Maintaining Pump Prime

Diane Dierking, Senior Editor

While pumping ammonia to our unit in eastern Indiana, the centrifugal pump loses prime for no apparent reason. It then takes several attempts to get the pump primed again. The problem seems to occur more often in the summer, but has occurred in every month of the year. The ammonia is stored in 10,000-gal., insulated saddle tanks with a positive head of at least 10 ft. when the tanks are nearly empty. The typical flow rate is between 5 and 10 gpm. The pump has a minimum flow requirement of 5 gpm, so there is a minimum flow line with a control valve to maintain the flow. What could be causing this problem?

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Determine the NPSH
It sounds as if you don't have enough net positive suction head (NPSH), which is the total suction head in feet of liquid absolute at the suction nozzle and referenced to the datum, less the vapor pressure of the liquid in feet. Your pump specification sheet should chart the NPSH. Check this number with the density and vapor pressure of ammonia at the service conditions, and then calculate the pressure drop across the suction pipe and fittings. Any pumping system must have the available NPSH of the system be equal to or exceed the NPSH required by the pump. A control valve or flow meter installed in the suction line will add to the suction pressure drop. Relocate them to the discharge if this is the case. If not, consider cooling the pump suction line and/or tank, with a traced line of cooling tower water. (I once had to use ice in a pilot plant installation to keep the vapor pressure reduced enough.) The sun might be shining on the tank, which will heat the ammonia and increase the vapor pressure, thereby decreasing the NPSH.
Robert L. Heider, engineer
PEC, St. Louis

Cool pump with water
The problem is caused by ammonia vaporizing in the pump case. Run water over the pump case to cool it, which should condense the vapors and allow pumping.
Margaret A. Vaughan
ExxonMobil Chemical Co., Beaumont, Texas

Locate minimum flow line correctly
A little-appreciated fact is that pump inefficiencies are applied to the fluid and cause a slight rise in temperature, which normally goes unnoticed. Fluid heating is more likely to happen at low pump rates when the pump is running in a poor efficiency area of the pump curve. However, when pumping fluids at or near the boiling point, small temperature changes on the suction side greatly affect the available head. Therefore, the placement of the minimum flow line and any control valve is critical to maintain prime.

For example, if the point of discharge for the flow control valve is in the input line for the pump, then the fluid (at a slightly higher temperature than the material in the tank) again passes through the pump and gains some more thermal energy. This recycling and temperature increase continues until all available head is lost due to ammonia bubble formation and pump cavitation. Ergo, the prime is lost. It will be very difficult to reestablish the prime since the fluid in the pump will need to cool back to a temperature similar to that of the fluid in the tank. To avoid this, the discharge of the control valve must not be piped directly to the suction line. Instead, it should be piped to the tank.
John Corn, instructor, Department of Chemical Engineering
Ohio State University, Columbus, Ohio

Replace centrifugal pump
I would replace the centrifugal pump with a positive displacement pump, which is more reliable for handling ammonia (the internal bypass can be adjusted to suit your line pressure needs).
Kirt Matson, plant manager
Van Diest Supply Co., McCook, Neb.

Increase pressure on the tank
The problem is that the ammonia is flashing to vapor in the pump. At 70F it boils at about 100 psig, so 10 ft. of suction head is not enough. Since the ammonia is no doubt in a sealed tank, pressurizing the tank is a possible solution. Using a controller to turn the pump off instead of bypassing might help, and also save energy.
Mark Arnold, P.E., engineer
U.S. Army Medical Material Development Activity, Ft. Detrick, Md.

Size piping correctly
I had a similar experience with a pump we used for high-purity alcohol. On our pump, the feed line was the same diameter (1 in.) as the output line. I redesigned the pump for a new process unit using a 2-in. feed line and kept everything else 1

in. on the output line. Before the design change, the pump made a lot of cavitation noise; now it runs smoothly and silently and our working pressure is lower with better results.
Michael Gill, manager, Clean Room
Tarr LLC, Portland, Ore.

Check instrument lines
The problem may reside in the flow measurement itself. If a minimum flow line regulated by a control valve is required for pump or system protection, then the flow transmitter will probably be connected to a trip system. If the flow is measured by an orifice with a differential pressure transmitter, then the line connections and transmitter may be of interest. If the high-pressure port of the transmitter becomes overheated relative to the low-pressure port (due to sunlight or other heat sources), then the transmitter may show a low flow and trip the pump. This occurs because the liquid ammonia in the high-pressure port can vaporize if it is heated, which results in less head and differential pressure at the transmitter. If the flow transmitter is on the suction side of the pump, this condition can be exacerbated by the lower pressure of the suction header compared to the discharge and, of course, the overall relationship to ambient temperature. The same uneven heating problem can occur with ammonia and other easily volatized liquids in sight-glass level gauges and differential pressure level transmitters.
Tobin D. Kueper, technical services manager
CYANCO, Winnemucca, Nev.

De-gas the ammonia
We used to have a very similar problem when we were pumping an aqueous reactant solution that had sulfur dioxide as one of the reactants. The pump would cavitate and we would lose all of the flow, which would shut down the process. We determined that this was happening because of the dissolved gas in the liquid, thereby lowering its density to have less than the minimum NPSH. We would shut down the process and let the liquid de-gas until the density became normal and then restart, which often took several attempts. We were able to solve the problem by maintaining sufficient head and making sure that there was no dissolved gas in the liquid.
Girish Malhotra, P.E.
EPCOT International, Pepper Pike, Ohio

Turbulence creates gas pockets
At our plant, we pump monomethylamine, which has many properties similar to ammonia. The reason you may be losing prime is that the ammonia is flashing inside the pump, or even before the pump. Ammonia has a very low boiling point (-28F) as well as a very high vapor pressure (125 psi at 68F). As the temperature increases, so does the vapor pressure.

One of the main opportunities for ammonia to flash occurs if the product flow is very turbulent as it enters the pump, creating a large number of gas pockets/bubbles in the liquid. This problem is amplified in the summer by the higher ambient temperatures.

There are two ways to alleviate this problem. The first is to increase your straight piping run into the pump. This will help stabilize the liquid flow and decrease the amount of turbulence. Your pump supplier can help you determine the straight run length in equivalent pipe diameters you need to the pump suction. The second is to oversize the suction line of the pump (i.e., a 2-in. suction line and a 1-in. discharge line). I would employ both of these methods to solve the problem.
Robert Inouye, lead operator
Tessenderlo Kerley Inc., Burley, Idaho

Summer temperatures heat the ammonia
My first guess would be that the ammonia is heated during the summer in the tank, lines and pump. This heat is enough to cause the fluid to flash at the eye of the impeller. This then vapor locks the fluid and breaks prime. You can increase the head on the suction side, insulate the pipe and pump casing, get a pump with lower NPSH requirements or physically lower the pump so you increase the suction head.
Carl Jones, director of sales
Bott Equipment, Houston