Who likes a low-down, lousy, leaking pump seal?

Part one: How to extend the life of your cryogenic centrifugal pump seal

By Keith Hall, Applied Cryogenic Technologies (ACT)

For externally mounted centrifugal cryogenic pumps, manufacturers expect mechanical seals to last for at least 1,000 hours if run under recommended conditions. Given the hassle and expense to make repairs, and the associated downtime, leaky pump seals are costly.

Achieving 1,000 hours at a minimum, or even better, extending the life expectancy of a cryogenic pump seal, saves headaches and provides significant value to your bottom line. Cryogenic pump manufacturers and some cryogenic trailer manufacturers offer on-site, regional, or tailored-to-you-at-your-location training seminars, often for free, designed to educate your operators with a foundational understanding of pump seals and train them on the proper operation of cryogenic pumps. This service can be of great value to your company.

But even if your cryogenic delivery operators have not had the opportunity to attend a cryogenic pump training class, please take the time to share with them these five simple, yet important things they can do to extend the life of the pump seals on the external cryogenic centrifugal pumps they operate every day.

By following these five simple steps delivery operators can greatly extend the life of pump seals.

1. Properly prechill the pump before starting it

Cryogenic centrifugal pumps are generally cast and machined from bronze or in some cases aluminum alloys. The pump and associated piping make up a significant thermal mass (a lot of metal) to cool down. To more easily catch prime and to run properly, pumps must first be completely cooled down. If not, liquid product may still be boiling inside the pump.

© ACT | **Electric motor driven cryogenic pump with leaking seal**

Proper pre-chilling of the pump will prolong the life of the seal by preventing cavitation which occurs when bubbles form in the suction line due to boiling, or when the pressure drops below the saturation pressure of the liquid, causing it to flash and boil. The cavitation action and resulting vibrations damage the seal and other pump components. A secondary benefit of correctly cooling the pump down is to ensure correct operating tolerances of pump components. When assembled at ambient temperatures some of the tolerances are tight but these contract to the correct design measurements at cryogenic temperatures.

Pump manufacturers recommend that 6 or 7-inch impellor diameter pumps should be cooled for 15-20 minutes, and 10-inch diameter pumps should be cooled down 20-25 minutes to ensure the pump cavity is full of liquid (no vapor) before attempting to start the pump.

Sometimes operators feel that just because they made a previous deliver 20 minutes ago, and the pump is still frosted up, that the pump is still cold and they need not wait again through the pump manufacturer's prescribed cool down period. This results in catching prime, or in attempting to catch prime with liquid boiling inside the pump. The result is cavitation damage to the seal. And cavitation, no matter how brief, adds up to decreased pump seal life. Just because a pump has frost on it does not mean it is cold. If the pump is only -31°F there will be frost on the pump. And 31 degrees is 10 times warmer than the boiling point of nitrogen, oxygen, or argon!

Never attempt to start a cryogenic pump without first cooling it down for the manufacturer's prescribed time period!

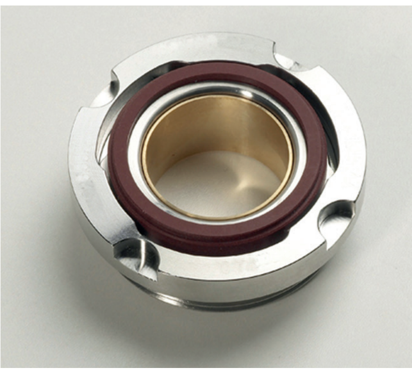
When cooling down a pump the operator opens the inlet valve from the cryogenic supply tank (aka pump suction valve) and the pump recirculation valve. As cryogenic liquid is introduced into the warm cryogenic pump, it begins to boil. Vapor that is generated returns to the top of the cryogenic tank through the recirculation circuit. If the pump is not properly cooled down, boiling gas bubbles will remain in the pump when it is started, damaging the pump seal and internal parts. Lockout control systems can be added to ensure a pump is properly cooled down before it can be started. Many flow metering systems on the market today include a pump cool down feature that will not permit the pump to start until the temperature probe has sensed liquid temperature for the prescribed time. Such systems are also capable of monitoring actual pumping time so that you can track operating hours on the pump seal.

Cavitation action and resulting vibration damages the pump's seal and other pump components.

2. Build and maintain sub-cool pressure on the product before starting the pump and throughout the pumping operation

Each cryogenic centrifugal pump design requires a minimum amount of Net Positive Suction Head (NPSH) pressure be provided at the suction of the pump in order to catch and maintain prime throughout the delivery. This pressure serves to "push" the liquid into the pump. Additionally, the liquid must not boil inside the pump.

Before cooling down the pump, the operator should always make a mental note of the tank pressure. And as a rule of thumb, the operator must never attempt to start a pump unless the tank pressure is at least 5 psi higher than before the pump cool down was initiated. Moreover, it is



© Cryostar USA LLC | **A seal assembly for a centrifugal, externally mounted, cryogenic pump. This maroon colored seal is a "composite" material. The seal housing is the outer stainless steel. The brass center of the seal is referred to as the 'protection sleeve'**

© ACT | **Many flow meter totalizers include a pump cool down timer with a pump cut out feature to prevent the pump from being operated until it has been cooled down for the required time (see the icon of the hand pitcher water pump with 100 seconds remaining on the timer)**

the operator's responsibility to maintain the additional 5 psi throughout the entire pump off-load operation.

NPSH is naturally provided by vertical bulk storage tanks on tall legs. But horizontal cryogenic transport trailers, for example, cannot provide enough natural head pressure. Instead of vertical height, artificially generated head pressure is employed. Artificial head pressure refers to the fact that the pressure did not occur as a result of natural heat leak into the tank, rather the added tank pressure was generated by the intentional addition of heat to vaporize liquid to raise the pressure in the head space of the tank above the liquid. Artificial head pressure is created in two ways. First, the thermal mass of the cryogenic pump and associated piping circuit, when being cooled down generate a significant amount of vapor, which, when added to the vapor space in the tank, increases the tank pressure. For a tank full of product with a correspondingly relatively small vapor space, simply cooling the pump down may generate more than 5 psi, and the pressure building unit on the cryo tank may not have to be used until you start pumping. Thus, use of the pressure building unit on a cryogenic tank is the second method used to generate artificial head pressure to meet and maintain the NPSH requirement. A pressure building valve is opened to permit liquid from the bottom of the tank to be introduced into external, aluminum star-shaped fins via gravity flow. Heat from the ambient air is transferred to the aluminum fins which in turn transfer the heat to the liquid, causing it to boil and turn to vapor, increasing the pressure in the tank.

The addition of 5 psi to the vapor space also serves as a giant invisible hand, if you will, that presses down on the surface of the liquid, to suppress boiling. This is referred to as "sub-cooling" the liquid. Given the artificial pressure added to the vapor space, the temperature of the liquid is now lower than the new boiling point would be for the liquid at that higher pressure. The temperature of the liquid has not changed. It is not colder than it was. But the pressure has increased so now the liquid temperature is lower than its new higher-pressure boiling point. This is like securing the lid on a pressure cooker or the cap on a radiator which allows the boiling point to increase as the pressure increases. The 5-psi rule provides the NPSH that the pump requires to catch and maintain prime, and sub-cools the liquid to inhibit boiling. The additional "artificial" head pressure generated by the pressure building unit on the tank helps the pump stay primed throughout the delivery by pushing uniformly on the surface of the liquid to suppress the boiling action both in the tank and in the pump while also pushing a continual flow of liquid into the pump.

Building 5 psi pressure, minimum, suppresses the boiling action of the liquid, effectively "sub-cooling" the product below its saturation temperature, and provides the required NPSH to keep the pump primed.

Once the pump has caught prime and is off-loading product, as the liquid level in the tank drops, so does the tank pressure; the vapor space is getting larger. For every gallon of product removed from the tank, one gallon of vapor at the same pressure must be introduced back into the tank to maintain the 5-psi sub-cool pressure to prevent boiling.

<u>The 5-PSI Rule:</u> The operator must never try to start a pump unless the tank pressure is at least 5 psi higher than before he or she started to cool down the pump. And it is the operator's

responsibility to maintain the additional 5 psi throughout the pump off-load operation.

The 5-psi sub-cool pressure is maintained during an off-load operation using the Forced Feed Pressure Building circuit. Instead of waiting for gravity to drive the liquid flow into the pressure building unit, a small stream of liquid is tapped from the pump's discharge, upstream of the flow meter (so the customer is not billed for this product), and is pumped (forced) into the pressure building unit to build pressure very quickly. The Forced Feed Pressure Building circuit helps the operator quickly and efficiently maintain control of the NPSH and sub-cool requirements throughout the delivery.

If the operator is having problems catching prime, or if the pump loses prime during the off-load operation, the first measures taken are to immediately stop the pump to let bubbles escape, and to build more artificial head pressure. Once the proper pressure is achieved the pump will be ready to start again.

3. Maintain back pressure on the pump throughout the pumping operation

Cryogenic pump manufacturers provide pump curves showing the optimum pressure and flow rate ranges each pump should be operated at given the pump's speed, product, and pump suction pressure (supply tank pressure).

Very high discharge pressures/low flow rates conditions (the extreme left side of a pump's curve) and very high flow rates/low discharge pressure conditions (extreme right side of the pump curve) should be avoided. Putting your thumb over the end of a garden hose increases the pressure but decreases the stream of flow from the hose (left side of the pump curve). Removing your thumb results in an increased flowrate, but lower pressure (right side of the curve). The rule of thumb when operating a pump is to let it self-adjust over the wide-operating range for which it was designed but avoid the extreme left and right sides of the pump curve. Not following the pump manufacturers' recommendations will result in cavitation; choking back and restricting the flow too much, or not maintaining the minimum required back pressure to limit the pump's flow. Either extreme will result in cavitation and eventual loose of prime. The pump operator must control the pump discharge pressure (the corresponding flow rate is inversely proportional) using the Recirculation valve when catching prime, and the discharge valve when off-loading, so that the pump always "sounds" and operates smoothly.

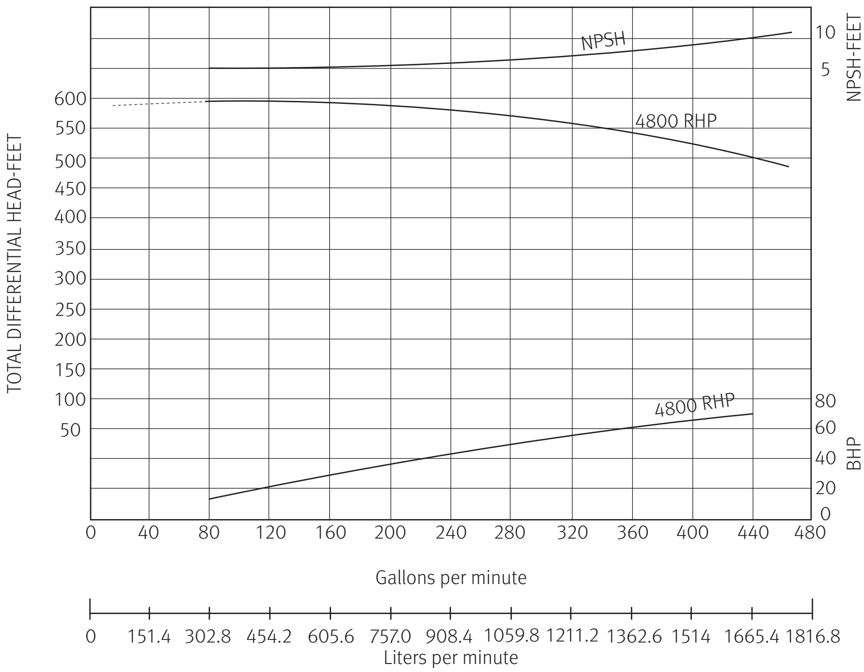
The rule of thumb when operating a pump is to let it self-adjust over the wide-operating range for which it was designed but avoid the extreme left and right sides of the pump curve.

When off-loading a trailer, which may take 90-minutes, the two biggest mistakes an operator can make are: 1) Not using the Forced Feed Pressure Build to maintain the 5-psi rule described above. And 2), fully opening the pump discharge valve at the beginning of the off-load operation and leaving it open. While the pump is cooling down the recirculation valve

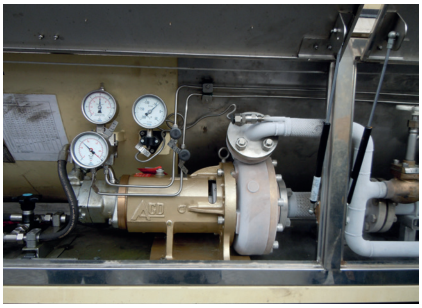
"Not following the pump manufacturers' recommendations will result in cavitation"

is fully open. Once properly cooled for the prescribed time, the pump can be started. The operator should close the Recirculation valve to approximately the half open position. The pump can then be started and ramped up to one-fourth to one-third speed while the operator is also slowly choking (partially closing) the pump recirculation valve until the pump catches prime (as noted by a small jump of the pump discharge gauge needle). This choking action creates a back pressure on the pump, helping it catch prime.

As soon as you catch prime you will hear the noisy pump cavitating. Immediately continue to choke down (close) the Recirculation valve, while keeping an eye on the pump discharge needle, until the pump discharge pressure gauge no longer increases. Then back



© CS&P Technologies | **Example of a pump curve, nitrogen service. Head Pressure is on the vertical axis, and flow rate on the horizontal axis. The Net Positive Suction Head Pressure requirement curve along with the Braking Horse Power associated with the 4800 RPM pump performance are also shown**



© Nikkiso ACD's Houston Cryogenic Industries | **A hydraulic driven, cryogenic pump being cooled down on a UN Portable Tank ISO Container**

off (open) the recirculation valve just a little (never fully close the recirculation valve or you will dead head the pump). The pump will continue to run within its design parameters as long as the operator maintains proper NPSH and subcool pressure. The receiving vessel's pressure should be a minimum of 25 to 50 psi lower than the pump's discharge pressure. Increase the pump speed (or before starting the pump, vent the receiving tank pressure down) until the 25 to 50 psi differential pressure can be achieved. When you are ready to fill, start opening the pump discharge valve while slowly closing the recirculation valve, to avoid "dead-heading" the pump. Keep your eye on the pump discharge pressure gauge needle and keep it in a steady range.

NEVER fully open the pump discharge valve; and adjust it as necessary throughout the off-load delivery operation. Always keep the discharge valve "choked" back just a little, at minimum, so that the pump "sounds good." Cavitation will sound like a distinctly bad gurgling, rattling and vibration. Should you hear cavitation, immediately adjust the back pressure by adjusting the discharge valve a little more closed, and by building additional tank pressure as needed. The longer a pump cavitates the more damage is being done to the pump's seal.

Frequently when you commence a delivery, the pressure in the customer's receiving vessel is high. And if the operator has fully opened the discharge valve at the beginning of the off-load, the pump will still "sound" happy. The receiving vessel is providing the necessary back pressure to keep the pump centered on the pump curve, away from the right side. However, as the receiving vessel is "top-filled", the fresh cold product raining down through the warmer vapor in the tank's head space will cause the vapor to recondense and also rain down through the vapor space, dropping the tank pressure. During the delivery, the operator will likely begin to control the receiving tank's pressure by adjusting the bottom and top fill valves accordingly (bottom filling increases the tank pressure as the liquid rises like a piston and compresses the vapor above it).

However, the operator may forget that the discharge valve was left fully open. As the pressure in the receiving vessel drops, the pump's discharge rate increases (with a corresponding decrease in pump discharge pressure). The pump is self-adjusting farther to the right along its curve. If nothing is done the pump will run off the right side of the curve, meaning that the flow rate will increase so much, as it does not have any back pressure to push against, that the pump will start cavitating and damage the pump's seal. Thus, the operator is free to open the discharge valve fully at the beginning of a fill operation (not recommended), providing he or she is vigilant of the pump's discharge pressure and flowrate and most importantly, is listening to the pump. As the receiving vessel pressure drops, the operator must choke back a little on the discharge valve to maintain back pressure on the pump. The pump needs back pressure to push against to remain happy.

The two biggest mistakes an operator can make during a delivery operation are: 1) Not using the Forced Feed Pressure Build to maintain the 5-psi rule described above. And 2), fully opening the pump discharge valve at the beginning of the off-load operation and leaving it open.

An analogy to controlling a pump may that of a cowboy who is always in control of his horse. He gently holds back on the reins as he rides to maintain control over the horse. He only pulls back on the reins to slow the horse and to stop it. He gives the horse rein to let him run. But a good cowboy never drops the reins on the ground to let his horse run off with a stampede. Whether walking, trotting, loping, or running, he has control of the horse.

Likewise, an operator must always maintain control over the pump. While building pressure may be comparable to nudging the horse along with heels, controlling the Recirculation valve when catching prime and controlling the discharge valve when dispensing product is analogous to handling the reins. The operator must never let the pump run away off the right side of the pump curve and cavitate, nor must he choke the pump too far on the extreme left side of the pump curve or it will dead head and cavitate. When the receiving vessel's full trycock spurts white liquid, the operator must immediately open the Recirculation valve while closing the discharge valve, and then slow and stop the pump. However, if another vessel is to be filled at the same location within the next minute or two, the recirculation valve should be partially opened as the discharge valve is closed, and the pump speed decreased to idle range i.e., ¼ speed).

Maintain Back Pressure Rule: Never fully open the pump discharge valve during a delivery. Adjust the discharge valve as necessary throughout the delivery.

To be continued in next month's issue. gw

ABOUT THE AUTHOR

Keith Hall is a member of the gasworld editorial board and Vice-President of Product Development and LNG Sales at Applied Cryogenic Technologies in Houston, TX. ACT designs and manufactures cryogenic transport trailers and other cryogenic transportation and vaporization equipment. The views expressed in this article are those of the author and do not necessarily express the views of his employer. Hall would also like to recognize the contributions to this article by Sean Hardy - Cryostar USA, LLC; Shane Dilling, Nikkiso ACD's Houston Cryogenic Industries; and Brannon Baskin - CS&P Technologies. Hall can be reached at (281) 888-3884 or keith.hall@appliedcryotech.com.

Who likes a low-down, lousy, leaking pump seal?

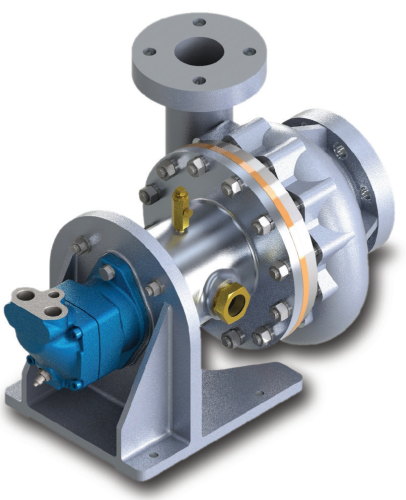
Part two: How to extend the life of your cryogenic centrifugal pump seal

By Keith Hall, Applied Cryogenic Technologies (ACT)

Last month, in part one of this article, we discussed the first three of five simple, yet critical things operators can do to extend the life of the pump seals on the external cryogenic centrifugal pumps they operate: 1. Properly prechill the pump before starting it; 2. Before starting the pump and throughout the delivery, build and maintain sufficient net-positive suction head (NPSH)/sub-cool pressures; 3. Maintain back pressure on the pump throughout the pumping operation.

In this second part and final instalment we will discuss: 4. Never let the pump run dry; 5. Keep the pumping system free of moisture, before some advice from experts and some final thoughts.

© CS&P | **A sealess pump**



4. Never let the pump run dry

The fastest way to ruin a pump seal is to run a pump dry. An operator should never attempt to start a pump when it is dry, nor even while it is cooling down. Not even for a quick instant. And a maintenance person should never "bump" a dry pump, ie., to verify rotational direction (such as when you are connecting up the three legs of power on a 440-volt, 3-phase supply and you want to make sure the electric motor driven pump is rotating in the correct direction to make the pump discharge product).

Under any circumstances, before operating, a pump must be cold and the seal lubricated with the cryogenic liquid, or serious damage to the pump seal will instantly occur. Even during normal off-load operations, damage to the pump's seal is caused, for example, when a pump is permitted to run dry at the end of off-loading an entire load of product.

If the operator is not paying attention, the pump, running at full speed, will lose prime and cavitate as the supply tank nears empty, leaving the seal dry while rotating at high speed.

Never, ever, under any circumstance run a cryogenic pump warm or dry, not even for a quick instant!

If the operator is paying attention, he will notice the pump discharge pressure gauge needle begin to flicker when the liquid level gauge is showing only a few inches of water column on the differential pressure liquid level gauge.

"Before operating, a pump must be cold and the seal lubricated with the cryogenic liquid, or serious damage to the pump seal will instantly occur"

The operator may choke back the discharge valve, open the forced feed pressure build valve, and slow the pump, and be able to off-load a bit more product. But this is done at the risk of running the pump dry – spinning the pump seal dry at high speed, will cause significant wear and can even destroy the seal. The best course of action for the operator is to note the minimum liquid level at which he or she should stop the pump – and do so.

The operator may simply slow and stop the pumps, or may partially open the recirculation valve while closing the discharge valve, and then slow the pump to a complete stop. Leaving a small heel of product in the transport trailer or bulk storage supply tank serves to help keep the tank cold until it is filled again.

And by so doing the risk of running

DID YOU KNOW?
Did you know that the units of measure for pressure head is "feet of water column" pressure?
One foot water column, 1-inch wide by 1-inch across by 1-foot tall, weighs 0.4334 pounds.
Thus a one-foot tall column of water, no matter its lateral dimensions exerts a downward force of 0.433 pounds per square inch (psi).
The table below shows the respective column heights of water and common cryogens to produce 5 psi.

Regarding the 5-psi sub-cool rule, when converted to head pressure, 5 psi is the same force exerted by a column of water 11.5 feet tall. Since it is less dense than water, a taller column of nitrogen, over 14-feet tall, is required to produce the same 5 psi force an 11.5-foot tall column of water produces. Argon is denser than water and only requires a column 8.6 feet tall to produce the same 5 psi force. At 3.54 pounds per gallon, LNG is very light and would require
a column over 27-feet tall to produce the same 5 psi!

For your reference a table showing the densities of various common cryogens compared to water is provided below.

Pump manufacturers provide pump curves for their various model pumps. Unique head pressure versus flow rate curves are generated for each cryogen at the pump speed necessary to produce the required discharge pressure range and corresponding flow rate range; and given an assumed pump suction pressure (tank pressure is additive to the pump's discharge pressure capability). From the table below, you gain an understanding that a pump used to discharge different density cryogens at the same head pressure will product vastly different PSI pressure values.

500-feet of head pressure when pumping water results is almost 217 psi. The pump discharge pressure is only 91.9 psi when pumping less dense LNG. In contrast, 500-feet head pressure of argon equals 302 psi!

THE 5 PSI RULE - FEET HEAD PRESSURE EQIVALENTS

PRODUCT	PSI	HEAD (feet)
WATER	5	11,547
LIN		14.366
LOX		10.132
LAR		8.619
LNG		27.189
ETHANE		21.210
ETHYLENE		20.327
NITROUS-OXIDE		9.372

COMMON PRODUCT DENSITIES

POUNDS	GALLONS
WATER	8.345
LIN	6.745
LOX	9.528
LAR	11.630
LNG	3.540
ETHANE	4.538
ETHYLENE	4.735
NITROUS-OXIDE	10.270

PUMP DISCHARGE PRESSURE EXAMPLE

PRODUCT	HEAD (FEET)	PSI
WATER	500	216.8
LIN		175.2
LOX		247.5
LAR		302.1
LNG		91.9
ETHANE		117.9
ETHYLENE		123.0
NITROUS-OXIDE		266.8

the pump dry is eliminated. Consistently waiting for the pump to lose prime when the supply tank empties before shutting down the pump takes significant life from the seal.

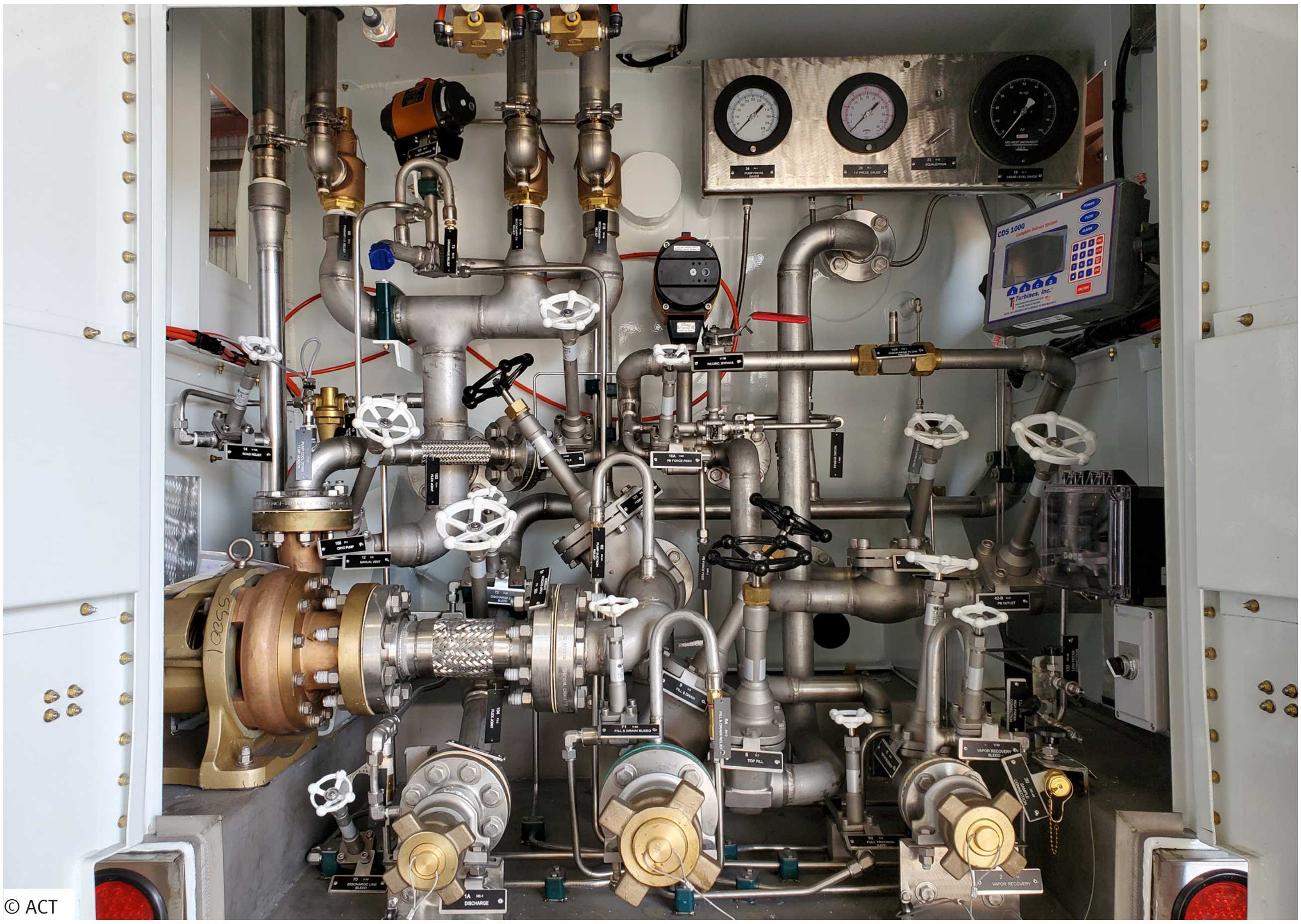
5. Keep the pumping system free of moisture

Ice crystals do great damage to pump seals. All cryogenic tanks and piping circuits, including the pump recirculation and discharge circuits must be kept dry. A dewpoint of -40F/C is recommended (-40F & C is the same temperature). Guard again the entrance of moisture into the pump piping circuit. When you cool down the pump and when you are pumping, frost forms on the outside of the pump and all associated cold piping.

After a delivery operation, as the piping warms the frost melts into water. It is very important to install the caps back over the fill hose connections immediately upon removal of the hose. Avoid letting frost form inside piping circuits. The least obvious, but perhaps the most frequent means for the ingress of moisture into piping circuits occurs when an operator leaves the purge/bleed valve open, for example, when venting down and draining the discharge hose.

Just as frost has formed on the outside of the hose and piping, once exposed to the atmosphere, humid air enters the circuit and frost forms inside the piping during the first few minutes after the off-load operation. As the piping warms, like the external frost, the frost that was formed on the internal piping walls melts into water.

And then when the Purge/Bleed valve is finally closed, the moisture is trapped inside. For this reason, bleed valves must be closed as soon as all liquid and pressure have been purged from the circuit. Always immediately cap the discharge hose connection piping at



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the end of a delivery, and vent and drain the circuit. Note that these circuits are protected with thermal line reliefs which will prevent over-pressurization of the piping.

Additionally, an understanding of how this internal moisture issue occurs illustrates the importance of a thorough purge of not only the piping, but of the dispense hose, before commencing the next delivery operation. When you purge the hose before a fill, you are not just purging air or debris from the hose and discharge piping connection circuit, but also any moisture.

Ice crystals do great damage to pump seals. Guard again the entrance of moisture into the pump piping circuit.

For many permanent ground-mounted installations, a slight positive pressure dry nitrogen gas purge is applied to the pump seal before the pump cool down sequence is initiated. And the slight purge remains on the seal throughout the off-load operation, and as the pump warms up. If a slight positive pressure of dry nitrogen gas is emitting from a pump seal, it is impossible for moisture to enter. Purging of the pump's seal aids in extending its useful life.

> "The operator needs to keep the pump on the operating curve to avoid cavitation abuse which will damage the pump's seal"

Advice from the experts

Shane Dilling, with Cryogenic Industries Houston, a Nikkiso ACD pump service company, says there are several factors that contribute to extending pump seal life, but in his opinion the most critical are "proper pump installation, religiously following a thorough cool down procedure, and attentive operator control."

Dilling states that during initial installation of the pump, "the pump needs to be cooled down with liquid before completely tightening the mounts and flanges to avoid piping strain which could cock the seal and cause a premature leak."

Although the pumps have flexible hose vibration dampener sections before the inlet (suction) and after the discharge ports, these are not meant to compensate for misalignment.

Fit up alignment of the pump in the relaxed, chilled down position must achieved before the pump bolts are tightened down.

Finally, Dilling concludes, "The operator needs to keep the pump on the operating curve to avoid cavitation abuse which will damage the pump's seal."

Sean Hardy, Sales Manager for Cryostar USA, points out that "Across our industry, it is widely recognized that mechanical seals represent the largest

"When any of the installation and operational guidelines are relaxed or omitted, premature wear and damage occurs to the mechanical seal"

investment for pump maintenance – in addition to the inconvenience caused due to seal failures."

Hardy also laments that "when pump seals fail prematurely due to incorrect operation, an inaccurate reflection is cast on the reliability and reputation of our equipment. For this reason, we strongly support the good practices highlighted in this article."

Finally, Brannon K. Baskin, Director of Operations for CS&P Technologies agrees that, "Strictly adhering to the industry accepted practices outlined in this article will ensure maximum service life of your cryogenic pump. When any of the installation and operational guidelines are relaxed or omitted, premature wear and damage occurs to the mechanical seal. Continued operation of a cryogenic centrifugal pump with a leaking seal results in accelerated mechanical damage to the pump. Consequently, the customer incurs a repair cost that is triple to that of a standard repair."

Note, ACD and Cryostar also offer seal-less pumps that are submerged in the cryogenic tank or vacuum-jacketed sump. These pumps are expected to last up to ten times longer than the seal on an external centrifugal pump. But not all applications lend themselves to submerged pumps.

CS&P Technologies manufactures patented seal-less magnetic drive cryogenic centrifugal external pumps that eliminate the need for the mechanical seal and feature a pump service life of five times that of conventional pumps.

Final thoughts

A Pump Cool Down Timer, which locks out the pump, preventing it from being started before it has cooled down for the manufacturer's prescribed time period, is a strongly recommended feature to have with each cryogenic pump.

It may also be worth your time to investigate computerized pump monitoring and control systems which not only assist the operator and perform such functions as auto-stopping when filling certain liquid cylinders and mini-bulk tanks, but which also monitor the pump to protect it.

Such systems monitor key pump parameters, and take action when needed, to protect the pump. Such parameters include controlling proper pump cool down; controlling the 5-psi NPSH/Sub-Cool pressure; monitoring differential pressure to detect the on-set of cavitation; detecting high and low flow rates; and detecting high and low pump discharge pressures conditions; etc.

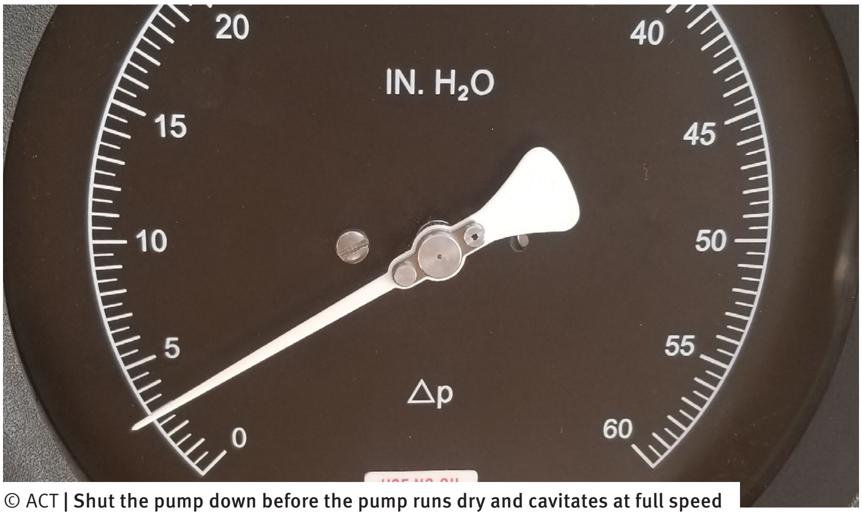
Making deliveries to fill mini-bulk tanks and liquid cylinders using an externally mounted cryogenic centrifugal pump is perhaps the worst-case service environment for such a pump.

Instead of being cooled down once and then off-loading an entire load (a bulk delivery, for example), these systems are cooled down and make deliveries at one stop, then the pump is shut down and warms back up as the bobtail or trailer travels to the next customer, then the pump is cooled down again and the delivery process is repeated many times a day.

With trained, conscientious operators, and using computer-controlled systems, the author knows of multiple pump seals that have lasted over seven years in mini-bulk service.

However, a competent operator, trained with a basic understanding of cryogenic principles and the rules described in this article, can do what the computer does... and probably much more.

One important asset the operator has that a computer does not, is ears – to listen to the pump to make sure it "sounds" happy. And if the pump sounds happy the boss will sound happy too! gw



© ACT | Shut the pump down before the pump runs dry and cavitates at full speed

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