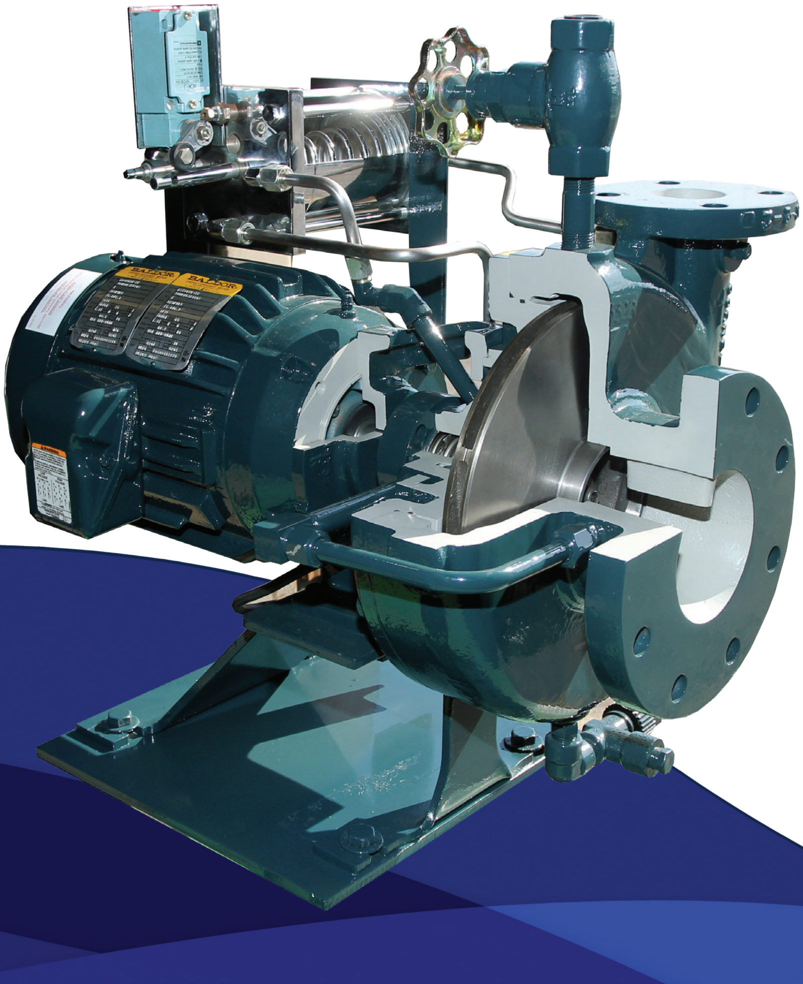
REFRIGERATION PUMP TROUBLESHOOTING

FOR LIQUID OVERFEED AND TRANSFER PUMPS



CORNELL PUMP COMPANY
TERMS AND CONDITIONS OF SALE

Exhibit 1

WARRANTY COVERAGE BY PRODUCT

PRODUCT	0-12 Months	13-18 Months	19-24 Months	25-36 Months	37-60 Months
REFRIGERATION PUMPS	100%				
IRRIGATION PUMPS*	100%				
FOOD AND HOT OIL PUMPS	100%				
INDUSTRIAL PUMPS*	100%				
MUNICIPAL PUMPS*	100%				
SUBMERSIBLE PUMPS*	100%		50%		25%
PORTABLE PUMPS**	100%	50%		25%	
DAF PUMPS	100% (6 month)				
STX, STL & STH SELF PRIMER PUMPS	100%				
VERTICAL TURBINE PUMPS	100%				
OTHER PUMPS NOT LISTED	100%				
PARTS	100%				

Warranty for Motors, Controls, and other accessories not manufactured by Cornell are provided by the manufacturer of those products.

**For permanent Installations*

***Pumps used for Rental, Dewatering, and other non-permanent applications*

Proration periods are based on months after shipment (unless otherwise agreed upon).

Wear Parts: This limited warranty does not cover parts that by nature of their function require replacement as the result of normal wear and tear (seals, wear rings, wear plates, or other parts subjected to abrasion, cavitation, or corrosion) unless a defect in materials or workmanship can be determined by Cornell.

Effective Date: September 1st, 2017
Supersedes All Previous Warranties

ISO9001:2015 CERTIFICATION

Cornell Pump Company proudly maintains its ISO9001:2015 certification which validates that Cornell is in compliance with all necessary processes to meet customer requirements.

The elements associated with ISO 9001:2015 certification include such areas as contract review, design and development, production, purchasing, quality control and service.

INTRODUCTION

This guide is designed to provide assistance for resolving problems associated with a liquid overfeed or transfer pump application. The trouble shooting guide is divided into two sections to include: 1. Operational troubleshooting, and 2. Mechanical troubleshooting.

1. OPERATIONAL TROUBLESHOOTING

Cavitation, recirculation and vapor entrainment generate the most frequent operational problems. Unfortunately, the most common operational problems are many times interrelated, misinterpreted or difficult to isolate. As a result, the troubleshooting guidelines employ a hierarchical method of evaluation. The hierarchical method provides the troubleshooter a logical means of evaluation through a process of elimination. Potential operational problems should be evaluated in the following order:

1. **CAVITATION**
2. **RECIRCULATION**
3. **VAPOR ENTRAINMENT**

1. CAVITATION

When too much flow is demanded of the liquid overfeed or transfer pump, cavitation will result. Cavitation is a result of inadequate Net Positive Suction Head Available (NPSHA), and occurs when the Net Positive Suction Head Required (NPSHR) is greater than NPSHA. The typical consequence of cavitation is a noticeable erosion of the pump differential pressure. When the noticeable erosion of the pump discharge pressure occurs, it will be necessary to quickly start closing the pump discharge stop value and observe the behavior of the pump. If the pump is suffering from cavitation due to an excessive flow rate, the closing of the stop valve will bring about immediate recovery.

2. RECIRCULATION

Recirculation is a phenomenon common to all centrifugal pumps when operated at a low capacity. Refrigerant pump capacity characteristics are unique to each type of pump within Cornell's refrigeration product group. At one half to one third of the best efficiency point, a secondary flow begins within the impeller, whereby the fluid actually reverses direction and exits the eye and/or enters the discharge. This results in turbulence and small vortices. The high velocity at the core of the vortices results in low pressure, often below the vapor pressure of the fluid, and cavitation may ensue. As previously mentioned, if the pump is suffering from cavitation due to an excessive flow rate, the closing of the discharge stop value will bring about immediate recovery. However, if the operational problem is due to recirculation, the pump will stumble even more quickly. If the pump begins to stumble even more quickly, the operator should reopen the stop valve and establish a minimum flow requirement via the bypass line. The minimum flow requirement for a given refrigeration pump can be established by the following procedure:

1. **FULLY OPEN THE BYPASS LINE VALVE**
2. **CLOSE THE DISCHARGE STOP VALVE**
3. **SLOWLY CLOSE THE BYPASS LINE VALVE UNTIL THE PUMP DISCHARGE PRESSURE STARTS TO BECOME UNSTABLE AS INDICATED BY "BOUNCING" OF THE PRESSURE GAUGE NEEDLE**
4. **OPEN THE BYPASS LINE VALVE UNTIL THE GAUGE STABILIZES.**

3. VAPOR ENTRAINMENT

The phrase "vapor entrainment" implies that the vapor is carried into the pump from an external source. This is distinct from cavitation where the vapor is actually generated within the pump. Vapor entrainment is traditionally misinterpreted as cavitation. However, similar to cavitation, vapor entrainment may actually result in an auditory signal or diminish the amp draw by the motor. Moreover, vapor entrainment typically restricts the flow of the pumpage through the eye of the impeller to the point that coils may not be adequately fed. When vapor entrainment restricts the flow of the pumpage through the eye of the impeller, inclusion of a bypass line will not resolve this operational problem.

However, if the pump is connected to an adequately sized and adjusted bypass line and/or there are system loads on line then recirculation can likely be ruled out. Vessel and piping design are always involved no matter what is deemed to be the greatest contributing factor. Horizontal vessels always have less submergence available to separate the surface boiling from the mouth of the drop leg. Simple vortexing is not often a problem anymore as most vessel manufacturers have learned to include crossed plate vortex eliminators or similar devices in the mouth of the drop leg. However, vapor entrainment due simply to the proximity of the boiling layer to the mouth will still occur if the submergence is less than about 18 inches.

If any pressure drop in the vessel is quicker than 1 psi/min, boiling will occur about 3 feet below the liquid surface, and then obviously 18 inches of submergence will not prevent vapor from entering the drop leg. In a vertical vessel it would be unusual if there were not more than 3 feet of submergence. However, if the drop leg is properly sized, then the full liquid height from the operating level to the pump level can be used to protect against vapor entrainment rather than just the submergence above the mouth of the drop leg. Vapor entrainment problems are also directly related to the rate of pressure drop during any transient in the vessel.

This leads to the discussion of false loads. The key to avoiding vapor entrainment in a vessel is to keep the rate of pressure drop as low as possible during any pressure reduction. Pressure reductions occur when a system is started up from ambient-the temperature and pressure must be brought down to their design values before they stabilize. Pressure reductions also occur when something upsets the system, such as increased refrigeration demand caused by a new batch of warm product being brought to a freezer or increased shipping and receiving activity which allows more warm air into the refrigerated space. Another source of false load occurs as a result of hot gas defrosting practices. During hot gas defrost of an evaporator the liquid supply solenoid to that evaporator closes, the defrost regulator on the evaporator outlet closes, and a hot gas supply solenoid opens.

Hot gas from the high side enters the evaporator and warms the coils. After a while the pressure inside the evaporator builds high enough that the defrost regulator opens, and now hot gas starts blowing down the wet return line to the LPR. In addition to the aforementioned recommendations, there are a variety of piping considerations designed to minimize the effects of vapor entrainment. In particular, the bypass line, pump leg line velocities, suction vent line, and volute line.

2. MECHANICAL TROUBLESHOOTING

PROBLEM	PROBABLE CAUSE	CORRECTIVE MEASURE
Loss of prime at start up	Vent line has liquid trap, preventing gas movement to separator.	**Slope the vent line from the pump to the separator so all horizontal portions have slope with no sagging, which could cause a liquid trap.**
	Vent line feeds to another line instead of directly into separator.	**Vent piping should be directly into separator above the maximum liquid level. If lines are combined, arrange valves and slopes so pump being primed has no liquid in vent line and has separator pressure.**
	Vent line closed.	**Open valves.**
	Pump started before completely filled with liquid or before cooled down.	**Follow "Start-up Instructions" carefully and allow ample time for system to balance and pump to cool down.**
	Pump started with discharge valve fully open.	**Throttle discharge valve at start up to almost shut-off and open it very gradually. Maintain pressure just less than shut-off pressure.**
	Suction valve not fully open or partly plugged.	**Open valve. Compare vacuum gage readings at pump suction and at separator when pump is running (but before it loses its prime). Reading at pump adjusted for liquid level in separator should be almost same as separator pressure.**
Loss of prime while pump is running	System demand reduced to zero because all coil, etc., shut-off. Pressure gage goes to shut-off pressure and loss of prime is slow.	**Energy used to circulate liquid within the pump raises temperature of liquid until it boils and forms gas at eye of impeller. Open the valve in the by-pass line. Make sure the by-pass line does not contain a relief valve (which would normally be closed). A minimum flow of approximately 10 GPM is required to keep NPSHR down.**
	System demand increased (as after a defrosting cycle), raising the NPSH required above the maximum NPSH available.	**Make suction line as large as pump suction and use low loss valve, properly located. Change system cycling to avoid periods of high capacity pumping. Install flow control to limit flow so NPSH available will be greater than NPSHR. Raise minimum level in separator or raise separator.**
	Compressor lowers pressure in separator (for a fast temperature draw down) to a point where pressure in the suction piping is lower than the vapor pressure of the liquids. This results in instant boiling.	**Reduce rate of temperature draw down.**
		Frequently temperature draw down and increased system demand occur together after defrost and combined corrective measures are required.
Re-priming difficult	One of a combination of above probable causes.	**When as many of the above measure as practical have been tried without success, an ejector system may be of assistance. For information on this, consult the factory.**

PROBLEM	PROBABLE CAUSE	CORRECTIVE MEASURE
Low pressure	Over capacity if a new system or if system has been changed.	**Check amperage and voltage. Compare with normal power demand. Higher capacity will require higher power. Evaluate system requirement.**
	Plugged pump vane(s).	**Check power – lower if less liquid being pumped. Clean impeller.**
	Restricted suction system.	**Make vacuum gage check as for Corrective Measure #6 and power check.**
	Oil in pump from drop leg or leaking seal.	**Check amperage and voltage. Compare with normal power. Oil in pump will increase power requirement and reduce pump capacity, thus reducing refrigeration capability. Drain off the oil. Locate oil source and correct.**
Motor overloading – new installation	Incorrect rotation.	**Check rotation – refer to "Start-up Instructions."**
Motor overloading – existing installation	Pump Selection wrong.	**Review system and consult factory.**
	Oil in pump.	**Check amperage and voltage. Compare with normal power. Oil in pump will increase power requirement and reduce pump capacity, thus reducing refrigeration capability. Drain off the oil. Locate oil source and correct.**
Oil leakage at seal gland	Outer mechanical seal is leaking	**Replace mechanical seal – see "Operating Instructions."**
Oil consumption high	Inner mechanical seal is leaking.	**Dismantle pump. After impeller has been removed, look for leakage at inner seal. If leakage is apparent, replace the seal following "Operating Instructions." If leakage is not apparent, pressurize the reservoir at refrigerant inlet with dry air or nitrogen to normal operating pressure. Connect and run the motor. Leakage may occur only when the pump is running.**
	Reservoir piston O-ring is allowing oil to leak into the pumpage side.	**Dismantle reservoir and examine the cylinder. If it has scratches, replace the cylinder.**

	PROBLEM	PROBABLE CAUSE	CORRECTIVE MEASURE
Mechanical seal failure	**Ruptured bellows**	Reservoir filled completely full with no reserve for oil expansion.	**Stop filling reservoir when indicator rod still projects .75 inch from the reservoir face.**
	Carbon seal washer pitted	Oil viscosity too great.	**Use lightest ice machine oil available and never heavier than grade recommended in "Start-up Instructions." Make sure the heater is working. Bronze seal washers generally appear to have better pitting resistance, but have greater oil leakage and wear. Some customers have had success with carbide washers running against carbide seats.**
	Refrigerant in oil	Sudden system changes causes surges that result in opening the inner seal, allowing pumpage to enter the seal chamber. Refrigerant in the oil degrades lubrication.	**Check by-pass line adjustment. If the sudden system changes cannot be eliminated, an external compressed air or nitrogen supply can be used to pressurize the reservoir – consult factory. See also corrective measure for "O-ring partly out of seal seat" (below).**
	Uneven wear of washer	Shaft may be bent. This can be done when removing the impeller unless extreme care is used.	**Shaft should be concentric within 0.002-inch total indicator reading. If shaft exceeds this, it should be straightened. (All shafts are checked at the factory when pumps are built).**
		Face of bracket or frame may not be square with the shaft.	**Face of bracket or frame should be within 0.004-inch total indicator reading. If this amount is exceeded, consult factory.**
		Piping loads have produced strain within the pump – localized wear showing on impeller wear surface.	**Check shaft and bracket as above. If these are correct, check piping to be sure it does not place stress on pump when installed and that piping has contraction provision which will prevent stress transfer.**
	O-ring partly out of seal seat	Sudden system changes cause rapid dynamic pressure variations outside the seal. Seat is pushed into seal chamber far enough for O-ring to be displaced into seal chamber.	**Follow "Hydrostatic Test Instructions" and "Start-up Instructions" exactly. In addition, check by-pass line adjustment and liquid level in accumulator.**

For technical support, please call our factory at (503) 653-0330. Technical support from Cornell engineers is available via phone between 7:00 A.M. and 5:00 P.M. Pacific Time, Monday through Friday, excluding holidays.

Please note: a seal replacement video is available from Cornell Pump Company and at https://www.cornellpump.com/refrigerant-seal-replacement/

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