

***HALE***

# Priming Midship Fire Pumps — *Questions and Answers*

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Consider the consequences of a priming system malfunction or failure during a drafting procedure at a working structure fire. A delay in delivering water, or no water delivery at all, is likely to lead to catastrophic structure damage and may compromise firefighter safety. Not a pleasant picture. And a few conditions considered “minor” — like loose pump shaft packing, a bad suction hose connection and lack of lubricant in the primer oil reservoir — when combined, can cause priming system failure.

Fire pump accessories might not be glamorous, but priming systems are critical to pump drafting performance. Pulling a prime quickly is key to fast water delivery, a basic fireground necessity. In this article we will give priming systems the much needed attention they deserve. We will review how they work, the theory behind priming centrifugal pumps, the procedures used to prime a fire pump and recent advances in priming system technology. Our discussion will focus on priming midship mounted fire pumps. However, the principles apply to all centrifugal pumps — including front mount, rear mount, auxiliary engine and Power Take Off driven.

***Question: Why is a priming system needed on a centrifugal fire pump?***

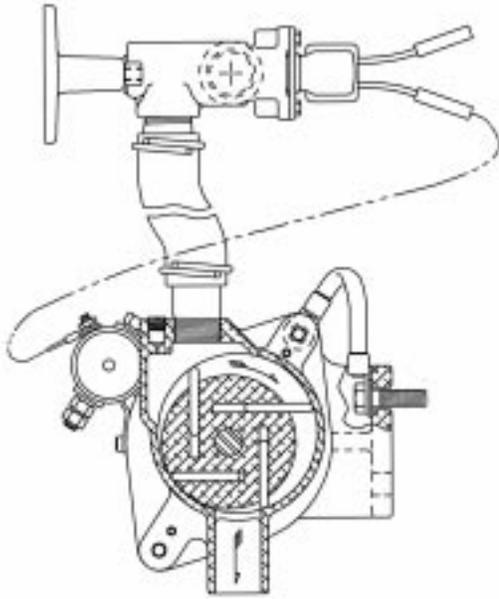
A centrifugal, midship-mounted fire pump on a fire

department engine must be primed before it will operate. Primed means fully water flooded and all the air inside the pump casing preferably removed.

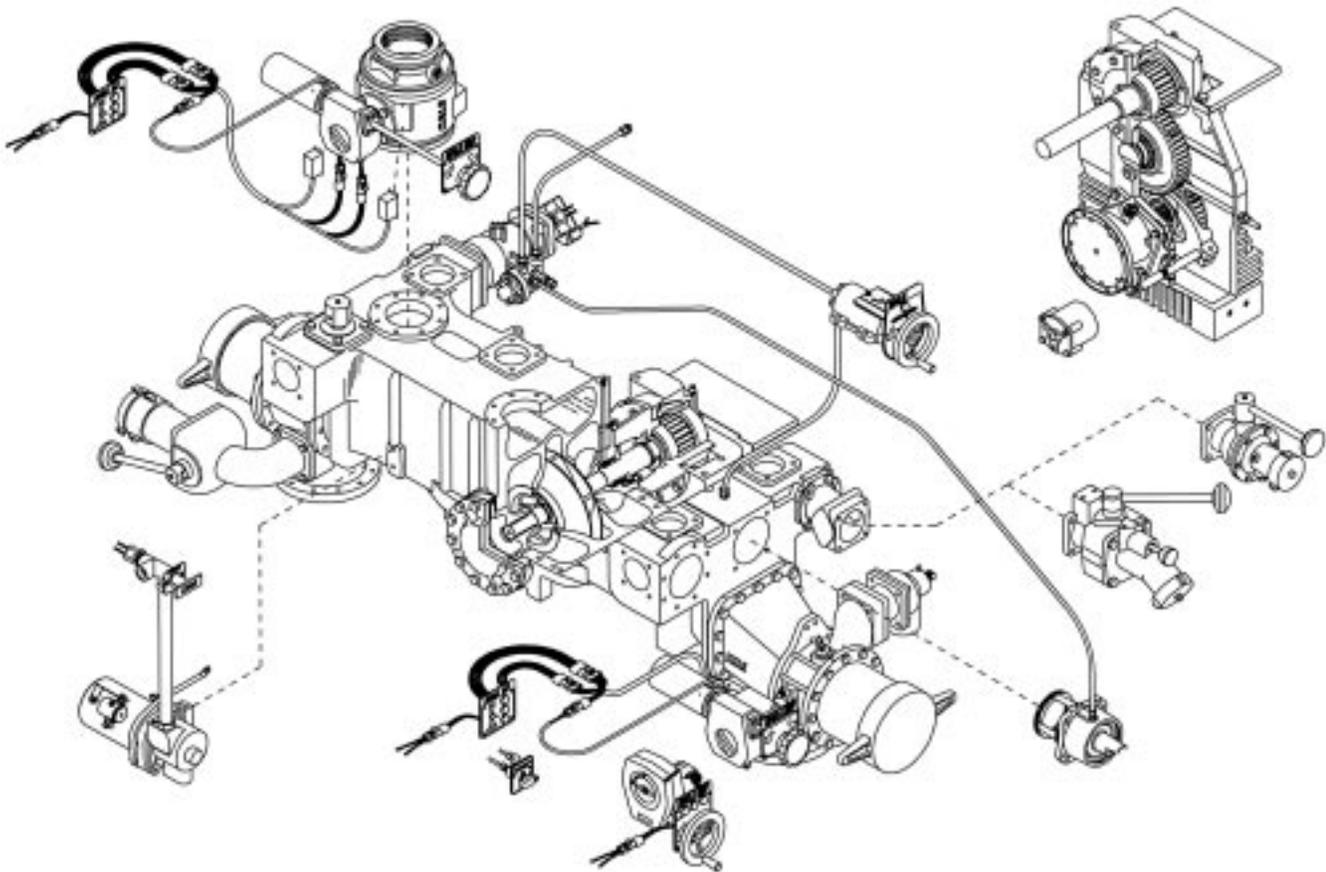
An operating midship pump filled with water is self-sustaining in that it creates quite a high vacuum at the eye of the impeller. This provides a continuous intake of water when drafting from a static supply source. However, when water is drained and the pump is filled with air, the centrifugal pump impeller is a very poor vacuum pump. This presents a problem when trying to draft from a static source where the physical level of the water supply is lower than the pump itself, such as when operating from a portable tank or pond. Operating an air filled midship pump fails to produce enough vacuum required to provide lift, which is needed for the fire pump to flood itself when the pump is above the supply source. Under most drafting conditions, operating an air filled pump will not initiate a prime and it therefore requires the aid of an external priming system.

***Question: What are the main hardware components found in a priming system?***

A priming system’s main components normally consist of: 1) a priming valve, 2) an electrically operated positive displacement vacuum pump powered by the truck’s



**Figure 1:** A cross section view of a Hale Model SMP priming pump, with a PVG manually operated panel-mount priming valve. Notice the four sliding vanes in the rotor of this rotary-vane vacuum pump.



**Figure 2:** An exploded, cut-away view of a single-stage Hale Midship Muscle Pump. Notice the internal pump-casing waterway paths on the suction and discharge sides of the impeller. Activating the vacuum priming pump evacuates air inside causing a low-pressure area. Atmospheric pressure pushing on the static water source then provides the force to move water into the pump through hard sleeve suction hose.

electrical system and, 3) a primer lubricating oil reservoir. (Various manufacturers recommend different types of lubricants). The vacuum pump and oil reservoir are typically located inside the apparatus pump house. The design of the vacuum-priming pump is usually a rotary-vane or rotary-gear pump type.

The latest technology available today is a new priming pump that totally eliminates the need for lubricant — it is “oil-less” — a rotary-vane vacuum pump that runs dry with no lubrication required. We’ll discuss this device in more detail at the end of this article.

***Question: How does a priming system work?***

An electric vacuum priming pump is a positive displacement air pump. Activating the vacuum primer removes air from inside the suction and discharge casings of the fire pump. Removing air lowers the pressure inside the pump casing below atmospheric pressure. It is atmospheric pressure — 14.7 pounds per square inch absolute (psia) at sea level — pushing on the static supply source that ultimately provides the force to move water into the hard sleeve suction hose and up to the eye of the impeller. This activity happens simply because of pressures trying to reach equilibrium — the higher pressure exerted by the atmosphere on the static water supply moves water toward the low pressure area inside the fire pump casing. Once the fire pump is flooded (primed) and then discharging water, it creates its own vacuum at the impeller eye to carry on this low-pressure area for continuous operation.

***Question: After arriving at a fire scene and engaging the fire pump from inside the cab, how long can I wait before priming a dry fire pump?***

As a rule of thumb, midship pumps should be primed immediately after being engaged (run). This is to prevent serious damage that can occur from running the pump dry (drained of water) for an extended time period. (Check with your fire pump manufacturer for pump-brand specific recommendations).

Damaging a pump by running it dry for an extended period can happen after positioning an engine for a drafting operation at a pond and engaging the pump. If problems

ensue, it may take minutes to remove the pump suction cap and connect and tighten lengths of hard suction hose from the supply source. In a situation like this, you are better off assembling your suction connections first, priming the pump second and engaging the midship pump third.

Damaging the fire pump by running it dry for an extended period means that the apparatus must be taken out of service for a potential costly repair.

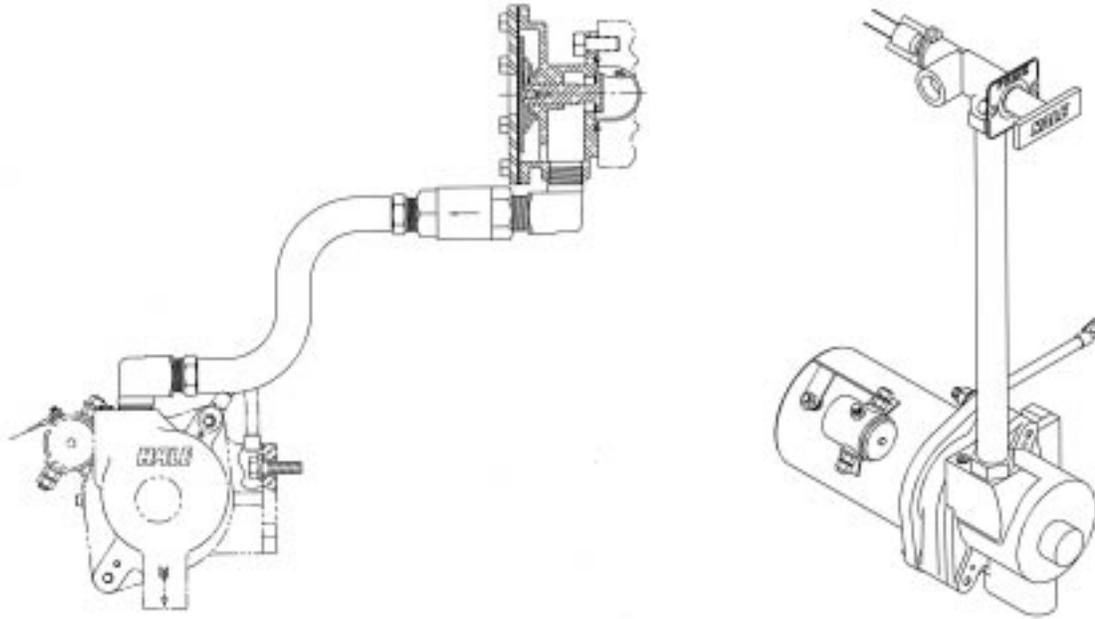
**Caution!** Always chock the rear wheels immediately after setting the parking brake!

***Question: After activating a vacuum priming system, how do I know when the fire pump has achieved a “prime,” so I can turn off the vacuum primer?***

Assuming a good suction hose connection from the static water supply source to the pump inlet and a “tight” pump (no air leaks) after primer activation, you should see a small amount of primer lubricant being discharged onto the ground from the vacuum primer outlet. This changes to a steady lubricant/water mixture after the pump achieves a prime. As an audible verification of pump prime, you may be able to hear a noticeable difference in the sound of the primer as soon as it starts discharging the lubricant/water mixture. Always verify a fire pump prime by checking the pressure readings on the master-discharge gauge. If the pressure readings vary with corresponding increases in pump rpm speed, the pump is indeed primed.

If you have to operate a vacuum primer for an extended time period to get a pump primed, you have problems either with the primer itself, or with air leaks into the pump (we’ll talk more about these later).

Do not continuously run the primer for more than 45 seconds because the electric primer motor amperage draw may cause it to become too hot if run for an extended time without a cool-down period, causing damage. (Check with the primer manufacturer for their recommended maximum activation time and cool-down period).



**Figures 3 and 4:** A Hale SMP priming pump connected to a PVG manually operated panel-mount valve (located right) and a semi-automatic priming valve (SPV), located left. With an SPV, the pump operator uses a push-button panel-mount priming switch to activate the primer motor. The SPV (bolted directly to the midship pump) is a “priming valve” that automatically opens and closes, as needed, dependent upon pressure inside the pump and vacuum conditions produce by the primer.

**Question: Every time a fire pump is placed in service, is priming system activation required?**

In many instances activating the electric vacuum primer is not required at all if the pump is “wet” (water filled).

If the pump is “dry” (drained) and you are working from a booster tank or pressurized hydrant water supply, you can purge the air out of the pump without activating the primer by using incoming water pressure.

For example, most midship pump equipped engines carry an on-board water supply in a booster tank. Booster tanks generally hold from 500 to 1000 gallons of water. Since the water level in a full booster tank is at a higher level (elevation) than the pump, it naturally exerts force called head pressure — on the pump, after opening the tank-to-pump valve.

The slight pressure of incoming booster tank water is enough to expel air inside the pump if the air is bled off by momentarily cracking open a discharge valve or the booster-tank fill valve. Therefore, if we start operation with

a “dry” pump (the pump was previously drained) and proceed to open the tank-to-pump valve, the slightly pressurized incoming water from the booster tank fills the pump casing and “primes” the pump.

The slight head pressure exerted by the column of water in the booster tank forces water into the pump without the need to manually activate the electric vacuum pump priming system. This same procedure will work when the fire pump is connected to a hydrant fed by a city water supply — only the hydrant has much more pressure to do the job.

**Caution:** When using large diameter hose (LDH) always open a bleeder valve on the hydrant side of the fire pump inlet valve/supply hose connection prior to opening the hydrant, so trapped air can escape from the supply hose!

**Question: We sometimes encounter problems when setting up a fire pump drafting operation — such as not being able to achieve a pump prime. What causes lack of prime?**

One situation where a no prime will always occur is where

the pump lift (the elevation between the pump inlet and the top of the static water source) is too high. For example if the maximum capability of your priming system is 24 in. Hg., the maximum water lift capability (at sea level) is 27.2 ft.

Besides remembering maximum static lift limitations, keep in mind that when operating a fire pump at lifts over 10 ft. and up to as many feet high as maximum vacuum primer lift capacity — maximum fire pump gpm capacity may be significantly reduced. To explain, your vehicle mounted NFPA 1901, *Standard for Automotive Fire Apparatus, 1996 Edition*, compliant pump is rated at a 10 ft. lift. Pumps 2000 gpm and over are rated at a 6 ft. lift. Therefore using lifts greater than 10 feet, but less than the maximum primer lift, inherently reduce the fire pump’s maximum gpm rated capacity while increasing risk of cavitation and vacuum leaks due to the higher vacuum required. When drafting, another factor in reduced pump capacity is suction hose friction loss. As you add extra lengths to the suction hose assembly for deep lifts or for hard to get at water sources, friction loss increases, which also reduces pump performance.

“Watch them mountains.” Due to lower atmospheric pressure, pump lift capability and gpm performance naturally reduce as geographic elevation increases.

### Priming System Integrity

After excessive lift is eliminated as a “no prime” problem, a recurring no prime condition can occur due to a variety of reasons. To weed out problems a good place to start is in the maintenance shop, checking the integrity of the priming system.

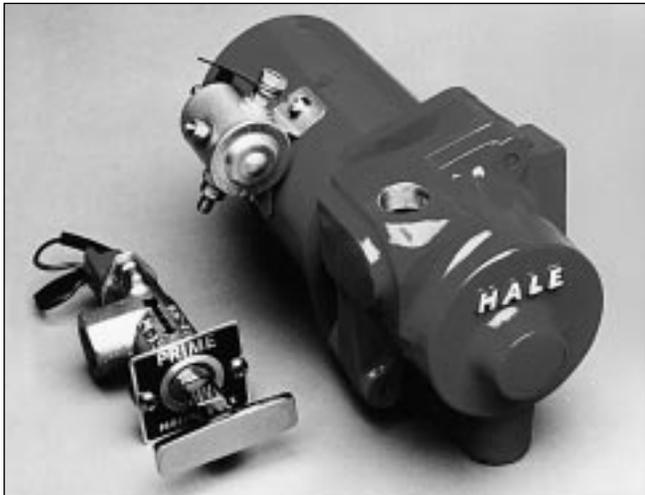
First, perform cursory checks to see if: 1) there is lubricating oil in the primer reservoir (If the primer is using an excessive amount of lubrication, check to see if the vent hole in the oil line that functions to prevent a siphon is blocked), 2) the priming valve is working correctly and 3) the power and electrical connections to the electric primer motor are sound. Now go beyond that and see what gauge wire is connected to the primer motor/solenoid. How long is the power cable? Is the wire gauge sufficient for its total length in feet versus its amp carrying capacity? (Check with the primer manufacturer for wire-gauge/amp draw/total

Inches of Mercury (In. Hg.)	Pressure		Feet of Water
	psig	psia	
0	0	14.700	0
1	-0.492	14.208	1.133
2	-0.984	13.716	2.266
3	-1.476	13.224	3.399
4	-1.968	12.732	4.532
5	-2.460	12.240	5.665
6	-2.952	11.748	6.798
7	-3.444	11.256	7.931
8	-3.936	10.764	9.064
9	-4.428	10.272	10.197
10	-4.920	9.780	11.330
11	-5.412	9.288	12.463
12	-5.904	8.796	13.596
13	-6.396	8.304	14.729
14	-6.888	7.812	15.862
15	-7.320	7.320	16.995
16	-7.872	6.828	18.128
17	-8.346	6.336	19.261
18	-8.856	5.844	20.394
19	-9.348	5.352	21.527
20	-9.840	4.860	22.660
21	-10.332	4.368	23.793
22	-10.824	3.876	24.924
23	-11.316	3.384	26.059
24	-11.808	2.892	27.192
25	-12.300	2.400	27.192
26	-12.792	1.908	29.450
27	-13.284	1.416	30.591
28	-13.776	0.924	31.724
29	-14.268	0.432	32.857
29.89	-14.700	0	33.865

**Figure 5:** A vacuum/lift table

length requirements). Does the primer motor have a good ground connection? A primer needs a good electrical supply and a properly sized electrical connection to work correctly and keep on working over time.

In addition to the above items, one reason for not being able to prime the pump is a damaged electric vacuum primer that does not turn, or if turning, is worn and not able to “pull” the required amount of vacuum.



**Figure 6:** A Hale PVG priming valve and Environmentally Safe Primer (ESP) pump. The ESP runs dry — no lubricant is required. This eliminates the fire department priming system lubrication service requirements over the life cycle of the apparatus (as compared to installing a lubricated primer.)

## Vacuum Primer Test

To test for a worn or damaged primer in the maintenance shop, isolate the primer by disconnecting the vacuum primer/fire pump tubing connection at the vacuum priming pump. Connect a manometer or master vacuum gauge to the primer. Activate the primer and see how deep a vacuum it will pull.

NFPA 1901 contains guidelines to be used during a vacuum primer test:

The maximum vacuum attained shall be at least 22 in. Hg..

See how the vacuum reading stacks up against both NFPA minimum requirements and the primer's original vacuum specification available from the manufacturer. Repair or replace the priming pump as required.

If a no prime condition still persists when drafting from a static water source, air leaks into the fire pump are the likely culprit. Here are some common reasons for air leaks into the fire pump:

- The pump operator left pump discharge, suction, or drain valve(s) in the “open” position
- Fire pump suction cap(s) are loose or have bad gasket(s)
- The pump's discharge and suction valves — even in the fully “closed” position — leak
- The pump's external relief valve(s) may be damaged and leak
- The pump casing, flanges and discharge or suction manifold piping have pinholes, the pump shaft seal leaks, the pump shaft packing needs adjustment, or a gasket is defective
- Hard sleeve suction hose has pinholes, has bad gaskets at connections, couplings leak, or connections are loose

## Pump, Manifold, and Suction Hose Assembly Vacuum Test

Once the above causes of air leaks are checked and any obvious deficiencies are corrected, it is a good idea to run a “vacuum test” on the entire pump and suction assembly.

To do this:

- 1) Fully charge the truck batteries.
- 2) Drain the pump and close the tank-to-pump valve.
- 3) Install the suction hose you normally use on the intake of the fire pump.
- 4) Cap the end of the suction hose.
- 5) Remove all caps from the fire pump's discharge valves (keep the discharge valves in the “closed” position).
- 6) Open all pump suction valves and cap every pump intake opening.
- 7) Check and clean out the test gauge connector line.
- 8) Connect a manometer to the test gauge connector line.
- 9) Run the primer until the vacuum reading is 22 in. Hg. (or greater, as stated by the primer manufacturer's original specifications).
- 10) Over the next five minutes watch the manometer to see if or how far the reading drops.

NFPA 1901 contains the following guidelines for a vacuum test:

The vacuum shall not drop more than 10 in. Hg. in 5 minutes. The primer shall not be used after the 5-minute test period has begun....

If the vacuum drops faster than 10 in. Hg. in 5 minutes, look for and correct any additional air leaks.

(Note: Even though you may meet the NFPA minimum leakage requirement, a small air leak in the wrong spot will reduce pump performance. Preferably, your performance should exceed the minimum set by NFPA. In reality, this 10 in. Hg. in 5 minutes was allotted for pump shaft packing adjustment and not for plumbing or valve leaks! If a mechanical seal is installed on your pump, the vacuum drop over a 5-minute period should be insignificant).

During the test, major air leaks normally cause a hissing sound and can be located just by listening for them. A leak in a discharge valve can be located by placing the palm of your hand over the discharge outlet for about half a minute. If there is a vacuum leak, suction can be felt on your hand. (Do not open the valve while your hand is on it — serious injury can occur!). If you believe you have several small air leaks in the suction hose assembly after the vacuum test, you can use water to pressurize the suction hose and fittings and check for leaks — but, be careful not to exceed the maximum pressure recommended by the suction hose manufacturer! Vacuum testing the suction hose alone is also good idea because some pinholes in the hose may self-seal under pressure.

### Priming Time Test

Now that you have repaired all the air leaks and the vacuum test proves satisfactory, it's time to drop the suction hose in a static water supply source for a priming time test. NFPA 1901 recommends:

The time required to prime the pump if the rated capacity is 1250 gpm or less shall not exceed 30 seconds. If the rated capacity is 1500 gpm or more, the time to prime the pump shall not exceed 45 seconds. An additional 15 seconds shall be permitted to meet these requirements when the pump system includes an auxiliary 4 in. or larger intake pipe....



**Figure 7:** Various suction hose and suction hose accessories are available to make drafting easier in real-world fireground conditions. Each of the above is a “tool in the toolbox.” Are you using some of these, or are you making drafting more difficult and cumbersome than it has to be?

If you own a 1500 or 2000 gpm midship pump that has a large diameter suction connection located at the front or rear of the apparatus, expect lengthened priming times.

Suction and discharge piping manifolds found on industrial foam pumpers also contain large volumes of air. For example, Hale manufactures an 8 FG midship or rear mounted pump used for industrial applications that is rated at 3000 gpm. This pump has 8 in. suction and discharge pump body connections. Apparatus builders normally install two vacuum priming pumps within the priming system to reduce the time required to evacuate the large volume of air found inside the 8 in. and 6 in. pump suction and discharge manifolds. (The 8FG pump, when equipped with these manifolds, will normally move over 5000 gpm when connected to



**Figures 8 and 9:** Standard basket strainers (above) and floating strainers (below).

a suitable positive water supply).

Other reasons for extended priming times (beside large piping manifolds) are a damaged primer pump electric motor (which runs the priming pump under-speed) or a damaged priming pump (caused by a stuck rotary-vane in the priming pump rotor, or a priming pump that ingested a large amount of solid particulate). Check these out and repair or replace the components.

**Question:** *During some of our drafting operations we prime the pump, start to move water, and then immediately lose prime. Why does this occur?*

Many times it is because of an air trap in the suction hose. If you have quite a few lengths of hard suction hose off the pump into a static water supply, and the elevation of the hose does not follow a downward slope from the pump to the water source, an air trap occurs. Even though the suction hose has this air trap, it is still possible to initially prime the pump. However, the air pocket stays trapped inside the suction hose. As soon as the fire pump discharges a significant volume of water, flow in the suction hose increases and sweeps the air pocket up into the pump, resulting in a temporary loss of prime. Try to avoid suction hose air traps — if they are unavoidable, immediately re-prime the pump.

Another reason for loss of prime is a whirlpool developing by the suction strainer. This allows air to enter the suction hose causing a temporary loss of prime. Debris can also wrap itself around and block flow into the suction strainer resulting in lost prime.

**Question:** *Every so often when we set up a drafting operation we prime the pump, start discharging water, and find pump pulsation (air in the discharge water). What causes this?*

Constant pump pulsation or a ragged discharge stream indicates that air is being entrained in the water flow at some point in the suction side of the pump. This can happen after a pump achieves a prime and moves water, even though there are air leaks in the suction assembly. The result is lowered pump efficiency and reduced maximum pump capacity. This problem magnifies itself on lifts that are higher than normal

and at high altitudes. Find and fix the air leaks in the suction hose fittings or assembly. A ragged discharge stream can also occur because of a whirlpool at the suction hose strainer allowing air to enter the suction hose and pump.

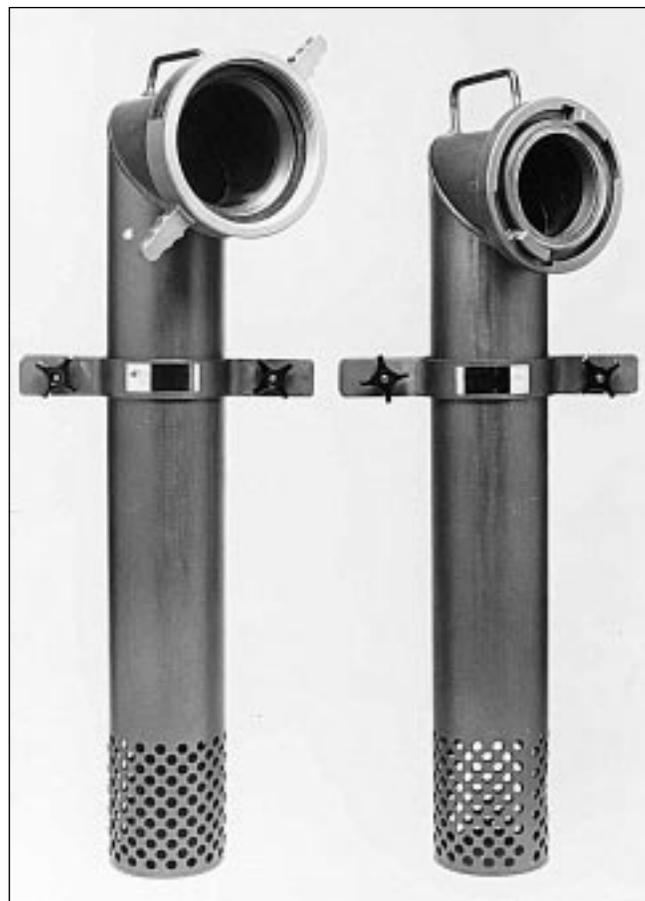
**Question: What steps must we take to maintain our priming system?**

Recommendations for each priming system will vary by manufacturer. Contact yours and ask for testing and maintenance information. Make priming system checks an integral part of your scheduled fire pump preventative maintenance and testing program. Failing to care for your priming system is foolish. Think about it; the cost of your engine may be in the \$150,000 to \$300,000 range. If your priming system fails because of benign maintenance neglect, your engine (and your investment in it) could be useless at the next fire where drafting is required. A few suburban departments have been lulled into a false sense of security because their fire districts have lots of hydrants and therefore they don't need to use the primer much. Don't let it happen to you.

**Question: What's new in priming system technology?**

The latest change in technology regarding vacuum primers deals with "environmentally friendly" priming pumps. With increased environmental awareness and legislation to eliminate chemical discharge into the environment, Hale Products, Inc. has developed an "oil-less" priming system. The Hale Environmentally Safe Primer's (ESP) internal components look virtually the same as their older vintage oil-fed priming pump. However, the subtle visual but big internal difference is that ESP components are made of hi-tech composites that entirely eliminate the need for lubrication. This is a "win-win" situation for the fire department and the environment. Not only is oil pollution into the environment eliminated, there is never a maintenance requirement to refill a lubricant oil tank (the ESP is installed without a lubricant reservoir).

Fire apparatus manufacturers such as Emergency-One, Kovatch Mobile Equipment, and Sutphen, have switched their new Hale pump-equipped apparatus production entirely over to the oil-less primer. There are thousands of these primers at work in the field with impressive track records.



**Figures 10 and 11:** Ninety-degree turn suction basket strainers (top). These low-level strainers are excellent for portable tank drafting applications (bottom).

You can now specify an oil-less primer on all of your new apparatus, regardless of who manufacturers the apparatus and the fire pump. And, if you have an existing fleet of engines with oil fed primers, it's easy to retrofit the ESP — no matter who manufactured the fire pumps. Yes, you can now go with oil-less primers totally across the board on all engines. For more information on the ESP primer contact Hale at 610-825-6300.

While a priming system is an important fire pump accessory, it is often thought of secondarily when planning apparatus specifications, and not given adequate attention during pump testing and maintenance. Good priming system design, installation and maintenance are critical for effective drafting operations. Make sure the integrity of your priming system, fire pump and pump operation training are up to par to prevent a fireground catastrophe.

### **Priming System Diagnosis: Symptoms and Possible Cause**

Priming pump electric motor doesn't turn.

- Dead battery
- Main power feed wire has bad connections
- Bad electric primer motor ground
- Bad master disconnect switch or solenoid
- Solenoid switch which activates primer is bad
- Wiring to control solenoid had bad connections or is disconnected
- Defective solenoid
- Defective motor
- Defective switch on priming valve

Vacuum priming pump is slow to pull a prime or priming maximum vacuum is lower than normal (vacuum holds).

- Low charge on batteries
- Batteries not sufficient size
- Cable between battery and primer insufficient size
- Electrical connectors on cable dirty
- Bad ground
- Extremely large quantity of suction hose or suction piping
- Too small or too long a length of piping between primer

and pump

- Priming valve not fully opening (operator error)
- Lift is too high
- Primer vanes worn
- Loose or broken V-belt (on belt driven primers)

Priming pump can pull some prime, but it will not hold vacuum.

- Air leaks somewhere in the system
- Bad suction hose gasket
- Pump or discharge drain was left open
- Gauge or drain tubing line disconnected
- Leaking or stuck priming valve
- Priming valve seat defective
- Leaking suction relief valve
- Rusted out piping
- Leaking suction hose
- Bad mechanical seal
- Leaking packing
- Bad flange gasket on pump
- Cracked or broken casting

Can pull full prime, it holds, but pump loses water when you start to pump, or pump cavitates prematurely, or pump cavitates at high pressures.

- Pump impeller is damaged or severely worn out
- Suction hose not submerged in adequate water supply
- Air leak during water flow (see list directly above).
- Clogged inlet strainer on pump suction hose
- Pump impeller pre-rotation baffle is missing
- Air pocket in piping or air trap in suction hose
- Air accumulation in piping
- Turbulence in piping
- Too much vertical distance to water source and, or, too many lengths of suction hose
- Failing (collapsing) suction hose

***How to get more information on priming systems:***

Contact Hale Products Customer Service by phone at 610/825-6300 or by fax at 610/825-6440. You can also reach them at their web site at [www.haleproducts.com](http://www.haleproducts.com)

For suction hose and accessories, contact Kocheck at 800/420-4673 or by fax at 800/772-0255. You can also reach them at their web site at [www.kocheck.com](http://www.kocheck.com)

***End Notes***

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