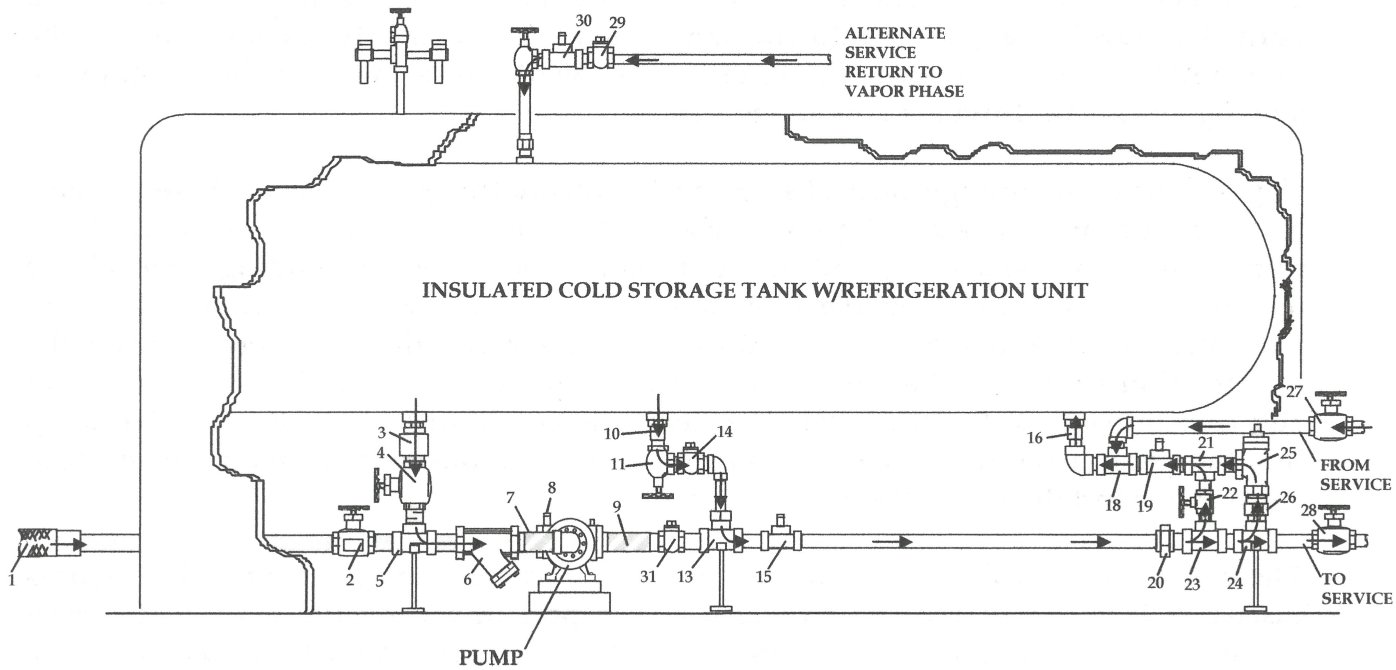
SMITH PUMPS

PUMP VAPOR LOCK PROBLEMS WITH CO_2 RECIRCULATION

<u>IMPORTANCE OF PROPER INSTALLATION DESIGN</u>. Pumps intended for handling low-pressure *liquid* Carbon Dioxide, do not generally handle CO_2 vapor very well. Many transfer systems have been constructed without giving sufficient consideration to this aspect. Most pump vapor lock problems can easily be avoided by simply following a few basic principles, as illustrated in the drawing, below.[1]



Note these important aspects:

(A) The pump is at the lowest point in the inlet line, always *below* the bottom of the receiver, and *below* the minimum liquid level in the tank. Liquid should never be supplied through a top outlet, or end outlet, with a standpipe or curved tube, which approaches the bottom inside the receiver. The pump liquid supply outlet is directly through the *bottom* of the receiver.

(B) The pump is protected from abrasive particulates by a properly-sized strainer (6). The strainer should be designed specifically for this service. It should have a minimal

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[1] See Technical Bulletin "AL-93", engineering texts, and other authoritative references, for additional information. The drawings in our literature illustrate general principles, and are not to be taken literally.

pressure drop, while being capable of removing particles as small as 0.006 - 0.008 thousandths of an inch.[2]

(C) The pump suction line is short and simple, consisting of a few short nipples, union, coupling (3), shut-off valve (4), tee (5), strainer (6), and optional flexible connector (7).

(D) Any high points in the pump inlet line, which do not allow accumulating vapor to immediately return to the supply tank, will become vapor traps. Any inlet line, which is excessive in length, will also become a vapor trap. The *short* inlet line shown, which should never be more than 10 - 12 feet long, normally does not serve as a vapor trap. The liquid remaining within it is always close enough to the tank to stay adequately refrigerated. Throughout its entire length, the liquid can only travel toward the pump either *horizontally,* or *straight down,* and any vapor formed in this line would normally travel straight up into the tank before it had overly accumulated in the horizontal section. A better design, of course, would have the inlet line continually sloping *downward* from the tank to the pump.[3]

Vapor formation through heat absorption is potentially aggravated in these systems because the low-pressure liquid Carbon Dioxide is artificially maintained by refrigeration, at about 0° F., and that is usually below the surrounding atmospheric temperature. Even though the lines are well insulated, when the liquid does not circulate, and critical areas of the suction and discharge lines are *too far* from the refrigeration system in the tank, they will pick-up heat, allowing for vaporization of any remaining liquid. Under extreme heat gain conditions, vapor actually backs-up into the pump from the outlet line during non-use periods, unless an approved check valve (31) is installed after the pump.

(F) There is a bypass valve (25), supplied by a tee in the pump outlet line. The bypass discharge is directed into the *dedicated* return port in the supply tank, sufficiently removed from the pump supply connection. *It is never piped back to the pump suction line, or to the vapor connection servicing the safety relief valves.* The maximum recommended setting of the bypass valve is 40 PSID, but *the system design differential pressure should be kept below 30 PSID.* In a sense, the bypass valve, properly utilized, is a passive safety device: it helps to prevent over pressurization of the outlet lines without product discharge to atmosphere.[4]

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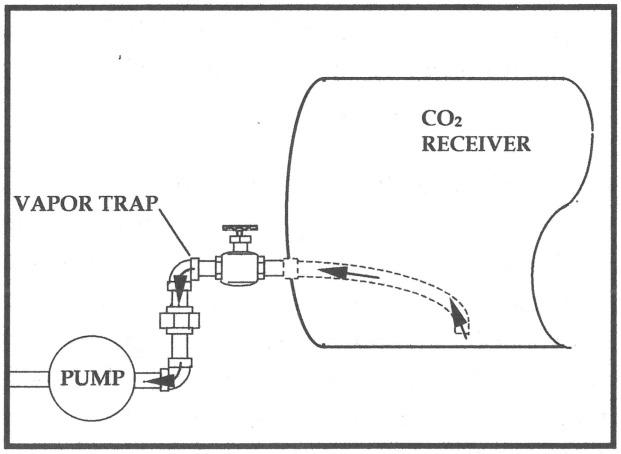
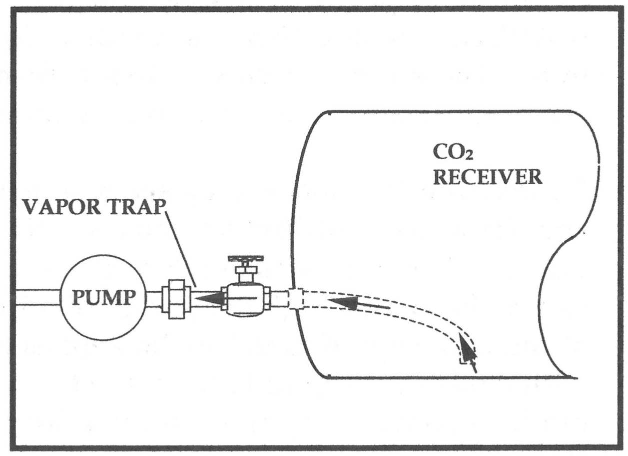
[2] The SMITH "W-Series" strainers with their 80-Mesh reinforced stainless steel screens, are ideal for these applications. They are designed for minimal pressure drop, and are supplied with *flanged* access to the screen. See Technical Bulletins "AL-40", "CP-6", Catalogs "CP-1" and "CP-3" for additional information.

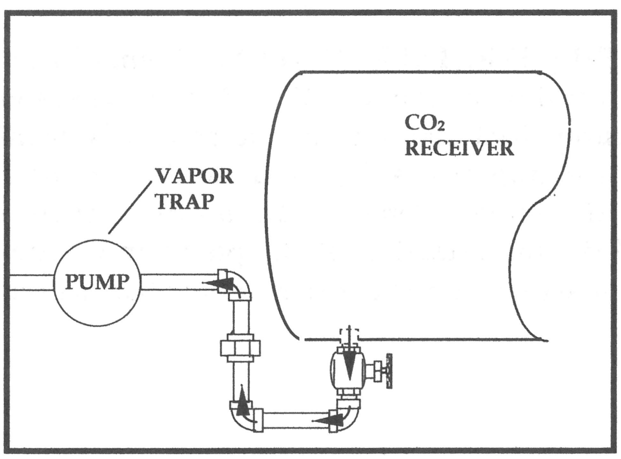
[3] If the inlet line sloped upward from the tank to the pump, it would allow excessive vapor to accumulate in the pump during non-use periods.

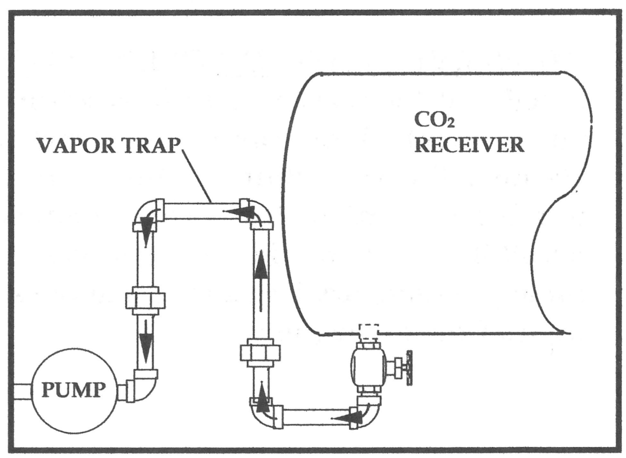
[4] SMITH "WW-Series" bypass valves are ideal for these applications, and are U/L listed for CO_2 service. They have a fully-adjustable stainless steel spring, stainless steel guide-piston, and incorporate a unique flow-evening dissipation plate. The SMITH "WW-Series" bypass valves can even be utilized for continuous metering. See Catalogs "CP-1", "CP-3", "DBV-L", and Tech. Bulletin "DBV-1" for additional information.

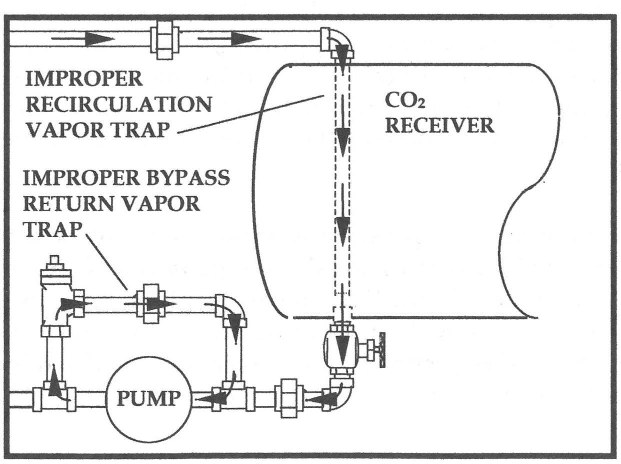
EXAMPLES OF IMPROPER SYSTEM DESIGN. **Typical examples of improper piping for low-pressure liquid Carbon Dioxide recirculation systems, are shown below. Note that from beginning to end, the pump inlet line must *never* occupy any position, which is higher than its point of origin. It should never run above the lowest liquid level. It should be designed so the liquid always travels either downward or horizontally, on its way to the pump inlet connection. Neither the loop return discharge, nor the bypass valve discharge, should ever be in close proximity to the pump liquid supply flow. *Absorbed heat must always be able to dissipate in the receiver before the liquid is handled again by the pump.***

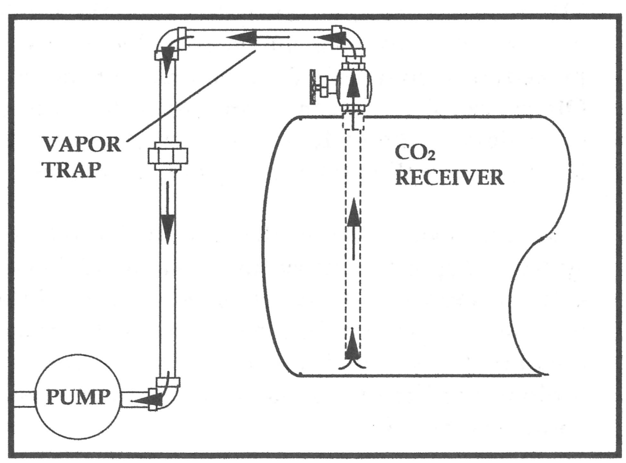












In addition to the most common sources of pump vapor lock problems illustrated, there are other potential sources of excessive suction line vaporization, which are less obvious.

CORIOLIS ACCELERATION. There are natural interactive relationships between the Earth's rotation, hemispherical location, and product density, aggravated by exiting flow velocity and frictional factors, which produce a whirlpool, or "Coriolis acceleration", further defined as a localized, flow-related, interface-destabilizing vortex above the fluid exiting the pump supply tank, where centrifugal action forms a "funnel" through which the vapor in the tank acquires a dynamic level below its measured static height. In a typical installation where there is another liquid supply to the use point, which bypasses the pump, there can be two whirlpools forming simultaneously in the same tank. Whirlpools can highly contribute to pump cavitation and vapor lock problems.

Controlling this factor may seem somewhat complicated, because it is affected by several simultaneous contributive causes. Never the less, since whirlpools worsen as the flow velocity increases at the tank outlet, the key to their control rests with the relative speed of exiting liquid through the pump inlet line connection at the supply tank. Fluid velocity out of the tank should therefore be kept as low as possible, especially when the pump is started with a minimal liquid level in the tank (less than two feet from the bottom). This situation can be aggravated by the continual loop return, and by the bypass return, if the integrating flow stream provokes rotary motion in the stored liquid.

EXCESSIVE TRAPPED SOLIDS WITHIN THE STRAINER SCREEN. It should be duly noted that the resistance to flow within a typical wye strainer utilized in these systems, is not constant. From the moment that the pump first starts, until the screen is eventually cleaned, the restriction continues to increase unpredictably, as a randomly increasing number of particulates become trapped in the screen element. In addition, there is the possibility that should an excessively rapid depressurization of the pump inlet line occur for any reason, dry ice can form in the strainer screen and may excessively obstruct required liquid flow to the pump. [5]

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[5] When it becomes necessary to vacate the product in the pump and its inlet line, depressurization should be done slowly through a small controlled orifice, such as that provided by an approved, 1/4" needle valve. This procedure accomplished in this fashion helps to prevent excessive pressure drop in the area of discharge. Otherwise, dry ice can form inside the pump, and inside the strainer screen. This phenomenon occurs, regardless of the style or size of the spaces open to flow. The source of the Carbon Dioxide, or its purity levels, essentially make hardly any difference in such cases.

It should also be noted that eventual product contamination is impossible to avoid in an average transfer system. Typically, every time a standard low-pressure liquid Carbon Dioxide storage tank is filled from an external source, it always receives at least a little contamination. Production process residues, air, moisture, as well as component internal surface deterioration, all contribute to the particulate and acidic impurity accumulations, which can eventually become intolerable. The proper use of a recommended strainer will prolong the life of the pump and transfer system, but not indefinitely. See Technical Bulletin "AL-93" for additional details.

__IMPROPERLY SIZED PUMP INLET LINE__. The resistance to flow through the pump inlet line must be kept within recommended parameters.[6] Just as it is important to keep the line relatively short and simple, the nominal size of the pipe, fittings, and other devices must properly relate to the projected flow rate. As a general rule it is a good idea to insure that the minimum size of all components is at least the same as that of the pump inlet port. However, there are certain circumstances, which require inlet lines of larger size, especially due to the continuous use nature of these systems.

Also, each time the pump starts, the liquid at rest in the pump suction line must rapidly accelerate to attain a velocity commensurate with the flow demand rate. This momentarily higher flow velocity during initial liquid column acceleration affects the dynamics of inlet line flow, and may interfere with required liquid feed. As the motor accelerates, the initial fluid surge velocity can be more than double that of the figured pump output rate. In extreme cases unless the inlet line is appropriately sized, even with theoretically sufficient "N.P.S.H.A." (Net Positive Suction Head Available) at the pump inlet connection, the pump will still handle excessive vapor each time it is started.

__HEAT ABSORPTION IN THE PUMP INLET LINE__. If enough heat is absorbed by the pump inlet line during non-use periods, the pump can vapor lock on initial start-up, especially if the inlet line is too long. It is always a good idea to provide the pump piping with a means to eliminate potentially damaging vapor accumulations, which could occur even in a well-designed system. This can be accomplished by __*slowly*__ bleeding product to atmosphere through a small, approved 1/4" needle valve, either installed near the pump outlet, or directly into the 1/4" port at the top of the pump main housing.[7] Vapor can also be purged from the pump and inlet line without external venting, through the use of a hand-operated valve (22) which allows the pump discharge to pass directly into the bypass return line.[8]

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[6] Please refer to Technical Bulletin "AL-3" and other appropriate literature, for recommended pipe sizes for use with most Smith models. Contact the factory if there are any questions.

[7] Excessively rapid pressure discharge is detrimental. It can create obstructions inside the pump and inlet line. It can cause the pump to turn while the pressure is being relieved, which has the same internal effect as "dry running". Once dry ice forms in this manner, it can block the strainer screen, and fill the spaces between the gear teeth with solid product. This condition could last for hours before the dry ice finally sublimes. If the dry ice is still in these areas when the pump starts, there will be pump failures. However, by venting in a gradual, controlled manner, the pump will not be driven by product flow, and the pressure drop above the diminishing liquid phase will not be severe enough to cause a temperature drop that provokes product solidification in the pump and strainer, before all of the liquefied gas is vacated.

[8] See the drawing on pg. 1 of this bulletin. See Technical Bulletin "AL-93" for additional information on this and related subjects of concern. __*Always follow all applicable local, State, and Federal safety regulations*__.