APPARATUS ENGINEER

Appendix A2 of the Standard Operating Guidelines

Revised 12/21/2022

Engineer Index

This version will have some incorrect links from the document, these will be corrected in the next

Goals of the Program

1. *To train and produce effective apparatus engineers for safe responses to and from emergency and routine situations.*
2. *For apparatus engineers to be knowledgeable in traffic laws, apparatus placement, use of specific apparatus functions and driving under various road and weather conditions.*

PREREQUISITES FOR DRIVER'S TRAINING:

1. License requirements

Volunteer: Possess a current Class C N.C. Driver's License.

Paid (Part-time or Full-time): May begin training with a class C NC license but must have a valid Class B license to conduct the supervised emergency runs.

2. Minimum age 18 to begin training
3. Minimum 21 for conducting supervised emergency runs and full certification.
4. Complete SVFD rookie program or equivalent level of fire and rescue related training.
5. Complete pumps program (except for rescue driver certification) with 80% or better on written and practical exams.
6. Satisfactory completion of 90 day probation
7. Background check of driving history. Cases will also be evaluated by the board of officers on a one-to-one basis.

DRIVER'S TRAINER REQUIREMENTS

1. Must have a minimum of two years experience as a driver operator with at least 1 year with SVFD. Less experience may be considered such as combinations of Instructor methodology and Driver Operator or an individual who has obtained Driver Operator instructor.
2. Are appointed by the Training officer.
3. Must retain all requirements of other driver/operators and all prerequisites for trainees.
4. Must have had a certified driver's training course such as, EVOC, NC certification class for Driver Operator or other classes or experience approved by the training officer.
5. Must be familiar with maintenance procedures including inspection sheets, snow chain installation, etc.

CLASSROOM AND WRITTEN EXAM REQUIREMENTS

Objectives

1. Know the effects of vehicle control for breaking reaction time, load factors, general steering reactions, speed and centrifugal force
2. Know applicable laws and regulations
3. Identifying specific gauges, their purpose and ranges of normal operation.
4. Know principles of skid avoidance, shifting and gear patterns, negotiating railroad crossings, weight limitations for bridges, operation on adverse road conditions
5. Familiarize with SVFD standard operation procedures and it's application to apparatus response and training.
6. Familiarize with SVFD truck response sheet
7. Principles of vehicle maintenance; reporting of problems and adverse affects of non compliance.
8. Principles of apparatus/vehicle placement

Support Equipment driver certification (Truck 6)

1. Log 10 miles and document, Class C license etc.
2. Normal driving (non-emergency) can be conducted by any member (including those under 21 but at least 18) after the 10 documented miles.
3. Emergency traffic can only be conducted if the member finishes rescue driver certification.

Rescue driver / non pumping apparatus certification

1. Trainee must have their driver's license in their possession during each practical driving exercise.
2. At least one vehicle maintenance checksheet will be filled out for every vehicle and attached to a signin sheet. The trainee shall be competent in completing the checksheet on their own (Can locate fluids, gauges etc.).
3. Each trainee shall drive a minimum of 15 miles in Rescue 6 or 61. 15 miles does not have to be completed in each of the rescue trucks as they have the same handling characteristics, controls and other features. Brush 6 *(If pumps completed)*. At least 5 miles of both will done at night time.
4. It will be the decision of the trainer as to the amount of time to be spent in each truck after the 15 mile mark. It may range from 0 to whatever the trainer feels is necessary for the trainee to attain an acceptable level of competency.
5. Watch the videos listed in the last page of the entire manual.
6. Successfully complete driving courses as setup by driver's trainers which should include a serpentine, diminishing alley, alley dock etc.
7. Notice will be posted to all current drivers as to your beginning of emergency response checkouts
8. Satisfactory completion of 3 supervised *(means another certified driver)* emergency responses. The supervisor will report to the trainee's primary driver trainer and forward any comments to them before it is recorded. Only satisfactory runs will be recorded on your tracking sheet. Emergency runs may be credited on Brush 6 (brush-truck) if that person has completed the pumps program. Emergency runs may also apply to response of Truck 6 with a supervised driver

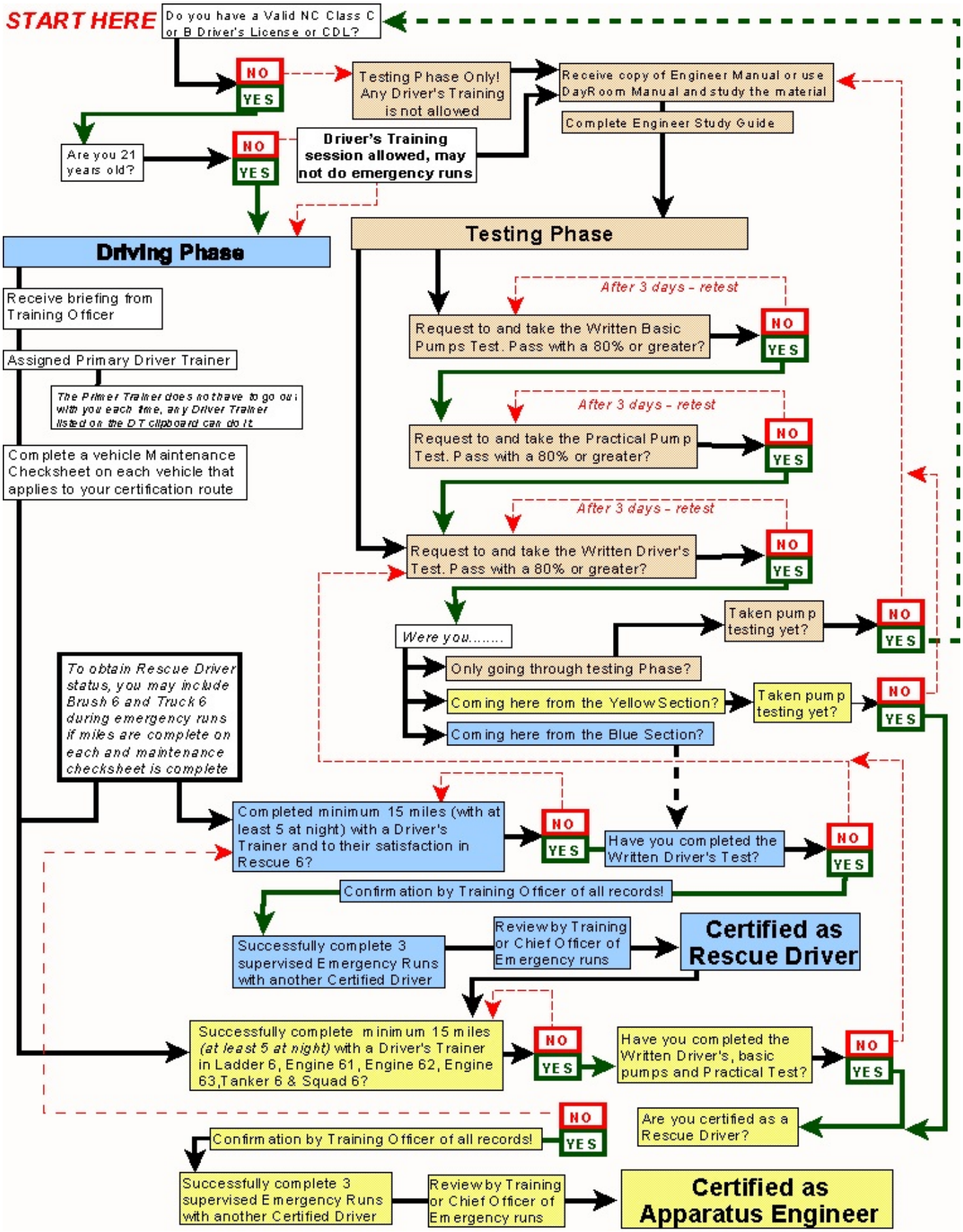
Apparatus engineer certification

1. Successful completion of rescue driver first.
2. Each trainee shall drive a minimum of 15 miles in all vehicles as defined by the driver's trainer. At least 5 miles for each will done at night time. Aerial/Ladder truck training will be conducted after an individual competes our basic engineer program.
3. Trainee must satisfactorily complete a total of three supervised emergency runs in any of the larger apparatus.
4. Final release after review of all training documentation and sessions

Hours required in the Driver's Training Program

1. 60 hours
2. The 60 hours total is tracked by the Training Officer and includes all time for program orientation, study guide completions & review, practical sessions with maintenance knowledge, miles and time training in each vehicle, written testing for pumps section and driver's section, practical testing for pumps, special driving courses and several other sessions conducted as part of the program.

Engineer Program Flowchart



Documentation of the Program

For completing the study Guide

After reviewing any needed information with a trainer, fill out an SVFD training sheet. Make sure to apply appropriate credit to “Fire” and “Driving or Pumps” categories. Training credit for completing the guide on your own is 4 hours of training and the “instructor” will be your own name. If another person assists or helps explain certain areas, include them on the training sheet and add any additional time spent with other personnel. Place the training sheet in the Training officer’s box.

For documenting written & practical tests

Fill out a training sheet after taking the test. Even if the test is not passed it will still be credited for training time. The driver trainer grading the test will document the passed test on the “Driver’s Training tracking form” which is located on Training Officer’s door.

For documenting driver’s training miles

Fill out a training sheet which lists you and the driver trainer who supervised you and credit the same categories as above. Write any special descriptions *(which vehicles, routes, miles, day or night)* about what occurred during the session. The driver trainer must log your miles for each vehicle on the “Driver’s Training tracking form” which is located on Training Officer’s door. ONLY DRIVER’S TRAINERS may mark on this form. This form remains accessible for trainers and trainees to stay informed on status of each potential driver.

For documenting emergency runs

The driver trainee is responsible for knowing which vehicles they have been cleared on for emergency runs.
For example: If a trainee attempts to respond a rescue truck or truck 6 emergency traffic before being informed by the Training Officer that they may do so, the event will likely result in disciplinary action.
For example: If a trainee has not completed their three emergency runs and been certified as a rescue driver they may not respond larger apparatus emergency traffic.
Training sheets are not filled out for supervised emergency runs.
The driver who supervised the trainee during the run must document the event on the “Driver’s Training tracking form”. Only satisfactory responses are logged. If problems occur, the Training Officer should be contacted and consulted with. If a serious safety issue occurs, a Chief Officer may be conferred with and the trainee may be taken off of emergency run status until the Training officer is consulted with.

Your Attitudes & Purpose as a Pump Operator

It is hard to express how vital the role of the pump operator is to the incident at hand. The fire service has always had to function on the concept of teamwork. Without everyone doing their respective duties, the mission will not be as effective or will totally fail for yourself, your team and the people you serve.

How effective is a fire ground commander if he makes a perfect decision on strategy and tactics on an offensive attack of a fire but the pump operator does not supply the proper gallonage or pressure because of lack of skill? ***Not effective!***

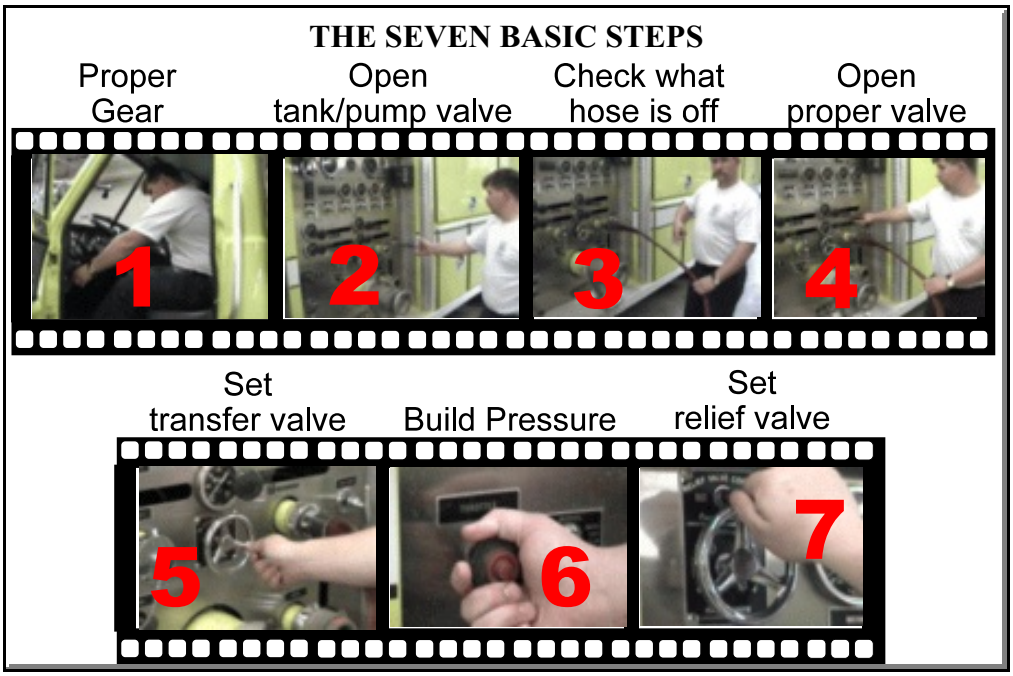
How effective is the firefighter on a hoseline crew and in the middle of an attack on the interior of a structure and the hoseline goes limp because the pump operator was not paying attention to their water supply and ran out?

Not effective and may become seriously injured!

The scenarios could go on and on but with the same result. In reverse roles, the firefighter or fire ground commander must be skilled or a very experienced pump operator will not be effective. Being a pump operator carries with it a lot of responsibility and part of that responsibility is to learn the skills and keep improving on them. The team needs **pump operators, not lever pullers**. Just about anyone could pull the right valves and eventually get water to where it is needed but it must be the right amount of water and the right pressure. These are very respected skills when attained and implemented.

Just remember, how important would think this is....
if you were on the nozzle?

The Basic Pumps information in this manual is just that...basic, but it is the foundation that will always be relied on for the rest of your career as an Engineer. Even these 7 basic steps can be repeated to help make for successful operations. When problems occur, you can usually trace it back to a missed step or one completed incorrectly. When a problem occurs, retrace your steps and solve it.

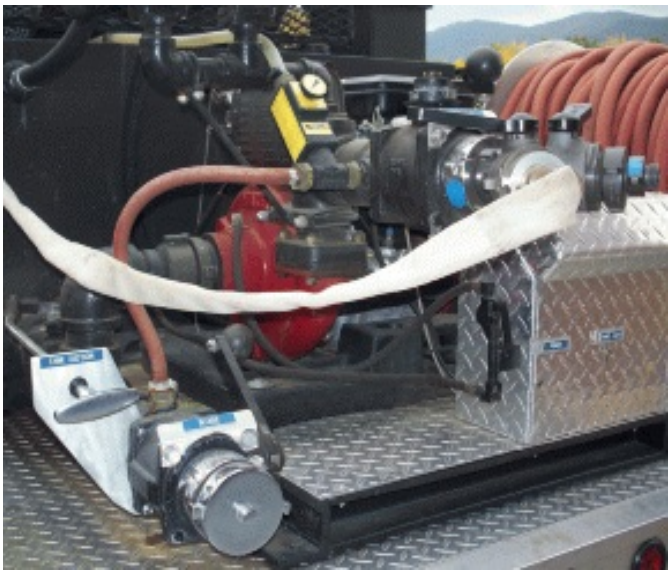


Step 1. Proper gear

Every pump must have a source to power the pump and make it turn. The primary ones we will discuss are the Direct Drive, PTO and Midship. Each type requires a certain procedure to activate the pump.

Direct Drive

Direct Drive pumps usually have a very short or no shaft that connects a motor to the impeller similar to the way a lawnmower engine turns the cutting blade.



A Direct Drive Pump

Direct drive pumps can be beneficial because they may run independent of the vehicle's engine system. The pump's engine may need electricity from the vehicle to start but can be ran with the vehicle's engine shutoff.

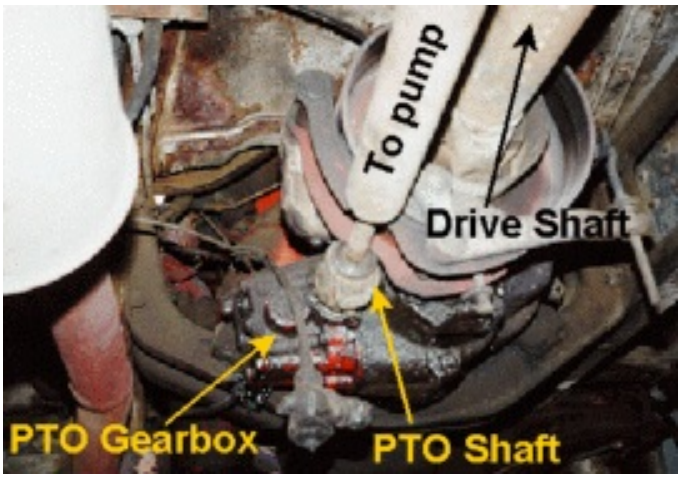
These type pumps allow for ***"pump & roll"*** capability. Pump & Roll simply means that the vehicle can drive and pump water at the same time.

You only need to start the pump's engine to consider "Proper Gear" since there is no gear to shift into or other lever to activate after the engine is running.

PTO

PTO stands for ***Power Take Off***. Other devices that are called a PTO unit such as winches *(all of our winches are electric, not PTO)*, electric generators *(E63, L6)*, hydraulic pumps *(air compressor on E62)* and even 4x4's activating the other two wheels for total 4 wheel drive, operate by the same basic principles.

In a PTO system, the power is derived from the engine & transmission which turns the axle to drive the wheels. The power either "takes off" from a special gear box on the side of the main gear box or a hydraulic port that comes out of an automatic transmission. The biggest difference is that PTOs are not "inline" with the drive axle, they divert off to the side in some fashion.



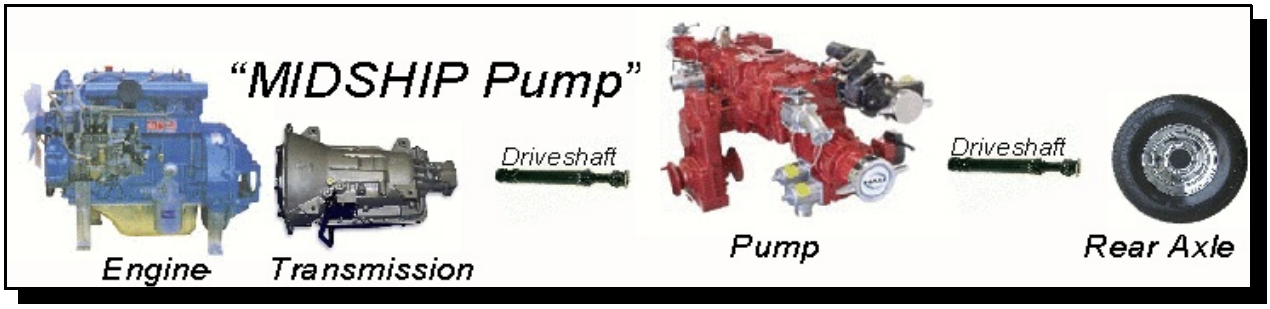
A typical PTO (Power Take Off) system

Each PTO type pump may or may not have "Pump & Roll" capability. Squad 6 and Tanker 6 have PTO pumps but neither can "pump & roll." If an apparatus has PTO pump & roll, the speed of the impeller, pressure increases and decreases may be effected by the speed or gear selection of the vehicle.

Refer to "Procedures for proper gear" for each vehicle in the next section.

Brush 6 during the Florida Fires 1998.

Midship Power Transfer



The midship main pump gear is "inline" with the driveshaft coming from the transmission and the driveshaft leading to the rear drive axle. This system DOES NOT have "pump & roll" capability. You can only apply power to the pump or to the rear axle but not both. The selection takes place inside the transfer case (gearbox or lower portion of the pump unit).

When the switch/gears are placed in "Road Gear" the power from the transmission is directly applied and connected to the rear axle, thereby turning the wheels.

When the switch/gear is placed in the "Pump Gear," the gear in the transfer box moves away from gears connected to the rear axle and moves toward the gears that drive the pump.

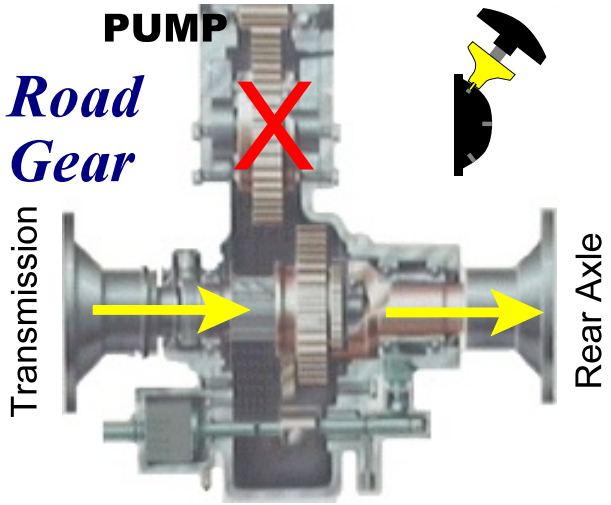
When in road gear you cannot pump.
When in pump gear you cannot drive.

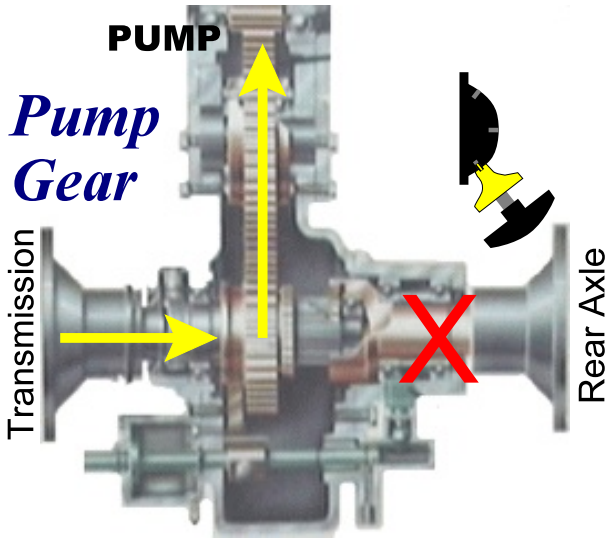
The change is usually activated by an air switch located on the dash of the vehicle and/or by a manual switch *(in case the primary switch fails)* located underneath the vehicle. This type of pump applies to E61, E62, E63 and Ladder 6.

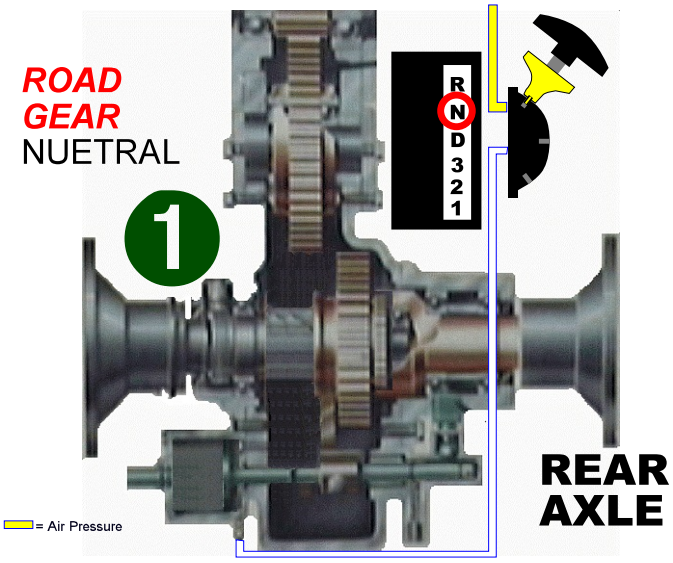
When activating midship pumps, always allow a pause with the air switch when it is in it's middle position. Hale Pumps recommends that the entire sequence of placing into pump gear takes **no less than 4 seconds.**

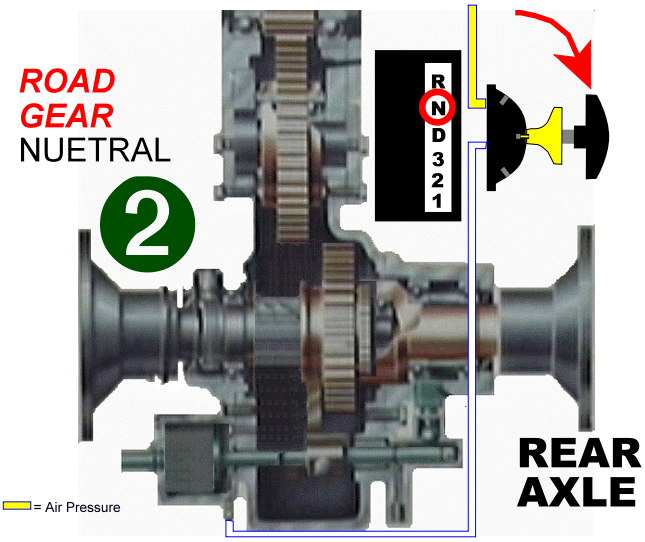
Improper sequence can cause severe gear damage such as this gear which has had it's teeth ripped apart.

Moving the air shifter to "pump gear" is only part of the sequence. So far, you have only put the gears in place but no power from the transmission has been applied. To apply power, you must move the transmission shifter into "D" or drive.






ROAD
GEAR
NUETRAL
1
R
N
D
3
2
1
REAR
AXLE
= Air Pressure


ROAD
GEAR
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2
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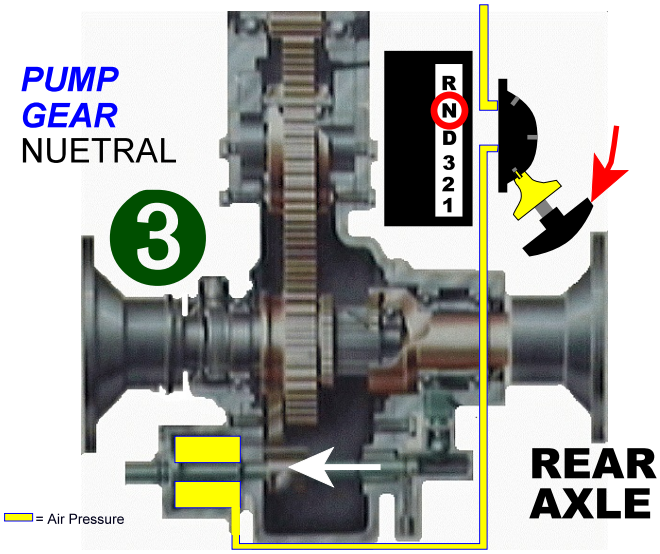
REAR
AXLE
= Air Pressure


PUMP
GEAR
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3
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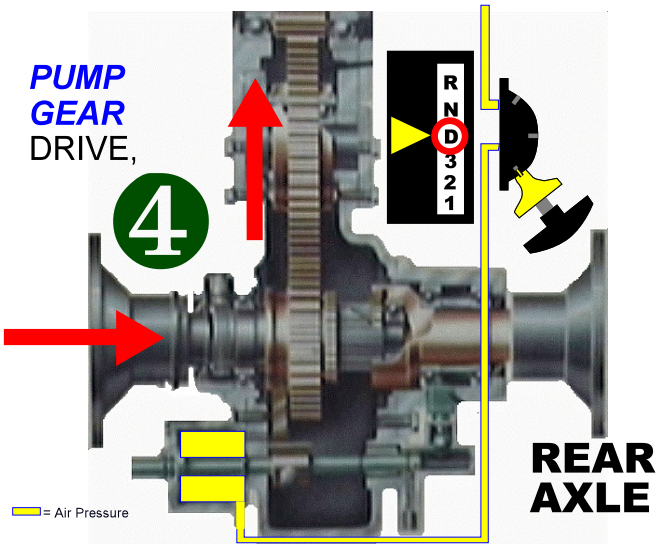
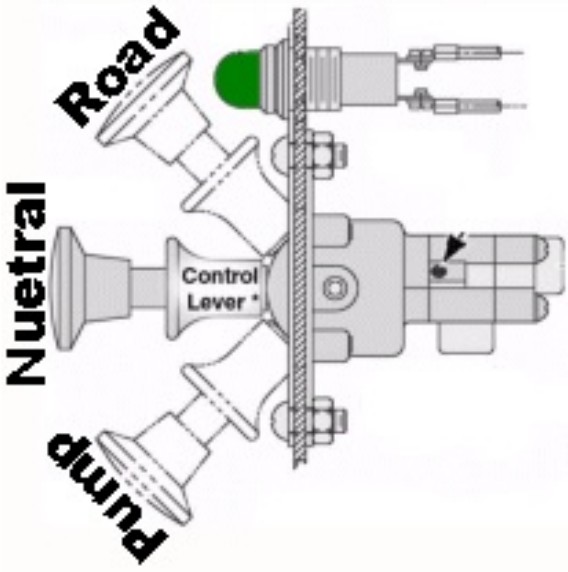
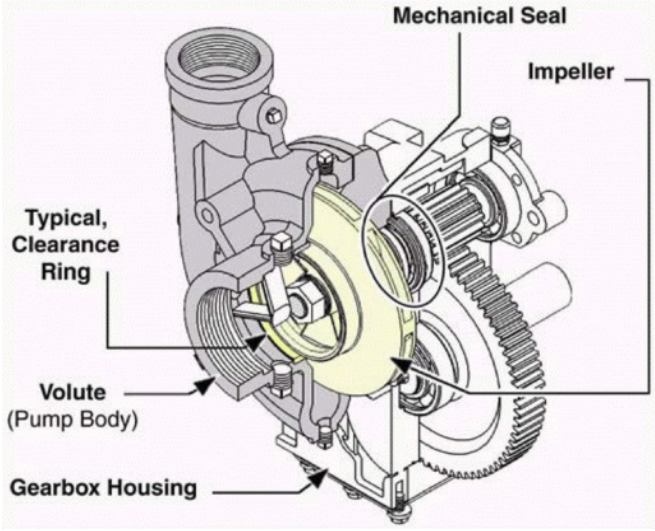
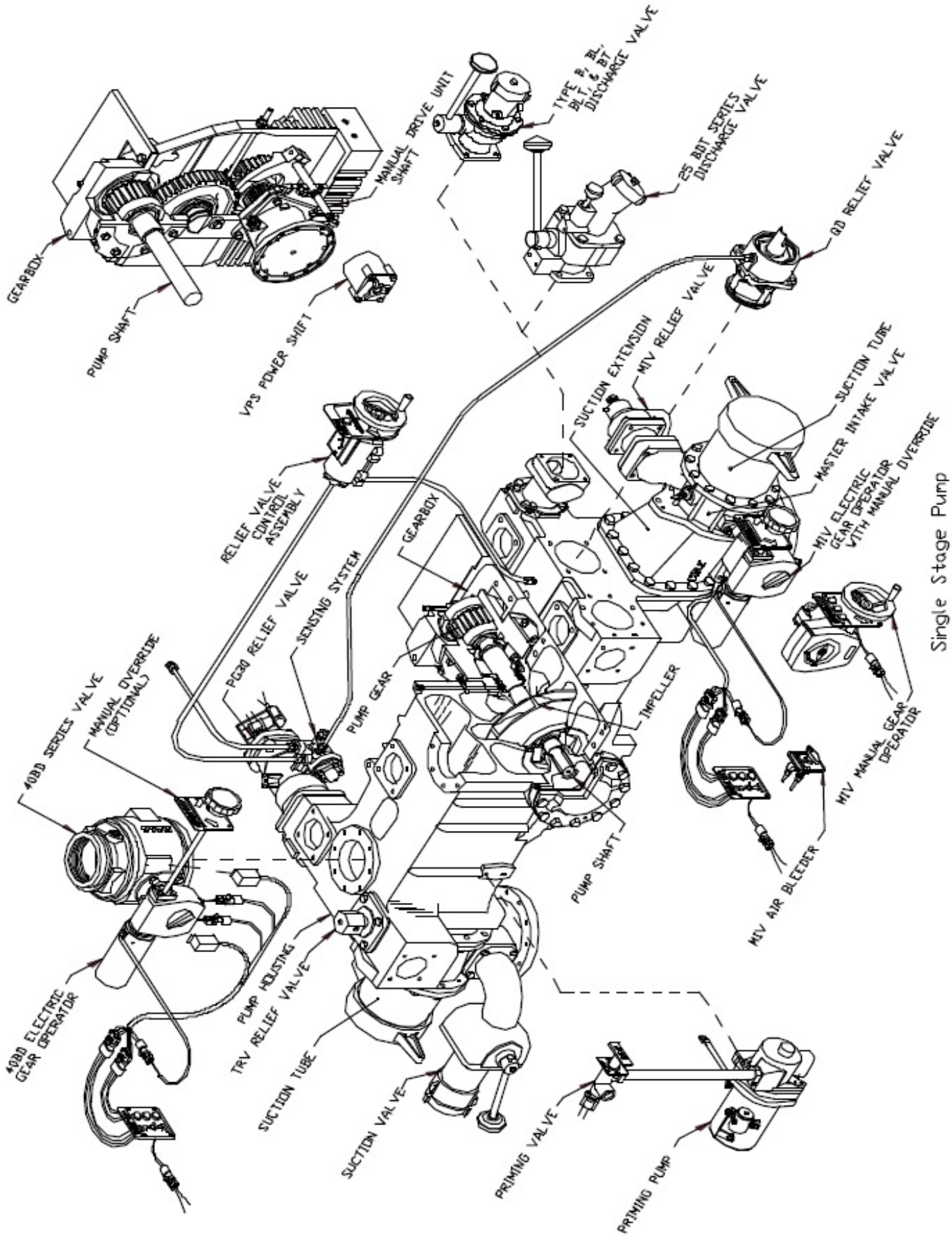
1
REAR
AXLE
= Air Pressure


PUMP
GEAR
DRIVE,
4
R
N
D
3
2
1
REAR
AXLE
= Air Pressure


Road
Nuetral
Pump
Control
Lever


Mechanical Seal
Impeller
Typical,
Clearance
Ring
Volute
(Pump Body)
Gearbox Housing



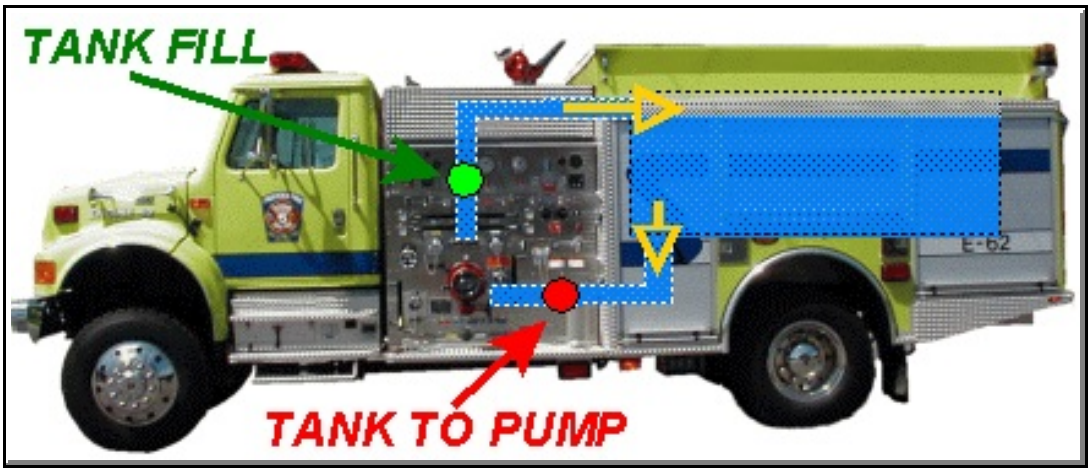
Single Stage Pump

Proper procedures for placing in gear

Don't forget your emergency or air brake and chock block!

Ladder 6 not included here, covered under ladder engineer program

Brush 6 ***(Dodge Brush Truck)***	**For stationary or Pump & Roll** 1. Vehicle engine running or battery switch on 2. Open tank to pump valve 3. Pull choke handle out (if a cold start) 4. Place red ignition switch to on 5. Press start button until ignition, then return choke 6. Throttle to desired pressure
Engine 6	1. Place transmission in neutral 2. Move rocker switch to "pump" 4. Look for "pump engaged light" (idiot light) You may hear the actual transfer take place 5. Place transmission in "D" for drive If light not on listen for pump sounds or a change in rpms 6. If light or sounds are not present repeat steps 7. Go on to step 2 of seven basic steps --Reverse steps for taking out of gear
Engine 61	
Engine 62	
Tanker 6	
Squad 6 ***(Heavy Rescue)***	***1. Place transmission in neutral*** ***2. Move rocker switch to "pump" position*** ***3. Press "Mode" button on shifter panel***



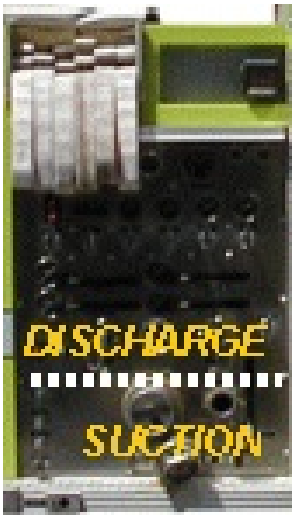
Open the "Tank to Pump" Valve. Opening both the tank/pump and tank fill valve will allow water to circulate to reduce heating or to keep the pump from freezing

Step 2. Open Tank to Pump Valve

The tank to pump valve simply opens a valve allowing water to flow from the tank into the intake side of the pump. This is where your water supply is when you are not hooked to a hydrant or drafting.

Since you have already placed the truck in proper pumping gear, the impeller is turning and will build heat without circulating water through the pump casing. Even if water is present in the pump casing but is not moving, it will still build heat and eventually cause damage.

For step 2 we are only immediately referring to using the booster tank on the truck as a water supply but in many situations we will be using an alternate water source such as a hydrant or a supply line from another truck. In those cases you will have to open the valve that the supply line has been hooked to.



In general, to help you find the valve handle you need to open a valve remember the following; A typical pump panel is split into two sections, the top being discharge and the bottom being intakes or suction.

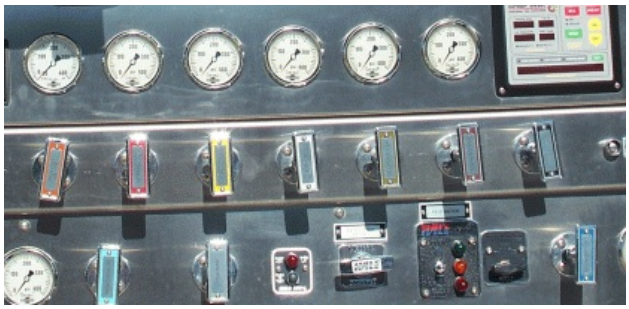
Step 3. Check hose off truck

This step's purpose is to determine what hoselines have been pulled off the truck by other firefighters and to make sure that they are all the way out of the hosebed and properly connected.

Do not assume! Be absolutely sure what is being used. You may end up pulling the wrong valve in step 4 and charging a hoseline that is still in the hosebed! It may cause the charged line not come out of the hosebed if it is eventually needed and either way your going to have repack a line that did not even need to be used. If a hoseline has been pulled by attack crews, but not all the way and you charge it, the same problem exists. In fact it may be worse! It will most likely put the line out of service because water cannot flow through it and another line will have to be selected, delaying the attack and you guessed it, not being effective! This step helps determine step 4.

S

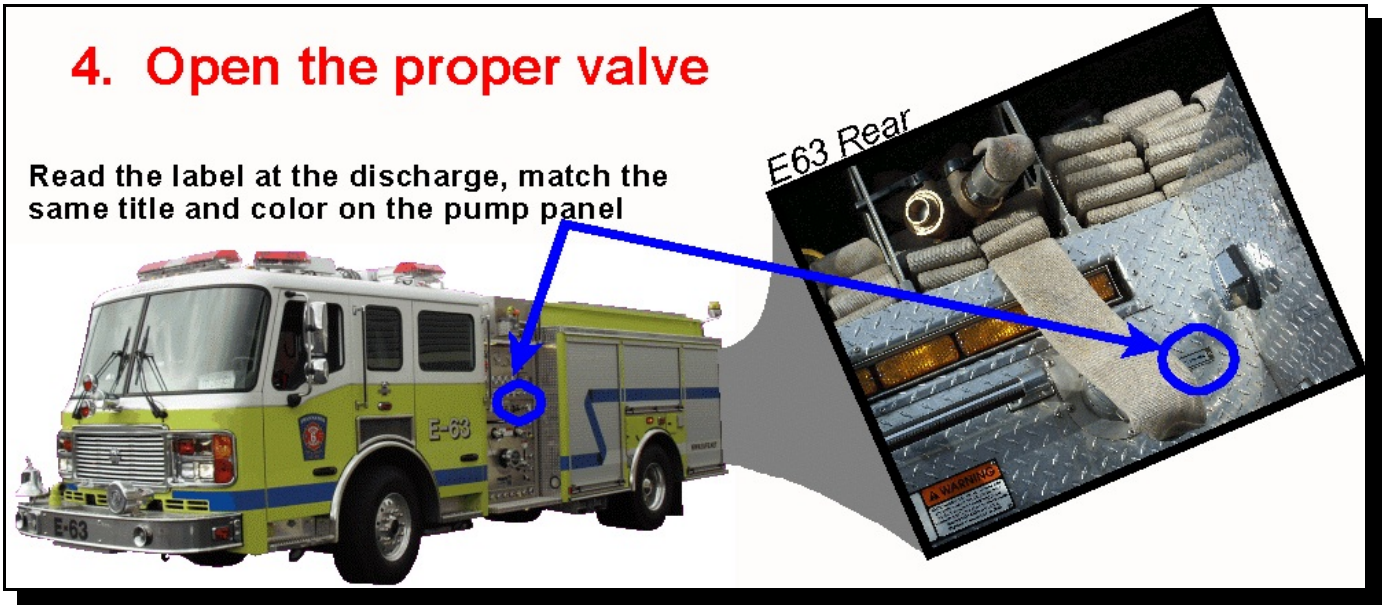
tep 4. Open proper valve



After being thorough with step 3 we now know what valves to open to get water into the hoselines that have been pulled off of the truck. On flat ground, filling the hoselines with water is relatively easy at idle pressures but kinks in the hose and hoselines stretched uphill will require a little more pressure to fill. OPEN VALVES SLOWLY!

Different apparatus use different labeling systems to identify a discharge and it's respective valve handle that supplies it with water. Some refer to positions on the apparatus itself such as Left Rear, referring to left side of truck at the rear and yet another manufacturer may be referring to the very back of the truck on the left side. This could be confusing if you are not familiar with particular apparatus, therefore become familiar! Newer apparatus have been labeled with color coded systems, where you match up the color on the discharge with the same color on it's valve handle.

There will be times when you have already completed the seven basic steps and are already pumping. If another line is pulled, it's valve must be



opened slowly because pressure is already on the system and may cause a water hammer if opened too quickly (Refer to Section 7)

Step 5. Set the Transfer Valve

The only apparatus that requires step 5 is Engine 61 (Brigadier), on all other pumps at the station, this step may be omitted.

Volume mode may also be referred to as "parallel" or "capacity". Pressure mode may also be referred to as "series".

This valve changes between the settings of Volume & Pressure on a two stage pump. Engine 61 has the only two stage pump (which has two impellers) of our vehicles. All others are called a single stage pump (which has one impeller). A two stage pump is designed to optimize power given to it and reduce engine wear.

The rule of thumb for deciding when to be in volume or pressure is decided by the GPM you will be flowing. Find out what the rated capacity of the pump is. For example, Engine 61 has a rated capacity of 1250gpm. Divide it in half, which would be 625.

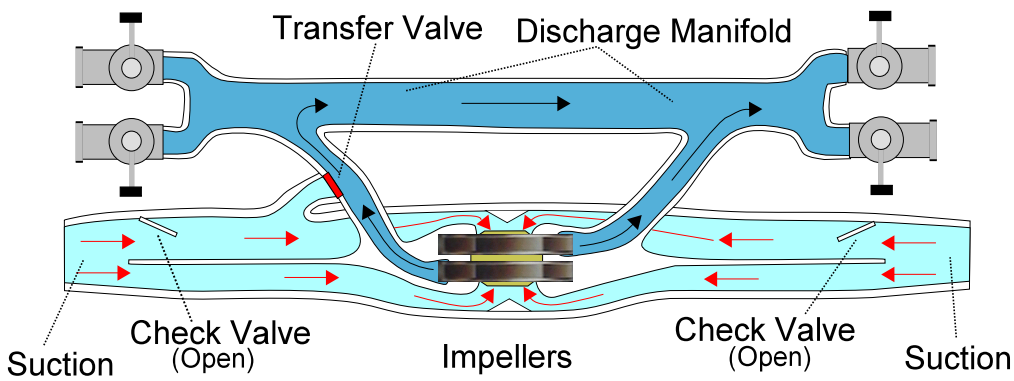
If the total amount that the apparatus would be flowing would be below 625gpm then you set the transfer valve in pressure. If your total gpm would be more than 625gpm then you set the transfer valve in the volume mode.

*If **over ½** the rated capacity of the pump set in **volume***

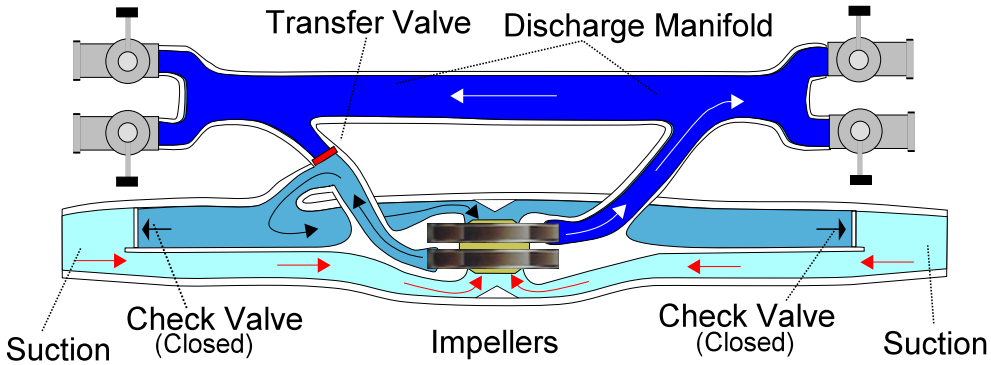
*If **under ½** the rated capacity of the pump set in **pressure***

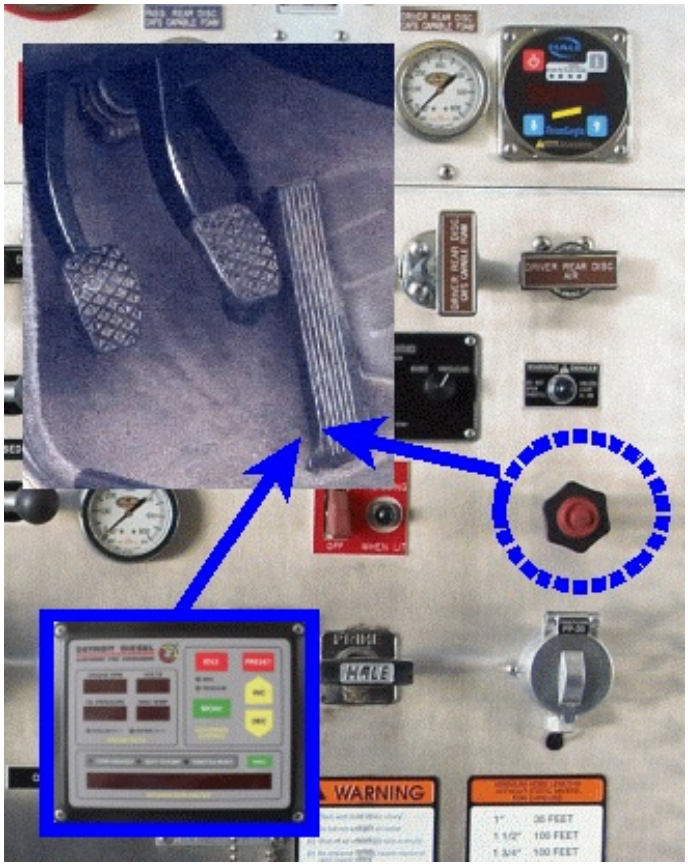
If while operating in pressure mode, other lines are pulled off the truck and their added gpm puts you over ½ the rated capacity and you still must switch to the volume mode, you must throttle down below 50 psi before switching.

Volume Operation
(Parrallel)



Pressure Operation
(Series)





Using the manual pump throttle or electronic control device such as the "Fire Commander" is essentially the same as pressing or depressing the fuel pedal. These devices allow a consistent throttle setting during pumping.

Step 6. Build pressure

In this step your purpose is to build pressure within the pump casing so that after going through a valve, hoseline and an appliance that it reaches the nozzle and produces the desired gpms. Usually the increase in pressure comes from turning the throttle or operating the electronic control on the pump panel which acts the same as the fuel pedal in the cab. To build the proper pressure you must know what size hose, the length of hose, what

✔ Advise Command
✔ Wait for permission
✔ Throttle below 50psi
✔ and changeover

appliances are being used and what nozzle is on the end. All these factors affect friction loss and the needed pressure.

What is friction loss?

Friction can also mean resistance. When water passes through a hose or other object it meets certain frictions or resistances such as the interior lining of the hose. These frictions take away the force or power of the moving water so we must compensate with higher starting pressures.

If you can picture a creek flowing over smooth rocks in the bottom of the creek you will see that the water meets little resistance and is able to maintain it's speed. If the same creek was flowing over an area that has a lot of boulders and rocks then the water hits these rocks and loses some of it's forward momentum and loses power (Elevation also effects speed but it is not a form of friction). The creek met friction or resistance.

Another example would be imagining a football field. Your objective is to run from one end to the other when no one else is on the field. Not too difficult, the only thing you have to worry about is your momentum and forward progress. If you make mistakes, you lose forward momentum. Now put a defensive football team in front of you and their job is to stop you from reaching the other end. Would not work to your advantage. You would meet friction from the defense and it is going to slow or stop your progress.

Small barn fire off Powlas Dr.

WWC Shafer Dorm Fire 2003

Part of your job in determining proper discharge pressure from the truck is done by accounting for and overcoming friction losses that are always going to be the system. Sometimes there are factors out of the normal that can account for extra friction loss.

Some examples of friction losses are:

1. Hose size
2. Hose length
3. Kinks in the hose
4. Bends in the hose

5. Crushed couplings
6. Improper sized "O" rings
7. Obstructions (rocks or debris)
8. Rough interior lining of hose
9. Valves not open fully (sometimes desirable)
10. Appliances used in the hoselay

The friction losses that will always be there, such as those caused by the hose, must be compensated by memorizing the general "rules of thumb for friction loss" tables on the next page. Others can be prevented or cured by proper maintenance or by simply straightening out a hoseline.

For every appliance in the hoselay add 10psi to the total friction loss amount.

door. This principal can be applied to selection of hoselines for attack and for supply operations.

Rules of thumb friction loss

	Hose lengths					
GPM 250 / 150	4" 5psi per 100 feet					
	3" 15psi per 100 feet					
	2½" 15psi per 100 feet					
	1¾" 25psi per 100 feet					
Hose	100'	200'	300'	400'	500'	600'
1"	50	100	150	200	250	300
1½"	25	50	75	100	125	150
1¾"	25	50	75	100	125	150
2½"	15	30	45	60	75	90
3"	15	30	45	60	75	90
4"	5	10	15	20	25	30

All you need to be concerned with memorizing from this chart ***is the per 100 foot category.*** *You will be able to add any type of hoselay with this in your memory.*

Notice the chart... given the <u>designed</u> flow:

The smaller the hoseline, the higher the friction loss

The larger the hoseline, the smaller the friction loss.

Try walking through a small door in which the door frame touches you on both sides compared to walking through a large door with plenty of space in the door frame... you pass through easier

Now try to have a larger person pass through the small door and they may need someone to "push" them through to overcome friction. The larger person may still fit easily through the larger

Notice that the 2½" and 3" hoselines have the same rule of thumb friction loss. This is because the rules of thumb are derived from a formula. After this equation is done, the 2½" hose comes out just over 15 and the 3" just less than 15. Remember, these are "rules of thumb" friction loss, designed to simplify fireground calculations so 15 is used for both 2½" and 3".

(It should be noted that some newer accepted friction loss formulas would place the 1¾" hose and others with higher friction losses but we are still at rule of thumb numbers and each hose manufacturer, model and condition will result in different real friction loss numbers if tested with gauges).

One of the factors considered to determine how much friction is present in a hoseline is based on the gpm that flows through it. The above chart is based on set gpm that are recommended for use of that particular line. An attack line requires a certain amount of water to properly extinguish the fire.

Some of the gallons per minute (with combination nozzles used @ 100psi) for different attack lines are listed below. Remember, supply lines and solid bore nozzles can vary depending on tip sizes and flow changes.

1¾" 150gpm
2½" 250gpm

NOZZLES & PRESSURES

Nozzles also require certain flow rates and pressure to operate properly. While there are subcategories and specialty nozzles, there are three main nozzle PSI requirements. The pressures listed are what pressure needs to arrive at the nozzle, not what they are discharged at.

It should be noted that several fog nozzles are available on the market referred to as "Low pressure nozzles." These nozzles may only require 50psi or 75psi instead of the normal 100psi. These nozzles are per manufacturer's specifications and the pump operator should be aware if this type nozzle has been placed on a line.

Another type of nozzle is the "Dual Pressure." These nozzles may be switched from "Low" (45psi or 50-55psi) or to standard pressure (75 or 100psi). This type of fog nozzle is used on the "Blitzfire" portable monitor.

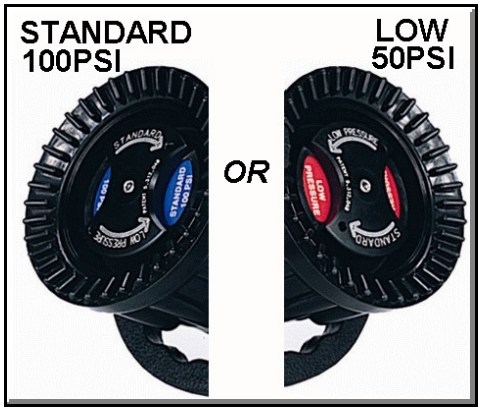
STACKTIP NOZZLES

Another type of nozzle to be considered is the stacktip nozzle. The stacktip uses removable solid bore tips of various size. The various size tips will cause more or less water to exit the nozzle when the nozzle is supplied with the same pressure. No matter what tip is used the nozzle still must receive 50psi. You will have to adjust the throttle accordingly for each to maintain 50psi. Throttle up for a large tip because you are pushing more water and throttle down for a small tip because you are pushing less water.

Different tips require a different calculation of friction loss per 100 feet. Since a 2½" line's friction loss under "rules of thumb" is calculated at flowing 250gpm we are going to have to adjust the friction loss for more or less gpm. The graphic includes a rule of thumb and exact numbers for each tip. The following chart will guide you for stack tips.

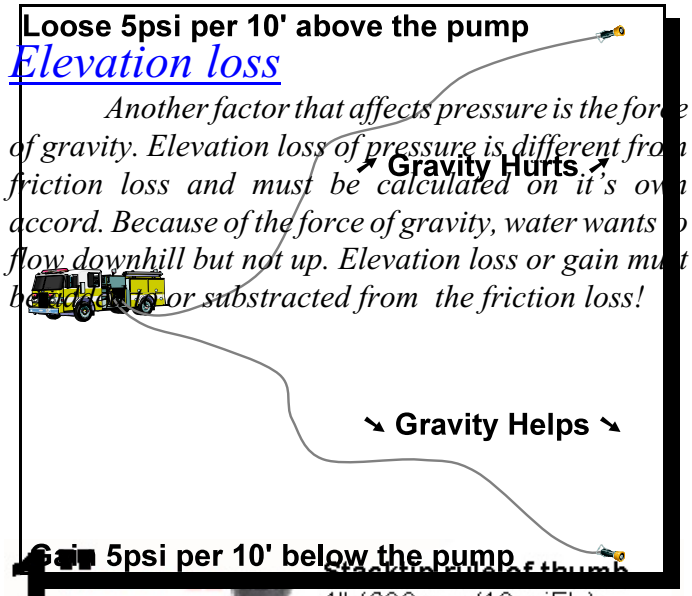
Friction loss allowances for various stacktips on a 2.5" line

3 Main nozzle pressure requirements



The Blitzfire nozzle has 2 modes

GUIDE FOR MOST NOZZLES
AND SPECIALTY NOZZLES



Lose 5psi per 10 foot above the pump
Gain 5psi per 10 foot below the pump

Elevation loss or gain is calculated and then added to the total friction loss for that particular line.

Blitzfire
100psi Fog
50psi SB tips

Master Stream Smooth Bore
80psi

Master Stream Fog
100psi

Fog-Combination
100psi

Smooth Bore
50psi

Cellar Nozzle
100psi
260gpm

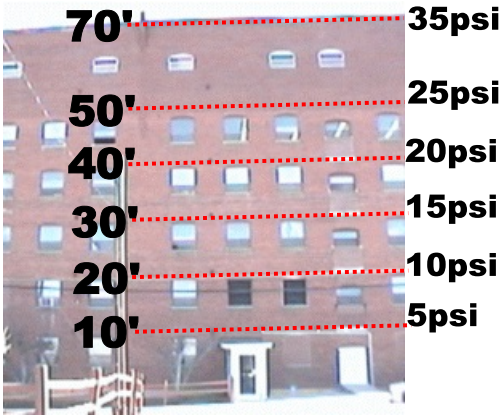
Piercing Nozzle
100psi
125gpm

Chimney Nozzle
60psi
0.7gpm

Foam Eductor
200psi

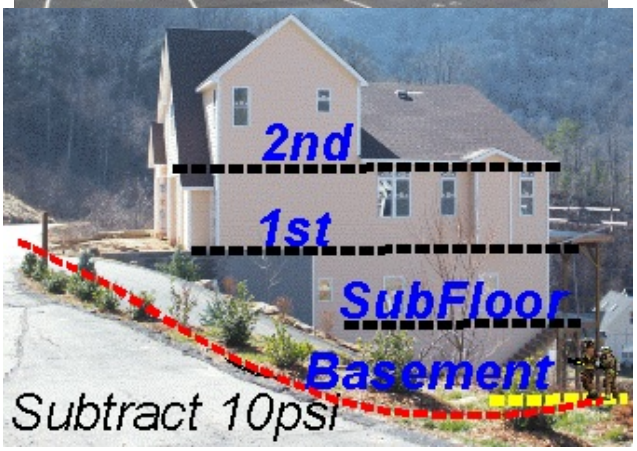
For elevation loss, it does not matter how much hose is on that line , just the total loss or gain in elevation. It also does not matter what size hose. You could have a 200' hoseline that runs up a steep 30' bank and another 1000' hoseline that runs along a road that gradually goes up 30'. Both situations would have 15psi elevation loss. Other situations you may encounter would be with a multistory structure.

NP + FL +/- ELV = PDP
Your needed Nozzle Pressure +
Friction Loss in the Hoselay +/-
Elevation Loss or Gain =
The Pump Discharge Pressure



Old Beacon Mill

Most residential structures have floor heights of around 10 feet, while commercial structures may be from 12-15 feet.
For simplicity, figure 10 feet for most floors.



Dalya Drive off Jim's Branch

Gauges

To obtain the proper pressures for the attack lines or supply lines you will have to rely on the gauges on the pump panel to tell what pressures are present in different parts of the system.There are two gauges called the master gauges. ***The master intake gauge tells the total pressure before it enters the impeller and the master discharge tells the total pressure of the water that is being produced right after it exits the impeller.*** *These gauges are used in every situation. Each attack or supply line has it's own individual gauge so you can tell what each one is doing on it's own. I some situations, several lines may be in use for a fire and each line may have different size and lengths of hose so they will need to operate at different pressures.* ***Whatever line needs to operate at the highest psi is what determines what the master discharge gauge will have to be at.*** *For instance, lets say we had two attack lines that needed to operate at 100psi and one line that needed to operate at 150 psi. If we set the master gauge to 100 psi, then the first two attack lines would operate fine but the second line would also stay at 100psi and would be far from it's required 150psi. The master gauge would have to be set at 150psi. Would this not cause the first two lines to also operate at 150psi? Yes, but this can easily be taken care of. Remember one of the causes of friction loss.....a valve not fully open? We can* ***"gate down" the valve*** *by starting to close the valve handle, thereby increasing friction loss at the valve. As you start closing the valve you will notice that line's individual pressure gauge beginning to show a lower psi. Just keep closing until it reaches it's own required pressure.*

Types of pressure

Static-*Standstill pressure. The pressure of water when it is not moving. For instance, an attack line may charged but if the nozzle is closed then the pressure within the line is static.*

Flow*-Pressure of water actually moving or flowing*

Residual- *Derived from the word residue, or meaning leftover. If a system is flowing water then there is most likely some pressure leftover in the system. The available pressure left while flowing.*

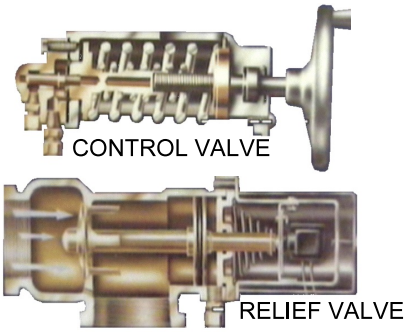
If we have a charged line on the ground with the nozzle closed then within the line exists it's static pressure. When the nozzle is opened, the water begins flowing and turns from a static pressure to a flow pressure. If the nozzle had 100 psi at a static pressure and then the nozzle was opened, would the flow pressure also be 100psi? No, it would be lower. You have just "released" pressure from the system. It is the same as a static pressure that has built up within a hot water heater. When the pressure relief valve or "pop off" valve opens it releases pressure so it can return to a safe operating pressure.

7.Set relief valve

The relief valve is designed to relieve pressure on the system when it reaches an undesirable amount and prevent a water hammer.

Water hammer

As we discussed before in the friction loss section, water, when moving, has a forward momentum or force. Unlike air, water is not compressible in it's volume. If a nozzle is closed quickly on a flowing line, then the force moving towards the nozzle is suddenly stopped and the energy must be transmitted somewhere. The energy usually travels back through the hoseline and seeks a weak point in the system to relieve the pressure. This weak point may be the lining of the hose, coupling, parts in the pump or part of the main water supply. Although good maintenance can provide some protection the water hammer still should be compensated for by using the relief valve. ***Failure to do so could cause the pumps or equipment to fail and place firefighting crews in danger!***



The relief valve system is made up of two major components.

1. The Pilot or Control Valve *(what you see on the pump panel)*

2. The Relief Valve itself

The control or pilot valve has a spring inside of it's casing that keeps pressure against a diaphragm.

The handle that you turn on the pump panel moves a metal disc back and forth to cause either greater or lesser spring tension.

A line comes into the control valve from the discharge side of the pump. If the pressure of the water coming from the discharge side of the pump is less than the tension of the spring then it won't move and the diaphragm and needle valve stay closed.. If the discharge pressure from the pump becomes greater than the spring tension, it will move the diaphragm and needle valve back and allow the higher pressure water to pass through and travel to the Relief valve

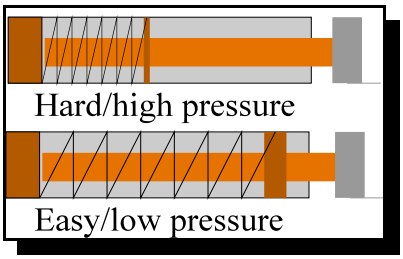
Once the higher pressure water enters the relief valve, it builds up pressure behind the relief valve piston.....

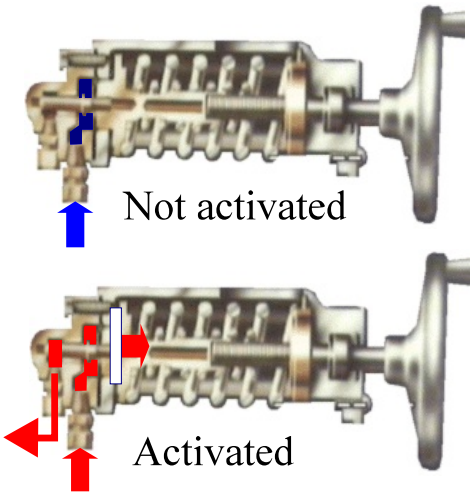
Causing the piston to move and allow pressure from the discharge side of the pump to flow into the suction or intake side, thereby releasing the excess pressure. When the piston moves, it releases contact with the electrical switch causing the light on the control valve to come on.

Since the pressure relieves itself, the diaphragm in the control valve closes back again. If the discharge pressure remains higher than the spring tension then the relief valve will continue to bleed pressure.

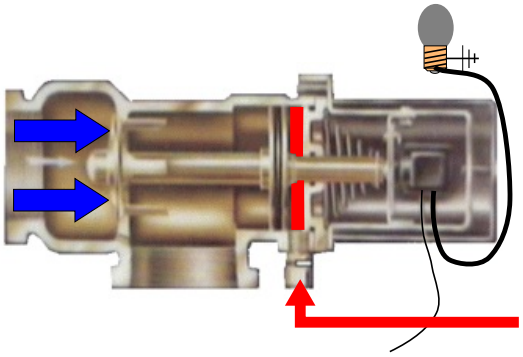
To set the relief valve, throttle till you reach the pressure you want then start backing the control valve down until the relief valve barely opens, then turn the control valve back in until the relief valve closes. Just after it closes, turn the handle appx. ***1 to 1½ turns farther****. This will cause the spring tension to be set appx. 15-25 psi above the static pressure of your line.*

A "Total Pressure Master" system is one that controls pressure for both the discharge and intake pressure.

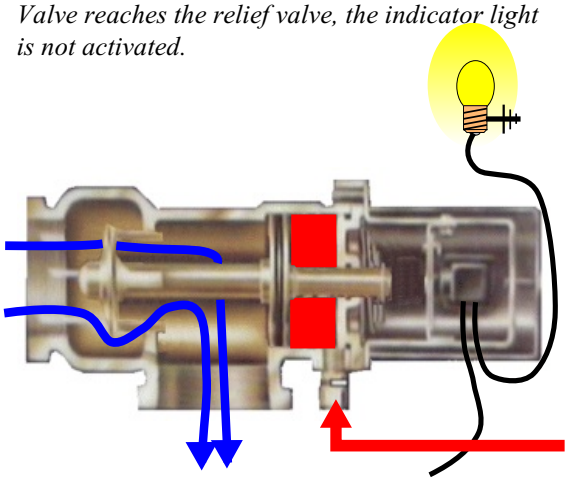




The "Pilot Valve" on the pump panel is adjusted to provide spring tension on the diaphragm that will allow water to flow by or not. Water comes from the discharge side of the pump to here and if the pressure is greater than the spring tension, it will travel to the actual relief valve.



Just before the pressurized water from the Pilot Valve reaches the relief valve, the indicator light is not activated.



When the pressurized water begins to move the disk, it opens the other end which allows higher pressure water from the discharge side of the pump to flow to the intake side of the pump to relieve pressure. When the shaft moves, the switch is activate and the indicator light comes on.

Section 8. Water Supply

This section will show what types of water supply can be available and how to use them.

A. Booster tank

Each apparatus contains a "booster tank" that allows the vehicle to carry water with it and operate independently. Although the vehicle carries water, there are many situations when the tank has the potential or will definitely run out of water for a given situation. You may have enough water for a small car fire but not for a structure fire. You must know how much water a line flows to predict how long your booster tank will last.

Apparatus	Rated GPM it can flow	Gallons in Tank
Engine 6	1750gpm	1000
Ladder 6	1500gpm	400
Engine 61	1500gpm	1500
Engine 62 (CAFS)	1000gpm	500
Tanker 6	1250gpm	2000
Squad 6	500gpm	300
Brush 6	250gpm	250

The following information will tell you how much water a particular truck's pump will flow and how much water is available in it's tank.

All that needs to be done to use the booster tank is to open the "tank to pump" valve. As discussed in section 2, the valve helps keep the pump casing at a safe temperature. In some instances, you may operate the pumps in a freezing environment. If the water within the pump casing freezes it will expand and damage the pump. ***Opening the "tank to pump" valve and the "tank fill" will allow water to go from the tank into the pump and back into the tank again, preventing either freezing or high temperatures by circulating.*** *During freezing temperatures, this should be done even if you do not intend to pump water.*

Another important reminder is that if firefighters are inside of a structure and you run out of water they are going to become injured. You must allow sufficient time for firefighters to retreat from the structure which means they must be warned in time. The rule of thumb, when operating with only the booster tank as your supply, notify the Incident Commander when the water level reaches ***½ of the tank*** *capacity. This also allows the IC to communicate with interior crews and decide when they should retreat, and begin preparations for other water supply.*

B. Nursing / supply from other apparatus

This section applies to using another apparatus's booster tank for your supply or supplying another apparatus. Many areas do not have hydrant coverage or the availability of lakes or streams to furnish you extra water. The first situation covered is receiving water supply to your attack pumper.

Either your water supply is eminently going out or the situation has the potential for using all your available water. You are going to have to replace water used by attack crews or prepare for water that is going to be used by attack crews. In other words, ***the supply must meet the demand.***

To begin with, you must know the total amount of gpm used by the attack pumper. If the attack pumper is flowing 250gpm then you must supply at least 250gpm.

No matter what size hose is being used for supply, the attack pumper should be receiving at least 50psi at it's intake. *Even around 30 psi, the system may work but the danger of "cavitation" will exist. Cavitation is basically trying to pump more out than your taking in. This will be explained more in classroom sessions.*

The available hose for water supply is the 2.5", 3" & 4" hose. The total gpm of a situation will dictate what hose should be used. First we will discuss the use of 2.5" hose.

2.5" hose

2.5" hose is the lightest of supply hoses and is fairly easy to move around and hook up. These lines will hook into either a tank fill valve that only goes straight into the tank instead of through the pump, or into a suction or intake connection with "quick connect" couplings. The 2.5" hose should be limited to a supply flow of about 300gpm. If anything more than two 1.5" or two 1.75" lines are used then another type of supply line should be used.

General Rule of Thumb Friction loss when using 2.5" supply line.

Remember on the regular rules of thumb chart, that 2.5" hose had a friction loss per 100 feet of 15psi. That is because it was flowing 250gpm. When using this size line for water supply there will different gpm flowing through it for different needs, therefore either more or less friction loss. This supply hose rule of thumb only applies when trying to flow between 150 & 300gpm..

	Required GPM	-10 from 1st two numbers	Friction Loss
Subtract 10 from the first two numbers of the gpm to find it's friction loss that needs to be accounted for. Per 100 feet FL	150gpm	15θ -10 =	5psi FL
	200gpm	20θ -10 =	10psi FL
	250gpm	25θ -10 =	15psi FL
	300gpm	30θ -10=	20psi FL

If supplying, add the total friction loss to a minimum of 50 to get your discharge psi

3" Hose	*Virtually the same as 2.5", but the rule of thumb does not apply. Allows more gpm. Just make sure that the attack pumper is receiving at least 50psi.*
4" Hose	*4" hose greatly expands your capabilities for water supply. The main two benefits are that it can flow close to 1000gpm and in most applications, only has a 5psi amount of friction loss per 100feet, allowing longer hoselays.*

Compare how much difference there would be if using a 2000foot lay of 2.5" and a 2000foot lay of 4".		
2½" Hose	*15psi FL per 100'*	*300psi of Friction Loss to account for*
4" Hose	*5psi FL per 100'*	*100psi of Friction Loss to account for*

If you desired 50psi intake pressure, the 2.5" would have to have a discharge pressure of 350psi and

*the 4" only 150psi. Operating at 350psi is **extremely** hard on a pumper. So for large fires at long distance lays we will select the 4" hose. Also note that you can far more water through the 4" if needed*

Some other facts about the 4", is when you have that size hose it will contain a lot of air. The longer the supply line the more air. Remember, a centrifugal pump, like those in our trucks, cannot pump air. If the air is pushed into the pump casing, the pump will lose it's prime. On the intake vale for 4" hose there is a "bleeder valve", which when opened, allows the air that is present to be pushed out by the oncoming water.

Proper procedures for 4" hose

1. Hook the "storz" or sexless coupling to the 4" intake and turn a 1/4 turn to lock.
2. Open the bleeder valve.
3. Allow air to escape and wait till the bleeder valve flows a steady stream of water.
4. Close the bleeder valve finger tight.
5. Open valve on intake that allows water to flow into the pump.
6. When shutting down, assure the source of the supply is shut down.
7. Shut the valve leading into the pump.
8. Open the bleeder valve to relieve pressure.

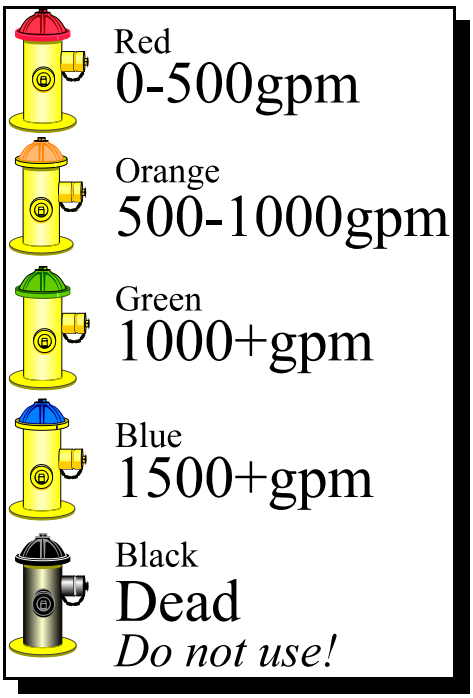
The intake valve for 4" hose has it's own relief valve set at 175psi. This assures that pressures greater than that do not enter the pump casing.

We still want at least 50psi intake pressure at the pump.

C. Hydrants

The most basic issue of hydrants is knowing what gpm they can flow. This information may even make you pass up a lower gpm hydrant and go to another hydrant with a higher gpm that is further away. How many gpm am I going to need for this situation? This should be considered every time!

On a hydrant, you will also notice the color of the caps. These caps tell what type of thread is on it and if you can hook your hose straight to it or if you will need an adapter.



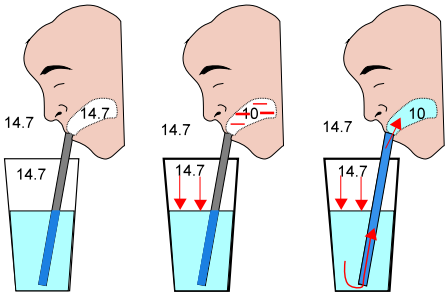
Yellow caps indicate National Thread
Silver caps indicate Asheville Thread

With yellow caps which are National Thread, your hose will hook up to the 2.5" connections. With silver caps or Asheville Thread you will need an Asheville to National adapter so your hose will connect properly.

There are 3 required items that must be left at a hydrant for it's operation when using 2½" or 3" supply lines.

1. Asheville to National Adapter
2. 1/4 turn valve
3. Hydrant wrench

D. Drafting



Drafting is basically "pulling" water into the pump. Using the primer, air is pulled from inside of the pump casing to create a lower atmospheric pressure than outside. The pressure will want to equalize resulting in a "pull" of the water in the hard suction tubing or a push from the outside, however you look at it. It is very similar to using a straw to drink a milkshake. When you suck on the straw, you create a lower atmospheric pressure inside the straw and since the pressure wants to equalize, the milkshake is pushed up the straw by the greater outside atmospheric pressure. If you had a straw with a hole in it, you may not be able to drink it or have to exert a tremendous amount of effort to get any at all. The pump is your mouth, the hard suction hose your straw and the water supply in the dump tank or lake, the drink.

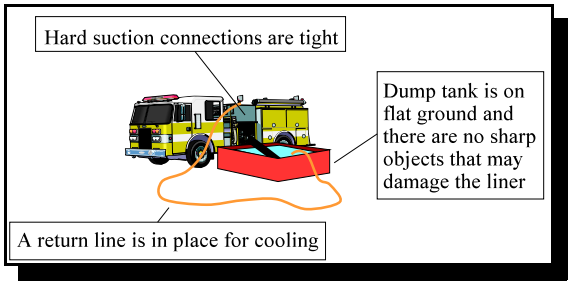
The primer itself is an electric motor mounted to a small positive displacement pump that can pump air as well as water. The motor uses a lot of electricity, therefore the throttle must be increased so the alternator can keep up with the loss. ***A primer pump should never be operated for more than 30 seconds at a time.*** *When you first activate the pump, air and an oil substance will be coming from underneath the truck. The oil substance is used to lubricate the primer pump. Once the pump is primed with water, you will see water coming out of the primer discharge beneath the truck.*

If you are driving a tanker for shuttle purposes, there are several tips that can make your mission effective.

1. Always drive safely. If you wreck you may injure yourself and others and hinder the water shuttle operation.
2. Always have someone back you up to the dump tank.
3. You can leave the tank to pump and jet dump valves open between shuttles. This way all you have to do when you arrive back at the dump tank is put the pumps in gear and run the throttle up in the cab. You never get out of the cab and your dump time is decreased.

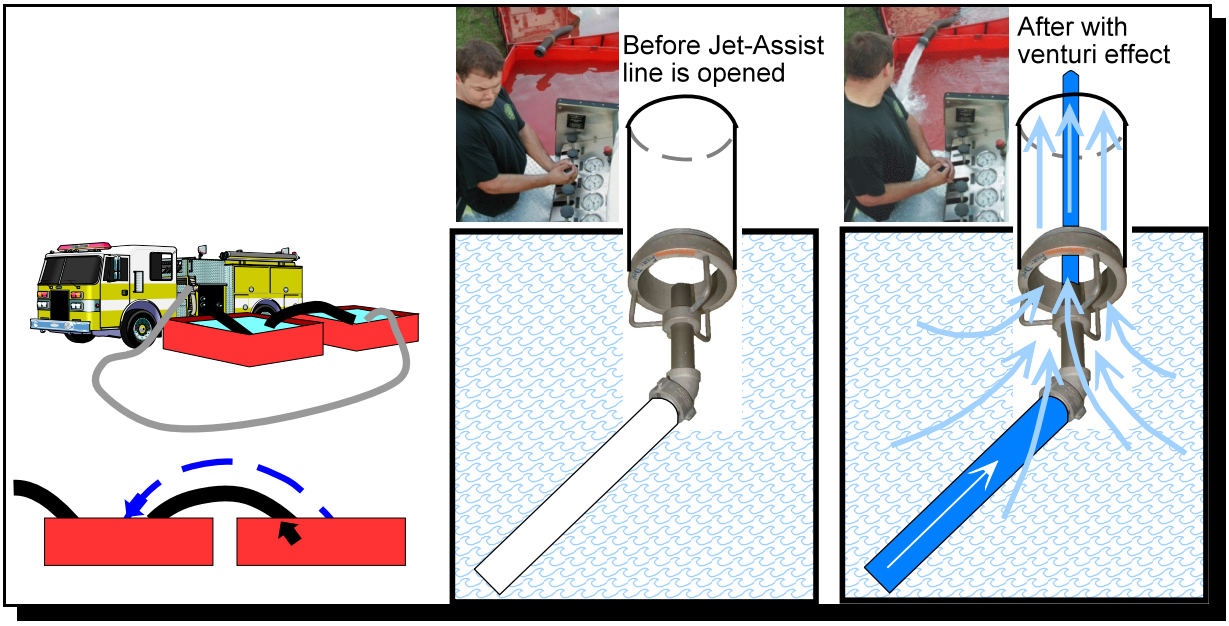
Basic recommendations for dump tank operations

During a dump tank operation, water will have to be "shuttled" by other tankers from a hydrant or other supply to the dump tank you are using. The shuttle operation will also have to be able to supply as much water as you are using. The output of the attack pumper, the tank size of the tanker delivering water and the distance the tankers will travel to and from the water source will all be a factor in determining how many tankers are needed.



Double Dump Tank Operation using the Jet Assist Appliance

On the pump panel of Engine 61 and Tanker 6, you will notice a valve labeled jet dump. This valves opens a line leading to a pipe inside of the tank. It acts the same way as the venturi effect on the double dump tank system. This venturi effect greatly increases your rate of dumping water.



D. Lakes, streams and pools

All of the same information applies as in the drafting section since all of these applications must use drafting to obtain the water. The following are tips when utilizing these type resources.

Lakes/streams

1. Must use a barrel strainer on the hard suction hose to stop algae, grass and any debris in the water from obstructing lines.

2. Barrel strainers should not rest on the bottom. A ladder may be used underneath the hard suction to keep it higher or the use of a float.

3. Remember, you must be close enough to the water for the hard suction hose to reach. This may put the apparatus in danger of the bank caving in or becoming stuck in wet ground.

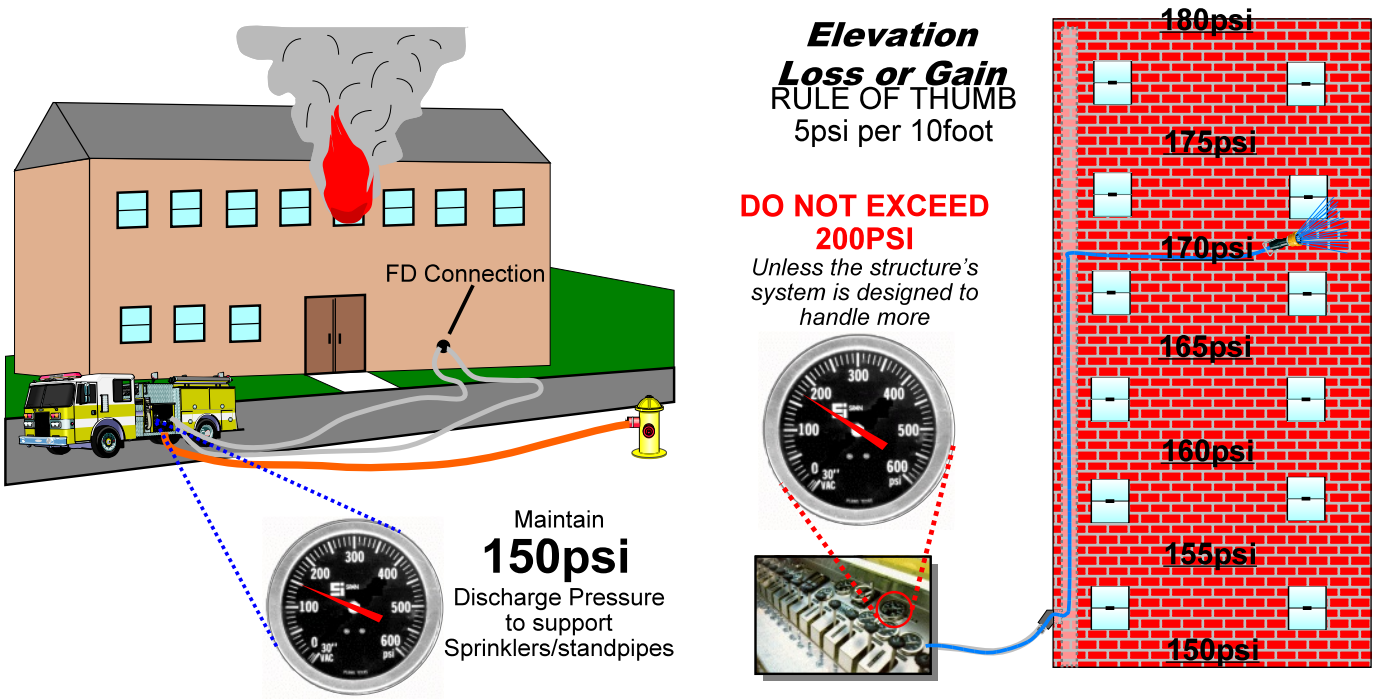
Pools

1. Pools usually contain a clean water source but the weight of an apparatus may collapse the sides of a concrete pool.

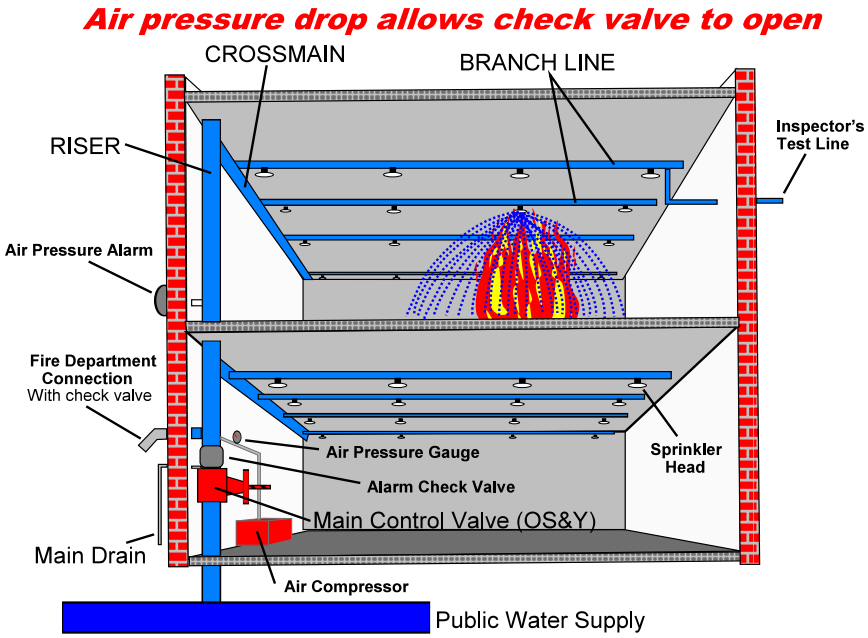
2. Above ground pools have liners that may shift with the rise or fall of water and may become damaged.

Supplying water for Sprinkler Support

Sprinklers systems are one of the most effective firefighting tools we have available. In some situations, we may have to support or supply the sprinkler system to help control or extinguish the fire. Not only may you be supplying water and pressure to sprinkler heads but also to standpipe connections that firefighters are connecting to for hoseline operations. You may have to hook to a hydrant and lay a supply line to your location you'll be pumping from. You will be placing at least 2 2½" supply lines of hopefully not more than 150' each to the fire department connection. The amount of GPMs needed will depend on how many sprinkler heads are activated or how many handlines are being used off of standpipe connections. No matter the GPM needed, all you need to worry about is that you need to be discharging at 150 psi plus the elevation loss.



Figuring elevation loss for a sprinkler system is the same as you normally would for any hoseline. Gravity still has the same effect. The only difference is that <u>we do not want to exceed 200psi</u>.



Typical Dry System operating

Supply versus flow chart

Flow time = Supply divided by gallons per minute being flowed

	25	50	75	100	125	150	175	200	225	250	275	300	325	350	375	400	425	450	475	500
250	10:00	5:00	3:20	2:30	2:00	1:40	1:25	1:15	1:07	1:00	:53	:50	:46	:43	:40	:38	:35	:33	:32	:30
500	20:00	10:00	6:40	5:00	4:00	3:20	2:50	2:30	2:14	2:00	1:49	1:40	1:32	1:26	1:20	1:16	1:10	1:06	1:02	1:00
750	30:00	15:00	10:00	7:30	6:00	5:00	4:17	3:45	3:20	3:00	2:46	2:30	2:18	2:09	2:00	1:53	1:45	1:39	1:35	1:30
1000	40:00	20:00	13:20	10:00	8:00	6:40	5:40	5:00	4:28	4:00	3:38	3:20	3:04	2:52	2:40	2:32	2:20	2:12	2:04	2:00
1250	50:00	25:00	16:40	12:30	10:00	8:20	7:09	6:15	5:33	5:00	4:33	4:10	3:51	3:34	3:20	3:08	2:55	2:45	2:36	2:30
1500	60:00	30:00	20:00	15:00	12:00	10:00	8:34	7:30	6:40	6:00	5:47	5:00	4:36	4:17	4:00	3:45	2:30	3:20	3:09	3:00
1750	1:10:00	35:00	23:20	17:30	14:00	11:40	10:00	8:45	7:47	7:00	6:22	5:50	5:23	5:00	4:40	4:23	4:07	3:53	3:41	3:30
2000	1:20:00	40:00	26:40	20:00	16:00	13:20	11:.26	10:00	8:53	8:00	7:16	6:40	6:09	5:43	5:20	5:00	4:46	4:27	4:13	4:00
2250	1:30:00	45:00	30:00	22:30	18:00	15:00	12:51	11:15	10:00	9:00	8:11	7:30	6:55	6:26	6:00	5:36	5:18	5:00	4:46	4:30
2500	1:40:00	50:00	33:20	25:00	20:00	16:40	14:17	12:30	11:07	10:00	9:05	8:20	7:36	7:09	6:40	6:15	5:53	5:33	5:16	5:00
2750	1:50:00	55:00	36:40	27:30	22:00	18:20	15:43	13:45	12:13	11:00	10:00	9:10	8:28	7:51	7:20	6:53	6:28	6:06	5:47	5:30
3000	2:00:00	60:0	40:00	30:00	24:00	20:00	17.09	15:00	13:20	12:00	10:55	10:00	9:14	8:34	8:00	7:30	7:03	6:40	6:19	6:00
3250	2:10:00	65:00	43.20	32:30	26:00	21:40	18:34	16:15	14:27	13:00	11:49	10:50	10:00	9:17	8:40	8:08	7:36	7:14	6:50	6:30
3500	2:20:00	70:00	46:40	35:00	28:00	23:20	20.00	17:30	15:33	14:00	12:46	11:40	10:46	10:00	9:20	8:45	8:14	7:47	7:22	7:00
3750	2:30:00	75:00	50:00	37:30	30:00	25:00	21:26	18:45	16:40	15:00	13:36	12:30	11:32	10:46	10:00	9:23	8:49	8:20	7:54	7:30
4000	2:40:00	80:00	53:20	40:00	32:00	26:40	22:51	20:00	17:47	16:00	14:32	13:20	12:18	11:26	10:40	10:00	9.25	8:53	8:25	8:00

Water supply available in gallons ***Gallons per minute being flowed***

**** Most times are exact or rounded off --- several factors could create a quicker depletion of the supply----- always expect a shorter flow period ****

A few definitions

Atmospheric Pressure	***Pressure caused by the weight of air above the earth. Atmospheric pressure is 14.7 pounds per square inch at sea level. Pressure increases below sea level and decreases above sea level. The weather also effects atmospheric pressure. Atmospheric pressure effects a pumps ability to pump from draft. Higher pressures increase a pumps performance, while lower pressures can cause a noticeable decrease in lift.***
Auxiliary Cooling Valve	***Permits water from a pump to cool the radiator water through a heat exchange.***
Capacity	***Pump flow rating.***
Cavitation	***Occurs when the pump attempts to deliver more fluid than is being supplied. This causes the formation of bubbles in the pump. When the bubbles collapse, the liquid, under pressure, rushes in to fill the empty space. This damages the pump and must be corrected immediately.***
Centrifugal Force	***Force that tends to make rotating bodies move away from the center of rotation.***
Centrifugal Pump	***A pump that uses a rapidly spinning disk or impeller to create the pressure for fluid movement***
Certification	***Pumper test in accordance with NFPA standards to determine if a pump can deliver its rated volume and pressure***
Check Valve	***A one-way valve or non-return valve that allows flow in one direction, but shifts to prevent flow in the reverse direction. In two stage pumps, there are two swing check or flap valves in the suction passage of the second stage. They are located in each side of the pump between the suction tube and the pump body. These valves swing open when pumping in parallel for volume. They are closed by first stage pressure when pumping in series for pressure.***
Clearance Ring	***Prevents discharge fluid from returning to the eye of the impeller.***
Compound Gauge	***A compound gauge is graduated to read pressure in "pounds per square inch" and "vacuum in inches of mercury."***
Cut Water	***Cut water is a wedge-shaped point between the volute (pump body) and the pump discharge where the volume of fluid is directed to the discharge connection***
Dead Heading	***Operating a pump without any discharge. The lack of flow causes temperatures to rise inside the pump. WARNING ! IF A PUMP IS OPERATED WITHOUT WATER FOR EXTENDED PERIODS, OR WITHOUT DISCHARGING WATER, IT MAY OVERHEAT. THIS COULD DAMAGE THE MECHANICAL SEAL OR THE DRIVE MECHANISM.***
Double Suction Impeller	***Fluid enters on both sides of the impeller***
Dry Prime Test	***Provides information on the ability of a priming pump to evacuate air from the main pump. If the vacuum does not hold, it is an indication there is a leak in the system***
Flow Meter	***Measures the volume of fluid that is flowing.***
Friction Loss	***Loss of pressure in hose, fittings, standpipes, and other appliances because of the resistance between the fluid molecules and the inside surfaces of the hoses, fittings, standpipes, piping, and other appliances.***
Front-Mount Pump	***Pump mounted ahead of the vehicle's engine – usually on the front of the radiator.***
Gauge Pressure	***Pressure read from a gauge (PSIG)***
Governor	***Minimizes pressure changes by controlling engine speed to maintain pump discharge pressure.***
Horsepower	***A measure of mechanical work***
Impeller	***The working part of a centrifugal pump that, when rotating, imparts energy to fluid. Essentially, an impeller consists of two disks separated by vanes. The vanes force the fluid to move outward between the disks so that it is thrown outward at high velocity by centrifugal force. The water from the impeller discharges into a diverging passage known as a volute, converting the high velocity energy of the water into pressure.***
Impeller Eye	***Point where fluid enters the impeller***
Net Pump Pressure	***The difference in pressure between discharge and suction pressure***
Packing	***Material that maintains an airtight seal at the point where the impeller shaft enters and exits the pump body***
Parallel	***Capacity position in which each impeller on a two-stage pump works independently into the discharge – often termed "Volume Mode."***
Pitot Gauge	***Measures velocity head at the discharge of a nozzle and can be converted to flow using a chart or simple calculation***
Positive Displacement Pump	***A pump with a fixed flow delivered to the discharge with each revolution***
Positive Pressure	***Pressure above atmospheric***
Pressure	***Force per unit area***
Pressure Gauge	***The pressure gauge is usually graduated in pounds per square inch (PSI) only. It is connected to the pump discharge manifold, thus indicating pump discharge pressure.***
Priming	***Priming evacuates the air from the main pump and suction hose, thus creating a vacuum. This allows atmospheric***

	pressure on the source of the fluid to push the fluid up into the suction hose and pump.
Priming Pump	***An auxiliary positive displacement pump which pumps air out of the pump body that creates a vacuum to prime the main pump. The priming pump is a rotary vane type, electric motor driven. Once the main pump is primed and pumping, the priming pump is shut off.***
Pump Shift	***A midship pump is usually mounted with a split gearbox installed in the drive shaft. The pump shift moves a sliding gear in the gearbox that transmits power either to the pump or the rear axle. In ROAD position, power is shifted to the rear axle for driving; in PUMP position, the rear axle is disconnected, and power is shifted to the pump shaft.***
Relay	***Movement of water from an apparatus at a water source to additional apparatus until water reaches the fire ground.***
Relief Valve	***An automatic valve which, when activated by the relief valve control, holds pump pressure steady when discharge valves or shut-off nozzles are closed. The valve maintains its given pressure by dumping the pump discharge flow into the pump suction***
Relief Valve Control	***A handwheel adjustment valve which controls and/or adjusts the relief valve to (PM) maintain the working pressure (i.e., set to control the desired pressure).***
Series	***Pressure position in which the first impeller's discharge is fed to the eye of the second impeller in a two-stage pump which then discharges the fluid from the pump (often termed "Pressure Mode").***
Service Test	***Pump test performed to determine if the apparatus can deliver its rated volume and pressure.***
Shrouds	***Sides of an impeller that confine the fluid.***
Slinger Ring	***Prevents fluid from continuing to travel down a shaft to the gears and ball bearings.***
Stages	***The number of impellers in a pump that are used in series; that is, one following another in terms of flow. Each impeller develops part of the total pump pressure.***
Tachometer	***Indicates the speed of the engine crankshaft in revolutions per minute.***
Torque	***The force that acts to produce rotation***
Transfer Valve	***A two-position valve in a pump that changes the operation from parallel (volume) to series (pressure) operation and vice versa (not used on single stage pumps).***
Vanes	***Guides inside an impeller that direct fluid to the volute (pump body).***
Volute	***A gradually increasing discharge waterway. Its function is to collect the water from the impeller and, depending on its design, it either increases pressure and decreases velocity or increases velocity and decreases pressure.***