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Solvent Handling:
DRY VS. LIQUID RING VACUUM PUMPS

Capture solvent vapors without internal lubrication

TUTHILL VACUUM & BLOWER SYSTEMS

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The most common and preferred vacuum pumps for handling solvents are Liquid Ring and Dry Pumps. Both types of pumps do not require internal lubrication which allows solvent vapors to be sucked through the pumps without jeopardizing their lubrication, whereas oil sealed pumps such as rotary vane or piston that do require internal lubrication might have a problem. The Liquid Ring has external grease-packed bearings which are isolated from the process fluid by mechanical seals. The Dry Pump has external bearings which are either oil lubricated or grease-packed and separated from the process by mechanical seals. In addition, the Dry Pump also has oil lubricated timing gears to maintain the two parallel shafts rotating in the correct phase to avoid contact.

The Liquid Ring does require a liquid sealant for sealing the clearances and cooling the heat load which is composed of the pump's BHP and any latent heat of condensation. The most common sealant is water but many process fluids can also be used which are compatible with the process and allow for recovery and return to the process to minimize waste. In some cases water is used as the sealant when the process solvent being handled is immiscible or only slightly miscible with water and can be decanted in an oversized separator tank. The Liquid Ring pump normally relies upon handling the process fluids as a vapor at inlet and condensing them to the liquid phase while passing through the pump. If the condensing process occurs at inlet while contacting the lower temperature sealant, the pumping capacity will be increased. If it occurs later before discharging, due to the increase in

Figure 1. Tuthill KLRC 100 Liquid Ring Vacuum Pump

pressure, the capacity will not be increased but the heat load due to the latent heat of condensation will still require handling, and if large enough, will increase the sealant ΔT. Since the Liquid Ring is operating with a liquid sealant it can handle a continuous liquid carryover from the process or from the condensate stream from an upstream condenser.

The Dry Pump does not use a liquid sealant and relies upon small clearances between rotors and housing and higher rotational speed to reduce gas slippage. The lack of a liquid sealant also causes the discharge temperatures to be higher which helps maintain the "dry" feature of the pump by helping to keep the process vapors in the vapor phase from inlet to discharge. The Dry Pump does not benefit due to condensing effects but does benefit by keeping high vapor pressure solvents like Methylene

Chloride, Acetone, MEK, etc. in the vapor phase while passing through the pump. Some Dry Pumps can handle a small amount of process liquid carryover but if this occurs continuously, the pump would not maintain its "dry" characteristics and performance would also become limited by the vapor pressure of the liquid. In cases of process liquid carryover due to upsets, knock out traps are normally used to trap the liquid ahead of the Dry Pump. In many cases dual traps are used in parallel where one trap can be valved off and emptied while the other is placed on line. In some cases a valved bypass around the trap is used to allow the Dry Pump to stay on line while the isolated trap is emptied. If an upstream condenser is used ahead of the Dry Pump the condensate would be collected in a separate condensate tank. Since the Dry Pump maintains the process vapors in the vapor phase passing through the pump an after condenser is normally used for collection.

When handling corrosive process fluids, the Liquid Ring pump can use a corrosion resistant material of construction such as 316 SST and a non-aqueous sealant while the Dry Pump relies upon using a corrosion resistant coating such as Teflon and keeping the fluid in the vapor phase to minimize the corrosion potential.

Advantages and Disadvantages

Dry Vacuum Pumps

ADVANTAGES	DISADVANTAGES
Lower ultimate pressure and higher capacity at low pressure end for single-stage pump	Higher purchase price
Lower power consumption	Higher complexity effects reliability
Lower cooling water usage	More difficult to disassemble on site by end user
More compact footprint	Solvent handling limited by auto-ignition temperature of solvent
Can pump high vapor pressure solvents	Limited liquid ingestion
Environmentally friendly with less pollution	

Liquid Ring Vacuum Pumps

ADVANTAGES	DISADVANTAGES
Can perform as both vacuum pump and direct contact condenser	Normally higher operating cost than Dry
Lower purchase price	Higher power and cooling water consumption
Simplicity of rotating parts improves reliability	Larger footprint
Lower maintenance	Pump performance is limited by vapor pressure of sealant
Because of pump simplicity, can be readily disassembled and reassembled on site by end user	Requires a supply of liquid sealant for makeup or change out
Lower operating temperature for thermal sensitive or polymerizable process material	Operation normally results in larger amount of hazardous waste
Liquid sealant allows for handling higher temperature inlet gases/vapors	
Can ingest liquid from process or condensater from upstream condenser	
Less sensitive to process particulate due to larger clearances	
Liquid within pump may act as quench to reduce chance of ignition from sparking	

Vacuum systems are used to pump solvent vapors in many chemical and pharmaceutical applications wherever excess solvents must be removed such as processes involving drying, distilling, chemical reactions, synthesis of compounds, separation and purification, cleaning, etc. Many organic solvents need to be recovered either due to their toxicity, flammability, or environmental impact and dry vacuum pumping systems provide a green vehicle for doing so. Dry vacuum systems have no internal sealing liquid that could be contaminated by incoming solvents or contaminate the outgoing solvents that need to be recovered. The solvent vapors are passed through the dry vacuum system and then usually condensed at the exhaust that provides a closed loop for containing and recovery with no contamination.

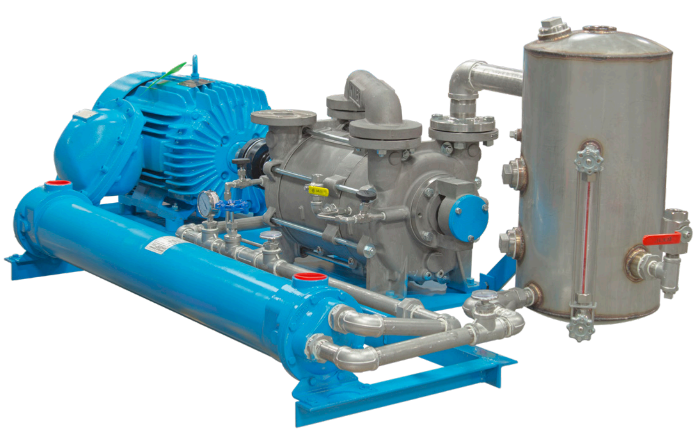

Figure 2. Tuthill KLRC System with Full Sealant Recovery

A typical system would consist of a dry vacuum pump with a shell and tube condenser at the exhaust. If higher capacities are required, a booster/dry pump combination could be used. Dry vacuum systems offer the advantage of reduced power consumption, decreased coolant usage (lower BHP/ACFM and cooling water flow), smaller footprint, and better control of maintaining the solvent as a vapor while passing through the pump so that condensing occurs where desired. Dry pumps are also more easily controlled by using variable frequency drives (VFD) for process pressure control compared to liquid ring pumps where the minimum rpm is determined by the collapsing of the fluid ring. Dry vacuum systems are also capable of handling volatile organic solvents such as methylene chloride, acetone, or methanol where the higher vapor pressures could cause problems for a liquid ring pump.

Maintaining a leak-tight system that avoids the entrance of air to avoid flammable mixtures or the leaking of process fluid to the environment is more easily handled with a dry vacuum system. Because of the elevated discharge temperatures of the dry vacuum pump, the solvent's auto-ignition temperature should always be greater than the dry pump's maximum discharge temperature which normally occurs at the lower inlet pressure range.

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