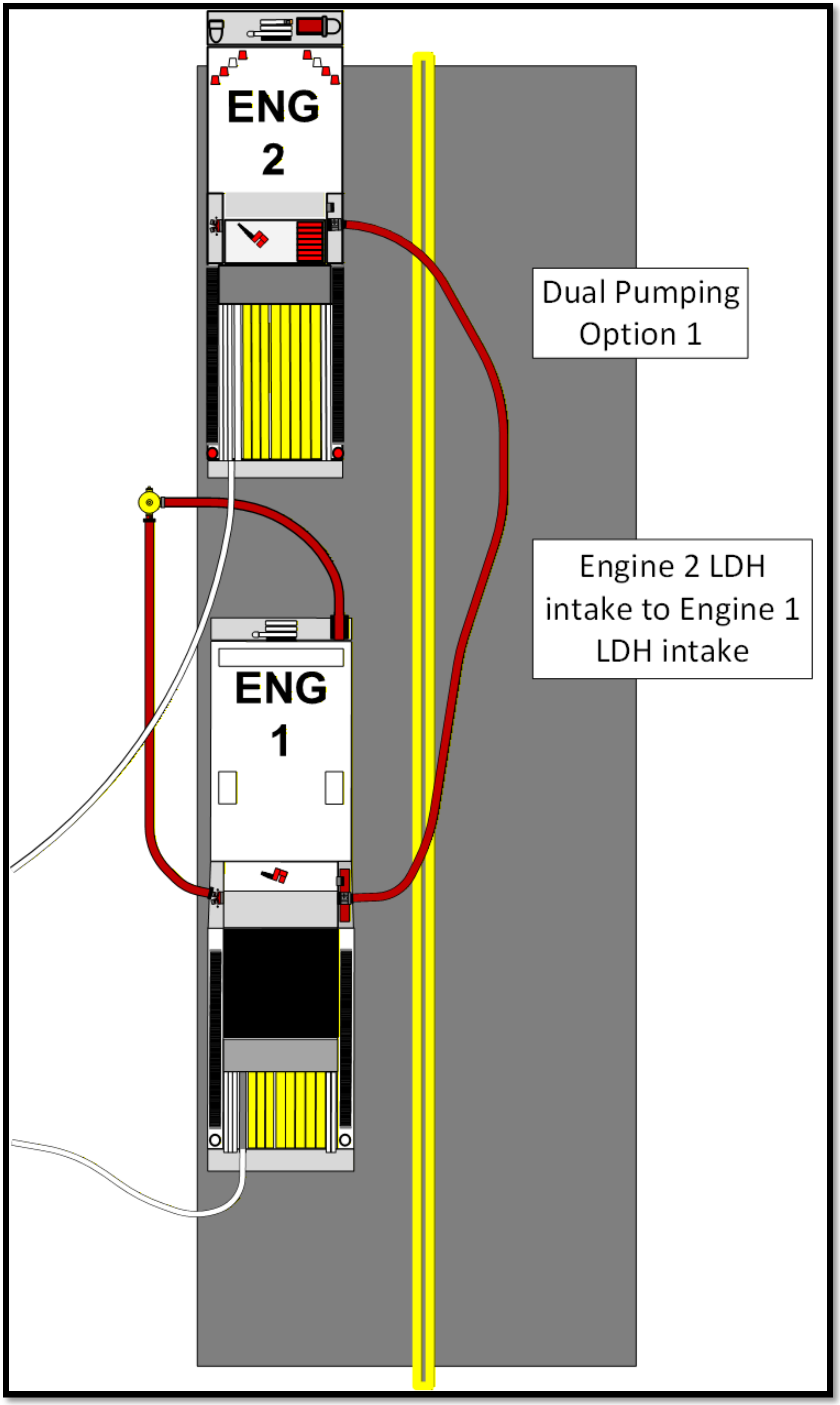
For this procedure to be effective there must be sufficient water flow from the hydrant. The first Engine operator needs to estimate the residual capacity available before attempting to set up for dual pumping.

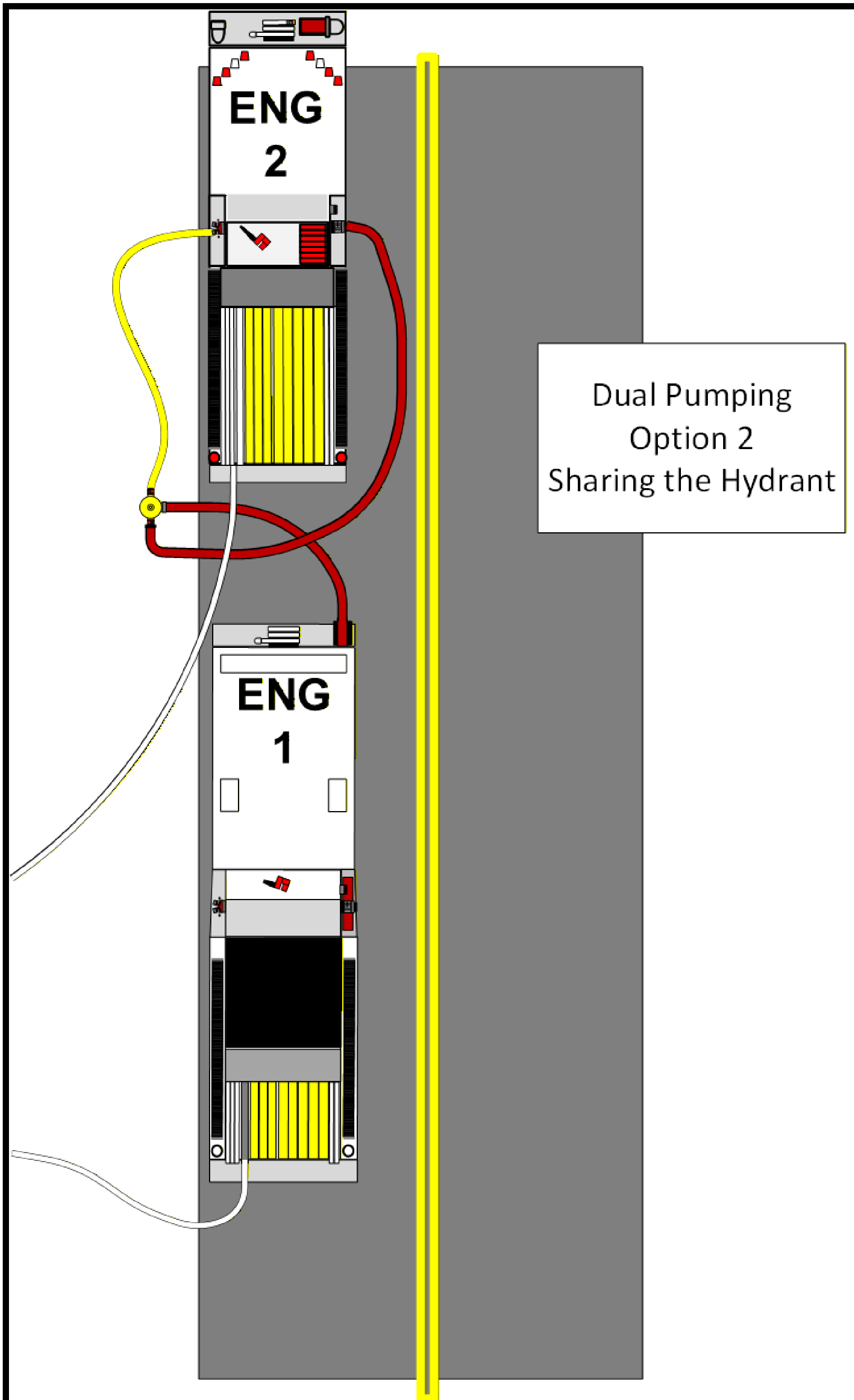
Estimating Residual Hydrant Capacity

$$\frac{\text{Static} - \text{Residual}}{\text{Static}} \times 100 = \%\ \text{drop}$$

<10% drop: 2x water available
<25% drop: 1x water available
>25% drop: less than 1x water available

Procedures: There are several procedures to accomplish dual pumping. With a variety of manufacturers of pumps and Engine companies, procedures may vary depending on the configuration of the pump and the appliances that Engine has available to them.


ENG 2
Dual Pumping Option 1
Engine 2 LDH intake to Engine 1 LDH intake
ENG 1


ENG
2
ENG
1
Dual Pumping
Option 2
Sharing the Hydrant

Key Operational Considerations:

- The intake pressure for both engines is critical and must be monitored closely whenever flow from either pump is increased. The first and second engine operators must coordinate any increased flows to avoid cavitation of either pump.
- Dual pumping may be used in areas with few hydrants or where hydrants are too far apart for practical use.
- Dual pumping may be used in areas where it would require Engines using secondary hydrants to cross railroad tracks or divided highways.
- Standard CCDFEMS hard sleeves are not rated for positive pressures and should not be used to connect to a hydrant under normal circumstances.

TANDEM PUMPING

Purpose: To provide a procedure to supply water to a standpipe system in upper floors in high rise buildings, when the fire pump is out of service, using a two Engine relay to overcome pressure losses due to elevation.

Background: Standpipe systems are designed to deliver 500gpm at 150psi from the riser outlets with an accepted elevation loss of 5psi per floor above the ground level. Without the assistance of the building fire pump the pressures required on upper floors may be too high for one Engine company to achieve and provide the required flow. The use of two Engines in series allows the 2nd Engine to take advantage of incoming pressures from the 1st Engine to supply the standpipe system.

For example, a fire on the 40th Floor of high rise building with fire pump out of service:

EL = 40 floors x 5psi per floor = 200psi in elevation loss

NP = 150psi at the riser outlet to supply 500gpm

FL = friction loss for supply hoses; assumed to be negligible here

AL = appliance loss = 0psi

PDP = EL + NP + FL + AL

PDP = 200 + 150 + 0 + 0 = 350psi to the FDC

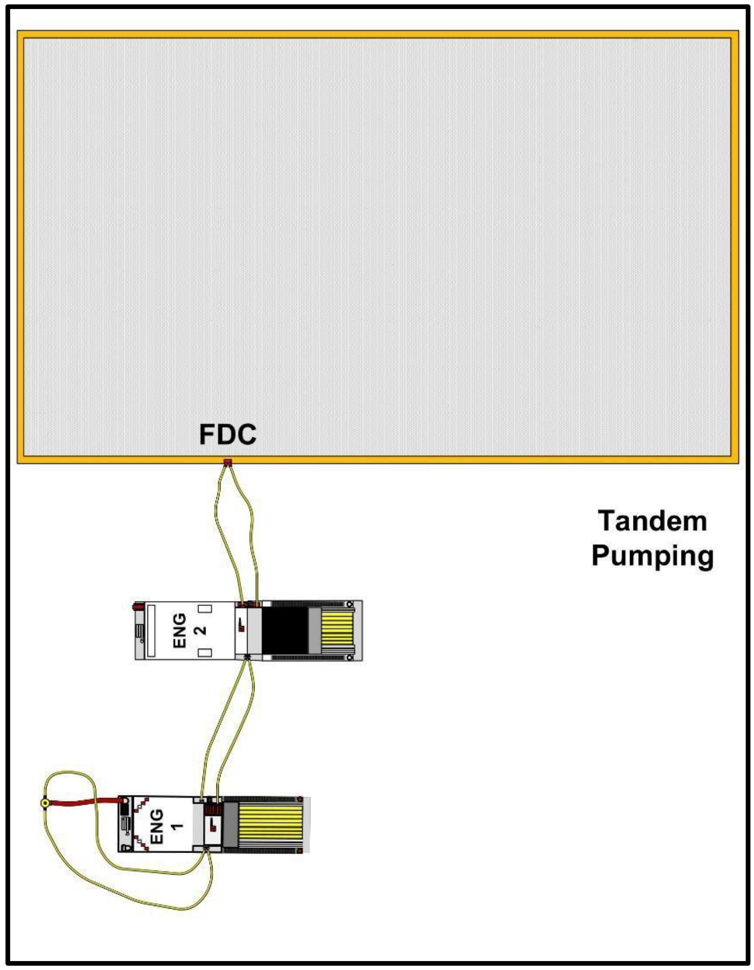
Using a single Engine to supply the FDC creates two problems:

- This pump discharge pressure is reaching dangerous levels for most hose as well as for the apparatus pump.
- The pump rating at this pressure is unknown, however less than 50% and may approach 20%.
  - Recall that centrifugal pumps are rated as follows:
    - 150psi = 100% capacity of pump
    - 200psi = 70% capacity of pump
    - 250psi = 50% capacity of pump
    - 350psi = ??? considerably less

Given the same scenario, using two engines in series makes adequately supplying the FDC more feasible. If Engine 1 is on a hydrant with 50psi intake pressure they can deliver 200psi to Engine 2 while maintaining a net pump discharge pressure of 150psi and 100% of their rated capacity.

Engine 2 now has 200psi to their intake and may pump 350psi to the FDC while maintaining a net pump discharge pressure of 150psi and 100% of their rated capacity.

To successfully achieve higher pressures and maintain volume, pump operators must understand Net Pump Pressure and how centrifugal pumps take advantage of incoming pressure.



NFPA 20, The Standard for the Installation of Centrifugal Fire Pumps, does not allow fire department connections (FDC) to be on the intake side of the building's fire pump. While there can be rare exceptions due to age or incorrect design, building fire suppression systems are supplemented by FDC connected to the discharge side of the building's fire pump. Plumbing the FDC to the intake side of the building's fire pump would then subject the supplemental water supply to the building's intake relief valve and defeat the additional pressure that fire department Engines could supply to the system. In other words, buildings with the FDC plumbed to the intake side of the fire pump do not allow the fire department to control the pressures in the standpipe system in the building. Further be aware that attempting to circumvent the fire pump or intake relief valve by connecting supply lines to a standpipe discharge may not be successful due to pressure limiting devices built into the standpipe valves. It is important to pre-plan buildings that may be large enough to require the higher pressures of tandem pumping.

Operations:

1. Engine 1 establishes water supply from a hydrant using heavy water hookup.
2. Engine 2 positions within 100 feet of Engine 1 and the FDC.
3. Engine 2 may either blind cap the intake relief valve discharge or adjust the intake relief valve to a higher pressure. Sometimes, the adjustment of the relief valve in the field is inexact and requires access behind the pump panel and a wrench. The

intake relief valve is pre-set at 125psi and has a range of 75 to 250psi on most CCDFEMS pumps. If given a choice, adjusting the relief setting is safer than blind capping the relief valve discharge.

4. Engine 2 closes auxiliary coolers, circulating lines, tank fill lines, tank-to-pump valves, and discharge relief valves so that high pressures do not cause damage.
5. Engine 1 supplies available flow and pressure to Engine 2.
6. Engine 2, leveraging the intake pressure from Engine 1, supplies the FDC utilizing discharges that are remote from the pump panel. All valves must be opened and closed slowly to avoid damage to the pump or rupture of hoselines.

Key Operational Considerations:

- Hose lines at pump panels must be tied off near couplings like in hose testing. Keep people clear of hose and connection. Discharges opposite the pump operator's panel should be used to supply the standpipe connections so the pump operator is not exposed to the hoselines. Pressures are at the highest here in this short relay.
- If using LDH, ensure it is designed as "attack" hose and with service pressure rating of 400psi. Regardless, the pressure of a tandem pumping operation will approach the limits of the design of the hose.
- Shut down at water supply first to prevent water hammer.
- Close auxiliary coolers, circulating lines, tank fill lines, tank-to-pump valves, and discharge relief valves so that high pressures do not cause damage.
- Consider marking hose at couplings with a magic marker that is used to supply standpipe FDC. Check after tandem pumping to see if it moves more than ⅛ inch after exposed to high pressures. If so remove from service.

Troubleshooting Guide for Pumping

Problem	Symptoms	Causes	Solution
Pump will not go into gear	No indication that pump is in gear Watch for 3 signs that pump is in gear 1. reading on speedometer 2. sound of pump engaging 3. indicator light in cab and at pump panel is illuminated green	Parking brake is not applied	Start from beginning. Apply parking brake
		Road/pump switch is not in correct position	Place Road/pump switch in pump position ensure green indicator light is illuminated
		Road/pump transfer switch transitioned too quickly	Pause in the middle position between road and pump to give air valve an opportunity to shift
		Transmission is not in correct gear	Ensure selection is in proper gear
Pump will not go in gear after 1st attempt	No indication that pump is in gear	Road/pump switch malfunctioned	Follow manufacturer's instruction for placing pump in gear manually. Newer apparatus may not have this option.
Pump will not go in gear after 2nd attempt	No indication that pump is in gear	Road/pump switch malfunctioned or Mechanical failure	Direct Supply Engine to pump water through your pump. Open appropriate intakes and discharges.
Discharge pressure drops while drafting	Low vacuum reading on intake gauge	Air leak from valves, packing, or appliances	Ensure all valves not used are closed and blind caps are tight Ensure enough water is covering strainer
	Increased vacuum reading	Blocked intake or strainer	Remove blockage and continue to flow water
Pump is overheating while pump is in gear	Overheat light and indicator is on & pump is very hot to touch. TRV is activated.	Lack of water flow through pump. High RPM with limited water flow.	Open discharge Open circulating valve Run a discharge line back to an intake. Open tank fill and tank-to-pump for circulation
Engine temperature gauge is indicating overheating of engine compartment	Temperature reading is above normal range	Engine is overheating, not enough air flow to cool engine	Open auxiliary cooler Check grill in front of radiator for debris

Problem	Symptoms	Causes	Solution
Relief valve does not work or is slow reacting	Excessive pressure surges as lines are opened & closed; relief valve does not control pressure increases	Blocked strainer in pilot valve to discharge relief valve	Remove strainer and wash out sediment. Turn relief valve off & on under pressure of 150psi for 1 minute.
		Relief valve is broken	Turn off relief valve and monitor pump gauges
Primer pump will not evacuate air and water adequately	Primer pump is running when primer is engaged (Old Rotary Vane style of primer)	Engine RPM too low	Increase RPM's
		No oil in reservoir	Add oil
		Vent hole in oil reservoir cap is clogged preventing the siphon effect	Loosen cap or unclog cap to ensure the siphon effect Pull handle out fully
Intake pressure in relay increases above 100psi	Intake >100psi	Hose lines being shut down or intake pressure has increased	Open dump line discharge to maintain residual intake pressure of 50psi Changes in pressure above 10psi to below 100psi should not be adjusted nor should dump lines be utilized. Expect some fluctuation in relay.
Supply line collapses while beginning to flow water or placing additional lines in service	Intake gauge is low or reads zero Water coming out of ground around barrel of hydrant	Kinks or vehicle on top of supply line	Remove kinks in supply line; move vehicle
		Burst supply line	Shut down and replace section with 2 sections
		Supply line not supplying the same amount of water being discharged Ensure the diameters of the hoses are the same. (not supplying 5" hose with a 4" line.)	Throttle down until you get an increased intake reading. Reduce flow in other line or shut down Ask Supply Engine for more water Place 2nd supply line in service
		Hydrant not opened all the way	Open hydrant completely

Problem	Symptoms	Causes	Solution
No pressure reading on master pressure gauge	All 3 signs that pump is in gear are present	Tank to pump or intake is closed (No water in pump)	Ensure proper valves are open. Operate primer pump
		Master gauge is defective	Check individual line gauge for that discharge
Pump will not prime	Water will not fill hard sleeve. No vacuum reading Possibly leaking water prior to attempting prime	Drain or bleeder valve left open	Ensure master drain, bleeders, drains, & auxiliary cooler are closed
		Intake valve open	Close intake valves completely and tighten cap Ensure tank to pump is closed if no water is in tank
		Open discharge or circulating line/ booster line	Close discharges, booster line cooling valves, and circulating lines.
		Intake relief valve leaking (bad gasket)	Blind cap and tighten
		Hard sleeves are not airtight	Tighten hard sleeve couplings
		Pump packing is leaking air	Readjust packing, take out of service
		Not operating primer long enough	Prime should be achieved in 15-20 seconds, operate primer until water is on ground and discharge is flowing water at 50-100psi. Do not operate rotary vane primer >45seconds
		Malfunctioning primer pump	See solutions in previous problems in “Primer pump will not evacuate air and water adequately” on page 3 of this guide