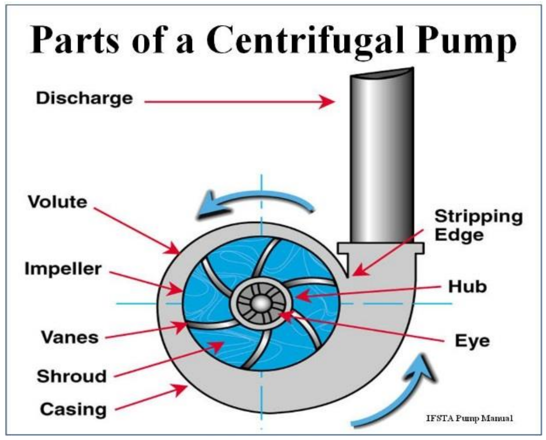
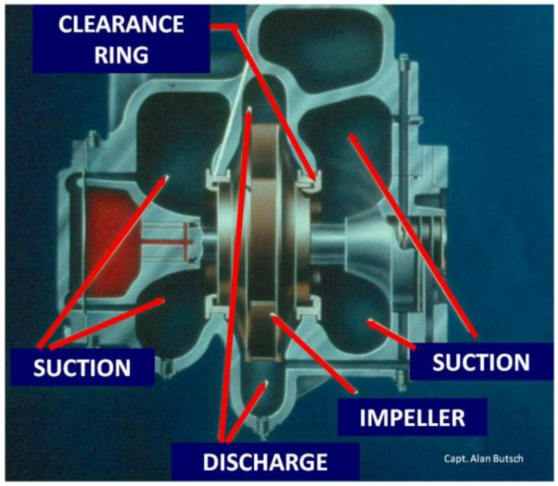
Fire Apparatus Pump Operations, Mechanics, and Components
Plain Water Operations

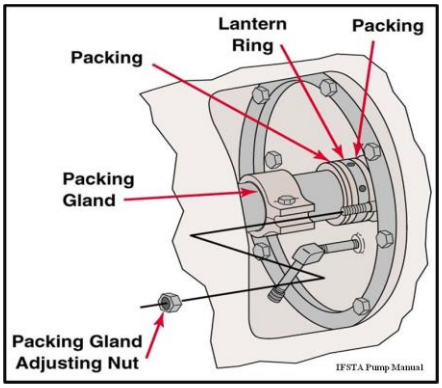
Centrifugal Pumps

Fire apparatus pumps use centrifugal force to deliver water to the fireground. Centrifugal force is an outward force associated with rotation. The rotation in a fire apparatus pump is powered by the same transmission output shaft that powers the drive axle. A centrifugal pump impeller slings liquid out of the volute creating pressure as it moves into the discharge piping. Water pressure develops in a pump volute when water accumulates faster than it can escape into a discharge. Centrifugal pumps can be classified into single or multiple stages (single or multiple impellers). **A very common misconception is that increasing pump pressure also increases volume, however this is not always correct. A fire pump cannot "make" water; it can only pressurize the supply it receives.**



Centrifugal Pump Components	
Element Name	**Element Purpose**
CASING	Collects water and delivers it to the discharge
IMPELLER	Uses centrifugal force to move water
EYE	Where water enters impeller
HUB	A lip around the eye prevents slip back
VANES	"Slings the water" adding velocity to the water
SHROUD	Confines the water as it moves through the impeller
VOLUTE	Captures the velocity of water as it enters the outermost diameter of an impeller and converts the velocity of the liquid into pressure. The taper of the volute maximizes water pressure in the area of the stripping edge and out to the discharge manifold.
STRIPPING EDGE	Directs water to discharge, prevents churning action
CLEARANCE RING	Between hub and impeller
PACKING RING	Prevents air leaks
LANTERN RING	Supplies water from discharge for cooling
FLINGER RING	Keeps water from getting into gear box
INJECTION PACKING	Packing is added, not replaced.





Cavitation

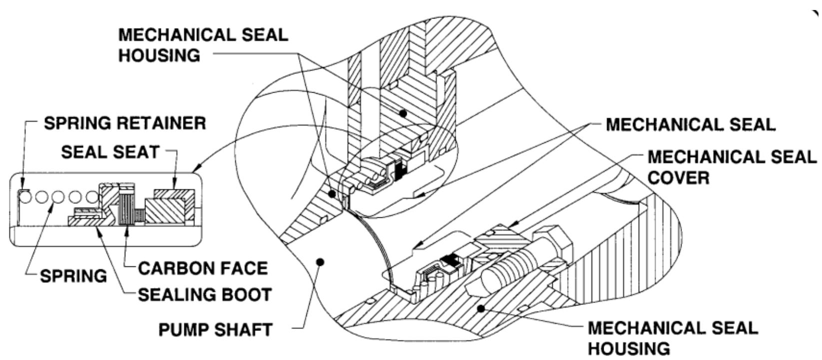
In simple terms, cavitation occurs when there is insufficient water entering the pump to meet the demand of the discharge side of the pump. The point of lowest pressure in a pump is found at the eye of the impeller. At this point, liquid is being drawn into the impeller but has not yet been acted upon by the rotation of the impeller. The greater the pump flow rate, the greater the pressure drop between the pump suction and the eye of the impeller. If the pressure acting on the liquid is drawn down too low, small pockets of vapor – bubbles – will form in the liquid. Any vapor bubbles formed by the pressure drop at the eye of the impeller are swept along the impeller vanes by the flow of the fluid. As the liquid is then accelerated by the rotation of the impeller, pressure increases rapidly, and the vapor bubbles collapse. This process of the formation and subsequent collapse of vapor bubbles in a pump is called cavitation.
Cavitation in a centrifugal pump has a significant effect on pump performance. Cavitation degrades the performance of a pump, resulting in a fluctuating flow rate and discharge pressure. Cavitation can also be destructive to pumps internal components. When a pump cavitates, vapor bubbles form in the low-pressure region directly behind the rotating impeller vanes. These vapor bubbles then move toward the oncoming impeller vane, where they collapse and cause a physical shock to the leading edge of the impeller vane. This physical shock creates small pits on the leading edge of the impeller vane. Each individual pit is microscopic in size, but the cumulative effect of millions of these pits formed over a period of hours or days can literally destroy a pump impeller. Cavitation can also cause excessive pump vibration, which could damage pump bearings, wearing rings, and seals.

Cavitation produces a very noticeable sound. When a pump is cavitating it sounds as if small rocks are rattling around inside the pump casing. When pump operators notice the sound of cavitation within a pump they should act swiftly to either increase water supply or reduce discharge pressure, thus effectively slowing the impeller RPM down.

Pump Seals

The drive shaft that powers the impeller has a seal where it passes from the interior (wet) of the pump to the exterior (dry). This seal could be in the form of packing or a mechanical system.

The HALE QMax pump currently specified by MCFRS employs a mechanical seal. A stationary seal seat is in constant contact with a rotating carbon face to prevent leakage. The sealing boot is made of a rubber elastomer that is specifically designed for high temperature operations. It is vitally important that this pump seal be cooled with water, therefore the pump should not be run dry for excessive periods.



Older apparatus or smaller pumps found on brush units may have traditional packing. Packing forms a nearly watertight seal at the point where the shaft passes from the inside to the outside of the pump. Packing material is cooled with pump water that absorbs into the packing material. Packing material may deteriorate if the pump is kept dry for long periods of time. In this case, charging the pump with water at least once weekly will prevent deterioration.

Single Stage and Two Stage Pumps

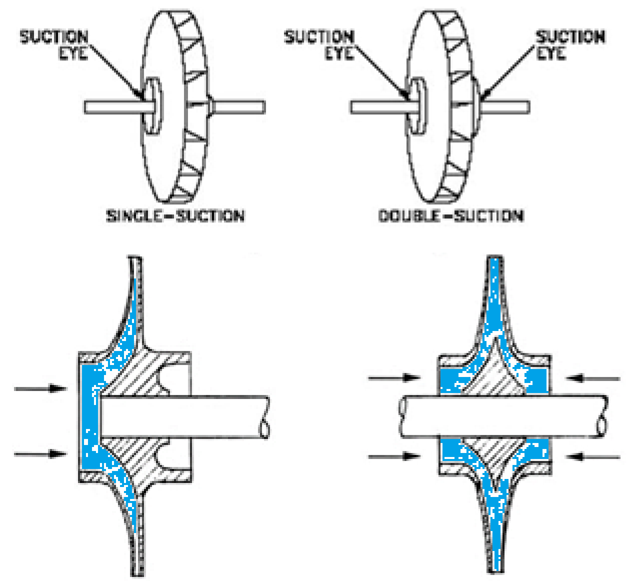
Single Stage Pumps

Single stage pumps use a single impeller to produce water pressure. There are no Volume/Pressure (Series/Parallel) Transfer valves to manipulate. Single stage fire pumps usually have larger impellers than Two-Stage Pumps to generate the desired volume and pressure combinations. The Hale QMax pumps on MCFRS fire engines use a single double-suction bronze impeller capable of pumping 2250 GPM with the use of multiple intakes.

Impellers of pumps are classified based on the number of points that the liquid can enter the impeller and the amount of webbing between the impeller blades.

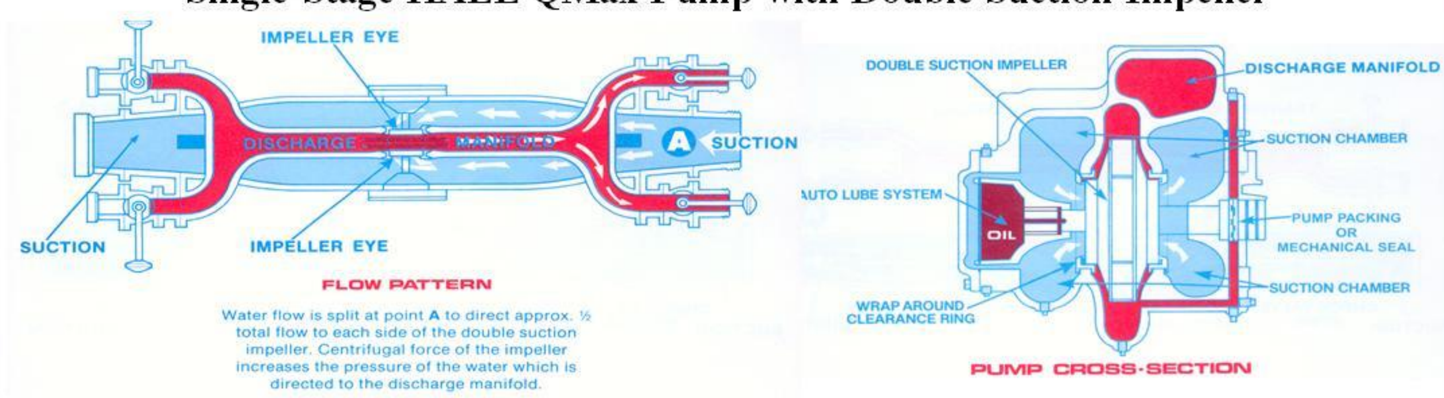
Impellers can be either single or double-suction. A single suction impeller allows liquid to enter the center of the blades from only one direction. A double-suction impeller allows liquid to enter the center of the impeller blades from both sides simultaneously and thus generate higher water flows.

The impeller on the Hale QMax pump has an enclosed impeller. This enclosed impeller (also called a shrouded impeller) has circular plates attached to both sides of the blades.

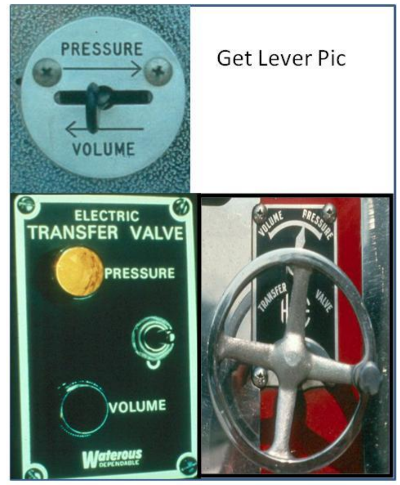


SINGLE SUCTION IMPELLER DESIGN DOUBLE SUCTION IMPELLER DESIGN

Single-Stage HALE QMax Pump with Double Suction Impeller



Two Stage Pumps

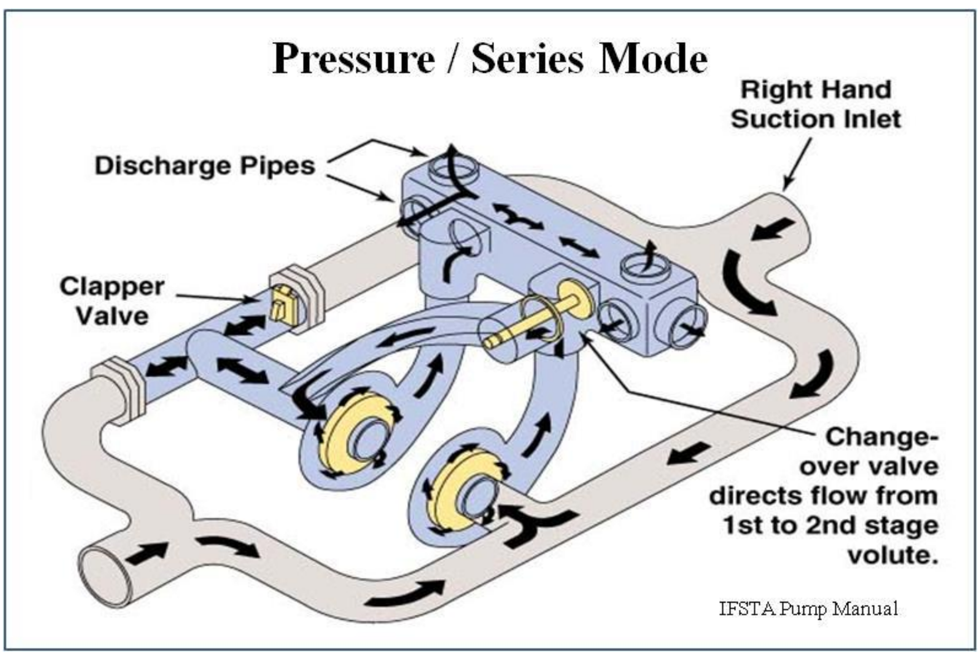


Common Pump Panel Transfer Valves

Two stage pumps were the standard in the Fire Service for many years and some departments still use them. MCFRS reserve apparatus may still have a two-stage arrangement. The primary difference between the two stages is the volume of water pumped at a range of pressures. MCFRS two-Stage pumps are typically rated to 1250 GPM. Pumps are transitioned between Pressure and Volume Modes using pump panel mounted Transfer Valve Controls.

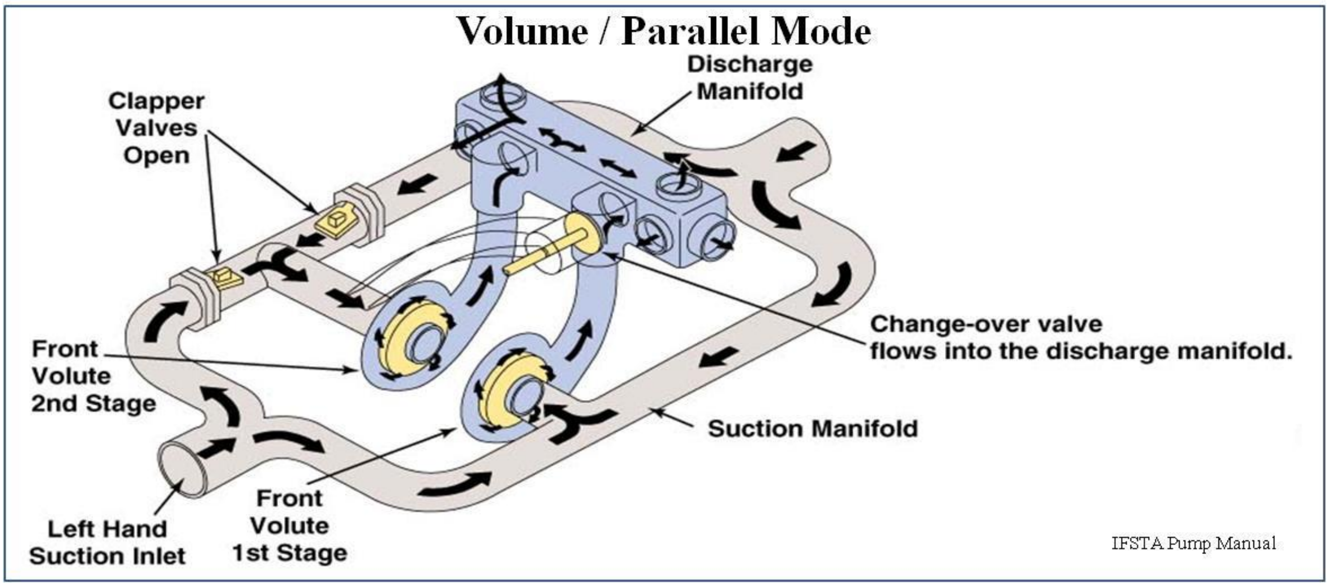
Pressure Mode - When the pump is in Pressure mode, a Transfer Valve located on the Engine Pump Panel closes clapper valves on one side of the intake piping, and one side of the discharge piping. These Clapper valves direct water into a "series" of two sequential volutes, hence this mode may also be referred to as Series. Water enters the first volute and gains pressure from the spinning impeller. This pressurized water exits the first impeller and enters the second volute where a second impeller further boosts the pressure before the water is routed to the discharge manifold. This mode is used where higher discharge pressures are needed due to friction loss, elevation loss, or other factors that mandate pressure over volume.

Higher pump pressures do not equate to higher volumes of water. Pressure mode is not appropriate for pumping more than one-half of a pump's rated capacity, i.e. Pressure Mode is not appropriate if operations require more than 625 GPM from a 1250 GPM rated pump. Pressure mode provides higher pressures at a cost of lower capacities.



Volume Mode – When the pump is in Volume mode, all of the clapper and change-over valves are open and intake water is distributed evenly to both impellers at the same time. The two impellers are operating in parallel to each other to feed water to the discharge manifold, hence this mode may also be referred to as Parallel.

Volume Mode delivers the maximum flow capacity available from a pump. This volume is provided at a cost of lower operating pressure. Volume Mode should be used when pumping more than one-half the rated capacity of a pump. It should be used during defensive operations (i.e. Master Streams) and when drafting.



TRANSITIONING BETWEEN PRESSURE AND VOLUME MODES – Typically, the mode should be set at the start of pumping operations before throttling up. If conditions change and require a transition between modes the Net Pump Pressure (NPP) must not exceed 50 PSI. NPP is the mathematical difference between intake and discharge pressure. For example, if intake pressure is 150 psi and discharge pressure is 200 psi, NPP is 50 psi, and it is safe to transition between Pressure and Volume modes.

Pressure Control Devices

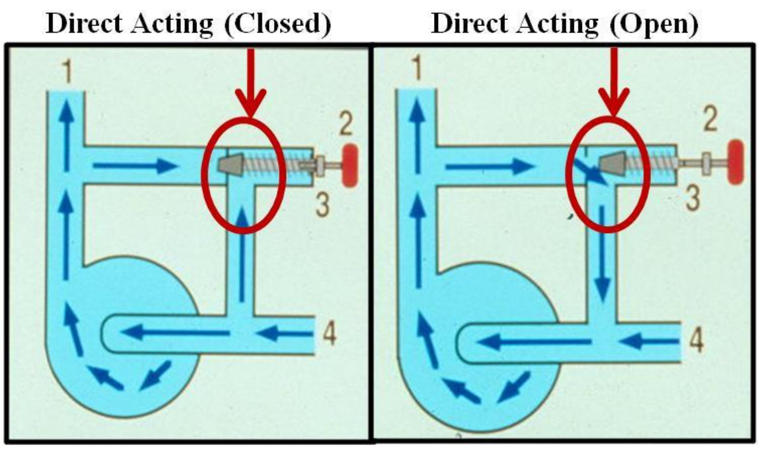
Pressure supplied to and delivered from fire apparatus pumps must be regulated to ensure safety and to deliver predictable water flows. The movement of water inevitably results in pressure fluctuations that can damage equipment, increase or decrease water flow, or cause hoselines to become unmanageable. Regulation of pressure occurs in two primary ways; automatic relief valves and pump discharge pressure management devices.

Automatic Relief Valves

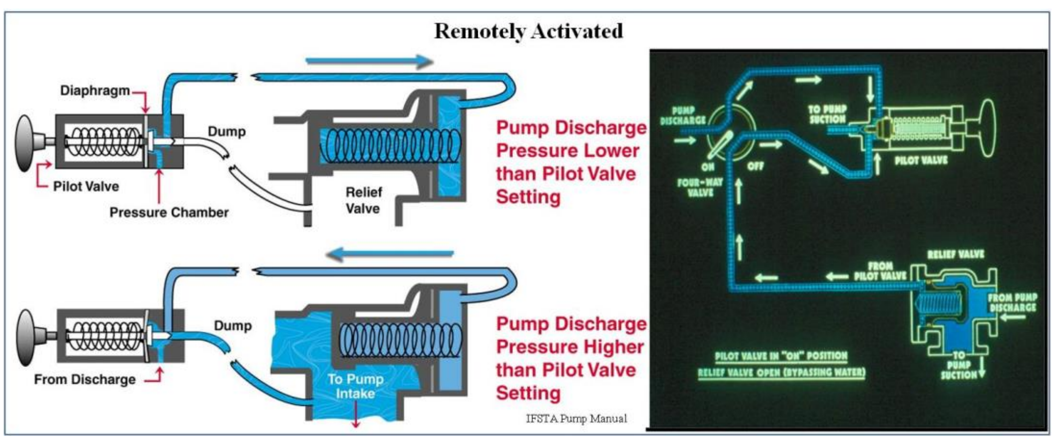
Automatic relief valves are generally intended to limit pressure extremes by diverting water flow away from its destination. These valves are most often found on the main body of the pump, large diameter intakes, and large diameter discharges due to the energy created by large volumes of moving water. Operators need to identify the specifics of their breed of apparatus.

Automatically relief valves usually fall into two types:

1. **Direct Acting** – relief and adjustment mechanism located directly on the piping
2. **Remotely Activated** – relief valve located on the piping and the adjustment mechanism (pilot) is accessible on the pump panel



1. Discharge Outlet
2. Pressure Adjustment
3. Relief Valve
4. Intake



Purposes of Intake Relief Valves:

- Safety valve set at the factory to prevent excessive supply pressure or water hammer. The valve is typically set for 125 or 150 psi for MCFRS pumps.
- Used to control a satisfactory residual pressure at the intake of the pump during a relay with changes in flow.
- Installed to limit pressure increases on the suction side of the pump.

Purposes of Discharge Relief Valves:

- Safety valve set at factory to prevent excessive pressure or water hammer being delivered from a specific discharge. This pressure is typically 185 psi for MCFRS units.

Pump Discharge Pressure Management Systems

Hale Total Pressure Master Relief Valve System

The Hale Total Pressure Master (TPM) Relief Valve System is a fully integrated high capacity relief valve system with the following components:

- Model QG Internal Relief Valve (Recirculating)
- Model PG30 External Relief Valve with Sensing Assembly
- Panel Mounted Controller

Control valve w/ hand wheel and indicating light

Total Pressure Master Features / Benefits include:

- Automatically responds to pressure variations on suction and discharge side of the fire pump
- Rated to relieve water flow at rates up to 1500 GPM
- Eliminates the need for a “dump line” when operating in a relay


Internal Valve

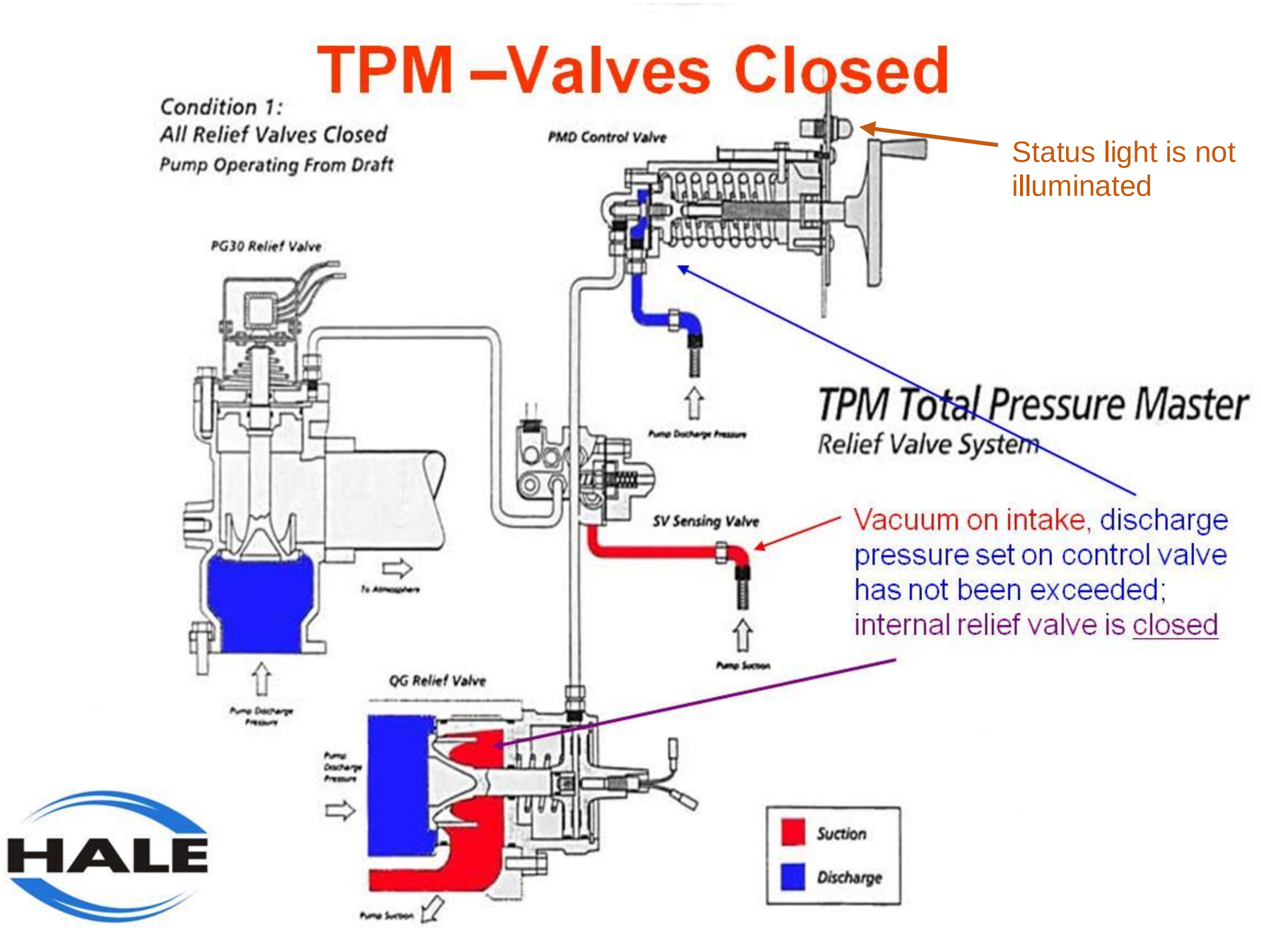
TPM Best Practices

- ✓ Regardless of the scope of the operation, the TPM control valve needs to be set for the desired discharge pressure.
- ✓ Following the daily checkout the control valve can be preset slightly above typical operating pressure, however returning the valve to zero between operations relieves pressure off the internal spring and reduces wear.
- ✓ The control valve should be exercised daily to prevent sluggish operation.
- ✓ During relay operations, initially set the control valve at a lower pressure and make adjustments to reach desired pressures.
- ✓ The TPM has no field serviceable intake screens. If it is sticking open let shop know.


External Valve

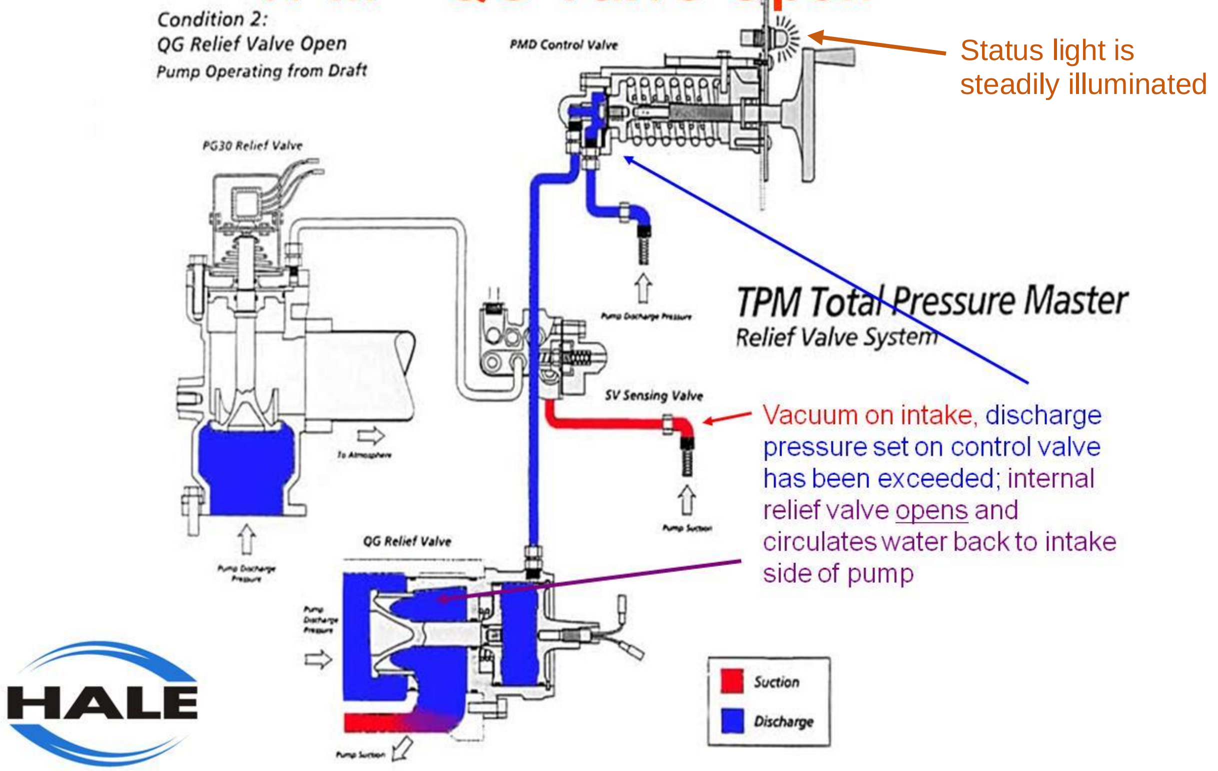
Total Pressure Master Functionality:

- Sensing valve monitors whether pressure on intake is vacuum or positive.
- As long as pump discharge pressure stays below the value set by the control valve, all relief valves remain closed
- <u>Drafting or Tank Water</u> (vacuum on intake side) – controls pressure using only the internal (recirculating) valve, or first stage.
- <u>Pressurized water source</u> (positive intake pressure) – controls pressure in two stages.
    1. First stage - internal valve operates and the status light glows steady
    2. Second stage – internal valve is not sufficiently controlling the pressure; external valve opens and dumps to ground. The status light flashes.



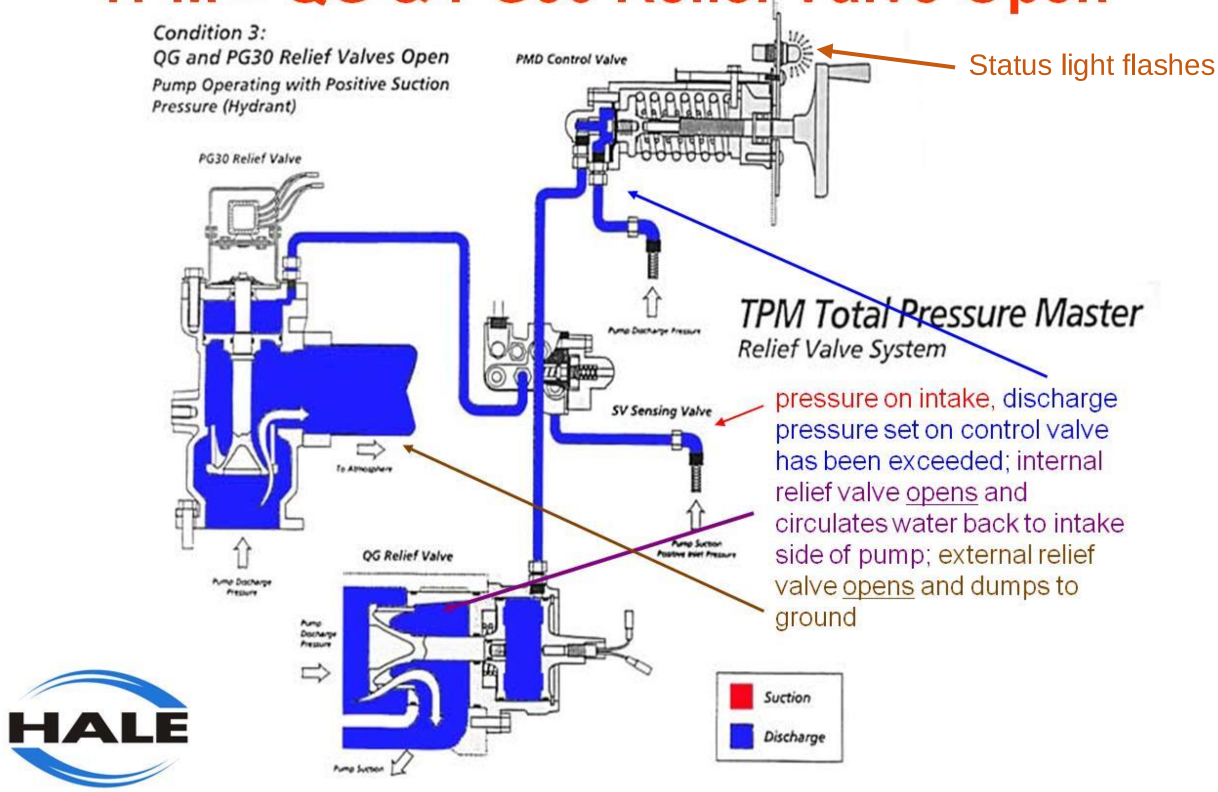
Stage 1

TPM – QG Valve Open



Stage 2

TPM – QG & PG30 Relief Valve Open



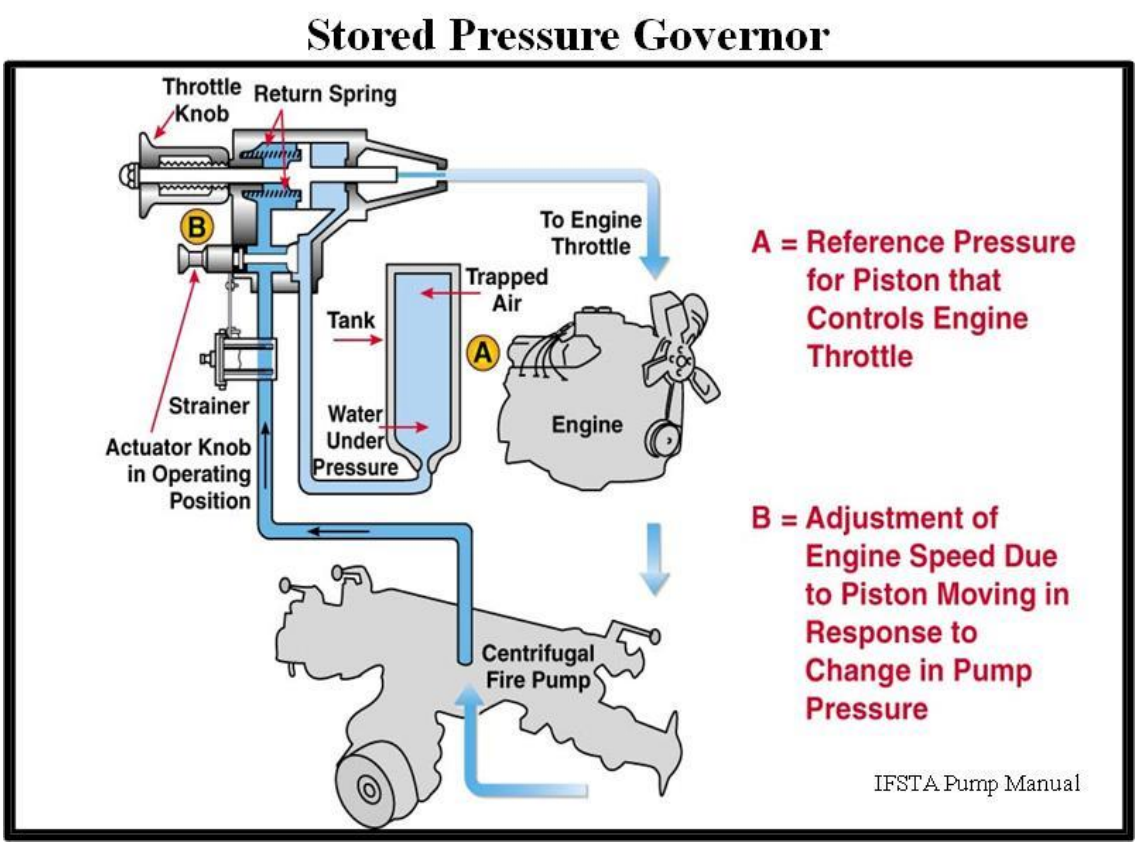
TPM and Relief Valve Daily Operational Check

1. Set up to pump from the onboard water tank with the tank fill valve open less than half way.
2. Turn the control valve handwheel clockwise until set above 150 PSI.
3. Increase pump pressure to 150 PSI per normal operating procedures.
4. Turn the control valve handwheel counterclockwise until the relief valve opens and the pilot light is lit. Master pressure gauge should drop at least 5 to 10 PSI.
5. Turn the control valve handwheel clockwise. Master pressure gauge should increase and pilot light should go out.
6. Exercise the valve by alternating clockwise and counterclockwise turns a few times to ensure that the handwheel turns freely. This action also ensures proper valve operation.
7. Reduce pressure and reset the control valve to its normal operational setting.

Pressure Governors

Pressure governors control the discharge pressure of the fire pump by automatically adjusting the speed of the apparatus motor. Since a pressure governor has control of throttle, it is possible to compensate for both decreases and increases in pressure. Pressure governors may be found on MCFRS Freightliner and LFRD Engines. There are two types of pressure governors – stored pressure and electronic.

Stored pressure - Balancing cylinder compares reference pressure with pump pressure and adjusts engine speed to maintain operating pressure. This was the original type of governor and is not commonly found on newer apparatus.



***Electronic* –** Electronic governors allow the operator to select whether to control the discharge pressure or motor RPM. In most operations it is more desirable to monitor and control the discharge pressure, however RPM mode may be used during drafting operations when a consistent RPM is desired. Most governors allow the operator to switch back and forth between pressure and RPM mode without shutting down the operation.

When operating in “pressure mode”, the governor receives a signal from a pressure transducer mounted on the discharge side of the pump. As the transducer senses a change in pressure, the pressure governor sends a signal to the engine ECU to increase or decrease engine speed to maintain the desired discharge pressure.

Many electronic governors have built-in safety features to reduce engine speed if faults are detected that may cause damage to the pump or apparatus. One such feature detects pump cavitation and automatically reduces throttle until the operator can balance the supply with the discharge.

While all electronic governors function essentially the same, there are a variety of manufacturers with a variety of user interface and display options, so personnel need to reference the operating instructions for specific guidance on their apparatus.

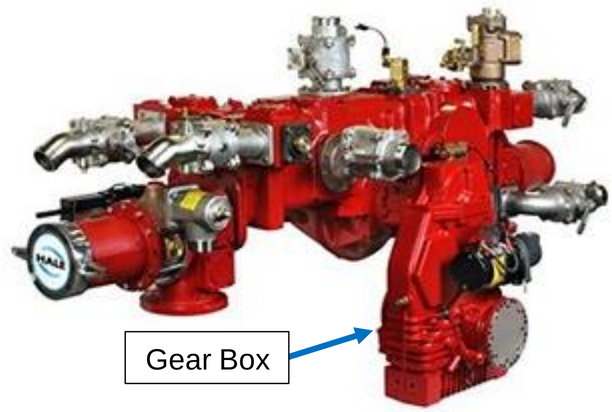
Governor Control Panel Examples

Pump Rating

Each fire apparatus pump receives rating from Underwriter’s Laboratories. The pump's flow capacity is listed on the specifications plate mounted on the pump panel. The flow is listed in relation to pressure and is verified by annual pump tests. A typical fire apparatus pump is rated to flow its full capacity at 150 PSI. It will flow 75 percent of its capacity at 200 PSI and 50 percent at 250 PSI. A pump's actual capacity depends on the size of its impellers and waterways. Typically, pumps are capable of flowing more water than their data plate indicates. The QMax Pump tested at the Hale factory to 18% over 2250 GPM, capable of 2655 GPM from draft (with the use of multiple intakes).

HALE QMAX Pump Components

Pump Gearbox

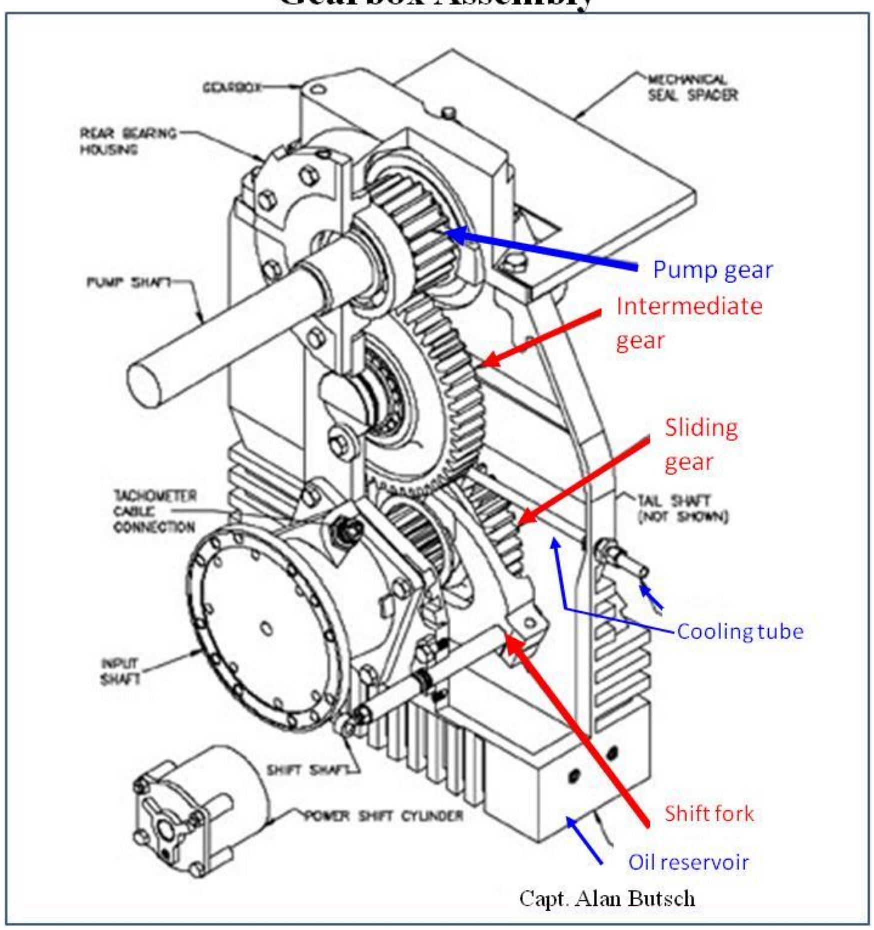


The gearbox is where the power of the vehicle's drive shaft is transferred to the pump. The MCFRS Crimson Engines utilize a Hale G-Style Gearbox while the 2018 Pierce Enforcer Engines utilize a Hale K-Style Gearbox. Both are a split shaft, mid-ship drive design capable of withstanding 16,000 and 18,500 lb/ft of torque respectively. The cooling line uses pump water from discharge side of pump and sends it back to intake. Oil is circulated through the gear box only when the sliding gear is engaged, i.e. the shift selector in the cab is in "pump" and not "road". Any time water moving through the pump could spin the impeller, wear on the pump shaft bearings and seals is reduced by placing the selector in "pump". Of particular concern are backflushing and filling WMATA below-grade standpipe systems where the impeller may spin, however the pump is not necessarily engaged.

The gearbox oil should be check daily to make sure it is filled to plug level with 4-6 qts of 90W Gear Oil. The gearbox is comprised of three heat-treated nickel steel gears:

1. Sliding Gear,
2. Intermediate Gear, and
3. Pump Gear.

Gearbox Assembly



Pump Shift Assembly

The Pump Shift Assembly controls the transfer of chassis transmission power from the drive axle to the pump gear box. Apparatus with a mid-ship pump have a split shaft, meaning that the driveline/shaft is split into two parts. The front part goes from the transmission to a gear box to drive or turn the pump, then from the gear box to the rear differential on the drive axle.

When the apparatus is in "road" mode, the drive shaft spins through the gear box to the rear drive shaft with the pump gears disengaged. When in "pump" mode, power to the rear drive shaft is disengaged via a shift collar within the gear box that engages the pump gears. This shift collar, or shift fork, is controlled by chassis air. It is imperative that pump shifts occur with the transmission selector in Neutral or damage to the pump gears or drive shaft may occur.

The Pump Shift Assembly is located in the cab within reach of the driver. It is a three-position black handle with a yellow safety collar. The three positions are:

- Road
- Neutral; and
- Pump

Placing Pump in Gear:

1. Place engine transmission in 'Neutral', set the parking brake, and allow the engine RPM to reach idle speed.
2. Move Pump Shift Assembly control into 'Neutral' position and pause.
3. Move Pump Shift Assembly control into 'Pump' position.
4. Place engine transmission into designated pumping gear. Most apparatus use 'Drive'.
5. Look and listen for indications that the pump is in gear.
6. Dismount the apparatus and proceed with pumping operations.

Indications that Pump Is in Gear:

- OK to Pump and Pump Engaged indicators are lit
  - Located in the cab by the Pump Shift Assembly
  - Located on the main pump panel
- Speedometer may change from 0 mph to 10-15mph (apparatus dependent)
- Depressing the accelerator pedal slightly results in no RPM change or no lurching of the apparatus (apparatus dependent)
- Motor changes sound
- Drive shaft is rotating between the transmission and pump gear box
- Positive pressure indication on discharge gauge

Operators need to become familiar with how their apparatus reacts when successfully placed into pump mode. The operator must know the sights and sounds for those times when light bulbs burn out or don't work.

For a video of the internal mechanisms of a pump shift, go to https://www.youtube.com/watch?v=4E_NNJHzj-w

Pump Impeller Assembly

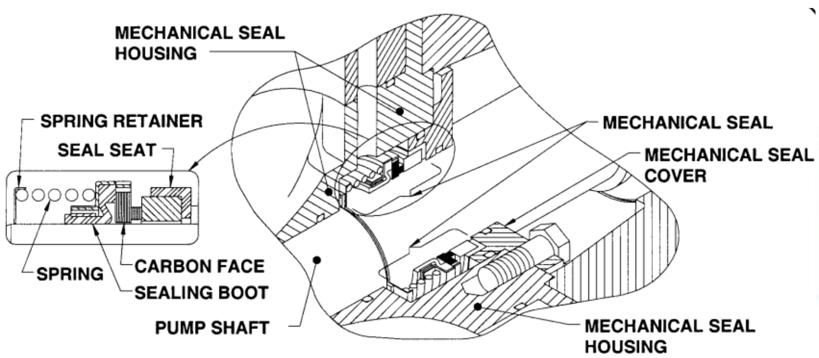
The primary elements of the Pump Impeller Assembly are:

- Pump Shaft
- Impeller
- Sleeve Bearing
- Pump Seal
- Clearance Rings
- AutoLube Assembly

Mechanical Pump Seal

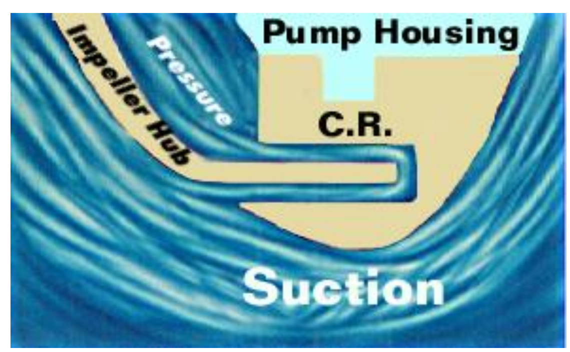
This replaces the traditional Pump Packing. This seal prevents water from leaking where the pump shaft enters the pump casing at the rear of the pump.

- Rubber seal rotates against carbon face
- Replaces packing
- Unlike packing it is not supposed to leak
- Heat sensitive
- Do NOT run pump dry! There are a lot of temperature sensitive elements within the HALE QMAX pump. Remember to always circulate water.



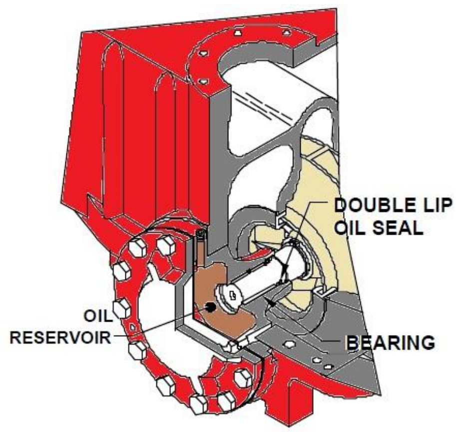
Clearance Rings

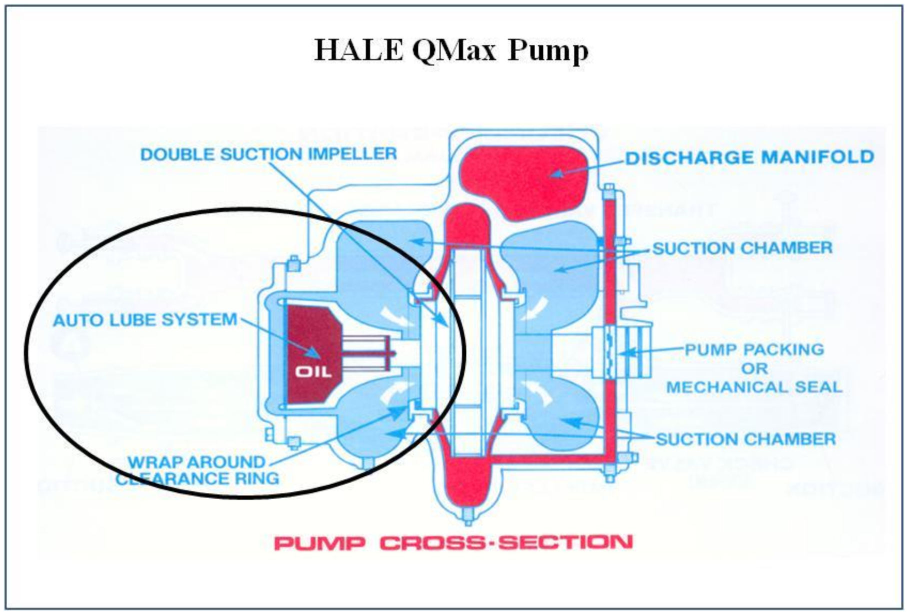
The Clearance Rings prevent water from circulating from the discharge side of the impeller back to the suction side. The clearance rings are brass and provide an extremely tight tolerance (~7/1000ths of an inch). This is another component that will be damaged by running the pump dry, pump overheating, or pumping sand (while drafting). Damage decreases pump capacity.



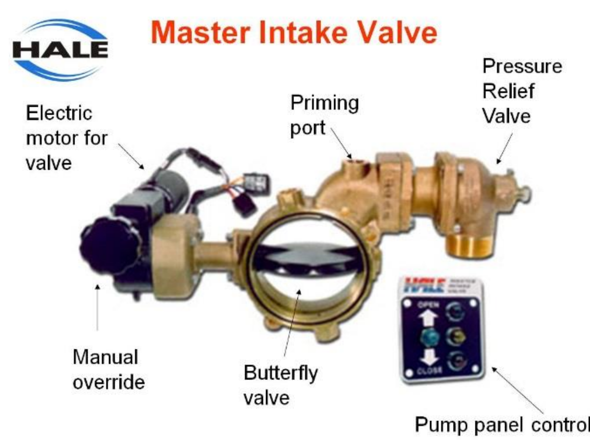
AutoLube Assembly

The AutoLube Assembly provides for continuous oil flow through the sleeve bearing on the front side of the pump where the pump shaft enters. This system eliminates the need for a second mechanical or packing seal. A rubber-based membrane separates oil and water. The system is designed to maintain oil pressure slightly above the water pressure in the pump housing, therefore helping keep out water and dirt. The system uses the same 90W gear oil as the gear box, however the fluid level is included in annual pump maintenance checks and not subject to daily preventive maintenance checks.





Master Intake Valve - Electric (MIV-E)



- Located behind the pump panel, 6” inlet butterfly valve
- Designed for use from either draft or a pressurized source.
- Designed to flow 1500 GPM through a single 6” connection from draft.
- Outboard Pressure Relief Valve
    - MCFRS Crimson – 150 PSI
    - MCFRS Pierce - 125 PSI
- 3/4” Air Bleeder port
- Outboard 3/4” Auxiliary Priming Port
- NFPA 1901 requires
    - LDH valves to close no faster than 3 seconds
    - Intakes >3” to have automatic relief valves
- Monthly - lubricate edges of nitrile-coated disk and rotate through operating range.

Large Diameter Discharges

Large diameter discharges are controlled by electrically operated ball valves to regulate the speed of the opening and closing.

Crimson engines have integrated sensors on the LDH discharges that display both flow and pressure located:

- Officers Front Discharge – rated to 2400 GPM
- Officers Rear Discharge – rated to 1500 GPM

MCFRS Crimson engines are equipped with outboard relief valves on large diameter outlets set at 185 PSI. The 2018 Pierce Enforcer engines rely upon the TPM for this function.

Hale Thermal Relief Valve (TRV-120L)

The Hale Thermal Relief Valve is a paraffin based thermostat set at 120 degrees F. When pump water exceeds this temperature valve opens and dumps water on ground. This should bring new, cooler water into pump. A pump panel light illuminates and a buzzer sounds when this relief valve operates. Always circulate water to keep pump from overheating.

Air Operated Tank-to-Pump Override

Crimson CAFS Engines are equipped with an air operated tank to pump valve. The valve automatically opens when the pump goes into gear. If the valve fails, it will fail in the open position. The tank-to-pump valve will only close if the operator pushes the “close” button.

The default to have the valve open is due to the desire to operate from tank water while using the CAFS system. The pump also provides cooling water for the gear box and the CAFS air compressor, therefore it is essential that the pump is *never* run without water in it.

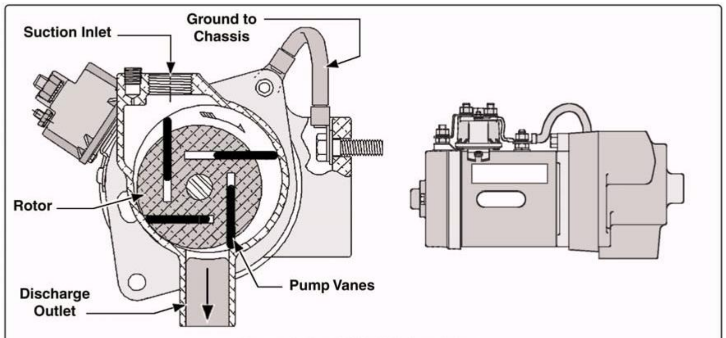
It is normal to close this valve if you choose to perform plain water pumping from a pressurized or draft source with the CAFS turned off.

Tank-to-Pump Valve

Non-CAFS Engines have manual tank-to-pump valves. These valves are installed with a “reverse linkage” so that the “open” position leaves the valve handle “in”. This allows the valve to normally be left in the open position without having the control handle extending from the pump panel.

Priming Systems

Rotary Vane Mechanical Primer



Rotary Vane ESP Priming Pump

Prior to the development of air primers, the standard mechanical primer on MCFRS engines was the Hale Environmentally Safe Primer (ESP). It is a 12 VDC electric motor driven rotary vane primer. The design requires no separate lubricating oil, therefore has no oil reservoir. The vanes are constructed of carbon material.

Avoid operating the primer continuously for longer than 45 seconds to avoid overheating.

During daily pump checkout, the primer needs to be engaged until water discharges on the ground. This ensures any debris created the vanes "scraping" against the inside of priming pump is cleared out of the pump.

4-Way Priming Valve

Units equipped with the ESP have a 4-way Priming Valve. This valve enables you to prime the main pump, or just outboard of the MIVs. An operator can be flowing tank water while setting up for drafting, and then achieve prime in hard sleeves without interrupting operations. This 4-way valve can establish draft out of one intake, and then set up and use another if wishing to achieve high flows or utilize multiple folding tanks.

This valve can prime the following intakes, independently:

- Pump
- Drivers MIV
- Officers MIV
- Rear MIV

The Drivers MIV, Officers MIV, and Rear MIV are plumbed to MIV priming ports which are outboard of the MIV butterfly valve. This valve allows you to achieve a prime all the way to the MIV. Remember to pull the primer as you open the MIV to avoid an air bubble.

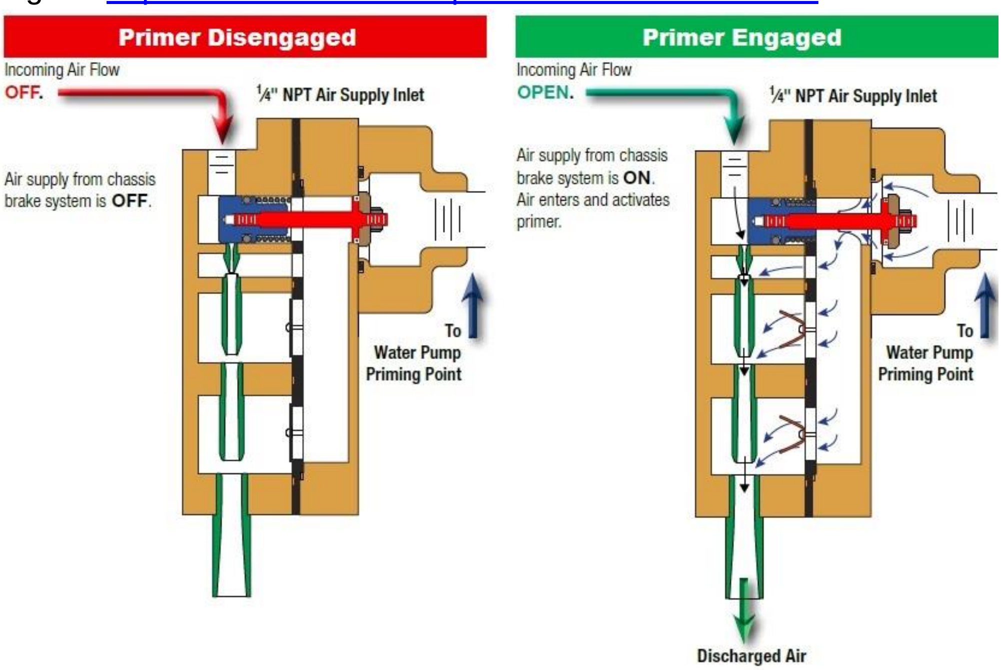
Trident Air Operated Primer

The widespread use of air operated priming devices began in Montgomery County with the arrival of the 2018 Freightliner Tankers and 2018 Pierce Engines. Prior to these apparatus the rotary vane electric powered primer was standard and may continue to be found on pumping apparatus in the County.

The Trident Air Primer has the following features:

- Uses chassis air supply from engine driven air compressor
    - No electric motor, solenoid valve, or heavy battery cables
    - Electric rotary vane primer = 300 amp draw on chassis electrical system
    - Auto AirPrime = 0.4 amp draw
- Design allows continuous primer operation – no motor or mechanical components to overheat
- Vertical lift capability to >27'
- Faster than an electric primer with lifts under 15'
- 4' lift from Folding Tank in less than 10 seconds with engine at idle speed
- All brass and stainless steel construction for durability
- Vacuum produced by venturi action within primer body
- Primer features automatic draining, No freezing
- Air only primer control lines (no water piping to pump panel – avoids freezing)
- No moving parts to create vacuum
- No maintenance required by station personnel
- Quieter operation than traditional rotary vane primers
- May be factory installed or retrofitted onto existing pumping apparatus equipped with air brake systems

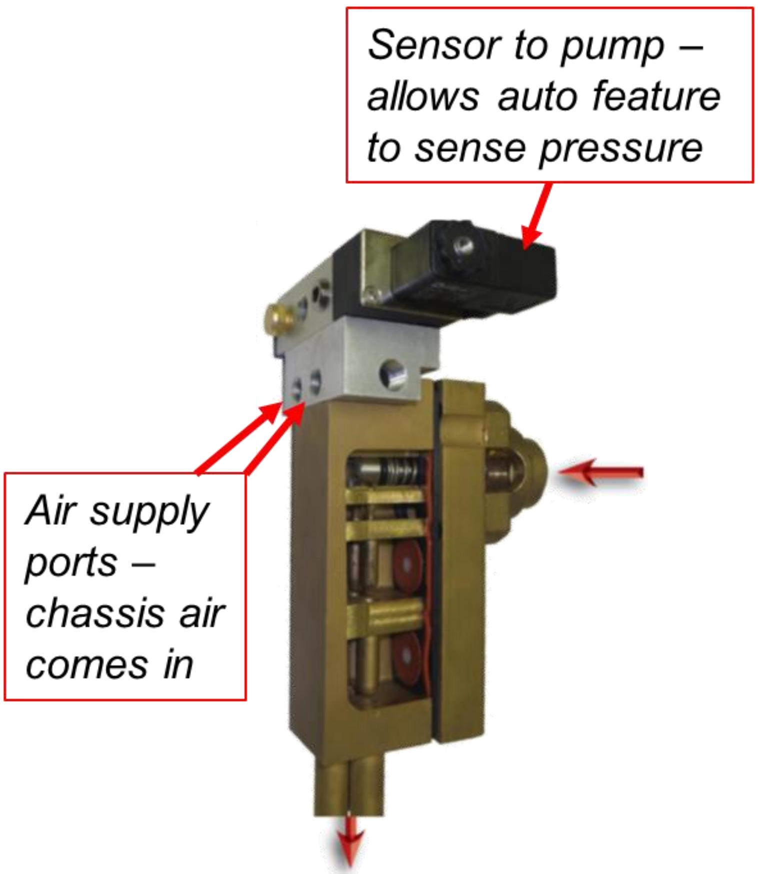
The uses chassis air to create a venturi action inside the primer body. For an animated demonstration go to http://www.tridentautoairprime.com/animation.html.



There are two types of air primer systems available; automatic and manual. The operating principles and priming equipment are nearly identical with the exception of the operator interface to engage the primer and a solenoid for monitoring pump pressure. Automatic systems may be augmented by outboard manual primers on individual intakes.

Controller - Automatic

Controller - Manual System



Primer Body - Automatic and Combination

Primer Body - Manual System

Automatic and Combination Systems

The automatic system monitors the discharge pressure near the pump impeller and automatically engages the main pump primer when conditions indicate a loss of prime. The automatic system evacuates air from the main pump housing. A combination system includes an automatic system on the main pump and manual priming mechanisms on individual intakes. The primers on the individual intakes are located on the outboard side of the intake valve, so the intake may be primed prior to opening. The presence of individual intake primers replaces the 4-way priming selector that was present on the Crimson engines.

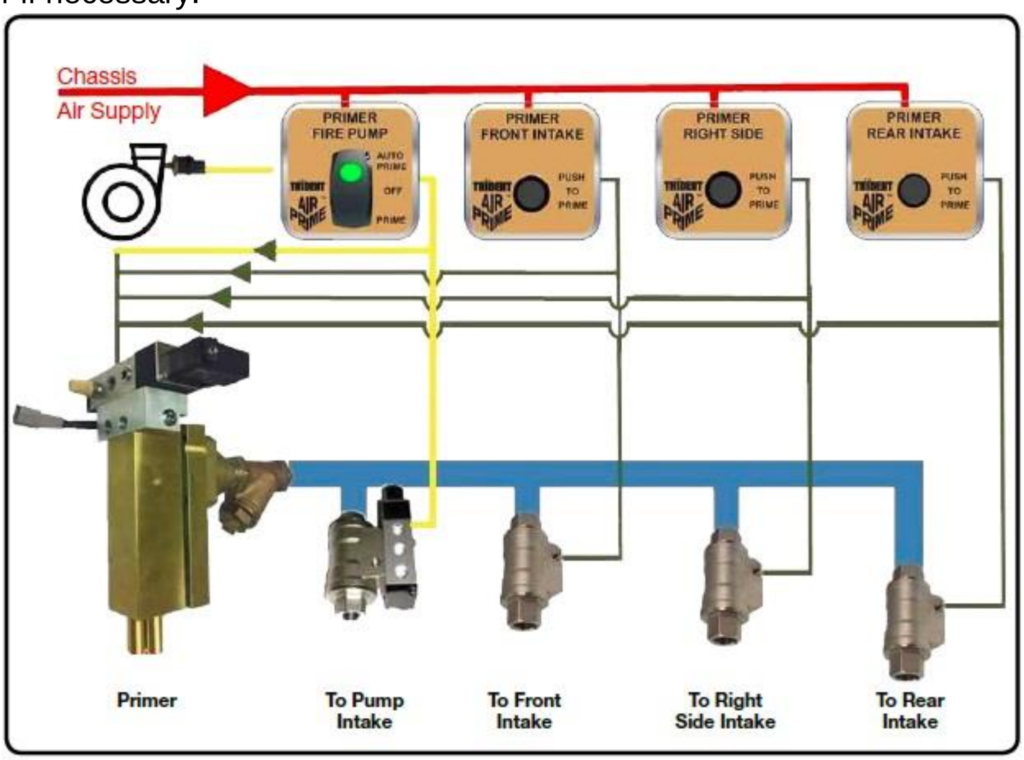
There are three conditions that must be met for the auto primer to engage:

1. The pump is in gear and the OK to PUMP light is illuminated
2. The auto primer control button is in the “AUTO PRIME” position and the light is illuminated
3. The pump discharge pressure in the main pump body drops below 20psi

Any time these three conditions exist simultaneously the air primer on the main pump will engage. This includes initial pump priming tasks or incidental loss of prime during pumping operations due to an air slug, rapid opening of a discharge, or switching from tank water to another source.

The automatic primer can also be operated manually by pressing the control button downward to the “PRIME” position. This is a momentary switch that only engages the main pump primer while depressed. This is useful for periodic operational checkouts and operates whether the pump is engaged or not.

In a combination system the manual intake primers and automatic main pump primer all utilize a single primer body. The individual intake primers may be engaged simultaneously with the main pump primer if necessary.



Manual Systems

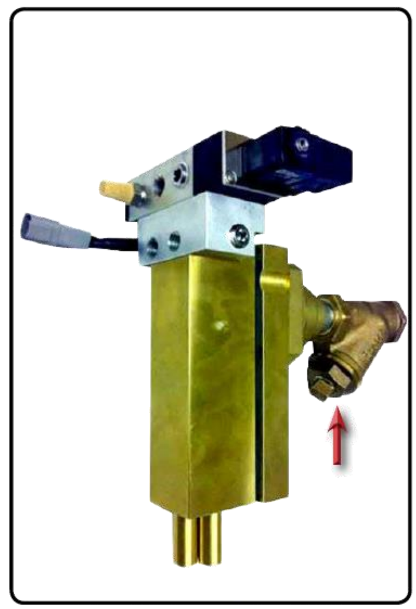
Manual systems may be used on the main pump as well as individual intakes as previously described. The manual system requires the operator to physically engage the primer much like traditional rotary vane primers. Instead of a pull handle, the air primer has a push button controller to operate the primer. The operator simply depresses the desired primer button to engage the primer and releases the button to disengage the primer. Unlike traditional mechanical primers, there is no time limitation when engaging the air primer.

Maintenance and Troubleshooting

All of the customary troubleshooting options for drafting apply when using an air primer, i.e. leaking couplings, minimizing vertical lift, closing pump drains, etc. The air primer offers the advantage of overcoming imperfect drafting setups more readily than traditional rotary vane primers due to its unlimited engagement time. Theoretically the air primer can overcome more air trapped or infiltrating the drafting setup.

There is no routine maintenance intervention required by station personnel for the air primer. There are no fluids or moving parts to lubricate. The primer operation should be checked as part of routine pump inspections. The primer body has an integral strainer to reduce the potential for debris entering the primer body and obstructing the air inlets. If priming performance seems to be reduced or impaired the strainer should be checked for debris.

Separate and Cleanable Wye Strainer



Integral Strainer on Primer Intake Shown With Red Arrow Above

Additional Resources

Troubleshooting Guide

- http://www.tridentautoairprime.com/troubleshooting.html

Trident Website

- http://www.tridentautoairprime.com/

CAFS Engines - Plain Water Operations Step by Step

CAFSPro Air Injection Control

FoamLogix Concentrate Injection Control

1. Put Engine in Pump Gear. Pump components default for CAFS operations.
2. Disengage the CAFS by pressing the "Power" buttons on the FoamLogix and CAFSPro Controllers. This turns off the foam pump and air compressor. The pump is now in Plain Water mode.
3. Conduct desired activities for attack or water supply relay without further interaction or need to monitor the CAFS components.

During plain water operations:

- supply lines may be connected to any intake
- Autofill may be used, however is not necessary for the operation
- any discharge may be used for attack or water supply
- engine RPM may be set within any range with the sole function of maintaining desired pump discharge pressure
- tank-to-pump may be closed if desired; the valve defaults to open

For guidance on Class A, Class B, and CAFS operations see Module 5.