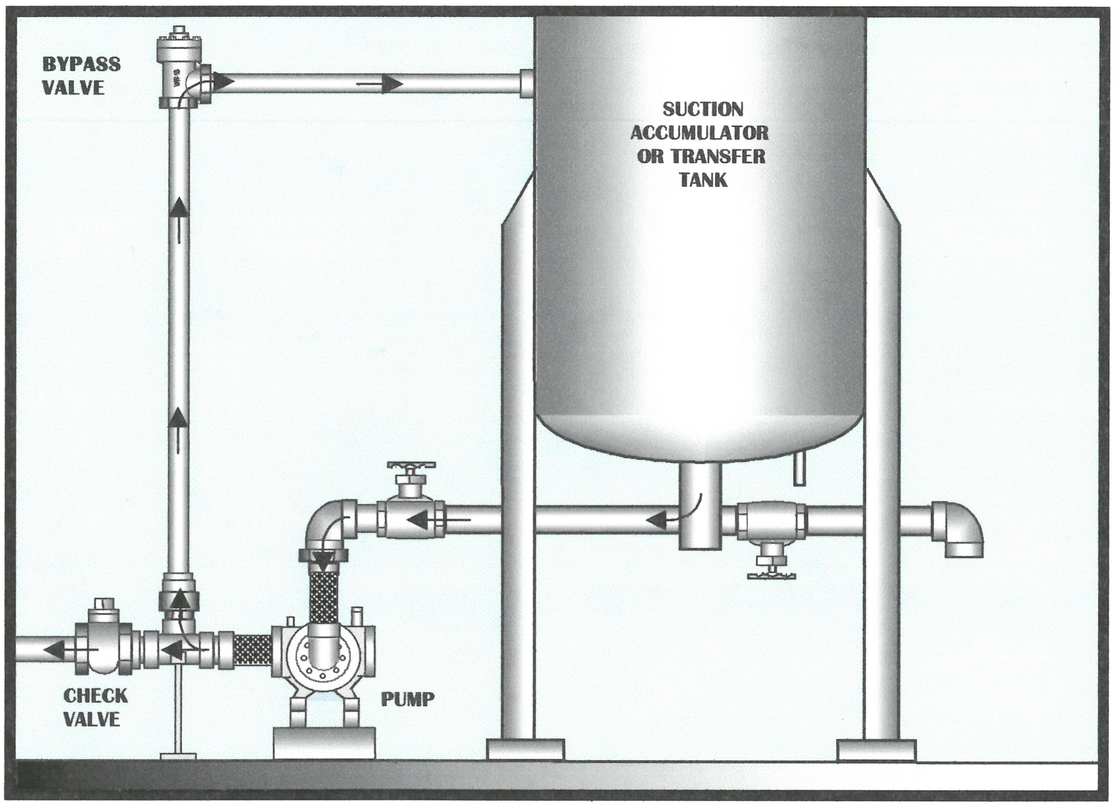
SMITH PUMPS

SMITH PUMPS USED TO VACATE NH_3 ACCUMULATORS

This discussion has to do with a type of intermittent transfer "stand-by" situation, involving Smith pumps used to vacate Anhydrous Ammonia accumulators. Although this use does relate in a sense to standard bulk transfer operations, its unique characteristics must be taken into consideration to be able to successfully utilize the installation.[1]



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[1] As a pump manufacturer, our viewpoint deals with recommendations for *pumping* equipment. However, it is just as important to consider in advance, all potential problems relating to each system component. This general guide, then, addresses what we feel are the most important issues involving our product line, as based on field experience; but it is not intended as a blueprint for a transfer system. *It is assumed that a proper engineering study will be done before initiating any such system construction, and that none of the construction materials will be chemically incompatible, or of improper configuration.* The proper use and application of all engineering principles, as indicated by appropriate texts and authoritative references, cannot be overemphasized. The Safety Authorities should be consulted, and their regulations given proper consideration. In addition, one should never overlook the manufacturers who can provide invaluable data on functional, compatibility, and safety aspects of the other equipment utilized along with the pumps.

This particular type of operation in question here, can be divided into three general categories, which have to do with the temperature and related pressure of the liquid supplied to the pump: (1) ambient temperature to -25° F.; (2) -25° F. to -40° F.; and (3) temperatures below -40° F.. Also, it should be noted that there are installations, which pump the liquid out of a "transfer tank" filled from the suction accumulator. Before starting the pump, the tank liquid inlet is closed, and its vapor phase is exposed to the discharge pressure of the "high side". The corresponding temperature of the colder liquid does not increase immediately. Therefore, the rapid pressure equalization results in a high temporary "artificial head pressure" above the liquid phase. This allows simple bulk transfer at nominal differential pressures, and can vastly reduce vapor accumulations. On the other hand, there are similar systems, which do *not* have this capability, and the pump is required to push against the total difference in pressures between the "low side" and the "high side". The pump utilized can be constructed for use within one or more of these temperature/pressure classifications.

The following important aspects of this service, will be covered under the following seven topics: (1) oil and debris in the product handled; (2) Static Head upon the pump; (3) the temperature and related pressure of the handled fluid; (4) the size and shape of the supply tank; (5) the differential pressure bypass system; (6) the use intervals for the pump; and (7) maintenance.

(1) OIL AND DEBRIS IN THE PRODUCT HANDLED. As in any liquefied gas recirculation system, there can be some common contamination, which is controlled in order to maintain normal operations. However, an inevitable contaminant, which is difficult to control, is the variable volume of insoluble compressor oil that is fed into the pump simultaneously with the Anhydrous Ammonia. Although the accumulator is made in such a way as to serve as an oil and heavy solids trap that is drained periodically, some of the oil and other debris will eventually pass through the inlet line to the pump due to the inherent use conditions and the state of liquid turbulence within the supply tank.

The exact amounts of oil and solids going through at any one time are practically impossible to predict in most cases. This has to be taken into consideration during the initial system design. It also must be taken into consideration when the pump is built. For example, the relative viscosity and density of the insoluble compressor oil can be many times that of NH_3. Given this condition, along with the prevalent use situations, even a standard liquefied gas line strainer *can cause excessive flow resistance* as it fills with the highly viscous contaminants which do not dissolve in the Anhydrous Ammonia.[2] They can accumulate, while traveling at a reduced velocity in the lower areas of the pipeline. They can actually displace the liquefied Anhydrous Ammonia in the inlet line while the pump is

[2] If there is no inlet line strainer, great care should be taken to remove initially any solid residues from a new system prior to using the pump. Likewise, if repairs or modifications are done to an existing installation, a thorough cleaning is required to prevent substances such as welding slag from remaining within the transfer system. Otherwise, they could eventually enter the pump causing extreme wear, or lock-up.

at rest. Therefore, under the worst conditions, the inlet line could completely fill with oily contaminants *prior* to the pump starting. This means that the pump might first have to handle pure oil, rapidly transitioning to extremely non-viscous liquefied gas. In addition, immediately following the initial acceleration surge in the pump inlet line, two distinct liquids with different flow characteristics would begin to interfere with each other. The Anhydrous Ammonia ("turbulent flow") constituent would initially start flowing at a higher velocity than it would in its pure state, through the reduced area partially occupied by the slower-moving ("laminar flow") oily residue. If this situation is not adequately taken into system design consideration, it will inevitably result in cavitating the pump whenever it started. The "dragging" of the oil, would then be responsible for "Net *Negative* Suction Head (NNSH)" upon the liquefied gas flow at the pump inlet connection.

Obviously, "Net *Positive* Suction Head (NPSH)", or "flooded suction" is essential for long-term successful use of the pump. When vapor is pumped with the liquid, both tend to separate and collect in two different areas, the vapor rising toward the upper pumping chamber, leaving the lower one to handle mostly liquid. This imbalance creates increasing torque demand, and may also cause the mechanical seal to chatter and bleed periodically. Audible effects caused by cavitation within the Smith pump usually manifest themselves as increasing functional noise beginning either as a low-frequency "rumbling", a series of loud "clicks", or a high-pitched "whining". However, *the collapse of vapor bubbles within the Smith pump, rarely causes immediate internal destruction.* Initial internal damage is usually minor, but could eventually be detrimental over several days or weeks. Two typically observed results, internal erosion (or "pitting"), and partial dry running, initiate in non-functional areas of the casings. Long-term chronic exposure to cavitation usually accelerates all normally observed wear patterns. For this reason *it is not recommended to run the pumps dry, or on boiling liquid.*

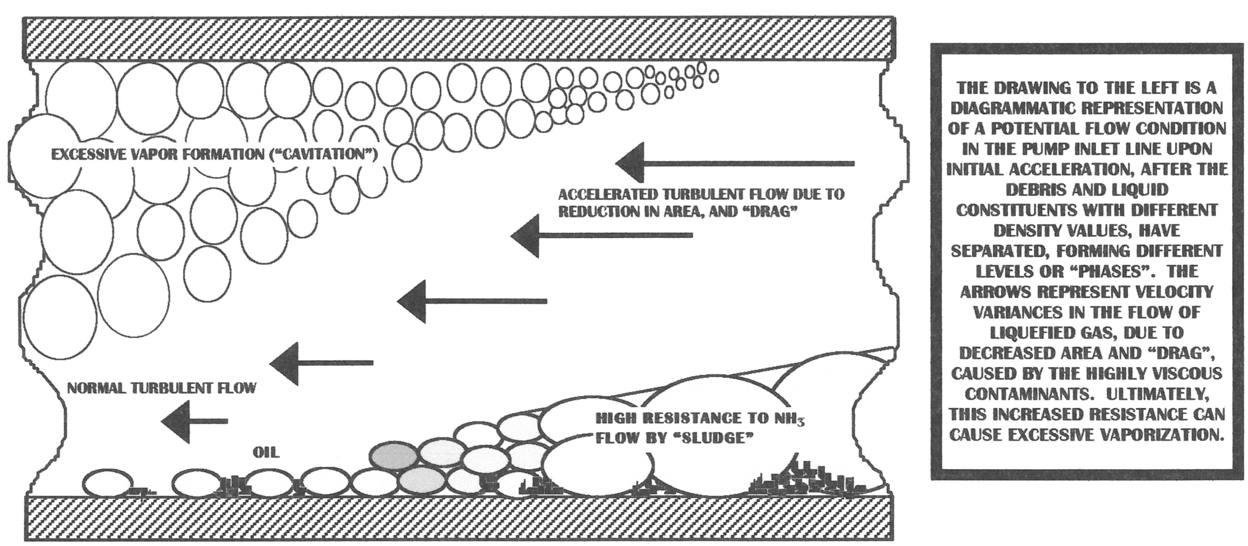
The effect of cold temperature may cause an increase in the oil viscosity of such proportions, that the pump would have to be modified to handle it. If the viscosity is above 110 CKS (500 SSU), the working clearances in the pump would have to be increased, and the drive speed would have to be decreased. Such modifications could be detrimental to pumping efficiency when handling pure liquefied gas, unless the required differential pressures were proportionately reduced. Likewise, a pump in this condition would handle vapor less efficiently. Obviously, the more oil there is, the worse the situation could become. The very worst scenario would occur when the pump first started, during the initial liquid acceleration up to the pump demand flow velocity. To counteract the inlet line "drag", the inlet line must be properly sized, and *there must be an adequate elevation between the minimum supply tank liquid level and the pump centerline.*

(2) STATIC HEAD UPON THE PUMP. The increase in pressure caused by elevation, or "Static Head", has been a long-term standard method to compensate for resistance to flow between the liquid outlet of the storage tank and the impeller(s) of the pump situated beneath it. All of the *homogeneous* liquids commonly transferred by Smith pumps have a

predictable increase in Static Head pressure, directly proportional to the liquid's density and its relative elevation above the pump suction connection. However, in the case of handling the contents of an Anhydrous Ammonia accumulator, the non-homogeneous fluid make-up is unpredictably variable. The oily contaminants not dissolved, have a much greater density, and viscosity, than the liquefied Anhydrous Ammonia. The interaction of these two substances causes an irregular factor of "drag" as they are simultaneously fed into the pump.

Therefore, even though practically all of the Static Head is due to the weight of the liquefied gas constituent, unlike most standard bulk transfer operations, *there is no inverse proportionality between the natural vapor pressure of the Anhydrous Ammonia, and the volume of liquid displaced by vapor formations in the pump inlet line.* The quantity of vapor formed would mostly be at variable levels *above* that calculated for pure NH_3. The worst cases would occur when there is a high amount of oil in the pump inlet line, the liquid temperature is below -25° F., and the natural vapor pressure is less than "0" PSIG. Before initial fluid acceleration to pump demand velocity, the two liquids usually have had time to separate. They have formed a pair of distinct phases, the oil occupying the lower of two fluid levels. These fluids have viscosity values at opposite ends of the spectrum. Even though the accumulator has been designed to collect insoluble oil, which is periodically removed, some of it keeps entering the pump supply line, and more will enter while the pump is in operation. Even if a strong magnet installed in the accumulator retains particles of ferrous origin, some of these and other solid contaminants may still mix with the oil, forming a dark-colored, semi-solid "sludge" or "slurry", especially over several years of operation.

POTENTIAL LAMINAR FLOW INTERFERENCE WITH TURBULENT FLOW



When the pump starts running, the drive mechanism (usually a directly-connected electric motor) instantly brings the pump up to speed (mostly either 1200 or 1800 RPM with a Smith pump). The lighter liquefied gas can flow much faster by gravity than the heavier oil and sludge. This in effect, reduces the turbulent flow area occupied by the Anhydrous Ammonia. Unless *"oversized"* pump inlet line components are used, and the Static Head is *"increased"* (both beyond that indicated by the usual method of calculation that assumes only the presence of pure liquefied gas), the pump will be chronically cavitated. At temperatures above +60° F., standard installation construction criteria would probably give good results, *provided there is a very minimal amount of oil present.* However, during the long useful life of the refrigeration system (one small part of which is the accumulator pumping installation), it is very likely that the handled product will become increasingly contaminated. The pump could be cavitated, unless the inlet line has been purposely *"oversized"*; and the *"increase"* in the minimum liquid elevation has been maintained. In order to assure "flooded suction", especially at temperatures below -25° F., it is not unusual for the minimum recommended liquid level to be no less than six feet above the pump, and for the pump inlet line components to be at least two sizes larger than those usually recommended for liquefied Anhydrous Ammonia. For every -5° F. or fraction thereof, below -40° F., an additional foot of Static Head is highly recommended. For best results in these extremely low pressure situations, the pump supply line should also be vertical, or slope upward from the pump toward the tank, throughout its entire length.[3] These precautions are due to the unique fluid qualities in these systems. The comparatively low pressure of NH_3 often reduced to a vacuum, can cause unusually high vapor displacement from seemingly minor flow restriction, turbulence, suction, heat gain, or back flow factors.

For example, if the check valve in the pump outlet line fails to seal *completely* against back flow from the "high side", the pump can totally fill with vapor during disuse. Depending upon the intervals between uses, the lowest pressure in the pump supply tank, the drive speed, the differential pressure requirements, and the optional pump modifications, the unit could either simply vapor lock, or slowly purge itself while handling excessive vapor during each use period. The resultant symptoms would be very similar to those caused by boiling fluid being fed to the pump inlet connection, due to insufficient "NPSHA".[4] "Blanketing" the cold liquid in the transfer tank, with hot vapor from the "high side", prior to starting the pump, is a method of compensating for insufficient "NPSHA" (Net Positive Suction Head Available) while the pump is functioning. However, the pump could still be exposed to highly detrimental conditions upon start-up, by being filled with vapor and liquid contaminants *before* initiation of the pressure balance cycle.

A transfer system set-up in this fashion is somewhat more complicated than a "standard transfer" system. The vapor phase in the pump supply tank must be temporarily exposed to much higher vapor pressure from another source, during the liquid transfer sequence. This requires a critically timed control valve sequencing. The advantage is that the pump would

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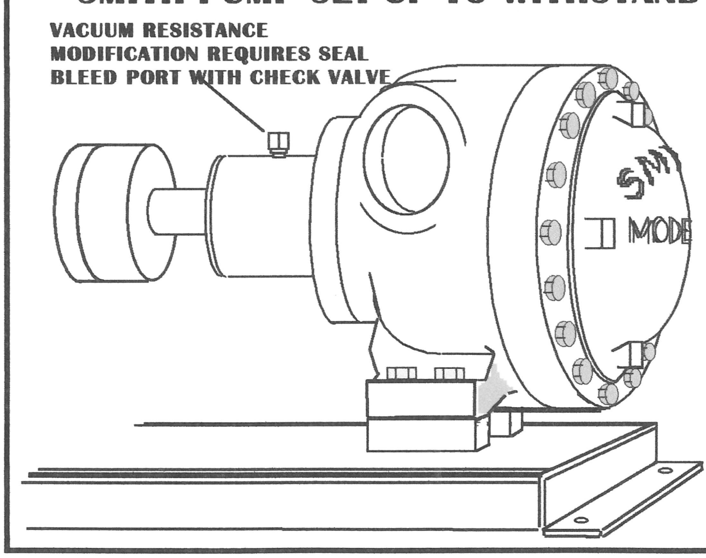
[3] See Bulletins "AL-3", "AL-17A", "AL-43", Booklet "A", and standard engineering texts for additional information on computing the Head Loss, and related subjects of concern.

[4] For this reason, the check valve should be periodically inspected, and repaired or replaced as required. Contact the manufacturer for additional information regarding proper inspection, repair and replacement procedures.

only have to work against a nominal line loss from the outlet piping, as opposed to overcoming a more substantial difference in system pressures, which could approach 200 PSID. The disadvantage is that the control valves may eventually "stick", chronically exposing the pump to excessive differential pressures and resultantly shortened service life. Many of these systems are in use at temperatures below -25° F., which result in natural vapor pressures lower than atmospheric pressure, and extremely high oily contaminant viscosity. In these situations, the pumps by necessity are modified to handle the oil as well as the Anhydrous Ammonia, and must therefore be run within narrower speed and differential pressure limitations. If the pressure balancing sequence should fail to occur in time, once the pump begins to handle primarily liquefied gas, its internal modification and lower speed would require it to remain "on" for an excessively extended interval, which would increase internal wear factors. *In order to avoid such occurrences, the pump must be used carefully, in a well-maintained system.*

(3) THE TEMPERATURE AND RELATED PRESSURE OF THE HANDLED FLUID. As mentioned previously, there are three temperature-related categories, each with specialized use conditions, for the "stand-by" vacating of liquid Anhydrous Ammonia accumulators. All relate to the natural vapor pressure and related temperature of the liquefied NH_3 handled. These two factors determine the viscosity of the insoluble oily contaminants, and whether the pump will be exposed to a vacuum. It has already been explained that if the temperature drops below a certain limit, the resultant viscosity increase of the oil will require pump modifications. It has also been noted that even with these changes, there could still be longevity problems involving improper use within the resultantly narrower margins of application. Likewise, at lower temperatures less than -25° F., the absolute pressure (PSIA) of the NH_3 can be less than atmospheric pressure ("0" PSIG). The pump must then be modified to *withstand* a vacuum. Smith pumps can easily be adapted for this service, and will *withstand* these special service conditions to 4 PSIA (about 22 in. "Hg Vacuum", or 28 "Kpa Absolute"), in both running and non-running modes.

SMITH PUMP SET-UP TO WITHSTAND VERY LOW INLET PRESSURE

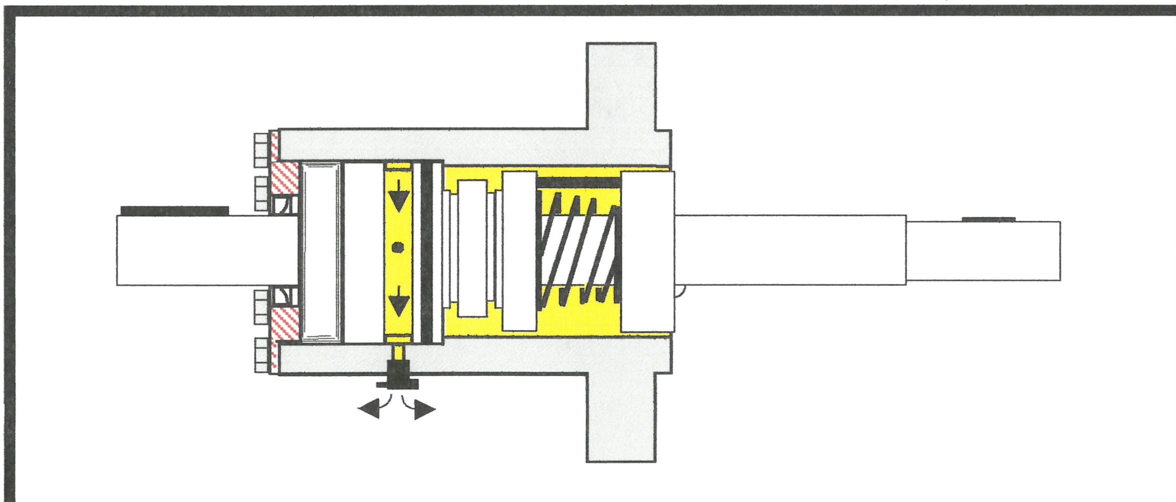


THE DRAWING TO THE LEFT SHOWS A TYPICAL SMITH MODEL "MC-2S NSSA" UNIT USED FOR ANHYDROUS AMMONIA TRANSFER, AT TEMPERATURES BELOW -25°F.. NOTE THE FITTING INSTALLED IN THE SHAFT END COVER AT THE 12:00 POSITION. THIS IS A CHECK VALVE WHICH PREVENTS THE ENTRANCE OF MOISTURE AND AIR PRESSURE INTO THE LEAK DETECTION PORT OR "SEAL BLEED PORT" DURING SUCH TIME AS THE PUMP IS EXPOSED TO A VACUUM. THIS IS THE ONLY EXTERNALLY-VISIBLE INDICATION THAT THE PUMP IS PROPERLY MODIFIED TO WITHSTAND EXTREMELY LOW LIQUID VAPOR PRESSURES.

Smith pumps with standard seal assemblies should always be exposed to positive gauge pressures. Smith pumps modified for vacuum resistance while handling liquefied gases, *should never be required to pull a vacuum*, or be exposed to absolute pressures less than 4 PSIA. If the installation must be evacuated at pressures lower than the pump design capability, the pump must be properly isolated from the rest of the system. If a Smith pump is exposed to negative pressure values beyond its capability, air and moisture will work into the pump, causing damage to it and possibly further contaminating the system. This would happen especially if the seal assembly is exposed to inlet pressure only. In these applications involving very low gauge pressures with liquefied gases, the pumps should always be run in the corresponding rotational direction for *outlet* flow surrounding the mechanical seals.[5]

Mechanical seal failure can be the first *noticeable* problem occurring with the pump. The discharge path of a typical seal leak is illustrated in the drawing, below. The rotary seals, which protect the ball bearing, force any leaking product to exit the pump casing as shown.

When the pump is exposed to extremes of internal stress beyond its design limitations, it will eventually expose the mechanical seal assembly to fluid with reduced beneficial qualities. Excessive reduction in the lubrication and cooling provided to the mechanical seal assembly by the pumped liquid, will result in adverse cumulative frictional effects. These effects interfere with proper seal face contact, manifesting themselves in an easily observed sporadic leakage out of the "leak detection port". This is due to mechanical seal



SEAL BLEED EXIT CHANNELING IN THE SMITH PUMP PROVIDES A "LEAK DETECTION PORT" WHICH IS USED TO VERIFY MECHANICAL SEAL SEEPAGE

TEMP.	PSIA
-50° F.	7.7
-45° F.	9.0
-40° F.	10.4
-35° F.	12.0
-30° F.	14.0
-25° F.	16.0
-20° F.	18.3
-10° F.	23.7
0° F.	30.4
+10° F.	38.5
+20° F.	48.2
+30° F.	59.7
+40° F.	73.3
+50° F.	89.2
+75° F.	140.5
+100°F.	211.9

** This table illustrates the approximate vapor pressure of NH_3 liquid, at various temperatures. It is only intended for comparative purposes. For exact values, see standard engineering references.

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5 Most Smith pumps are reversible, and as such can be run either clockwise, or counterclockwise, exposing the mechanical seal assembly to either inlet or outlet pressure. In any case, if the pump is exposed to exceptionally low fluid pressures while operating, it is advantageous to run it in the appropriate rotational direction for *outlet* pressure on the mechanical seal assembly. See Catalogs "CP-1", "CP-3", and Bulletin "AL-17A", or contact the factory for additional information.

"chattering".[6] In order to prevent rapid seal failure during an unexpected adverse vapor displacement episode, every precaution should be taken to protect the mechanical seals against excessive stress from this resultant obstruction of lubricating and cooling effects.

(4) THE SIZE AND SHAPE OF THE SUPPLY TANK. The size and shape of the supply tank actually do relate to this cavitational stress in the pump. They directly affect the available Static Head pressure, the amount of oil which may accumulate in the inlet line, and the amount of vapor displacement in the liquid fed to the pump inlet. Many of these tanks are cylindrical in shape and are vertically mounted. Theoretically, this allows a maximum of gravity head pressure gain, by maintaining the liquid phase at a higher relative position above the pump. However, in any such system the liquid remaining in the tank naturally continues to boil as the liquid phase descends. This inherent disadvantage is highly aggravated when the capacities of these vertical tanks are comparatively low. If not artificially pressurized with "high side vapor" prior to starting the pump, the accentuated vapor displacement and resultant turbulence continue to feed vapor and contaminants into the pump inlet line. *Keep in mind that in these cases the area of fluid boiling may extend far below the liquid level.* No matter what the liquid elevation is, if the liquid phase surface area and/or tank capacity are too small, there will be excessively forceful, rapid vaporization of the remaining liquefied NH_3. The pump will be increasingly cavitated as the liquid phase descends. A running compressor open simultaneously to the vapor phase of the tank, will aggravate this problem, as would a simultaneous discharge of product back to the same tank.

The most serious vapor formation occurs as the liquid in the pump inlet line initially accelerates, especially when the supply tank is of a relatively small size. Adding to this the presence of oil, the potential for turbulence, the possible vortex ("chorialis acceleration") aggravated by the small diameter of a vertical tank, and the effects of sub-zero temperatures on gauge pressure and contaminant viscosity, there is a high potential for pumping difficulties *unless the design and use parameters have taken these aforementioned trouble causes into consideration.* Unfortunately, the oil and the debris will inevitably build-up within the accumulator. It should be periodically drained, but even so, some contaminants will always make their way into the pump inlet line. Therefore, it can

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[6] All Smith pumps are provided with a shaft seal "bleed port" or "leak detection port", as a safety conduit for any mechanical seal leakage to bypass the outboard ball bearing, and to be readily detected during a product leak sequence. It is protected either by a small check valve having the appearance of an adapter fitting, or by what appears to be an oil fill cover (as in the previous drawings on page 6 or page 7). *This port is <u>not</u> for lubricating the ball bearings, which are permanently sealed.* Many times, if leakage is detected from this area, it is an external manifestation of an improper internal pump condition, which should be immediately investigated. In a properly-designed and properly-used installation, the mechanical seal assembly does not usually have to be replaced. If there is a seal failure in a pump which drains an Anhydrous Ammonia accumulator, this is usually indicative of an internal pumping problem related to cavitation, and not simply because the seals have worn-out on their own. *Should a seal leak occur, the seal assembly must be immediately replaced, and the cause of its failure should be immediately investigated.* Do not plug or obstruct the "bleed port" in any way. See Bulletin "AL-17A". Contact the factory for additional information.

be said that *if everything else remains unchanged, the larger the pump supply tank is, the less damaging the effects of vaporization and impurities will be in the pump.* Usually, the greatest possibility of excessive turbulence and vaporization occurs when the pump is fed *directly* out of the accumulator. An alternate liquid supply method is by a separate "transfer tank" gravity-filled from the accumulator. It can be isolated from the "low side", and pressurized with "high side" vapor. This improves the quality of liquid by temporarily increasing the "Net Positive Suction Head Available (NPSHA)" at the pump inlet. In either case, it is important to utilize a tank which always has adequate *liquid surface area as well as volume.*

Generally accepted sizing parameters for *horizontal* tanks indicate that the volume of pump output per minute should remain at no more than 2% of the total supply tank capacity. This should eliminate excessive vapor formation when the tank is not artificially pressurized. In other words, if the calculated capacity of the pump were 20 USGPM, the total volume of a horizontal supply tank would have to be at least 1000 USG.[7] Depending upon the design of the tank and its installation, if the same 1000 USG capacity tank were mounted vertically, the same vapor phase volume over a *lesser* liquid surface area with greater elevation, could either improve or worsen the fluid quality in the pump inlet line. If the vapor phase of the tank is not artificially pressurized from the "high side", a larger pump supply vessel *containing more liquid,* whether vertical or horizontal, (1) would have the effect of lengthening the time required to decrease the liquid level, (2) would lessen the potential for vapor formation and extreme turbulence in the exiting fluid, and (3) would increase pump service life when continually exposed to the same adverse system-related factors.

(5) THE DIFFERENTIAL PRESSURE BYPASS SYSTEM. One safety item which should never be overlooked is the back-to-tank differential pressure bypass system. The purpose of the bypass valve in this system is to insure that regardless of the functional circumstances, any excessive pump differential pressure will be harmlessly discharged back to the supply source without overtaxing the pump, and without allowing *external* venting of Anhydrous Ammonia to atmosphere through the safety relief valves. Even if the pump has an internal bypass valve, the pump outlet line should still be provided with an *external* bypass valve, to prevent unnecessary self-cavitational pump damage in the event of an excessive differential pressure situation. Given the presence of highly viscous insoluble oil, it would be possible for the transfer pump with an obstructed outlet line, to build an extremely high differential pressure that could possibly open the hydrostatic relief valves and / or cause damage to other components in the pump outlet

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[7] *This is provided that the proper "NPSHA" criterion is met, as previously discussed.* Obviously, if there is a condition present which still allows excessive vapor accumulations into the pump inlet connection, the pump cannot be properly utilized. For this reason, the tank liquid level and volume *should always be properly matched to the use conditions. The tank liquid level should never approach that of the pump inlet line connection, before the pump is shut-down.* This will help to prevent many of the adverse conditions that cavitate pumps and ultimately result in mechanical seal failures. See Bulletins "AL-3", "AL-17A", and standard engineering texts, for additional information.

piping system.[8] The setting of the bypass valve should be as minimal as practical, but at least 10 - 15 PSID higher than the maximum pumping installation design differential pressure.[9]

(6) "ON" TIME INTERVALS FOR THE PUMP. We have been discussing the relevance of differential pressure to safety considerations. It is also very important that the "RPM vs. *run-time* vs. PSID" be properly matched. The shorter the use interval is, the higher the differential pressure can be. The following shows several applications of Smith pumps within corresponding parameters, handling liquid Anhydrous Ammonia with oil at temperatures between 0° F. to +100° F.. The oil viscosity is at less than 110 Cks..[10]

MAXIMUM APPLICATION LIMITS FOR "ATC, MC, AND SQ-SERIES" SMITH PUMPS HANDLING LIQUEFIED ANHYDROUS AMMONIA W/ OIL OF LESS THAN 110 CKS VISCOSITY, *FROM 0° F. TO +100° F.*

Max. Use Interval	Recommended RPM	Max. PSID	Model Type	Optional Features
3 Min.	1400 -1800	250	SNSSA	L or H, F
7 Min.	1400 -1800	225	SNSSA	L or H, F
10 Min.	1400 -1800	200	SNSSA	L or H, F
13 Min.	1400 -1800	175	SNSSA	L or H, F
17 Min.	1400 -1800	150	SNSSA	L or H, F
20 Min.	1400 -1800	125	SNSSA	L or H, F
20 Min.	1100 -1300	80	HSNSSA	F
45 Min.	1400 -1800	100	SNSSA	L or H, F
2 Hrs.	1400 -1800	40	Std.	NS,SA,H,L,S,F
2-1/2 Hrs.	1400 -1800	75	SNSSA	F
6 Hrs.	1100 -1300	60	HSNSSA	F
Over 6 Hrs.	750 -1000	40	HSNSSA	F

This table serves as a general basic application guide. See the Pressure-Temperature table on pg. 7. *Contact the factory for additional information regarding acceptable parameters for pumps used at different temperatures.* These pumps can be reduction-run or direct-connected to electric motors. Before using pumps under these conditions, be sure to read and understand all available information in this bulletin, and others. Avoid hazardous use conditions.

These units can utilize gear reductions, and can also be belt-driven. Consult with the factory for additional information covering ranges of "RPM vs. run-time vs. PSID". It is very important to match these three factors, as per factory recommendations. Otherwise, the pump in question will wear out faster than what we would consider acceptable. There are

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8 A basic bypass system illustrating general principles only, is shown in the diagram on the first page of this bulletin. Be sure to avoid potentially hazardous situations. *Be sure that a proper engineering analysis is done.* Follow all applicable local, State, and Federal safety regulations. Consult with the manufacturers of the equipment utilized in these systems for additional information regarding excessively high pressures, and related subjects of concern. Be absolutely sure that the system in question is properly designed, and safe to use. Be sure that the bypass valve is designed to be used in these kinds of services.

9 See Catalogs "CP-1", "CP-3", "CP-9", "DBV-L", Bulletins "AL-17A", or contact the factory for additional information.

10 These figures are different for *pure* Anhydrous Ammonia liquid. Other conditions under these circumstances may require different limitations. Contact the factory for additional information on the same pumps which are used under different temperature conditions or when the oil has a viscosity rating above 110 Cks.. The highlighted area in the table represents the *only* instance where a standard pump can be used.

certain construction configurations, which directly relate to the severity of wear that could occur during the projected use intervals. These are indicated by "Designation Codes", which are stamped on the pump immediately following the basic model number. Be sure to supply complete information so the factory can recommend the appropriate "Model type" with "Optional Features", as shown in the preceding table. This will achieve the longest service life. The "S", "NS", and "SA" configurations are frequently recommended for the pumping applications covered in this discussion.[11]

EXPLANATION OF CONSTRUCTION CONFIGURATIONS USED IN DIFFERENT LIQUEFIED ANHYDROUS AMMONIA SMITH PUMP "MODEL TYPES" AND "OPTIONAL FEATURES".

Designation Code	Description
S	Extended temperature, pressure, and/or viscosity range
NS	High range gears: AIRCRAFT QUALITY STEEL
SA	Enhanced stress-resistant idler shafts: TUNGSTEN CARBIDE
H	Maximum flow gearing: for LOWER RPM APPLICATIONS
L	High-capacity standard configuration gearing: 25% INCREASE
F	Flanged ports: provided with SMITH COMPANION FLANGES

"Optional Features", and "Model Types", are factory designations determined by pumping requirements. The basic model number stamped on the pump will be followed by any of the pertinent "Designation Codes" mentioned above. Together they make up the use-specific pump model number. The "Z" Designation Code, a further refinement suitable for LPG and low-pressure liquid Carbon Dioxide mechanical seal assemblies, is not compatible with Anhydrous Ammonia services.

(7) MAINTENANCE. Some pumps may seem to last longer than others. In reality, just as any other mechanical device, transfer pumps that do last the longest length of time are *always used and maintained in accordance with the manufacturer's recommendations*. Since the pump is lubricated and cooled by the product handled, it will properly resist long term wear if it is supplied with "good quality" liquid.[12] Subsequent analyses of used pump wear patterns show that many failures are aggravated by the fluid transfer conditions within these systems which are highly variable. This is due to the accumulating debris, oil, moisture, and the interactions of other equipment used simultaneously in the same refrigeration system.

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[11] However, such modifications are not the answer to abusive conditions beyond design limitations. When consulting with the factory, have *complete* information about the specific transfer situation at hand. Only in this manner can the proper model, at the correct drive speed range, be recommended.

[12] In the light of this discussion, "liquid quality" is defined as the handled fluid's comparative capability of imparting certain beneficial factors. It can be quantified by measurement, or degree, of the *observed state or consistency of its effective "thermodynamic" or "physical" characteristics, as opposed to its apparent properties.* Once the installation acts upon the liquid in question, its "qualities" may change, and can even become unpredictable.

Therefore, there really can be no specific instructions, which would exactly pertain to every contingency in every accumulator pumping installation. The replacement parts, which must be on hand, and the maintenance intervals required, can only be determined by periodically inspecting the pump and other devices, and taking action accordingly.[13] We suggest that the end-user make a routine periodic inspection of the pump and the transfer system, after only a short use interval, to determine areas of potential wear and accumulation of contaminants, keeping in mind that these situations tend to progressively worsen until the refrigeration system is cleaned and recharged. Based upon this, the user can keep on checking, until significant wear is discerned, but *before a significant loss occurs in handling efficiency*. At that point, the *maximum* parts replacement interval has been determined for the pump. From that point onward, the *preventive* parts replacement must be done at <u>half</u> the determined *maximum* parts replacement interval.[14] *Please refer to Bulletins "AL-1", "AL-3", "AL-93C", "AL-97", and other appropriate literature, before repairing pumps. Avoid potentially hazardous situations. Before disassembling a pump in any way, be absolutely sure to depressurize the pump safely, and to properly isolate the pump, or remove it from the system, in accordance with company safety procedures, and all applicable local, State, and Federal safety codes.* [15]

The pump interior can be inspected, once the bolts are removed from around the "main housing", or "secondary gear housing" perimeter. Insert a screwdriver, or some other such blunt instrument with the appropriate thickness, into the seam between the cover and gear housing. Apply a twisting motion by hand with the instrument in several places around the circumference, separating the mating faces, and allowing disassembly of the two casings. In older units this may not be easily accomplished by hand; in such cases, lightly tap the end of the disassembly instrument with a hammer, while it is placed in several positions around the circumference of the two casings, until face contact is broken, and the gear end cover can be removed. *Be careful not to damage the casings or the mating surfaces.*

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13 We highly recommend that the manufacturers of the other equipment utilized in these systems be consulted with regard to maintenance, and that their recommendations be followed. As far as the Smith pump is concerned, please see Bulletins "AL-17A" and "AL-97" for additional information.

14 In other words, the inspections should be made at regular intervals determined by periodic observation of the pump interior. Each set of use conditions is different. Specific parts replacement time frames can only be determined by inspections accomplished at progressively extended periods, until significant wear is finally observed. Repair intervals may have to be readjusted, later on due to accumulating impurities and increasing wear. See Bulletin "AL-97".

15 *Never use the pump for any other service, or in any other way, than originally specified by the manufacturer.* Do not allow the pump to "Dead Head", dry-run, or go "hydrostatic". Avoid rapid blow-down situations. Do not allow the pump or system to fill with water. *Do not handle Aqueous Ammonia with the pump.* Avoid ice expansion and excessive moisture absorption by the NH_3 within the pump, and the system. Depressurize the system carefully, and safely, and isolate the pump properly, before disassembling it in any way. Avoid "wind milling". Do not pound on it. Clean the casings thoroughly. Apply the appropriate casing sealant in the recommended manner before reassembly. Contact the factory if there are any questions. Also, contact the manufacturers of the other equipment used in the transfer system, regarding any of the abovementioned situations, and be sure to read their literature. See Bulletins "AL-17A", and "AL-97".

The gear set should be inspected first. Critical wear can normally be visualized by comparing the working side of the drive gear teeth to the non-working side. If there is a visible difference in shape between the profile, or "curvature", of the two sides of the drive gear teeth, the gear set must be replaced. If maintenance personnel continue to replace the gears before they become excessively worn, a subsequent periodic inspection will usually reveal no functional casing wear. Visible wear by the gears into the corresponding bore diameters, end cover, and housings, normally occurs when the pump continues to run with excessively worn gears. Exceptions to this might happen if the liquid is unusually contaminated, or if the pump is chronically exposed to cavitational stress as previously discussed. If *excessive* casing wear is readily observed, it cannot be remedied by simply replacing some parts. In that case, the pump definitely has to be replaced.[16] Order an "exchange pump", and send the old one back for "exchange credit".[17]

Given the many variables at hand in a typical accumulator vacating application, the pump can see unpredictable ranges of conditions. By necessity, the pump must have application "flexibility" and even so, must be capable of being upgraded to match any changing installation requirements. Obviously, there is a valid case made here for the positive displacement nature of the Smith pump, which when properly applied as per factory recommendations is basically *unaffected* by variable density, temperature, and viscosity values of non-contaminated homogeneous fluids. The users should, therefore, make themselves aware of any detrimental pumping condition, as soon as possible, by doing the preventive maintenance inspections on a regular basis. A simple "spot check" done in time, will normally reveal potential internal problem conditions *before* they have a chance to cause irreparable damage. This gives the user ample time to repair or to modify the pump assembly, and to correct any installation problem, *before* it becomes critical to system function.

Eventually, in most of these installations, the handled product will become excessively contaminated with substances such as moisture, debris, and insoluble oil. It will have to be purified, or replaced.[18] Be sure to follow all correct procedures and applicable safety regulations for removing the contaminated refrigerant, and cleaning it or disposing of it properly, as well as cleaning, purging, and recharging the system. Periodic inspections of the system and the transfer pump will actually help to reveal detrimental liquid conditions, before they become critical. Proper understanding of what affects the pumps as they are operated in their particular installations, will explain why they last as long as

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16 The casing wear can be measured with a feeler gauge, to determine if the wear is excessive. Usually, excessive casing wear is easy to determine visually, by carefully observing the gear "pocket" ends, and diameters. Please see Bulletin "AL-97", for more specific information.

17 See Bulletin "AL-1", or contact the factory, for more information about the Smith pump "Exchange Plan".

18 Some refrigeration systems are only used seasonally. In such cases, if the system is annually drained, *the pumping installation should never be left open to atmosphere, or be completely voided of positive pressure.* Otherwise, air carried moisture will condense and concentrate within the transfer system, resulting in accumulations of water, rust, and other atmospheric exposure-related contaminants. Contact the Safety Authorities and the other equipment manufacturers for additional information with regard to proper maintenance and safety procedures during prolonged non-operational periods.

they do, and what can be done to increase their durability.

It is interesting to note that even as the pumping conditions continue to grow ever more demanding, the life expectancy of an average Smith pump is actually increasing. This is a direct result of our ongoing analyses of used Smith pumps, returned to us under the Exchange Plan. We have substantial renewing physical evidence on hand, which enables us to closely follow the evolution of pump market serviceability trends. As a matter of fact, this unique, invaluable up-dated information readily supports our technological advancement in the design and materials of construction that affect the Smith pump's performance.

SMITH PUMPS

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