Fauquier County Fire Rescue Association

Driver Release Policy

APPROVED:
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Preface

The scope of this manual is limited to the essential principles and procedures a Driver/Operator (DPO) must know to efficiently and effectively drive and operate fire department apparatus. Information contained in the manual has been extracted from the *Fire Service Training Association (IFESTA) manual, Driver Operator*, which should be consulted by those individuals that wish to increase their knowledge and comprehension of pumper operations.

Hydraulics, in its broadest sense, is an exact science that deals with water and other liquids while at rest and in motion. For the purposes of this manual and for the fire service in general, the definition is usually limited to the study of water used for firefighting purposes. The hydraulics portion of this manual is written to explain a practical method for the determination of the proper pump pressures to produce effective fire streams. In studying the manual, it should be remembered that there are several methods to arrive at approximate answers to fire ground hydraulic problems. However, calculations for this manual and its accompanying field exercise will come from the Fauquier County pump card. It should also be understood that each fire ground scene would have different factors that affect the hydraulics of pump operations. Thus, a necessity for the Driver/Operator to be able to quickly compute correct pump pressures is created. Therefore, a practical approach to hydraulics, such as the information contained in this manual, is needed.

Each chapter of this manual has a quiz that accompanies it. After completion of these quizzes, a final test will be given. Upon completion of the required driving and practical time, quizzes, and written and practical test, the student will be eligible to be a cleared Driver/Operator. Your learning should not stop with the completion of these requirements. Maintaining your skill level and acquiring further knowledge should be part for your standard practices. Some of the knowledge and skills you will learn from this manual may not be used for years, but that does not mean that they are less important and can be forgotten. **A good Driver/Operator will maintain a high level of proficiency at all times.**

Emergency scenes are often chaotic, operating in severe weather conditions, and are subject to change without warning. SOP’s exist but cannot be applied to every situation. To deal with the additional requirements and obstacles that come with this new responsibility, you need to develop a pool of knowledge and skills to draw from. As a skilled Driver/Operator you can make the difference in an incident running smoothly or turning into a disaster.

Table of Contents

Section I. Requirements

Requirements to begin Driver Training Program

- 21 years of Age
- Valid Virginia Driver's License
- Good driving record (as indicated by Fauquier County SOG 3.01 Apparatus Driver Release)

Driver Orientation

All drivers need to be familiar with the apparatus they are operating. Drivers will be oriented to the apparatus upon their first assignment to the station, as well as any time that the driver is not assigned/detailed to that station for a period longer than three months. Orientation will consist of, but is not limited to the following:

- Apparatus specifications (weight, fluids, pump capacity, tank size)
- Pump panel familiarization
- Operation of pump, foam systems, relief valves
- Operation of generators, hydraulic systems
- Hose loads

Section Quizzes/Final Test

Over the course of the driver training program, the trainee will review this manual, and complete the quizzes at the end of each section. These quizzes may coincide with a practical exam. At the completion of the program, the trainee will complete a written and practical test with approved trainer.

Driving Requirements

At a minimum, the trainee will be required to complete ten hours of non-response drive time in the appropriate EVOC Level equivalent vehicle, followed by at least six emergency responses over the course of the program. All drive time (non-response, emergency response) must be documented in a log. Upon completion of the above requirements, the trainee will be eligible to be released as a Driver/Pump Operator at the discretion of the trainer.

Section II. Motor Vehicle Laws

The following laws pertain to the operations of the Driver/Pump Operator while operating emergency vehicles to/from and on scene of an incident:

§ 46.2-829. Approach of law-enforcement or fire-fighting vehicles, rescue vehicles, or ambulances; violation as failure to yield right-of-way.

Upon the approach of any emergency vehicle as defined in § 46.2-920 giving audible signal by siren, exhaust whistle, or air horn designed to give automatically intermittent signals, and displaying a flashing, blinking, or alternating emergency light or lights as provided in §§ 46.2-1022 through 46.2-1024, the driver of every other vehicle shall, as quickly as traffic and other highway conditions permit, drive to the nearest edge of the roadway, clear of any intersection of highways, and stop and remain there, unless otherwise directed by a law-enforcement officer, until the emergency vehicle has passed. This provision shall not relieve the driver of any such vehicle to which the right-of-way is to be yielded of the duty to drive with due regard for the safety of all persons using the highway, nor shall it protect the driver of any such vehicle from the consequences of an arbitrary exercise of such right-of-way.

Violation of this section shall constitute failure to yield the right-of-way; however, any violation of this section that involves overtaking or passing a moving emergency vehicle giving an audible signal and displaying activated warning lights as provided for in this section shall constitute reckless driving, punishable as provided in § 46.2-868.

§ 46.2-920. Certain vehicles exempt from regulations in certain situations; exceptions and additional requirements.

A. The driver of any emergency vehicle, when such vehicle is being used in the performance of public services, and when such vehicle is operated under emergency conditions, may, without subjecting himself to criminal prosecution:

1. Disregard speed limits, while having due regard for safety of persons and property;
2. Proceed past any steady or flashing red signal, traffic light, stop sign, or device indicating moving traffic shall stop if the speed of the vehicle is sufficiently reduced to enable it to pass a signal, traffic light, or device with due regard to the safety of persons and property;
3. Park or stop notwithstanding the other provisions of this chapter;
4. Disregard regulations governing a direction of movement of vehicles turning in specified directions so long as the operator does not endanger life or property;
5. Pass or overtake, with due regard to the safety of persons and property, another vehicle at any intersection;

6. Pass or overtake with due regard to the safety of persons and property, while en route to an emergency, stopped or slow-moving vehicles, by going to the left of the stopped or slow-moving vehicle either in a no-passing zone or by crossing the highway centerline; or
7. Pass or overtake with due regard to the safety of persons and property, while en route to an emergency, stopped or slow-moving vehicles, by going off the paved or main traveled portion of the roadway on the right. Notwithstanding other provisions of this section, vehicles exempted in this instance will not be required to sound a siren or any device to give automatically intermittent signals.

B. The exemptions granted to emergency vehicles by subsection A of this section shall apply only when the operator of such vehicle displays a flashing, blinking, or alternating emergency light or lights as provided in §§ 46.2-1022 and 46.2-1023 and sounds a siren, exhaust whistle, or air horn designed to give automatically intermittent signals, as may be reasonably necessary, and, only when there is in force and effect for such vehicle either (i) standard motor vehicle liability insurance covering injury or death to any person in the sum of at least $100,000 because of bodily injury to or death of one person in any one accident and, subject to the limit for one person, to a limit of $300,000 because of bodily injury to or death of two or more persons in any one accident, and to a limit of $20,000 because of injury to or destruction of property of others in any one accident or (ii) a certificate of self-insurance issued pursuant to § 46.2-368. Such exemptions shall not, however, protect the operator of any such vehicle from criminal prosecution for conduct constituting reckless disregard of the safety of persons and property. Nothing in this section shall release the operator of any such vehicle from civil liability for failure to use reasonable care in such operation.

C. For the purposes of this section, the term "emergency vehicle" shall mean:

1. Any law-enforcement vehicle operated by or under the direction of a federal, state, or local law-enforcement officer (i) in the chase or apprehension of violators of the law or persons charged with or suspected of any such violation or (ii) in response to an emergency call;
2. Any regional detention center vehicle operated by or under the direction of a correctional officer responding to an emergency call or operating in an emergency situation;
3. Any vehicle used to fight fire, including publicly owned state forest warden vehicles, when traveling in response to a fire alarm or emergency call;
4. Any ambulance, rescue, or life-saving vehicle designed or used for the principal purpose of supplying resuscitation or emergency relief where human life is endangered;
5. Any Department of Emergency Management vehicle or Office of Emergency Medical Services vehicle, when responding to an emergency call or operating in an emergency situation;
6. Any Department of Corrections vehicle designated by the Director of the Department of Corrections, when (i) responding to an emergency call at a correctional facility, (ii) participating in a drug-related investigation, (iii) pursuing escapees from a correctional

facility, or (iv) responding to a request for assistance from a law-enforcement officer; and
7. Any vehicle authorized to be equipped with alternating, blinking, or flashing red or red and white secondary warning lights under the provisions of § 46.2-1029.2.

D. Any law-enforcement vehicle operated by or under the direction of a federal, state, or local law-enforcement officer may disregard speed limits, while having due regard for safety of persons and property, (i) in testing the accuracy of speedometers of such vehicles, (ii) in testing the accuracy of speed measuring devices specified in § 46.2-882, or (iii) in following another vehicle for the purpose of determining its speed.

E. A Department of Environmental Quality vehicle, while en route to an emergency and with due regard to the safety of persons and property, may overtake and pass stopped or slow-moving vehicles by going off the paved or main traveled portion of the highway on the right or on the left. These Department of Environmental Quality vehicles shall not be required to sound a siren or any device to give automatically intermittent signals, but shall display red or red and white warning lights when performing such maneuvers.

F. Any law-enforcement vehicle operated by or under the direction of a federal, state, or local law-enforcement officer while conducting a funeral escort, wide-load escort, dignitary escort, or any other escort necessary for the safe movement of vehicles and pedestrians may, without subjecting himself to criminal prosecution:

1. Disregard speed limits, while having due regard for safety of persons and property;
2. Proceed past any steady or flashing red signal, traffic light, stop sign, or device indicating moving traffic shall stop if the speed of the vehicle is sufficiently reduced to enable it to pass a signal, traffic light, or device with due regard for the safety of persons and property;
3. Park or stop notwithstanding the other provisions of this chapter;
4. Disregard regulations governing a direction of movement of vehicles turning in specified directions so long as the operator does not endanger life or property; or
5. Pass or overtake, with due regard for the safety of persons and property, another vehicle.

Notwithstanding other provisions of this section, vehicles exempted in this subsection may sound a siren or any device to give automatically intermittent signals.

§ 46.2-921. Following or parking near fire apparatus or rescue squad vehicle.

It shall be unlawful, in any county, city, or town for the driver of any vehicle, other than one on official business, to follow any fire apparatus or rescue squad vehicle traveling in response to a fire alarm or emergency call at any distance closer than 500 feet to such apparatus or rescue squad vehicle or to park such vehicle within 500 feet of where fire apparatus has stopped in answer to a fire alarm.

§ 46.2-922. Driving over fire hose.

It shall be unlawful, without the consent of the fire department official in command, for the driver of any vehicle to drive over any unprotected hose of a fire department laid down for use at any fire or alarm of fire.

§ 46.2-889. Location of parked vehicles.

No vehicle shall be stopped except close to and parallel to the right edge of the curb or roadway, except that a vehicle may be stopped close to and parallel to the left curb or edge of the roadway on one-way streets or may be parked at an angle where permitted by the Commonwealth Transportation Board or local authorities with respect to highways under their jurisdiction.

§ 46.2-890. Stopping in vicinity of fire or emergency.

No vehicle shall be stopped at or in the vicinity of a fire, vehicle or airplane accident, or other area of emergency, in such a manner as to create a traffic hazard or interfere with law-enforcement officers, fire fighters, rescue workers, or others whose duty it is to deal with such emergencies. Any vehicle found unlawfully parked in the vicinity of a fire, accident, or area of emergency may be removed by order of a law-enforcement officer or, in the absence of a law-enforcement officer, by order of the uniformed fire or rescue officer in charge, at the risk and expense of the owner if such vehicle creates a traffic hazard or interferes with the necessary procedures of law-enforcement officers, fire fighters, rescue workers, or others whose assigned duty it is to deal with such emergencies. The charge for such removal shall not exceed the actual and necessary cost. Vehicles being used by accredited information services, such as press, radio, and television, when being used for the gathering of news, shall be exempt from the provisions of this section, except when actually obstructing the law-enforcement officers, fire fighters, and rescue workers dealing with such emergencies.

§ 46.2-1028. Auxiliary lights on fire-fighting, Virginia Department of Transportation and other emergency vehicles.

Any fire-fighting vehicle, ambulance, rescue or life-saving vehicle, Virginia Department of Transportation vehicle or tow truck may be equipped with clear auxiliary lights which shall be used exclusively for lighting emergency scenes. Such lights shall be of a type approved by the Superintendent, and shall not be used in a manner which may blind or interfere with the vision of the drivers of approaching vehicles. In no event shall such lights be lighted while the vehicle is in motion.

§ 46.2-1029.1. Flashing of headlights on certain vehicles.

Emergency vehicles as defined in subsection C of § 46.2-920 may be equipped with the means to flash their headlights when their warning lights are activated if (i) the headlights are wired to allow either the high beam or low beam to flash, but not both, and (ii) the headlight system includes a switch or device which prevents flashing of headlights when headlights are required to be lighted under § 46.2-1030.

The provisions of clause (ii) above shall not apply in the City of Chesapeake, the City of Portsmouth, the City of Poquoson, or the County of York.

Section III. Driver Responsibilities/Safety

Driver Responsibilities

In addition to obeying applicable driving regulations, the Driver/Operator must be able to lay hose effectively and safely, secure water from an available water supply, operate the pump to develop effective fire streams, and identify potential apparatus problems.

Driver/Operators must have knowledge of the response area, response routes, and possible operational problems that may be encountered. The Driver/Operator is responsible for all equipment, proper placement of the apparatus, and ensuring effective communications between the apparatus officer and the communications center.

A Driver/Operator should possess steady nerves, good eyesight, quick reflexes, and overall, a good attitude. As a good Driver/Operator, he or she should consider that:

- Excessive speed, over reliance on warning signals, and dependence on assumed right of way lead to many of auto accidents involving emergency vehicles.
- Stopping distances on snow and ice are 3 to 15 times as far as on dry pavement.
- One mistake on his or her part can be detrimental to the department and its public image.

Drivers are also responsible for overseeing the actions of probationary members (red hats) while the crew is engaged in incident operations. Probationary members can be used to assist the Driver/Operator in a lot of his/her activities. It is the responsibility of the Driver/Operator to keep the probationary members in a safe environment, as they may not fully understand the dangers of the fire ground and/or incident operations.

Prior to entering the vehicle

The Driver/Operator is responsible for ensuring that the vehicle is in running condition prior to leaving the building. Make a 360° lap of the apparatus, being sure to check:

- Compartment doors - most apparatus is equipped with sensors that will tell you when a door is open, but they're not infallible. Manually check to make sure they are closed.
- Hose loads - if you drop your hose load while responding you will effectively prevent yourself from getting to the call. Check all loads including the cross lays, bumper/trash lines, and booster reels.
- Mounted tools - most apparatus have a tool or two mounted on the outside of the unit. Make sure they are attached securely to the unit.

- Bumper and side steps of apparatus - these are convenient places to set all kinds of items - drink cups, tools, clipboards, helmets, radios, etc. Again, make sure they're clear.
- Shorelines/air connections - manually disconnect these. Do not rely on the auto eject.
- Deck gun in lowered position - make sure that deck guns are lowered into position before exiting the building, so you do not catch the deck gun on anything coming out of the door.

This may sound like a lot to think about before getting into the unit, but it should only take about 30 seconds to do and it gives other personnel time to don their PPE. It is a lot easier to do a 360° survey than to clean up the mess when equipment comes off the unit en route to a call. ***Make this your habit!*** Perform this check every time the apparatus goes out the door, to prevent lost or damaged equipment.

Driving Safety

After the outside of the apparatus is secured you must also check the inside before putting the apparatus in motion. Make sure all occupants are inside, seated, and belted. Make sure all cab doors are closed. Check that all gauges are in normal operating range.

The Driver/Operator must drive in the safest manner possible while operating fire apparatus. This includes the safety of the crew and the safety of the public. No excuse is good enough for killing or injuring anyone while responding to a fire or EMS call. Excessive speed is the most common factor in fire apparatus accidents.

Vehicle Rollover

The majority of firefighter injuries and deaths are attributed to rollover accidents. Vehicle rollover most often happens when the right wheel of the vehicle leaves the roadway and moves into a ditch or soft shoulder. The driver then tries to correct the steering in the opposite direction. When the vehicle comes out of the ditch the wheels are now turning to the left and the vehicle heads for the opposite side of the road. To keep the vehicle from going into the opposite side of the road the driver then steers back to the right. These sudden changes of direction from right to left, and back to right cause the weight of the vehicle to push over the center of gravity and the apparatus rolls on its side. The result is major damage to the apparatus and serious injury to everyone on board.

To prevent such tragic consequences from happening, the driver must be prepared and know what to do. It is natural instinct to steer in the opposite direction. Once the apparatus leaves the roadway, it must be stopped before any attempt to steer takes place. The vehicle must be slowly brought to a stop, do not slam on the breaks! The driver can then make an attempt to safely drive the vehicle back onto the roadway. If unsuccessful, a heavy-duty tow truck will be needed to pull the apparatus back onto the roadway.

Do not try and use the winch of a Brush Truck for this job. Most wenches for Brush Trucks are designed for up to 10,000lbs. Fire apparatus generally weigh in at more than 50,000 lbs. ***Under no circumstance*** should the driver attempt to accelerate out of the ditch.

Approaching the Scene

There is often more than one way to approach the emergency scene. Choosing the best way takes consideration of several factors.

- Type and location of closest available water supply. (Tanker shuttles, drafting operations, domestic hydrant, relay pumping, etc.) You may have to drive past the fire scene to get to the water supply.
- Best location to place apparatus for attack or supply operations. Position so you do not block other apparatus from reaching the scene (or leaving, in the case of tankers).
- Turning apparatus around is difficult if not impossible on some roads, others will accommodate large apparatus.
- Proper staging will help incidents run more smoothly by keeping non-essential equipment from blocking or cluttering the emergency scene.

Remember to leave room for the Truck Company on side A, pull past or stop short.

Every emergency scene is different; there is no single best way to approach the scene. Knowledge of the district is the best way to properly plan your approach. Use tools such as ADC maps, first due map books, and cross streets from dispatch to assist in the process. The decision you make in the first few minutes will determine how the rest of the operation will proceed. Once you have started to flow water, you are committed. It is almost impossible to then move your apparatus. If not properly staged or placed, the whole operation will have to change to correct this. Positioning your apparatus in the right place begins with knowing the best way to approach the emergency scene.

Other things to consider as a driver

Be cautious of drainage culvers and low spots in roadways. On cab forward apparatus, the wheels are set closer to the center of the vehicle, which allows for a tighter turning radius. The bumper of these vehicles sticks out further than normal vehicles. Approach these locations slowly and at angles that minimize possible contact.

Disable engine brake during slippery conditions. Engine breaks, transmission retarders or other types of breaking assist devices should be disabled during conditions of reduced traction.

These types of devices are very useful in slowing apparatus during normal driving, but when the road surface is wet or icy these devices may cause the rear end to lose traction causing the apparatus to slide. Use only the vehicle break to slow or stop apparatus during slippery conditions. Take into account increased stopping distances.

Always use ground guides when backing fire apparatus. Due to the large size of the fire apparatus the driver cannot fully see what is behind them. Backing into an object is the most preventable type of accident and using a ground guide makes incidents of this type a non-occurrence. The damage caused by backing into something can be severe and costly. When backing, use at least one guide and if the situation is complicated, do not hesitate to make all passengers, including the officer, exit the vehicle and served as ground guides. If you come across a case where you do not have a passenger to act as a guide, the driver needs to get out of the apparatus and do a complete walk around before backing up.

Even though the officer is in charge, the Driver/Operator is still responsible for the safe and proper operation of the apparatus. If an incident does occur, the driver can be found negligent and will be responsible for damages.

Section IV. Abbreviations, Symbols, and Terminology

Abbreviations/Symbols

The following is a list of abbreviations and symbols used throughout this manual in regards to hydraulics. These should be familiar to the driver from Driver/Pump Operator class.

AL – Appliance loss

D – Orifice diameter in inches

EP – Elevation pressure loss or gain

FL – Friction loss

FP – Flow Pressure

GPM – Gallons per minute

NOP – Normal Operating Pressure

NP – Nozzle pressure

NR – Nozzle reaction

Q – Quantity of flow in hundreds of gallons per minute

PDP – Pump discharge pressure

PSI – Pounds per square inch

RP – Residual pressure

TPL – Total pressure loss

‘ – Feet

“ – Inches

/ – Per (as in per one hundred feet)

SQ – Square root

Terminology

Driver/Operators must have a complete understanding of hydraulics in addition to a good working knowledge of fire pumps and pumper operation techniques. To do this and be able to effectively communicate with others on the fire ground the Driver/Operator must know and understand the following terminology.

- ***Appliance*** – a device in which the direction of water flow is interrupted or changed.
- ***Back Pressure (head pressure)*** – the amount of pressure generated by the weight of the column of water above the pump. This is figured as 0.434psi per foot of elevation (IFSTA Fire streams).
- ***Capacity*** - the volume of water that a pumper can discharge from draft, with a ten-foot lift, at a prescribed pressure (150psi for Class A pumpers, 120psi for Class B pumpers).
- ***Discharge*** – coupling where water leaves the pumper
- ***Discharge Pressure*** – the quantity of water issuing from an opening; expressed in gallons per minute (gpm)
- ***Displacement*** – the volume of liquid that a container holds
- ***Engine*** – any pumper, which is supplying water
- ***Flow Pressure*** – the forward velocity pressure of water issuing from a discharge opening. Flow pressure is usually measured by using a pitot tube and gauge, and expressed in psi.
- ***Friction Loss*** – loss in energy (pressure) due to friction. This results from the turbulence in the water and the mater molecules rubbing on the interior surfaces of the hose and appliances.
- ***Head Pressure*** – see Back Pressure
- ***Hydrant Pressure*** – the amount of pressure found in a water system at a hydrant. This can be static or residual pressure.
- ***Intake*** – coupling where water enters the pumper
- ***Master stream*** – any fire stream that is too large to be controlled without mechanical aid. A master stream flows more than 350 gpm (IFSTA Pumping Apparatus)
- ***Negative*** – a measurement of the amount of vacuum, usually measured in inches of mercury.
- ***Net Pump Discharge Pressure*** – the total work done by a pump to get water into, through, and out of the pump, hose, and nozzles.
- ***Normal Operating Pressure*** – the amount of pressure which is found on a water distribution system during normal consumption demands (IFSTA Pumping Apparatus). For fire ground operations this is usually taken to be the same as static pressure.
- ***Nozzle Pressure*** – the amount of pressure required at the nozzle to make a proper hose stream.
- ***Nozzle Reaction*** – the backward force created by a stream of water as it leaves a nozzle.
- ***Pressure*** – a measure of energy contained in water that is measured and stated in pounds per square inch (psi).

- ***PSI*** – a measurement of pressure expressed as force (pounds) per unit area (per square inch).
- ***Pump Discharge Pressure*** – is the final pressure developed by a fire pump, generally indicated by the master pump discharge gauge, and expressed in psi.
- ***Residual Pressure*** – the amount of pressure remaining in a system when water is flowing. It can also be defined as the portion of total pressure that is not used to overcome friction loss in piping, appliances, and other devices.
- ***Siamese*** – an appliance that combines two or more hose lines into one hose line.
- ***Static Pressure*** – the pressure exerted by water when at rest.
- ***Total Pressure Loss*** – the total amount of pressure that is lost due to friction loss, appliance loss, and elevation.
- ***Vacuum*** – pressure that is less than atmospheric
- ***Velocity*** – the speed at which water passes a given point, usually measured in feet per second (fps)
- ***Water Hammer*** – the concussion effect of a moving stream of water against the sides and ends of pipe or hose line when its flow is suddenly stopped.
- ***Wye*** – an appliance that breaks one hose line into two or more hose lines

Relay Operations: The procedure of using two or more pumpers to supply the attack pumper with hose lines from a water source.

Water Task Force: A combination of pumpers and tankers under the command of one officer to perform water supply functions.

Section V. Hydraulic Principles

Hydraulics

Hydraulics is an exact science that deals with water and other fluids while at rest and in motion. The Driver/Operator must have an understanding of hydraulics to be able to develop effective fire streams for the firefighter to use to extinguish a fire. In this section of the manual explanations will be given for the six principles of hydraulics to develop an understanding of pressure.

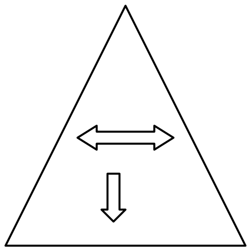
Pressure

The word pressure has several meanings in the dictionary. In the fire service pressure is usually spoken of in units referred to as pounds per square inch (psi). Pressure, by definition, is force acting upon a unit of area. A cubic foot (a 12" by 12" by 12" box) of fresh water weighs 62.5 pounds (force), acting on a 12 inch by 12 inch area exerts .434 PSI at its base.

With this understanding of what pressure is, we will next examine the six basic principles that determine the action of pressure upon fluids.

The First Principle

Fluid pressure acts perpendicular to any surface on which it acts.



In this example the pressure exerted by the weight of the water in the container is acting perpendicular to the walls of the container. This would be the case for water in a hose line.

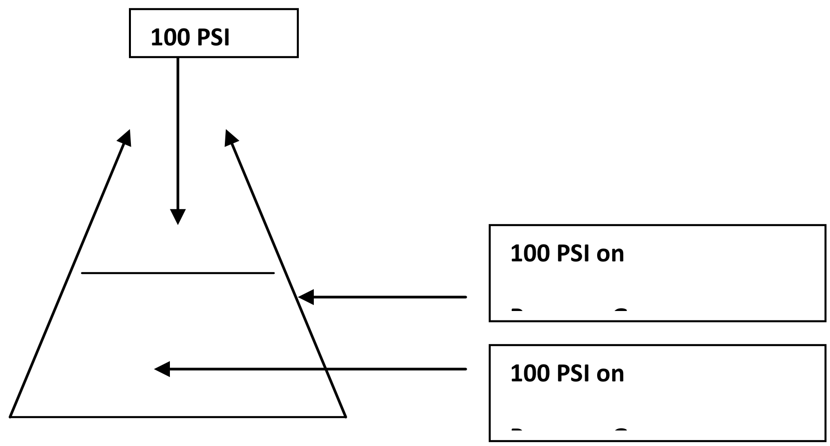
The Second Principle

Fluid pressure at a point in fluid at rest is of the same intensity in all directions; or, it could be stated that fluid pressure at a point in fluid at rest has no direction.

Imagine yourself in a swimming pool, feeling the pressure of the water upon you. The pressure is pushing equally on all parts of the body.

The Third Principle

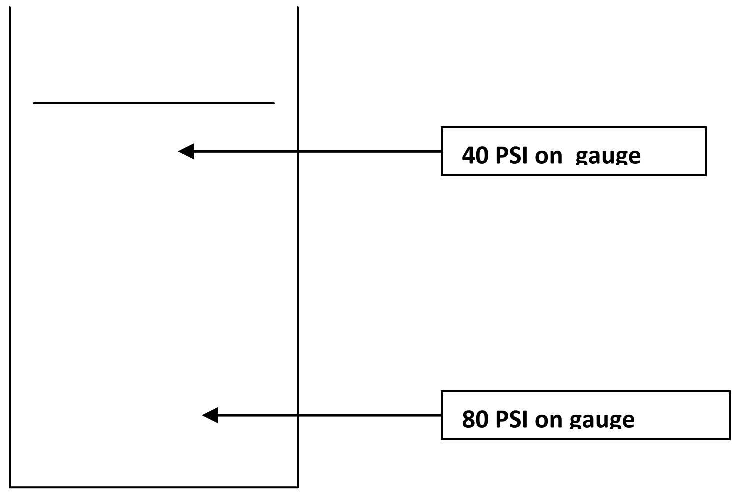
Pressure applied to a confined liquid from an outside source is transmitted equally in all directions.



In this case pressure applied to a container from outside, such as cylinder with a piston pushed into it, is transmitted equally throughout the cylinder. Pressure inside of a hose (a closed container) is equal in all directions.

<u>The Fourth Principle</u>

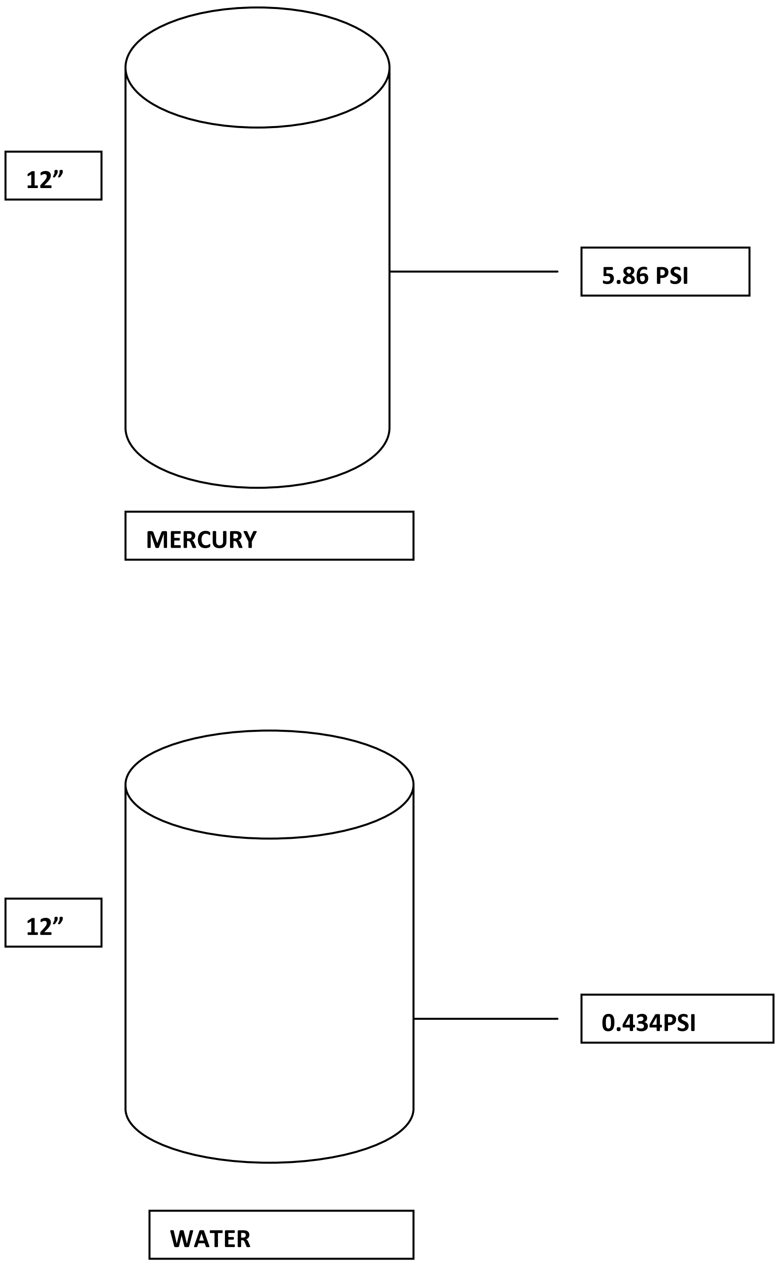
The pressure of a liquid in an open vessel is proportional to its depth.



As in the case of a water tower; by lifting the water in the air, it creates higher pressure at the base. This pressure is then sent into the pipes (a closed container), which creates static pressure in the system. So water towers/tanks do more than just store water, they add pressure to the water system also.

The Fifth Principle

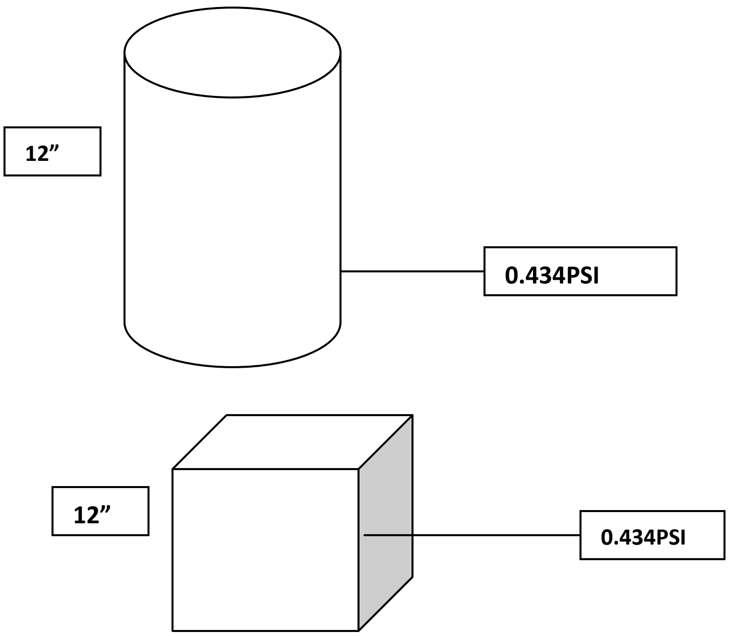
The pressure of a liquid in a open vessel is proportional to the density of the liquid.



In this case the mercury is denser than the water. Thus for the same height of the materials, the pressure that is exerted by the mercury is greater than that exerted by the water.

The Sixth Principle

The pressure of a liquid on the bottom of a vessel is independent of the shape of the vessel.



In this case regardless of the shape of the vessel containing the liquid the pressure is the same provided the height of the liquid is the same and the cross-sectional area at the bottom of the container is the same.

Types of Pressure

Atmospheric pressure is the pressure exerted by the weight of the atmosphere, which varies with the elevation above sea level. The atmospheric pressure at sea level is 14.7 PSI. It is important for the Driver/Operator to understand that atmospheric pressure is usually measured in either PSI or inches of mercury. The pressure shown on most gauges on a pumper are measured in PSI, which stands for pounds per square inch. Engineers make a distinction between PSI and PSIA, pounds per square inch absolute. The difference between the two is shown as follows:

$$PSI_A = PSI + 14.7$$

In this manual pressure is expressed in PSI, unless otherwise stated.

Head Pressure - In the fire service this refers to the height of a water supply above an orifice. Thus if the top of the water supply is 200 feet above your point of reference the head is 200 feet. To convert to pressure, .434 should be multiplied by the feet of head. This is because water exerts a force of .434 PSI for every foot of height. Thus in this example we multiply 200 feet by .434 PSI to arrive at 86.8 PSI.

Static Pressure - The pressure of a fluid when it is not moving. In the fire service we accept this as being the pressure at a hydrant or pumper intake before water is allowed to flow through attack or supply lines.

Residual Pressure - The pressure that is not used to overcome friction loss or gravity while forcing water through pipe, fittings, fire hose, or adapters. In the fire service we accept this as being the pressure at a hydrant or pumper intake before water is allowed to flow through attack or supply lines.

Flow Pressure - The pressure that causes water to flow in a forward direction. It can be measured with a Pitot tube and gauge.

Elevation loss or Gain - The pressure that is caused by the force of gravity working on water. When water is being moved in an upward direction this is referred to as backpressure. When water is being moved in a downward direction this is referred to as pressure gain. The pressure lost or gained is equal to .434 PSI per foot, which for calculation purposes is rounded to 5psi per floor not including the first floor.

Friction Loss

Friction loss is the loss of energy (pressure) caused by water flowing through pipe, hose line, or another similar device. There are several factors that affect friction loss (IFSTA, Fire streams):

Length - When all other conditions are equal, the loss by friction varies directly with the length of hose or pipe.

Flow - With the same size hose or pipe used, the friction loss will vary approximately to the square of the increased in the velocity of the flow.

- If the velocity (quantity) of flow in a hose line is doubled, the friction loss will be four times greater.
- If the velocity of flow in a hose line is tripled, the friction loss will be nine times greater.

Size - With the same amount of flow (discharge), friction loss varies inversely to the fifth power of the diameter of the hose. This principle shows the advantages of large diameter hose line versus smaller lines due to the larger volumes of water available at a smaller friction loss.

Velocity - For a given velocity of flow, the friction loss in hose is approximately the same regardless of the pressure on the hose line. Friction loss is caused by velocity of the water through the hose line, not the pressure. Thus if 300 GPM is being pumped through a three inch hose line, there will be a friction loss of 7.2 PSI in one hundred feet regardless of the pressure being pumped through the hose line.

Critical Velocity - For each size of hose line or pipe there will be a maximum velocity (flow) that will go through it. Increasing the pressure beyond this velocity will not result in increased discharge. Rather, it will cause a more turbulent flow introducing more friction loss.

Other Factors - There are several other factors that will create more friction loss in hose lines or pipe such as:

- Rough interior linings, old hose may have up to 50% greater friction loss than new hose
- Bends and kinks
- Improperly sized gaskets
- Appliances and adapters
- Partially closed valves

Section VI. Fire Pumps

Fire Pumps

Although there are numerous models and types of fire pumps used on fire department pumpers, most are designed to perform the same general function. That function is to take water, an extinguishing agent, form a source and deliver it through piping, hoses, and nozzles in sufficient quantity and pressure to develop a good fire stream.

Fire pumps are identified in many ways with the rated capacity of the fire pump being the most common. Capacity, as used for this purpose, means the volume of water that a pump can discharge from a draft at a given net pump discharge pressure, usually 150 PSI, as determined by testing. Recognized pump capacities are 500, 750, 1000, 1250, 1500 1750 and 2000 gpm, although larger capacity pumps have been built. The fire service uses two basic types of fire pumps, which are:

- Positive-displacement
- Centrifugal

Positive-displacement Pumps

The centrifugal fire pump has replaced this type of pump; however, it is still necessary as it will pump air where centrifugal pumps will not. These pumps are used as priming pumps on centrifugal fire pump systems.

The principle of the positive-displacement pump is the hydraulic principle of "pressure applied to a confined liquid is transmitted within the liquid, outwardly, and equally in all directions. Simplest of the positive-displacement pumps' is the piston pump and it is still used in some high-pressure pumps today.

Another type of positive-displacement pump is the rotary gear pump consisting of a pair of rotors resembling gears of spokes that mesh. As the rotors turn, water is picked up on the intake side at the pump, trapped between the gears, and discharged at the pump's discharge.

A third type of positive-displacement pump is the rotary vane pump. This pump is used primarily for small volume pumping and as a priming pump. This pump has only one rotor, which is mounted off center to the housing casing. The rotor is equipped with canes that are held against the housing by either centrifugal force or springs. Water and air is taken in at the intake by the close fit between the canes and the housing.

In summary, all positive-displacement pumps:

- Discharge a definite volume of water for each cycle,
- Are self-priming (can pump air),
- Have some slippage (backward movement of water from the discharge to the intake).

Centrifugal Pumps

Centrifugal pumps use centrifugal force to give water velocity (pressure). Centrifugal force is an outward force associated with rotation. Factors regulating the effectiveness at a centrifugal pump are:

- Pressure to be developed,
- Speed (RPM's),
- Quantity of flow.

Thus if pressure remains constant, an increase in RPM's of the impeller will cause an increase in flow. If the quantity of flow is kept constant, an increase in the RPM's will cause additional pressure to be developed. If the speed of rotation is kept constant, an increase in flow will cause less pressure to be developed and vice-versa. All of this can happen, because a centrifugal pump does not discharge a set amount of water in each cycle.

In a centrifugal pump, the rotating wheel is referred to as the impeller. The container in which the impeller is operating is known as the housing or case. The water inlet is the center of the impeller is known as the eye, and the outlet is called a discharge. The flow of water through the pump is as follows; water enters the impeller through the eye and is hurled outward between the impeller vanes by centrifugal force to the discharge. The impeller shaft is usually housed off-center to the housing, so the area of the housing increases as it approaches the discharge and is referred to as the volume. A centrifugal pump may have two impellers depending upon its design. Some centrifugal pumps have more than one impeller mounted on a common shaft. A pump of this type is referred to as multi-stage (two or more impellers) centrifugal pump. Pumps having only one impeller are referred to as a single-staged pump.

The main advantage of the centrifugal fire pump is its ability to use the incoming pressure of water where positive displacement pumps will not. Thus if high pressures are required, centrifugal fire pumps may be placed in series to develop the desired pressure.

The type of impellers on the fire apparatus will effect its classification as to whether it is a Class A or Class B pumper. As pumpers are classified by their capacity and the amount of water they can pump, the class A or B designation is important.

Class A pumpers are those pumpers that can produce the following conditions with the fire pump:

- Pump 100% capacity at 150-PSI net pump pressure
- 70% capacity at 200-PSI net pump pressure
- 50% capacity at 250-PSI net pump pressure

Class B pumpers are those pumpers that can produce the following conditions with the fire pump:

- 100% capacity at 120-PSI net pump pressure
- 50% capacity at 200-PSI net pump pressure
- 33 1/3% capacity at 250-PSI net pump pressure

It can be seen from these conditions that the Class A pumper is capable of producing higher pressures for the same volume of water than a Class B pumper. The requirement for higher pump pressure to support sprinkler and standpipe systems has made Class A pumpers favorable to Class B pumpers.

Small Volume Pumps

There are several ways that a fire pump can be mounted on fire apparatus. Each way requires a different means to transmit the power from the apparatus motor to the fire pump. The following are the four primary ways of transmitting the power.

Midship - The pump is mounted on the apparatus chassis, midway between the front and rear wheels, generally, a split shaft gear case, referred to as the pumper transmission casing, is installed in the apparatus drive train allowing engine power to be transmitted either to the fire pump or to the apparatus rear axle(s). In this case the apparatus transmission is used to select a designated gear ratio of engine RPM to pump RPM to turn the pumps impeller(s) at a speed that will develop the desired pump pressures. The transmission is generally placed in drive gear to accomplish this task. The apparatus manual, provided by the apparatus manufacturer, should be consulted for the proper gear. There are midship pumps that use power takeoff directly from the engine flywheel, allowing for pump-and-roll or stationary positions to be taken with the pumper. With this arrangement, the apparatus transmission may be placed in neutral or left in gear.

Front Mount – The pump is mounted on the front of the apparatus, ahead of the radiator. Front mount pumps are engaged and disengaged by a clutch. Power is transmitted directly or through a gear case from the front of the engine crankshaft. Front mount pumps normally have a pump-and-roll capability.

Separate Engine – The pump is mounted on the apparatus, and instead of using the apparatus engine power, a separate engine is provided to power the pump. Most aircraft crash-rescue vehicles are designed like this, along with brush trucks.

Power takeoff – As shown in front mount and separate engine above.

Pump Shifting Devices

The location and operation of controls required to transfer power to the pump will vary with the apparatus manufacturer. Generally, a control, whether manual, electric, or assist will be located in the apparatus cab. In the event of a failure in a mechanical shift device all pumpers will have a manual backup. The locations and type will vary with each manufacturer, but all will have it. In most cases, the activation of the pump shift mechanism and the placing of the apparatus in the proper transmission gear will cause power to be applied to the pump. It is important for the pump operator to consider that the steps used to engage the fire pump must be done correctly or the pump will not operate properly, or at all. In cab mistakes in transferring power to the fire pump are among the most common made on the fire ground during emergency conditions. If you are throttling up and getting any increase in pressure the pump is probably not in gear. Here are the steps

- Properly position the apparatus where it is to be utilized
- Bring the apparatus to a full stop and set the parking brake
- Shift the transmission to neutral
- Activate the road-to-pump-power gear as determined by the manufacturer (this is usually the drive gear)
- Check the speedometer. On most apparatus it will indicate a speed between 10-15 MPH with the vehicle standing still, and engine idling, if you are in the proper transmission gear to pump.
- Assure that the OK to pump light is “on”.
- As a final check, depress the accelerator to make sure the vehicle does not move forward.

To take the pump out of gear, reverse the sequence for the steps above. After shifting into neutral and before activating the road-to-pump shifting device, wait ten seconds for the transmission to fully stop. The speedometer should show “0” MPH or the gear inside the pump or apparatus transmission may clash, possibly causing damage to one or both of the devices.

Priming a Centrifugal Pump

When drafting water with a centrifugal fire pump, a priming pump must be used to remove the air from the pump and intake piping. Removal of this air creates a negative pressure inside the fire pump allowing atmospheric pressure to push water up the suction sleeves and into the pump. After water reaches the fire pump, the pump will maintain movement of it. Due to the creation of the negative pressure inside the pump, it is important to assure that the pump will be primed soon or damage to the unit may result. Also, many pump manufacturers use pump water to cool bearings and other critical elements of the pump’s construction.

The ability of a pump to draft water is a very important requirement. A priming pump must be able to raise water 10 feet into a dry pump through 20 feet of appropriately sized hard suction sleeve in not more than 30 seconds. Maintenance of the fire pump and its priming devices is important to the efficiency of the priming operations. An important part of this maintenance is the monitoring of the priming oil level. Rotary vane and rotary gear pumps will expel air with the aid of a lubricant, and than it will be used to form a seal and reduce the priming time of the pump. Some new priming pumps are Teflon coated and do not require the use of priming oil. Rotary vane priming devices require an engine speed of between 1200 – 1500 RPM’s.

In general, the following steps must be taken to prime a pump.

- Assure that all caps on intakes, except for the water supply intake, are in place and snug.
- Close all valves that are connected to the fire pump including those on cooling systems, tanks, discharges, hose reels, and drains.
- Engage the fire pump and increase throttle to 1500 RPM’s.
- Operate the priming device until the discharge pressure gauge indicates pressure, then disengage the priming device, and increase the engine speed until a discharge pressure of 50 PSI is shown. At a ten foot lift the pump should prime within 30 – 45 Seconds.

Other indications if the pump is being primed are:

- Water discharge from the priming pump at the bottom of the pump housing.
- Drop in engine RPM due to the engine having to do work.

- A change in the sound of the priming pump.

Pressure Control Devices

Pressure to and from the fire pump must be controlled to allow the firefighter to safely use the fire streams. Pressure may be controlled by several means, of which the relief valve and pressure governor are the most common.

Relief valves are devices that are sensitive to pressure changes and are able to relieve internal changes in developed pump pressure.

A pilot relief valve is an adjustable spring loaded pilot valve which is used to actuate the main relief valve. This reroutes a part of the water movement from the pump's discharge back to the pump's intake. This lowers the water pressure when the pressure at the pump exceeds the pilot valve's pressure setting. Normally this path of water movement is closed. The relief is adjusted to just above the highest discharge pressure the driver is pumping at. If the pressure discharge fluctuates higher than the set pressure, the relief valve opens and relieves the pressure.

A more complex system, but one that is easier to operate is a ***pressure governor.*** A governor has a two-position switch, one for RPM and the other for pressure. In the RPM position, increasing or decreasing the throttle will adjust engine RPM's. Once you have reached the desired discharge pressure, the Driver/Operator should switch over to the pressure position. Pump pressure is still adjusted with the throttle. By keeping the pressure governor in pressure mode the onboard computer of the engine will maintain the current pump set discharge pressure and it will adjust the RPM's to maintain such pressure. (Note: the pressure governor works off of Net pump Discharge Pressure.)

> ***Example:*** An engine is flowing a 1-3/4 line at 150psi off of tank water. The Driver/Operator sets the throttle switch to pressure mode. The Driver/Operator then hooks up to the hydrant, and opens the front intake. This causes the nozzle and discharge pressure to change, since the pumper is now receiving incoming pressure. The onboard computer automatically senses the incoming pressure and decreases the RPMs to keep the proper discharge pressure.

With a normal relief valve this excess pressure would show up as excess discharge and the pressure would be dumped back into the pump since the RPMs are so high. The Driver/Operator would have to lower the RPMs to allow for this extra pressure. (Note: if the pressure relief valve had not been set, this pressure will be transferred to the hand line.)

Intake Relief

Just as the pump needs protection from sending to much pressure out, it also needs protection from water coming in. The intake relief valve protects the pump from excess pressure. This valve is normally preset at 150psi and will dump excess incoming pressure onto the ground. Some pumpers that have pressure governors may not have an intake relief valve because the pressure governor can safely correct incoming intake pressure.

All large diameter hose intakes are equipped with relief valves. These steamer connection relief valves are also usually preset at 150psi and relieve any further pressure through a discharge valve onto the ground. These can be internal or a manifold connected to the steamer connection.

Section VII. Calculating Discharges

Calculating Discharges

Fire ground activities often prohibit the use of complex formulas to calculate the exact pump pressure required to develop effective fire streams. Because of existing conditions and lack of available time, it is necessary to utilize certain formulas and rules-of-thumb for determining friction loss at the fire scene. (IFSTA Fire Streams)

To determine the friction loss in a hose line the Driver/Operator should establish a system similar to the following. This is important to prevent mistakes that may result in improper pump pressures being developed. The following is the suggested method of determining the friction loss in hose line.

- **Step 1:** Determine the size of the hose line(s) to be used.
- **Step 2:** Determine the amount of flow going through the hose line(s)
- **Step 3:** Determine the correct friction loss for the size of hose line(s) to be used from pump card
- **Step 4:** Calculate for the length of hose in operation.

As appliances and elevation come into play, other steps are added to the equation.

Multiple Supply Lines

The friction loss in multiple supply lines is determined by using the following guideline.

Dual supply lines – when two supply lines of equal diameter and length are used, the procedure is to divide the total flow in half and figure the friction loss for one supply line.

> ***Example:*** 2 three-inch lines have the same friction loss as 1 four-inch line.

Triple supply – when unequal diameter supply lines are used, figure the friction loss for one supply line, flowing the given flow rate, and than multiply by the appropriate factor. In modern fire operations it is very unusual to find a case where you would be faced with this situation. As such you are not required to learn these computations. VADFP will require you to learn these during DPO class, but the chances for using these are very rare. The friction loss for unequal hose lays is included on the pump card but you are not required to memorize them and you will not be tested on this information. If this situation occurs you can refer to you pump card for the correct information.

4" Hose – Friction loss in 4-inch supply line is so minimal that it might not be necessary to connect a pumper to the line. Direct hydrant connections usually allow sufficient flow and pressure for operations. On long hose lays or large structures a pumper should still be connected to assure proper supply remember that 4' hose has the same friction loss as 2 – 3" lines.

Friction loss in Appliances (AL)

When appliances are used in hose lays they create additional friction loss that must be accounted for to develop the proper pump pressure. The following pressures must be added to overcome friction loss in appliances when the flow rate *exceeds 350 GPM* (Master Stream Appliances).

Wye and Siamese – 10 psi friction loss
Large appliances – 25 psi friction loss

a. ***Deck Guns*** - the 25 PSI friction loss is the total friction loss involved
b. ***Portable monitors or Wagon pipes*** – 25 PSI friction loss is the total appliance loss including the Siamese and the base.

Elevation Pressure (Loss or Gain)

When hose lines are laid to an elevation that is either higher or lower than the supplying pumper, an additional factor must be considered. This factor is the backpressure, or head of water, which is the amount of pressure that is exerted against a pump due to gravity.

A column of water one foot high and one-inch square area exert a pressure of .434 psi at its base. Therefore, the same column of water at a height of 10 feet will exert a pressure of 4.34 PSI. For fire ground operations, we round the 4.34 psi to 5 psi for every 10 feet of elevation. When a hose line is laid on an incline, add 5 psi for every ten feet of elevation, or if the hose lay is on a decline, subtract 5 psi for every 10 feet of lost elevation.

Engine Operations

When water is moved on the fire ground, proper and efficient communication is a must. For the purpose of this manual, the function that a piece of apparatus performs on the fire ground determines whether it is an attack or supply pumper regardless of its radio designation.

Attack pumper (the pumper pumping the attack hose lines) operations are concerned with five basic items in obtaining the correct discharge pressure:

- Nozzle pressure (NP)
- Friction loss in the hose lines (FL)

- Elevation pressure loss or gain (EP)
- Friction loss in appliances (AL)
- Pumping a maximum safe operation pump pressure of 200 psi

Supply pumper operations involve five items that regulate the amount of pressure that the pump should develop.

- Maintain a residual pressure of 20 psi at the intake of the pumper being supplied (for hose line operator's safety)
- The friction loss in the hose line between the supply and the attack pumper (determined by the flow rate, i.e. length of hose, and size of hose)
- Elevation loss or gain
- Friction loss in special appliances
- Pumping a maximum safe operation pump pressure of 200 psi

Standard Operating Pressures

Standard operating pressures and starting pressures for use on the fire ground allow for more efficient pumping operations. To pump water to another pumper or to supply a fire protection system, the establishment of such pressures gives the Driver/Operator a starting point. As time allows, the pressure may be corrected to a calculated value. The following pressures are adopted in order to give the Driver/Operator a guideline to charge fire suppression systems and supply lines:

Standpipe Systems

The friction loss in the standpipe piping is small enough that it is not calculated on the fire ground. While there are formulas for determining the loss of energy (pressure), they are not practical for use on the fire ground. Therefore, a quick and easy method for determining the pump pressure for building standpipe systems has been developed. Pump pressure must be sufficient to:

- Overcome friction loss in the attack lines
- Provide the proper nozzle pressure
- Overcome the elevation loss in the standpipe
- Overcome the friction loss in the hose layout from the supply pumper to the fire department connection

The initial pressure for standpipes is 50 psi at the fire department connection. For each additional floor above the first floor, add 5 PSI up to a maximum of 200 PSI. The Driver/Operator should be familiar with the standpipes in his or her area as some starting pressures may differ.

Automatic Sprinkler Systems

Unless otherwise noted, the initial operating pressure for automatic sprinkler systems is 150 psi at the fire department connection. Some systems are specifically engineered to work at 175 psi. Like the situation noted above, most sprinkler connections are within 50 feet of a hydrant. Calculations for friction loss between the hydrant and connection are not normally necessary. Know the sprinkler systems in your area.

Combined Automatic Sprinkler and Standpipe Systems

In some buildings, the sprinkler and standpipe systems are combined into a single system. The initial operating pressure for combined systems is the same as for standpipe operations - 150 psi, +5 psi for each floor above ground level.

Relay Pumping

Relay pumping is used when the friction loss in a hose line being used to move water from its source to the fire ground is too great for hydrant pressure to overcome. There are several factors that affect the number of pumpers and distances between the pumpers in the relay. These are:

- The fire flow required at the fire ground,
- The distance between the water source and the fire ground,
- The pump capacity of the pumpers, remember that a class A pumper can pump 100% capacity at 150 psi, 70% capacity at 200 psi, and 50% capacity at 250 psi.
- The elevation loss or gain,
- The need to maintain a 20 psi residual pressure at the intake of the pumper being supplied
- A maximum safe pump pressure of 200 psi

As one or more of these factors are often unknown during the early stages of fire ground operations, and with the importance of establishing water flow as soon as possible, a starting pressure of 100 psi has been established for use until the proper pump pressure can determined by formula. When appropriate, the Driver/Operator at the attack pumper should advise the supply pumper of the fire flow (GPM being flowed) and the approximate amount of hose laid and size of the hose.

Elevated Master Streams

Elevated master streams have six factors that affect the correct pump pressure to achieve the proper pressure. These are:

- Nozzle pressure
- Friction loss in the hose or piping to the device from the Siamese
- Friction loss in appliances, 25 psi for the ladder pipe
- Elevation loss due to the height above the pumper
- Friction loss in the hose between the pumper and Siamese
- A maximum safe operating pressure of 200 psi

The initial operating pressure for an elevated master streams is 150 psi. However, the proper pump pressure should be determined as soon as possible to insure adequate nozzle pressure and reach. The exact friction loss in the plumbing is not the same from one truck to another. Some trucks have their own pump; this is the same as supplying another pumper. The operator of the truck being supplied will be able to tell the operator how much pressure they need. Always visualize master streams and their operation. Excess pressure, even if it has been figured out by formula can cause the stream to deteriorate and break, reducing penetration. As a general rule there are three guidelines to follow when supplying a truck:

1. The pumper supplying the truck should be within 100 feet of the truck. Due to the large amount of water flowing and the high pressures that need to be generated to produce an effective fire stream, long hose lays would have too much friction loss to be practical.

2. The pumper supplying the truck should not supply any other apparatus. An elevated master stream is one of the most effective tools that we have in putting out a fire, and should not be compromised by trying to supply other apparatus. You may also exceed the capacity of your pumper by trying to supply more apparatus.

3. Communicate with the Truck driver prior to and during delivery of water.

Dual Pumping

Dual (or tandem) pumping is where one hydrant is used to supply two or more pumpers. When available, fire flow is equal to or greater than the combined pump rating of the pumpers. This type of operation has several advantages, including better use of available water and shorter hose lays. Additional hose lines may be placed in operation more quickly, and apparatus may be grouped close together allowing easier coordination. The method for duel pumping is explained below.

1. Pumper 1 connects to the hydrant steamer connection using large intake hose. This pumper then pumps water through its lines to the fire.

2. Pumper 2 is positioned with its intake in line with one of Pumper 1's intakes. The hydrant is closed down until the compound intake gauge of pumper 1 reads near 0 (about 5 psi, residual). This makes the volume of water entering Pumper 1 equal to the volume of water leaving Pumper 1, so that the unused intake's blind cap may be removed.

3. Intake hose attached from the unused steamer intake of pumper 1 to the intake of Pumper 2.

4. The hydrant is opened completely.

5. Pumper 2 pumps water through its hose lines to the fire. Its water supply is the water through Pumper 1's intake that is not being used by Pumper 1 (the residual pressure of Pumper 1)

This process should be practiced during drill sessions and not used during incidents unless both operators are confident in their pumping abilities. This can only be used on hydrants that have extremely high water capacity on a large water main.

Determining Water Supply Capabilities

A pumper taking water from a hydrant will reduce the available water supply with each additional hose line operated. The Driver/Operator must be able to estimate the amount of water available from the domestic water system before and during fire department operations.

Upon laying out to a hydrant, both the OIC and the Driver/Operator should have a good idea of the amount of water available from the hydrant in question. Once operations have begun, the Driver/Operator must be able to estimate the residual water pressure and how much water flow the fire hydrant can sustain.

There are two methods for calculating available water supply remaining in the system both depend on the Driver/Operator knowing:

- Static pressure in system – this is shown on the pumper intake gauge when the pumper is connected to a hydrant and is not discharging.
- Residual pressure – shown on the pumper intake gauge after water is flowing.

The first method is the ***Percentage of Pressure Drop*** method. This is figured out using the following formula:

$$\% \text{ DROP} = \frac{(\text{Static} - \text{Residual})100}{\text{Static}}$$

Percentage remaining indicates amount of additional water available

%DROP	ADDITIONAL WATER
0 – 10%	3 times the current fire flow
11 – 15%	2 times the current fire flow
16 – 25%	1 times the current fire flow

The second method is called the ***Digit*** method. This method is easier to use on the fire ground. The end result is the same but the calculations are much simpler.

1. Take the static pressure and move one decimal place to the left. (60.0psi = 6.0 or 10%)
2. To find out what 15% is, take half of the first digit (6), and add it to it. (6+3=9, or 15%)
3. To find out what 25% is, add your 10% and 15% digits together. (6+9=15, or 25%)

You should have come up with the following numbers:

0 -10% = 1-6psi
11-15% = 7-9psi
16-25% = 10-15psi

Section VIII. Positioning and Spotting

Positioning and Spotting

For fire apparatus to be used efficiently at an emergency scene the operator must be able to maneuver the vehicle into a position to allow for best performance. There are several factors, which enter into positioning of a pumper:

- Availability and amount of water needed at the emergency scene
- Immediate need for effective fire streams.
- The amount of available hose for supply and attack lines
- The pumper's rated pump capacity
- The nature of the emergency and the function the pumper will perform at the scene.
- The intensity of radiant heat and collapse factors of structure

Attack Pumpers

When the pumper is being utilized as attack pumper, factors that affect its proper positioning are:

- The possibility of structural collapse, possible fire involvement, and the size of the structure
- The wind condition, wind direction, terrain, exposures, and access obstructions
- The entrances to the structure that may be used for fire attack
- Keep in mind the other apparatus responding will need room to position. Remember there are other apparatus of different functions that will need close position to the structure. For example ladder trucks will need room to remove ground ladders. It is also very important to **never** obstruct side 1 of the structure. Side A is reserved for use by the truck company's aerial ladder.

To satisfy the requirements above, the attack pumper should always pull past the structure if possible. This will accomplish several things.

1. Allows the officer to see three sides of structure giving him/her a better idea of the fire conditions.
2. Will leave Side A open for access by the truck company.
3. Unless the building is very tall this will keep the pumper out of the collapse zone.
4. The Driver/Pump Operator will be able to see the front, as well as one of the sides of the structure. This is a safety issue, as the Driver/Pump Operator can advise the interior crew of what is happening on the outside of the structure.

Before charging into the scene, take a moment to evaluate the conditions around the incident. For example, when dispatched to a natural gas leak stop short of the scene, attempt to determine the location of the leak, than proceed closer to the scene if safety permits. This should be true for any possible HAZMAT event.

Remember: things which go wrong in the first couple of minutes cause major problems as an incident proceeds. "When in doubt, lay it out." You should never enter a court without laying out unless you're **sure** there is a water supply at the circle.

Establishing a water supply is one of the most important tasks in firefighting. Without it none of the other things we do would get done. The establishing of water supply should begin as soon as the call is dispatched. The call location should let you know whether or not you will be on a hydrant or if you will have a rural water supply operation, which is covered in separate chapter. If indeed you are operating in a rural setting additional tanker resources should be called upon early.

Hose Lays

The first in pumper must always consider how water will be supplied to it. This is most often done by the placement of supply hose. There are three main types of hose lays:

Forward Lay**:** This is the most common type of lay. It is when a pumper lay's hose from a water source (most often hydrant) to the fire scene. The second in pumper on arrival will secure a water supply and assure that the attack pumper has sufficient water. If the amount of water needed for firefighting is small and the length of hose is short and of large diameter (4inch or bigger) it may not be necessary for the supply pumper to be connected to the hydrant. On the other hand if the attack pumper is using their deck gun and they have 1000 feet of hose on the ground then the supply will certainly be needed to deliver adequate water. When in doubt the supply pumper should always connect to the hydrant and supply the attack pumper.

Reverse Lay**:** This situation occurs when the fire is between the first in pumper and the water supply. It is the opposite of a forward lay. A pumper lay's hose from the fire scene to the water source. It may not be practical for the first in pumper to forward lay so the second in pumper will lay out and secure a water supply.

Split Lay**:** A split lay is compromised of two pumpers laying out and connecting supply lines together. This situation occurs when you cannot forward or reverse lay from the water supply to the scene. This is normally associated with long driveways, but can occur anywhere when a fire ground and a water supply are not in line with one another. The first in pumper will lay down a driveway, road etc. The second pumper lays from the end of the first pumper's hose to the water supply. The two separate supply lines from the pumpers are connected, to create a single line from water supply to fire ground.

(An important note when dealing with 3-inch supply: remember that large diameter hose has unsexed stortz couplings on both ends. Threaded hose has male and female couplings. ***If you are doing a split lay with 3-inch hose you must leave a double male adaptor to connect them together!*** If not, the sections of hose will not be able to connect to each other.

There are no set rules on when to use each type of hose lay, the possibilities that exist are endless. But they will always depend on two factors:

1. Location of the fire scene in reference to the location of water supply.
2. Direction that the pumpers are coming from, and access to the scene of water supply.

Pumpers are large and cannot turn around anywhere. Also, *you cannot turn around while you are laying out hose or you will run over your own hose,* it is a one-way operation and you only have on chance to get it right.

<u>Supply Pumpers</u>

When a pumper is being utilized as a supply pumper, factors affecting proper positioning are:

- Adequacy of water supply for the emergency scene. The water source must be able to supply pumping capacity. If not, additional hydrants or sources will need to be accessed. The different types of water sources will require the operator to act differently. For example, fire hydrants will supply adequate pressure and water volume if they are installed and maintained properly for the area being protected. Hydrants will also supply different volumes depending on the height of water in storage tanks. Drafting locations may not have an unlimited supply of water. You should always have a backup plan for water supply.

When an engine is to connect to a fire hydrant the following factors will be present:

- Connection with collapsible sleeves will be easier if the operator knows the length of the suction sleeve, judges' distance from *the hydrant*, not the curb; and positions the pumper parallel with the edge of the roadway. It is important to keep access to and from the emergency scene open whenever possible.
- Two 3-inch lines hooked to a hydrant move less water than a direct connection to the 6' steamer connection.

Supplying water from a static source on a draft will have several unique factors:

- The unit should be placed as close as possible to the source as safety will permit.
- Be sure to position on a solid foundation that will support the pumper. While the pumper operates it will vibrate and tend to settle on soft material.

- The vertical lift should not exceed 10-12 feet optimally.
- Connect non-collapsible hose sleeves to the pumper **before** you put the apparatus into final position. This will keep you from trying to connect hoses while in the water.

Pumper Assignments

As a general rule, pumpers take their position based on the order that they arrive on scene. As incident priorities change so may the roles and locations. For most normal firefighting operations the list is as follows:

First in Pumper- goes directly to the fire scene, does size up, calls for additional resources as necessary and takes or passes command. Their role will be to do fire attack operations. Although water supply operations will be assigned to the next in pumper they should have already started a plan to get water to them.

Second in Pumper- goes to the location of water supply and establishes water flow to the attack pumper. This unit's manpower may go directly to the fire scene and assist with operations, but the DPO will be responsible for uninterrupted flow of water to the scene. During extensive operations the officer of the second pumper may coordinate water supply operations, especially if multiple resources are needed.

Third in Pumper- their assignment will depend on what progress the first two pumpers have made. If water supply has not been established you will assist in whatever role is needed to get water supply established. If the first two pumpers have already established water supply then they will go to the scene. Now there are a couple of options on where to go on the scene. If side C of the structure is accessible the unit should take up position on that side and prepare to assist in firefighting operations. If side C does not have access the pumper should position in a location that will not impede access to the scene or to specialized pieces like the truck or squad. **Always follow orders from command on positioning** or ask command for an assignment to make sure you will be in the best possible position.

Additional Pumpers- Operations that will require more than three pumpers should have some type of staging or assignments already for incoming units. This will happen on very large operations. Remember to be patient and to follow the orders given to you. Large operations can get complex fast and whoever is in charge of staging may not be ready to position you.

Section IX. Rural Water Supply Operations

Rural Water Supply Operations

Definition: To establish water supply for firefighting purpose in rural and suburban areas in which adequate and reliable water supply systems for firefighting do not exist.

All fire departments have the need to develop adequate fire streams to protect life and property. An adequate supply of water is an essential and basic component in firefighting. Firefighters can control a fire within a short time period by developing large enough fire streams or wait until a fire consumes enough fuel to burn down to the level of the fire departments ability.

Water supply is an essential component of all fire ground operations including; Rescue, Protecting exposures, Confinement, Extinguishment, Salvage, and Overhaul.

Components of a Rural Water Supply System

1. **People**: Adequate number of people to perform the job safely, effectively, and efficiently. All personnel must be properly trained and experienced in the performance of their assigned task. Rural water supply operations will require more personnel than hydrant operations.

2. **Apparatus and Equipment:** Adequate number and type of apparatus. What is the capacity of the apparatus that you have? Is all of the equipment compatible?

3. **Water Source:** Location, distance from scene, accessibility? What is the volume available? Is it limited or unlimited?

4. **Procedures:** Standard operating procedures define the method used by all units in a rural water supply operation. Standard tactical assignments are given so that everyone understands the operations.

Water Supply Plan

Preplanning: Target hazards need to be identified to determine the amount of fire flow needed in the event of a fire. The location of all possible water sources needs to be included. The method of water supply need should be determined. Ex. Pumper relay, tanker shuttle, or a combination of either. These features are very specific and individual to each fire district. Personnel at their stations should be familiar with target hazards and plan for getting water to the scene for firefighting. Simply plan your work and work your plan.

Water Supply Officer: Responsible for all water supplies to the incident scene. The officer must first establish the water requirements of the incident by a briefing with the incident commander. The officer must then estimate the available water supply and maximum fire flow available. If deficiencies exist they must modify plans to overcome the problem or notify the Incident Commander so that plans may be modified accordingly. The Water Supply Officer and the Incident Commander must understand the Incident Action Plan and must be made aware of any changes to the plan.

- In areas served by hydrants, the officer may require the assistance of County Utilities to locate water supply grids or to increase pressure to existing systems.
- In area not served by hydrants the Water Supply Officer may need to call on additional resources. This may include additional tankers, pumpers, portable tanks and personnel.
- The Water Supply Officer may have to establish dump and fill sites and control shuttle routes. Law Enforcement may be needed for traffic control.
- The entire Water Supply Operation may grow large enough that it may need to be moved to separate radio channel.
- Fill site and dump site officers will deal directly with the Water Supply Officer.
- The need to keep the Incident Commander advised on water supply availability cannot be emphasized too much. The ability to conduct an operation is primarily dependent of water supply.

Fill Site: Location to fire scene and accessibility are the most important factors when selecting fill site. A complete loop system is optimal for fill site. If a pumper can access the site, fill up with water and leave without having to back up and turn around the shuttle operations will move more quickly and safely. The drivers of apparatus shuttling water should not have to get out of their vehicle at all during a shuttle. The water source can be static, domestic or private supply. The fill site should be staffed by at lest two people. The fill site officer and an assistant, depending on the type of site the operation can have different forms.

Pumper on a hydrant: The easiest and quickest methods of setting up a fill site. A class A pumper connected to a hydrant by LDH or soft sleeve. The pumper should have 2-3" section of 4" hose which may be used as well but it should not replace two 3" lines. The reason for this is not all pumpers/tankers have LDH connections but they all have 2½" connections for 3" hose. This operation will require a minimum of two personnel, the fill site operator and an assistant.

1. Apparatus that need water will pull up to the fill site and stop and apply air brake, driver should remain in the cab of the vehicle unless instructed by the Water Supply Officer to get out and assist.
2. The two 3" and one 4" should all be connected to the shuttle vehicle if possible.
3. Once connected, the fill site pumper should start pumping the shuttle vehicle and intakes should be opened. The fill site personnel should do this, not the vehicle driver. Charging the supply lines can be done as soon as each hose is connected.

You do not have to wait until all hoses are connected before you start filling the shuttle vehicle.

4. The fill site pumper PDP should be 100psi, keeping in mind that a residual intake pressure of at least 20psi needs to be maintained at all times.
5. Once full, close all discharges and intakes and unhook supply lines from shuttle apparatus and prepare for the next shuttle vehicle

Hydrant only: If resources do not allow for a pumper on a hydrant it can still be set up to fill apparatus for fill site operations. The equipment needed will be:

1. Hydrant wrench
2. 25’ section of 4” hose
3. Hydrant to 4” LDH adapter
4. Gated 4” to two 2 ½ via gated wye
5. Two 50’ section of 3” hose

The fill site should still be staffed by at least two personnel but if resources are not available it can be unstaffed. The following steps are for setting up a hydrant only fill site.

1. Flush the hydrant
2. Connect the 4” hose to the hydrant using the adapter
3. Connect the other end of 4” to the gated wye
4. Connect the two 3” hoses to the gated wye
5. Charge the hydrant
6. Bleed air from the 4” hose using the gated wye

The fill site is now ready to fill apparatus. Once the apparatus arrives at the fill site:

1. Connect the two 3” hoses to the apparatus
2. Open the gated wye and intakes on apparatus
3. Once full, close all intakes and discharges and unhook supply lines from shuttle apparatus and prepare for the next shuttle vehicle.

Pumper on Draft or Dry Hydrant: The major considerations in choosing a draft site is accessibility and height of lift. The location of a draft site may not be near the roadway and there may be some distance between the draft site and the fill site. Hose will need to be stretched between the two locations.

Dump Site: Regardless of what type of fill site has been set up the dumpsite is pretty much the same for any operation. The dumpsite will be in close proximity to the fire ground, but access to units involved in a tanker shuttle is the most important consideration. Consideration must also be made for the portable tanks that will be set up to hold water. This location must also accommodate a pumper that will supply water to the fire scene. The supply pumper will than be acting as a pumper on a draft pulling water from portable tanks. The normal procedure is for tankers with drop tanks are to position in front of the supply pumper and deposit their water in them. From there they will make trips to the fill site bringing water to the fire scene.

The pumper at the fill site needs to set up to most efficiently manage the flow of water from dumpsite to fire scene. They will be operating from a draft but also need to be prepared to accept water from other apparatus as well. Additionally they will need a way to move excess water into the portable tank.

For the initial drafting operation the pumper simply needs to have a non-collapsible type hose connected from its large diameter intake placed into a portable tank. This is one way that it can receive water. Receiving water directly from other apparatus is another way. To be prepared for this a 50' section of 3" supply hose should be connected to an intake. If any apparatus arrive that cannot dump directly into the drop tank they can hook up the supply hose and pump water directly into the supply pumper. But you must now be prepared to have too much water. If you have units waiting to drop off their water you cannot keep them waiting while another pumper supplies its water into the supply pumper. The supply pumper must be ready to accept water as fast as other units can dump it. But what can you do if the fire scene is flowing 300gpm and you are receiving water at 700gpm. Here are your two acceptable and other unacceptable options.

Acceptable

1. If your booster tank is not full you can open your tank fill and let the excess water into your booster tank.

2. Since it is a good idea to keep your booster tank full at all times opening your tank fill will simply dump water on the ground through the tank overflow. This would be a useless waste of water. It is your job to make sure that every available drop of water gets to the fire. Since your booster tank is full you will need to get water into the portable tank where it can be stored until needed. To do this take another section of supply hose and run it from a discharge into the portable drop tank. Most portable tanks will have bracket that will hold the hose onto the portable tank. While carefully monitoring your pressure to the fire ground open the discharge and the extra water pressure you are getting will flow into the portable tank for use when needed.

Unacceptable

1. Restricting the incoming flow or slowing the dropping off water by units

2. **Dumping water on the ground!!!**

Running a tanker shuttle

The operation of the tanker shuttle has three areas. The first two, the fill site and dumpsite we have discussed. The final component is the shuttle route.

The shuttle route itself should be a loop if at all possible. This will be faster way for tankers to travel. Making of U-turns by apparatus should be avoided if at all possible. U-turns are time consuming and since tankers on a shuttle operate driver only they will not have a spotter to assist in turning around.

Once the shuttle is in operation you can then calculate the amount of water that can be delivered. This is very important for the incident commander to know how much water they have available. Here is how this can be calculated.

1. You will need know the how many and the capacity of the units in the shuttle.

2. Next the amount of time it takes for each unit to make a complete loop in the shuttle.

3. The next stop is to take the GPM of the individual unit divide this by the time it takes for the unit to make a trip on the shuttle route.

Section X. Maintenance

Maintenance

Fire apparatus and equipment is of little value if it does not arrive on scene or malfunctions once it is on scene. The Driver/Operator is responsible for the vehicle and all of its equipment. Various checks are performed in order to ensure the readiness of the apparatus. These checks can either be daily, weekly, or monthly. Maintenance means keeping something in a state of usefulness or readiness (IFSTA Pumping Apparatus). There are a variety of different programs and checklists that can be used for establishing a maintenance program. It is important to realize that maintenance should be performed in accordance with the operator's handbook furnished by the apparatus manufacture (IFSTA Pumping apparatus), and according to company SOP's.

Documentation

Log and record any maintenance or repairs on the apparatus or equipment carried on it. By keeping records up to date and performing maintenance, the life of the apparatus and equipment is increased, and repairs can be anticipated or avoided. Maintenance records are also ***legal documents***. If there is ever an issue concerning liability, the maintenance records will certainly be called into question. They should be through, dated, complete, and kept on file as long as you operate the apparatus

Daily Apparatus Maintenance

- Check all warning signals and lights
- Check apparatus fuel level (top off if less than ¾ of a full tank)
- Visually check the water tank level (gauges can and will be wrong)
- Visually check the foam tank level
- Check each tire for cuts, breaks
- Pressures test all brakes by operating the foot paddle
- Clean apparatus windows, and wash the entire vehicle if necessary
- Check all tools and equipment to see that it is accounted for
- Check all EMS equipment and see that it is accounted for in service
- Check all SCBA’s and pass devices
- Check all spare air bottles
- Make sure all hose is properly stored on the apparatus
- Account for all portable radios, hand lights, maps, Knox box keys etc.

Weekly Apparatus Maintenance

- Check all fluid levels
- Check battery fluid level
- Check master cylinders brake level and watch for any wheel cylinder or hose leaks.
- Check all belts
- Check battery terminal connections and cables
- Check all drains and all hose connections for tightness
- Check for loose nuts, studs, and pins
- Check air pressure in all tires
- Operate all power tools and generators
- Operate primer pump and check primer oil level
- Operate relief valve or pressure governor
- Operate all hydraulic tools
- Operate all electrical equipment