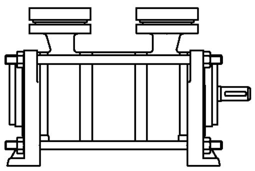
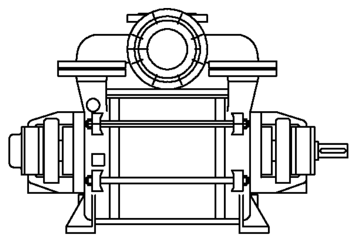
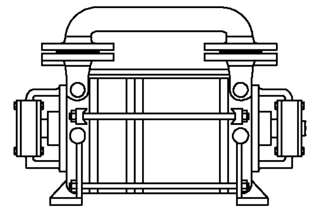
General Instructions
for Liquid Ring Vacuum Pumps







Installation, Operation & Maintenance

The pump model number, serial number and stock number are stamped on the pump nameplate located on the pump casing (see right). For inquiries regarding replacement parts or service, record all three pump ID numbers, and submit them along with any requests.

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Introduction to SIHI Liquid Ring Vacuum Pumps

SIHI's liquid ring pumps offer efficient compression of condensable vapors and gases in the rough vacuum field with a capability of up to 29" Hg vacuum (depending on the application and pump type used).

SIHI pumps use the liquid ring principle to ensure maximum safety in compression of hazardous mixtures. Reliability is ensured through the use of only one rotating assembly with no internal metal to metal contact.

Should you need any further information or assistance, contact the SIHI office or SIHI Agent of your choice. Major locations appear on back cover of this manual.

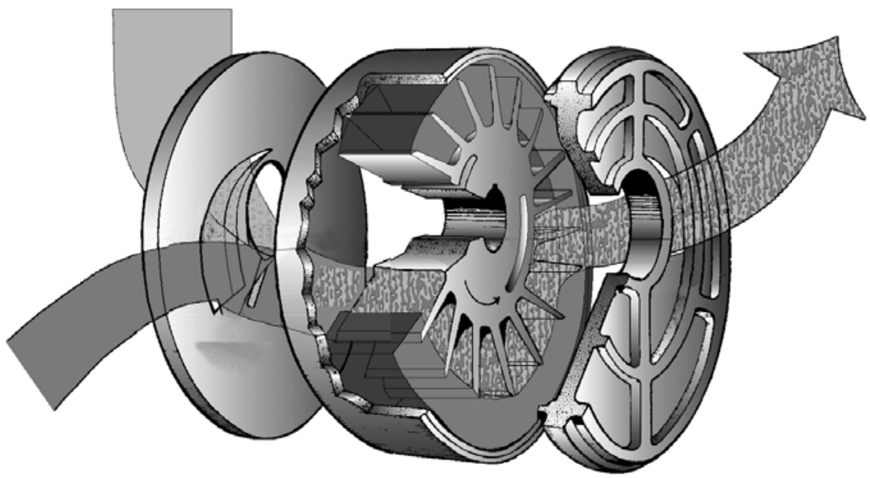


Figure 1

The Liquid Ring Principle

The "liquid ring" pump takes its name from its principle of operation. A cool liquid is introduced into a round casing and, due to centrifugal force when rotated, forms a nearly concentric ring around the pump casing.

The impeller is eccentrically mounted in the casing. Hence, at one side, the cells formed by the impeller blades and the boundary of the liquid ring increase in size; and on the other side, they decrease in size.

A suction port is positioned in the area where the cell size is increasing. This port ducts the gas from the pump inlet into the lower pressure cells.

The gas introduced into the cells is then compressed by the operating liquid in the area where the cell size is decreasing. A discharge port is positioned to duct the compressed gas to the pump discharge.

Since the liquid absorbs the heat generated during compression, a small quantity of fresh cooling liquid is continually introduced via the service liquid supply port, and the resulting excess warm liquid discharges with the gas to a downstream gas/liquid separator.

The liquid used as compressant allows the liquid ring pump to perform cool, reliable compression of virtually all gases and condensable vapors while easily handling liquid and soft solid carryover.

1.0 Safety

This operating manual gives basic instructions which are to be observed during installation, operation and maintenance of the pump. It is therefore imperative that this manual is read by the responsible personnel prior to installation, start-up and operation. It must always be kept available at the installation site. Not only the general safety instructions contained in this chapter "Safety" must be observed, but also the specific information provided under the other chapters.

1.1 Identification of safety notices in the operating instructions

Non compliance with the safety notices given in these operating instructions which would affect safety, are identified by the following symbols:

⚠ DANGER — **DANGER** Indicates a hazardous situation which, if not avoided, will result in death or serious injury.

⚠ WARNING — **WARNING** Indicates a hazardous situation which, if not avoided, could result in death or serious injury.

⚠ CAUTION — **CAUTION** Indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE — **NOTICE** is used to address practices not related to personal injury.

> **⚠ DANGER**
>
> **Receiving, handling, installation, operation and maintenance (routine or otherwise) shall be performed by competent personnel specifically trained to perform the operations to be undertaken. These technicians should be licensed and fully aware of local laws, restrictions, safety procedures and directives. Failure to use suitably trained and licensed personnel may result in personal injury or death.**

> **NOTICE**
>
> Failure to follow the directions for installation and operation of this equipment may result in equipment failure or mis-operation not covered by manufacturer's limited warranty.

1.2 Unauthorized alterations and production of spare parts

Any unauthorized modification of the unit will result in absolving SIHI of any liability. In such cases the operator of the machine assumes responsibility for safe operation of the unit.

Using spare parts and accessories authorized by the manufacturer is in the interests of safety. Use of other parts may absolve the manufacturer of any liability.

1.3 Unauthorized methods of operation

The reliability of the machine supplied will only be guaranteed if it is used in the manner intended and in accordance with the instructions of this manual. The specified operational limits must not be exceeded in any circumstances.

1.4 Safety instructions relevant for operation

If hot or cold components of the unit involve hazards, they must be guarded by the user against accidental contact. Guards for moving parts (e.g. couplings) must not be removed from the machine while in operation. Any leakage of hazardous (e.g. explosive, toxic, hot) fluids (e.g. from the shaft seal) must be drained away so as to prevent any risk occurring to persons or the environment. Statutory regulations are to be complied with. Hazards resulting from electricity are to be eliminated by the user.

1.5 Warranty

SIHI guarantees long term, satisfactory operation if: the pump is installed and operated in compliance with these instructions and under conditions approved by SIHI. No modifications are undertaken without SIHI's written agreement.

2.0 Equipment Handling

NOTICE

Shipment is normally provided FCA manufacturer's plant. Damage during shipment is the responsibility of the shipping company not the manufacturer and must be reported on the day of receipt to ensure insurance validation.

WARNING

Follow all applicable handling and safety rules! Always use proper lifting and handling devices. Failure to do so may result in serious personal injury or damage to equipment.

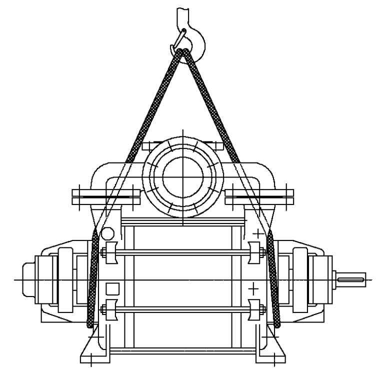


Figure 2

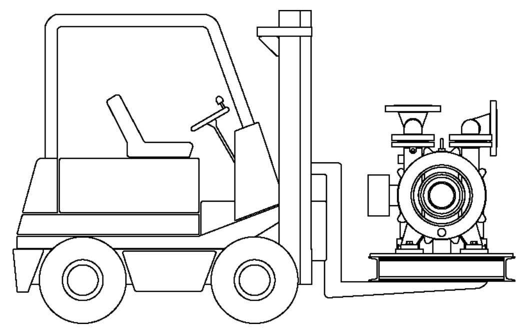


Figure 3

2.1 Loading and unloading

With equipment located in a safe area capable of supporting equipment weight, visually inspect crating for damage occurring during shipment.

2.1.1 Report all damage immediately to the shipping company in writing.

2.1.2 Remove protective packaging materials and inspect equipment visually for damage.

2.1.3 Verify shipment is received complete and intact as required by the purchase order and shipping documentation supplied.

2.1.4 Lift equipment as indicated in figures 2 & 3 maintaining horizontal position using suitable tools. Refer to shipping documents for actual shipping weights.

NOTICE

Pumps are supplied with preservatives suitable for a maximum 2 months of storage. Once installed, the pump should be placed in immediate operation. If pump is not properly stored, equipment failure will occur. If storing for periods longer than 2 months, refer to Chapter 6 Long Term Storage.

2.2 Preparation for Mounting

2.2.1 Before mounting any unit it is necessary to determine the requirements of the application. Liquid ring pumps require a system that provides service liquid to the pump (normally water) but most liquids with similar viscosity, specific gravity and vapor pressure characteristics; can be employed. Before proceeding with any mounting or operation of equipment, refer to Chapter 4 for details of system design that must be included if the pump is to perform as required.

NOTICE

Assistance with system requirements **for the pump unit** if required can be requested by calling your local SIHI Agent or SIHI directly at any of the locations appearing on the last page of this manual.

2.2.2 General Notes

WARNING

Ensure equipment foundation is capable of supporting operating weights including starting torques and all associated equipment. Failure to adequately support equipment may cause serious personal injury, and or equipment failure.

2.2.3 Before performing any installation ensure all piping within the mounting area is suitably isolated, leak free, and drained as required. Be sure to pay strict attention to site safety rules & procedures. Avoid allowing the presence of untrained personnel whenever performing work on this equipment.

2.3 Mounting

2.3.1 If the pump was purchased as a replacement in an existing process or application mount the unit on the base or supporting frame and connect to a motor assembly using suitable flexible coupling.

2.3.2 If the pump was purchased as a basemount or with accessories for a new installation mount the unit in place as planned.

NOTICE

Base mounted units are designed for mounting on a rigid support frame or foundation.

2.3.3. Baseplate flatness should be checked and adjusted before final grouting then rechecked immediately after grouting to ensure changes have not occurred.

NOTICE

Base mounted units or packages are supplied capable of field alignment. All units must be final aligned on site to avoid premature equipment failure.

WARNING

NEVER operate the unit without a coupling guard. Failure to comply could result in serious injury.

Pumps purchased as bare units must be installed with coupling suitable for the pump and motor power, speed, vibration and misalignment allowed.

Baseplates supplied by others must be suitable for the loads intended and firmly attached to frame and/or lag bolted and grouted as necessary.

2.3.4. Rotate pump shaft manually to ensure shaft is capable of turning. Pump size (rotor inertia) and friction of seals or packing, may make hand rotation difficult Rotation may require the aid of a suitable pipe wrench.

NOTE: Call the factory for information if rotation cannot be accomplished or if rubbing is felt or heard while turning.

2.4 Alignment of pump and motor

WARNING

When checking rotation or beginning alignment procedure, be certain equipment is locked out of service and cannot be started!

Failure to ensure equipment is positively locked out can result in serious personal injury.

Never start a pump unit before checking rotation by hand!

2.4.1 The pump and motor unit must be aligned using either a double dial gauge method or a reverse dial gauge or laser alignment tool as available. Alignment tolerances are indicated in the table below.

Acceptable alignment limits:

Double dial gauge:	less than 0.002” (0.05mm) T.I.R. (Total Indicator Runout)
Reverse dial Gauge or laser alignment	

NOTICE

Improper alignment is a major contributing factor to pump noise, vibration and premature failure.

2.4.2 Alignment methods

<u>Preferred – Dial Guage</u> The service life of the pump is dependent on good coupling alignment. Flexible couplings will not compensate for shaft misalignment. If the motor was mounted by SIHI, the pump and motor were aligned prior to shipment from the factory. Since baseplates are not perfectly rigid, handling during shipment, pipe loading and foundation stresses mandate an alignment check prior to start-up. Changes to alignment should be made by adding shims, as necessary, under the motor feet.

The dial indicator method for checking coupling alignment is preferred (refer to figures 4 and 5). To measure parallel misalignment, attach dial indicator to one coupling hub, or mount on one shaft end with the indicator button resting on the O. D. of the other coupling hub (figure 4) or shaft. To measure angular misalignment, the indicator button rests on the face of the other coupling hub near the O. D. (figure 5). Measure misalignment by rotating the shaft and dial indicator one full revolution; the other shaft remains stationary. Record the Total Indicator Runout (T.I.R.). Parallel and angular misalignment should be limited to ±0.002" T.I.R.

If a dial indicator is not available, an adequate alignment is possible using a straight edge, feeler gauge, micrometer or caliper. This method should be used as a last resort only.

NOTE: Reverse dial indicator alignment, or laser optical alignment, can be used satisfactorily. Contact the factory if details are required.

For maximum pump life, keep misalignment values as near to zero as possible.

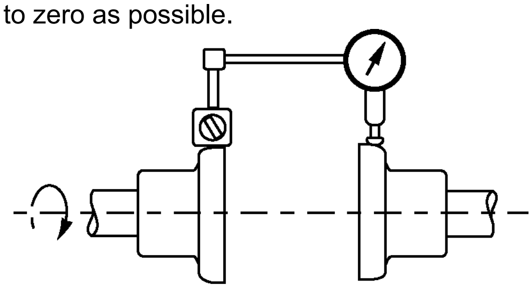


Figure 4

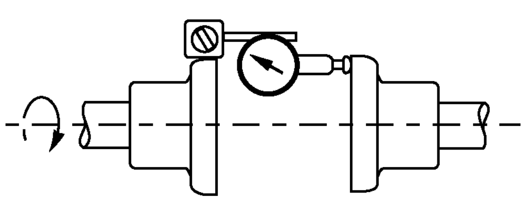


Figure 5

2.5 Piping Installation:

⚠ WARNING

Service liquid supply and system integration with <u>USER'S</u> process is the responsibility of the <u>USER</u> and his engineering team. Improperly designed service liquid supply systems, or gas handling systems including pump specification for hazardous or toxic use could result in personnel or environmental hazards and/or damage.

2.5.1 General:

Minimally, all liquid ring pumps should be fitted with an inlet check valve of special low loss type, and a correctly sized service liquid separator in the discharge line. Refer to Chapter 4 for system assistance. Contact the factory or your local SIHI Agent for information if required.

⚠ WARNING

Failure to isolate pump from pipe strain due to improper assembly design or temperature variations; can result in leakage or failure of the equipment leading to serious personal injury or environmental damage.

Never use mechanical equipment to draw piping to the pump connection!

Pipe stresses can be a major source of equipment failure, reduced pump life, and safety concerns. All pipes should be supported close to pump connections and hand connected to the connecting flanges when installing.

2.5.2 Inlet piping

Install minimum low loss inlet check valve and ensure piping slopes to the pump continuously from the preceding drain point.

2.5.2.1 When installing inlet connections, a temporary inlet screen should be used to prevent entry of weld slag and other debris into the pump body. Conical type screens in the inlet are recommended to prevent ingress of trapped solids during removal.

Be careful to check operation when screen is installed since debris can foul the screen and result in cavitation. Do not leave temporary screens installed as they can lead to failure due to plugging, deterioration and loss in performance.

2.5.2.2 Ensure all inlet piping is at least equal in cross sectional area to the pump discharge size being used. If multiple pumps are employed ensure line size cross sectional area is equal to the sum of all pump inlet nozzles to be employed on the same line.

NOTICE

Liquid traps must be avoided in the inlet lines to prevent the possibility of slug carryover to the equipment.

2.5.3 Discharge Piping:

⚠ DANGER

Ensure pump discharge system is designed to prevent pressure buildup exceeding pump, accessories or piping design. Failure to do so will result in serious personal injury or death, as well as equipment damage.

2.5.3.1 Pump discharge line should include as minimum a discharge separator and vented gas nozzle and drain as noted for the system installation to be employed (refer to Chapter 4).

NOTICE

Limit maximum vertical rise of piping to twenty four inches (24”) or less.

2.5.3.2 Gas discharge piping must be at least the same diameter as the pump discharge connection.

2.5.3.3 Avoid the connection of multiple pump units to the same discharge manifold unless provisions for prevention of liquid carryover to the discharge of the next pump are made. Contact the factory for information as required.

2.6 Service liquid:

2.6.1 Minimally the pump service liquid line should supply a clean cool service fluid and should include accessories as detailed in Chapter 4 as applicable.

2.6.2 Connect service liquid to the service liquid connection(s) as shown using suitable gasket compound on all connections in Appendix 1.

3.0 Prior to Operation

The following warnings must be observed before proceeding with equipment start-up.

DANGER

- **The use of hazardous or toxic fluids should not be used for once through, partial or complete service liquid supply unless the systems were properly designed and engineered for these fluids and USERS fully understand the operation and safety guidelines to be followed.**
- **Electrical connections and installations must be performed by trained personnel who are well versed in the NEC and NFPA Electrical Codes. Strict supervision and inspection in accordance with all Local, State, and National Codes and Standards must be provided and followed.**
- **Personnel must positively lock-out equipment while performing installation, pre-start up or mechanical checks.**
- **Equipment must never be operated without proper equipment guards in place.**
- **Where explosion hazards exist, coupling guards must be non-sparking such as, aluminum, brass or other non-sparking materials.**

<u>Failure to follow any instructions and equipment warnings will result in death, serious personal injury, damage to equipment and the environment.</u>

NOTICE

Operation of the pump dry will result in shaft seal failure leading to leakage.

3.1. Preparation for Operation

DANGER

Static Electricity - Potential

The operator must ensure that if the unit is used in an explosion hazard area, that potential for static discharges is eliminated by ensuring proper grounding.

The insulating effects of paint coatings must also be considered.

Failure to do so will result in death, serious personnel injury, and equipment damage.

Prior to start-up, half fill the pump with service liquid (do not overfill) prior to operation. This will ensure that the seals (if installed) are not damaged by dry operation, and unit is ready for liquid priming if installed in a recirculation system, refer to Chapter 4.

3.2. Connect the motor and any electrically controlled accessories such as service liquid solenoid valves as required. Ensure motor speeds, voltages and frequencies agree with the supply and the pump requirements.

3.3. Recheck alignment done previously, then install suitable coupling guard.

3.4. Ensure suction and discharge lines are properly attached to the system. Suction valves are half closed and discharge valves are fully open.

3.5. Jog the pump motor and check pump rotation. Arrows are provided on the pump cover. Should there be any confusion, call the factory before operating the unit.

4.0 Service Liquid Supply: General Notes

The operation of the liquid ring pump depends on a continuous supply of cool, clean service liquid, entering the pump at the service liquid supply port and discharging with the compressed gas via the discharge connection. The volume supplied to the pump should be regulated for optimum performance.

The service liquid flowing through the pump serves to carry away the heat generated by compression of the gas. The temperature rise from inlet to discharge normally is approximately 7°F (4°C).

NOTE: Actual temperature rises may be higher depending on:

1. Operating pressure
2. Quantity of service liquid supplied
3. Gas characteristics
4. Service liquid properties.

Systems for service liquid supply include once-through, partial recirculation and total recirculation. The P&I drawings for these are provided in Figures 6, 7 and 8. In each instance, different accessory items are indicated.

The attached information details the most usual requirements for non-hazardous or toxic conditions and is supplied for reference. Your process may require added or alternative devices (especially if fluids handled are toxic or hazardous).

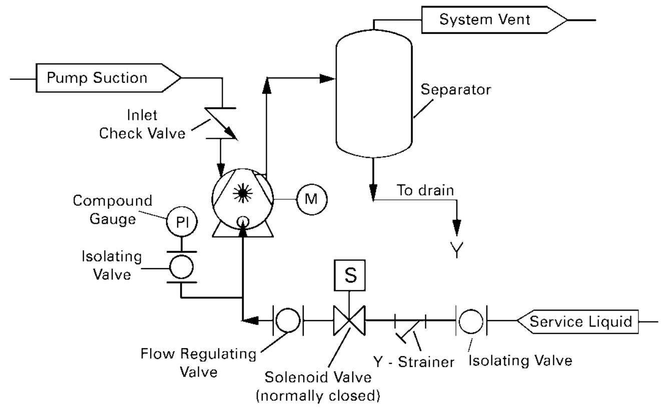
WARNING

Process integration is the USERS responsibility and must be performed by the user's trained, competent personnel.

Failure to adequately adjust the system to the process may result in severe personal injury or damage to the equipment, facilities and the environment.

<u>Refer to Appendix 1 for pipe sizes and locations, Appendix 2 for the effects of service water vapor pressure, and Appendix 3 for recommended service liquid flow rates for each pump model.</u>

4.1 System 1 – Once Through



Once Through System - Figure 6

Once through service liquid supply requires liquid to be available at some positive pressure to the liquid supply accessories prior to the pump.

Normal accessories for once through operation include: inlet check valve, discharge gas/liquid separator, compound gauge, flow regulating orifice (or flow regulating valve), normally closed solenoid valve, 'Y' pattern strainer and manual isolating valve all piped as shown in Figure 6.

4.1.1 Once Through - service liquid supply normal operation

4.1.1.1 The normally closed solenoid valve should be wired to open in conjunction with motor start.

4.1.1.2 Ensure all protective guards are in place prior to proceeding and also ensure service fluid is available to the pump supply line.

4.1.1.3 Jog the motor while observing the compound gauge. A variation in the pressure should occur if the solenoid valve is opening. If no variation occurs, check the solenoid and the supply line for closed valves or plugs.

4.1.1.4 Start the unit and monitor the service liquid pressure on the compound gauge. With the pump operating in the normal operating range, adjust the liquid flow using the manual flow control valve. The correct flow will occur when compound gauge reads approximately zero. However, the optimal setting occurs with valve set at the minimum opening possible, providing the pump runs smoothly and gas water discharge temperatures are satisfactory.

4.1.1.5 After setting the flow, mark the reading on the compound gauge.

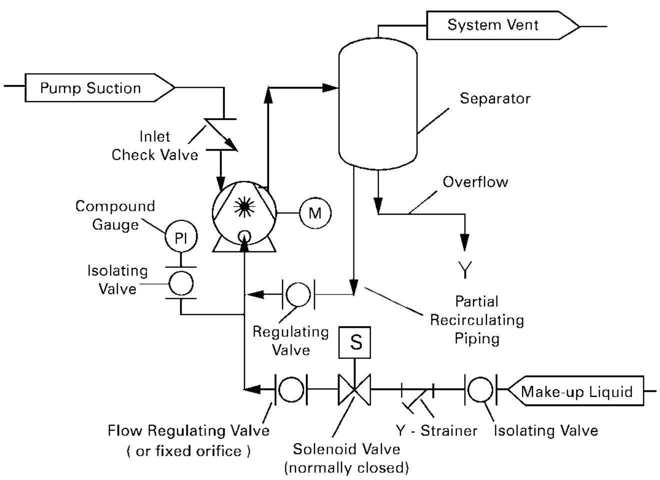
4.1.1.6 Monitor the service liquid pressure routinely to ensure variations are not occurring and pump operation is satisfactory.

If in the course of normal operation it is necessary to shut the unit off, ensure that the solenoid valve closes. If pressure is indicated on the compound gauge, the solenoid valve is not closing and the pump may be flooded. Check solenoid operation and drain pump to shaft centerline before restarting.

NOTICE

Starting liquid ring pumps flooded can result in high staring torques leading to pump failure or to motor shut down due to overload. Contact your local SIHI Agent or the factory for assistance.

4.2 System 2 – Partial Recirculation



Partial Recirculation System Figure 7

Partial recirculation can be employed in instances where make-up liquid is available at a temperature lower than the service liquid design temperature. Service liquid enters the pump and is discharged at a higher temperature to the separator. A portion of the liquid (still at higher than the design temperature), is then mixed with the cool make up liquid to return the pump liquid to design operating temperature.

The quantity of make up is determined by the difference in temperature between the design service liquid temperature and the temperature of the cool make up liquid available.

In many instances it is possible to reduce the fresh liquid flow to 50% or less of the normal flow. The excess liquid is drained from the separator via the normal overflow.

Normal accessories for partial recirculation include: inlet check valve, SIHI XBa type discharge separator (or similar liquid reservoir), make up line accessories including flow regulating valve (or orifice), normally closed solenoid valve, 'Y' strainer, shut-off valve and compound gauge, piped as shown in figure 7.

4.2.1 Operation of Partial Recirculation systems <u>with automatic fixed flow control orifice in the make up line</u>

4.2.1.1 The normally closed solenoid valve should be wired to open in conjunction with motor start.

4.2.1.2 Ensure all protective guards are in place prior to proceeding and also ensure service fluid is available to the make up line.

4.2.1.3 Close recirculation line control valve approximately half way.

4.2.1.4 Jog the motor while observing the compound gauge. A variation in the pressure should occur if the solenoid valve is opening. If no variation occurs, check the solenoid and the supply line for closed valves or plugs.

4.2.1.5 Start the unit and monitor the service liquid pressure on the compound gauge with pump operating in the normal operating range.

4.2.1.6 Adjust the recirculated liquid flow using the manual valve in the recirculation line until compound gauge shows approximately zero. Once the system is operating under normal conditions, check to ensure the pump runs smoothly and that pump temperature stabilizes. If pump operating temperature does not stabilize at a temperature where pump operates smoothly without cavitation, liquid make-up rate is not satisfactory. Re-check for plugs in the fresh liquid supply and open the manual recirculation valve slightly.

NOTICE

Do not continue to operate the unit if temperature continues to rise or pump operates with cavitation noise or premature equipment failure will occur.

4.2.2 Operation of Partial Recirculation system with manual make up flow regulating valve (without fixed orifice)

This arrangement allows the service liquid make up to be optimized to match system needs. Partial recirculation always requires introduction of some cool liquid to maintain stable operating service liquid temperature. However, the actual quantity required varies, depending on the system conditions and operating requirements.

The optimum make-up rate is the minimum flow rate required to maintain a stable service liquid supply temperature at the lowest operating pressure (highest vacuum) required, ensuring the pump operates smoothly and quietly.

4.2.2.1 The normally closed solenoid valve should be wired to open in conjunction with motor start.

4.2.2.2 Ensure all protective guards are in place prior to proceeding and also ensure service fluid is available to the make up line.

4.2.2.3 Close recirculation line control valve approximately half way and ensure manual make up flow control valve is open approximately half way.

4.2.2.4 Jog the pump while observing the compound gauge. A variation in the pressure should occur if the solenoid valve is opening. If no variation occurs, check the solenoid and the supply line for closed valves or plugs.

NOTICE

SIHI recommends a minimum of 10% fresh make-up in most instances, since the separators used have relatively small liquid volumes. Leakage or evaporation could quickly result in failure, from running dry. Should it be desired to reduce make-up liquid rates further, consult the factory, or consider installing a SIHI complete recirculation system.

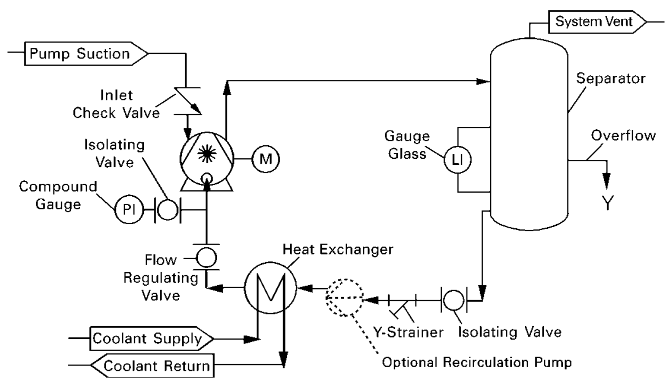
4.2.2.5 Start the pump and monitor the system inlet pressure until pump operates at the desired vacuum. Reduce the liquid make-up setting until the pump is just capable of maintaining system vacuum with a stable service liquid temperature.

4.2.2.6 Monitor the system in operation for a period of time to ensure temperatures are stable and pump operates smoothly and quietly. Remove flow control valve handle and wire it to the line to prevent loss and ensure availability.

NOTICE

Since the service liquid regulation was reduced to a low value per item 4.2.2.5 the service liquid supply volume may not be adequate to maintain performance if the ambient conditions or vacuum requirements change. Monitor the pump operation from time to time to ensure, temperatures are stable and equipment is operating normally (no objectionable change in vacuum levels, vibration or noise levels). Service liquid make up rate increase may be necessary if: water temperatures increase, vacuum requirements increase, or make up supply pressure changes to the control valves occur.

4.3 System 3 – Total Recirculation



Total Recirculation System - Figure 8

⚠ WARNING

If toxic or hazardous gases are handled, safety precautions must be followed. Failure to provide suitable shaft seals, protected drains, vents scrubbers, flare systems and/or other environmentally required systems may lead to serious personal or environmental damage.

Figure 8 details the normal installation of a self-contained service liquid supply system. This arrangement is normally used where, hazardous or toxic gas and/or liquids are processed and/or cost, availability or disposal limitations of waste liquids will be a concern.

Service liquids chosen under these conditions can be water, solvents, oils, or other liquids compatible with pump materials, performance requirements, and the process.

Normal accessories in a total recirculation system include: inlet check valve, discharge separator with level controls (either manual or automatic), service liquid recirculation line including isolating valve, y strainer, heat exchanger (or air cooler) manual flow control valve, temperature gauge and compound gauge.

Other accessories which may be required could include: gas demister and/or filters on the vents, gas coolers or condensers, and various accessories to make the system fit the requirements of the user.

NOTICE

In the event the pump will be required to operate for an extended time below 10 in. Hg vacuum, an orifice should be installed in the pump suction, or a recirculation pump should be employed to positively supply liquid. Otherwise failure to operate can occur due to loss of prime. Contact the factory for information.

4.3.1 Operation of Total Recirculation system without recirculation pump

Liquid to liquid heat exchanger system: prior to operation of the pump unit, ensure coolant is available to the heat exchanger.

NOTICE

If separator runs under positive pressure, a drain trap system must be employed on the overflow. If the equipment is required to handle toxic or hazardous fluids during operation: connect the overflow to suitable toxic/ hazardous drain.

4.3.1.1 Fully open all manual valves in the recirculation line.

4.3.1.2 Fill separator tank to the overflow connection or to normal liquid level (normally located at pump shaft center line).

4.3.1.3 Open plug on vacuum pump case at pump shaft center line and ensure pump is filled to this point before proceeding further. If no liquid is present, rotate pump shaft by hand and add liquid to the separator as necessary to maintain normal separator liquid level.

⚠ CAUTION

Never start System with service liquid level above shaft centerline as indicated by the separator gauge glass.

4.3.1.4 Once pump is half filled with fluid close plug tightly.

4.3.1.5 Check for leaks in the piping and repair as necessary.

4.3.1.6 Jog vacuum pump motor and check for proper direction of rotation. Also check that compound gauge pressure fluctuates. If compound gauge does not vary, system is not properly filled. If this occurs: redo points **4.3.1.1** through **4.3.1.6** until pressure is indicated on compound gauge.

4.3.1.7 Open heat exchanger coolant valves and ensure coolant is flowing. Monitor liquid flow and temperature and ensure data is per design.

4.3.1.8 Open the suction line to the vacuum pump approximately half way, and then start the pump. Monitor pump inlet pressure and ensure vacuum level slowly increases to above 10 in. Hg vacuum.

4.3.1.9 Adjust the vacuum level either by evacuating the system or closing the inlet valve until the vacuum reading at the pump is as required.

4.3.1.10 Adjust service liquid supply pressure on the compound gauge using the flow control valve. Compound gauge reading should be 0 to 7 in. Hg vacuum.

4.3.1.11 Check service liquid supply temperature from the heat exchanger. Temperature should stabilize at the design temperatures required compound gauge should read in the vacuum scale up to approx 7 in. Hg vacuum. If vacuum level is higher stop and check system for plugs (including strainer screen).

4.3.1.12 Once system is operating normally monitor to ensure operation is stable and pump runs smoothly and quietly.

4.3.2 Operation of Total Recirculation Systems with recirculation pump

For systems fitted with a recirculation pump ensure the pump has been installed and prepared for operation in accordance with the applicable manufacturer's procedures.

Ensure coolant is available to the heat exchanger.

> **NOTICE**
>
> If separator runs under positive pressure, a drain trap system must be employed on the overflow. If the equipment is required to handle toxic or hazardous fluids during operation: connect the overflow to suitable toxic/ hazardous drain.

4.3.2.1 Fully open all manual valves in the recirculation line.

4.3.2.2 Fill separator tank to the overflow connection or to normal liquid level (normally located at pump shaft center line).

4.3.2.3 Ensure recirculation pump is wired to turn in the proper direction and is filled with the liquid to be pumped.

4.3.2.4 Open plug on the vacuum pump case at pump shaft center line and ensure pump is filled to this point before proceeding further. If no liquid is present, rotate pump shaft by hand and add liquid to the separator as necessary to maintain normal liquid level.

4.3.2.5 Once pump is half filled with fluid close plug tightly. Check for leaks in the piping and repair as necessary.

> **NOTICE**
>
> The recirculation pump motor should be wired to start in conjunction with the start of the vacuum pump. Premature start (of the recirculation pump) or continued operation (after vacuum pump shuts off) can result in system flooding and premature pump failure.

4.3.2.6 Jog vacuum pump and recirculation pump motor and check for proper direction of rotation. Also check compound gauge for pressure fluctuation and that recirculation pump motor starts and stops in conjunction with the vacuum pump motor.

> **NOTICE**
>
> If compound gauge does not move, pumps or recirculation system is not filled with fluid and must be filled. If this occurs: redo points **4.3.2.1**through **4.3.2.6** until pressure is indicated on compound gauge.

4.3.2.7 Open heat exchanger coolant valves and ensure coolant is flowing. Monitor liquid flow and temperature and ensure data is per design.

4.3.2.8 Open the inlet line to the vacuum pump approx half way to the system and then start the pump unit.

4.3.2.9 Adjust the vacuum level either by evacuating the system or closing the inlet valve until the vacuum reading at the pump is as required.

4.3.2.10 Adjust service liquid supply pressure on the compound gauge using the flow control valve. Compound gauge reading should be approximately 0 to 5 in. Hg vacuum.

> **NOTICE**
>
> Check to ensure service liquid supply temperature stabilizes at the design temperatures required at the pump. If temperature continues to rise or is above design temperature check coolant supply, temperatures and other operating parameters for compliance with design. Should discrepancies be found contact SIHI service for assistance

4.3.2.11 Once system is operating normally monitor per the routine maintenance suggestions to ensure operation is stable and pump runs smoothly and quietly.

5.0 Routine Maintenance / Operation Checks

5.1. General:

SIHI liquid ring pumping equipment is designed for continuous use. Routine maintenance is minimal, however, as with all equipment some precautionary checks should be made.

5.2. Lubrication

Lubrication: Grease bearing every 3000 hours with lithium based bearing grease to NLGI – 3 specifications, where applicable. Some pumps are fitted with bearings sealed for life. Pumps so fitted do not have grease nipples and are not to be greased.

If the pump is operating in a harsh (i.e. dusty or hot) environment, the re-greasing intervals could be considerably shorter. Adjust re-greasing intervals accordingly.

NOTICE

Do not mix bearing greases as some grease additives are not compatible between brands, which could cause premature equipment failure.

5.3. Process /Pump Operating Conditions:

5.3.1. Cavitation

Cavitation results from collapse of vapor bubbles formed during the compression stroke of operation. The bubbles formed exist only temporarily and almost immediately collapse as the gas is compressed. This collapse causes the formation of a tiny jet of liquid which impinges on the surfaces of the pump's internal parts.

Cavitation is a condition usually detected by a crackling or sound which is described as a "grinding" noise.

Slight Intermittent cavitation can be withstood for some period of time however continuous or heavy grinding cavitation will severely shorten pump life and can lead to catastrophic pump failure. Should you detect cavitation: refer to the trouble shooting section or call SIHI service at your discretion.

⚠ DANGER

Continuous operation of pump in excess of 4 mils vibration, may result in death, serious personal injury, environmental damage, and/or premature pump failure.

Cavitation erodes the materials and sets up vibrations in the rotors of liquid ring pumps, resulting in the noises heard. These vibrations if not corrected, can lead to impeller blade failure from fatigue or erosion. Pump failures resulting from cavitation and abrasion damage are not covered by warranty.

5.3.2. Abrasive Particle Carryover

NOTICE

All liquid ring pumps can have their effective lives shortened due to abrasive particle carryover. If abrasive particle carryover is suspected, a knockout vessel should be employed and/or a suitable inlet filters or service liquid filtration system used.

Abrasive particle damage results in erosion of clearances leading to declining vacuum typically followed by leakage from the casing at final failure. Pump failures resulting from cavitation and abrasion damage are not covered by warranty.

5.3.3. Scaling

Liquid ring pumps used in areas where water has a high level of calcium carbonate or iron scale may become fouled, leading to seize-up, high motor loads and possible shaft seal leakage.

Abrasive water or dirty water should be avoided whenever possible.

Extremely hard water may result in the formation of scale deposits within the liquid ring pump.

Scale deposits can be removed by periodic treatment or installing a water treatment system.

Guidelines for water quality for liquid ring pumps are as follows:

- Hardness - maximum 200 PPM
- Dissolved solids – maximum 200 PPM
- PH Value – minimum 7
- Chlorides – maximum 10 PPM

NOTICE

In these instances, pump should be periodically flushed with a descalant as frequently as necessary to ensure scale build-up is removed. Recommended descalant is “Rydlyme”. Call your local SIHI Agent or SIHI Factory Service for information.

6.0 Long Term Storage

6.1. General

Cast iron pumps should be installed and put into service as soon as possible. In the event storage or installation followed by inactivity is possible, prepare the pump for storage as follows.

Storage Prior to Installation

NOTICE

Pumps are supplied with preservatives suitable for a maximum 2 months of storage. If storing for periods exceeding 2 months, anti-rust preservative must be added, and shaft should be rotated at least once per month.

Special care must be taken if the units are installed where freezing is possible. Ensure that the preservative remains liquid. Be aware that if the preservative solidifies and expands such as water does, cracking of the pump parts may occur. In addition, starting pumps with frozen fluids in the case will cause catastrophic failures not covered by warranty.

Store in a clean, dry, location protected from freezing or excessive heat and humidity.

Plug all miscellaneous connections securely to prevent leakage.

Fill pumps completely using inlet or outlet connections with a suitable rust preventative (such as a suitable biodegradable, automotive type, rust inhibited-anti freeze solution).

NOTICE

Ensure the solution used is acceptable to the process or process contamination leading to failures not covered by pump manufacturer's warranty may occur when installed.

6.2.1 Rotate shaft by hand from time to time during filling to ensure all areas are flooded. Refer to 2.3.4

6.2.2 Cap connections securely to prevent leakage.

6.2.3 Apply suitable anti-corrosion protection (wax based preferred, PDRP or equivalent) to shaft extension to prevent rusting.

6.2.4 Rotate shaft weekly to ensure they turn freely and to limit the possibility of bearing flat spotting leading to premature bearing failure in operation.

6.3 Storage After Installation

⚠ WARNING

Ensure pumps are positively locked out before proceeding with long term storage. Failure to prevent un-supervised starting or operation could result in personal injury or environmental damage.

6.3.1 Isolate the pump from the process.

6.3.2 Open a connection which will allow the introduction of a suitable process compatible anti rust preservative into the pump unit.

6.3.3 Drain all liquids from the casing using pump drain connections.

⚠ WARNING

Before draining operating fluids ensure any fluids introduced are not toxic or hazardous in nature or personnel injury and environmental damage could occur.

6.3.4 While draining rotate pump shaft by hand to ensure maximum draining occurs.

6.3.5 Reinstall drain plugs.

6.3.6 Fill the pump completely with the chosen preservative.

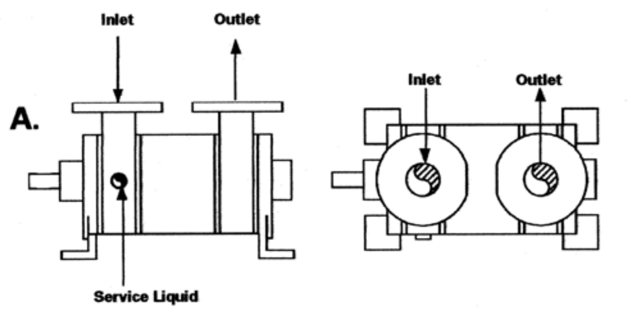
6.3.7 Close all connections securely.

6.3.8 Grease bearings if possible to ensure they are adequately sealed and prevented from exposure to the atmosphere.

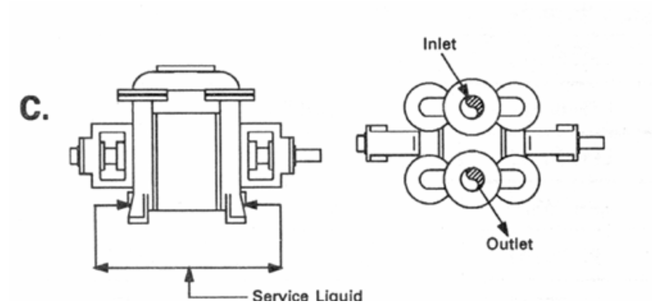
6.3.9 Rotate shaft by hand weekly to prevent possible bearing damage.

APPENDIX 1

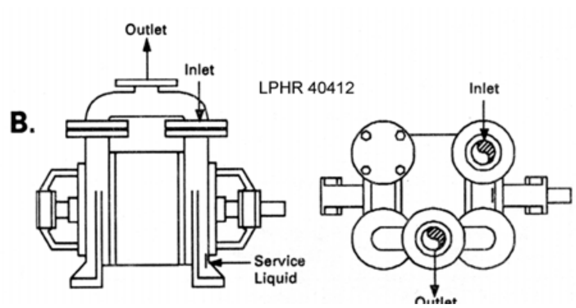
PIPING ARRANGEMENT TABLES – STANDARD CLOCKWISE DRIVEN PUMPS ONLY



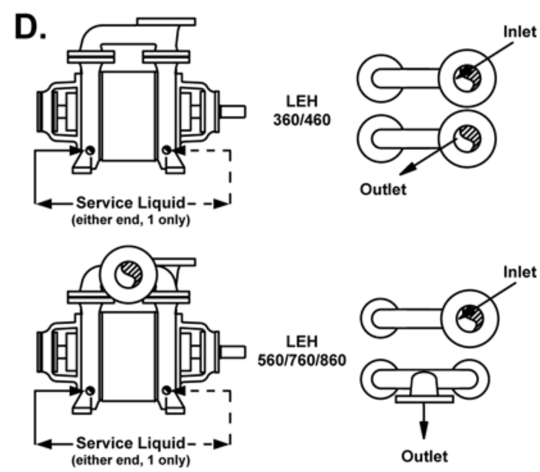
Pump Models Applicable	Estimated Weight	Suction/Vent Size/Rating	Service Liquid Size/Rating
XBAR 20103	219	1 1/4" - 150# R.F	3/8" NPT
XBAR 20105	220	1 1/4" - 150# R.F	3/8" NPT
XBAR 20107	272	1 1/4" - 150# R.F	3/8" NPT
XBAR 25003	223	1 1/4" - 150# R.F	3/8" NPT
XBAR 25007	291	1 1/4" - 150# R.F	3/8" NPT



Pump Models Applicable	Estimated Weight	Inlet/Outlet Size/Rating	Service Liquid Size/Rating
LPHR 40517	184	2" - 150# R.F	1/2" NPT
LPHR 50518	295	2 1/2" - 150# R.F.	1" NPT
LPHR 50523	310	2 1/2" - 150# R.F.	1" NPT

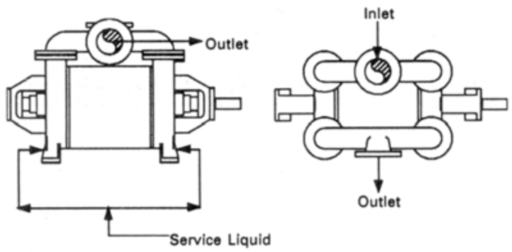


Pump Models Applicable	Estimated Weight	Inlet/Outlet Size/Rating	Service Liquid Size/Rating
LPHR 40412	150	1 1/2" - 150# R.F.	1/2" NPT



Pump Models Applicable	Estimated Weight	Inlet/Outlet Size/Rating	Service Liquid Size/Rating
LEH 360	332	3" - 150 # R.F.	3/4" NPT
LEH 460	368	3" - 150 # R.F.	3/4" NPT
LEH 560	532	4" - 150# R.F.	1" NPT
LEH 760	552	4" - 150# R.F.	1" NPT
LEH 860	606	4" - 150# R.F.	1" NPT

E.

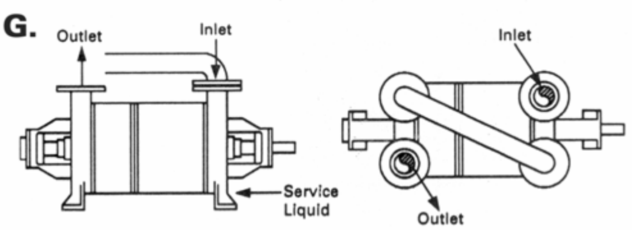


Pump Models Applicable	Estimated Weight	Inlet/Outlet Size/Rating	Service Liquid Size/Rating
LPHR60520[2]	420	4”-150#R.F.	1”NPT
LPHR60527[2]	490	4”-150#R.F	1”NPT
LPHR70530[2]	1100	5”-150#R.F	2”NPT
LPHR70540[2]	1200	5”-150#R.F	2”NPT
LPHR80540[1]	2400	8”-150#R.F	2”Pipe
LPHR80553[1]	2600	8”-150#R.F	2”Pipe
LPHR80557	3050	8”-150#R.F	2”Pipe
LEH3400	3100	8”-150#R.F	2”Pipe
LPHR90554[1]	1250	10”-150#R.F	3”Pipe
LPHR90567[1]	1450	10”-150#R.F	3”Pipe
LPHR10054[1]	7100	12”-150#R.F	3”Pipe
LPHR11055[1]	11025	14”-150#R.F	4”Pipe

1 Drilled to 150# RF standards or supplied with companion flanges at manufacturer’s discretion.

2 On 316 SS pumps, manifold discharge is vertical up, similar to arrangement (C) for these models.

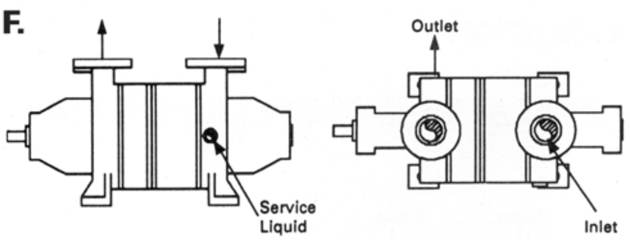
G.



Pump Models Applicable	Estimated Weight	Inlet/Outlet Size/Rating	Service Liquid Size/Rating
LPHR 45312	170	1 1/2" - 150# R.F.	1/2" NPT
LPHR 45317	190	1 1/2" - 150# R.F.	1/2" NPT
LPHR 55312	306	2" - 150# R.F	1" NPT
LPHR 55316	332	2" - 150# R.F	1" NPT
LPHR 55320	359	2" - 150# R.F	1" NPT
LPHR 65320	480	2 1/2" - 150# R.F	1" NPT
LPHR 65327	540	2 1/2" - 150# R.F	1" NPT
LPHR 70123	850	4" - 150# R.F	2" NPT
LPHR 75320	1000	4" - 150# R.F	2" NPT
LPHR 75330	1250	4" - 150# R.F	2" NPT
LPHR 75340	1450	4" - 150# R.F	2" NPT
LPHR 85340 [1]	2600	6" - 150# R.F	2" Pipe
LPHR 85353 [1]	2830	6" - 150# R.F	2" Pipe
LPHR 95354 [1]	1250	8" - 150# R.F	3" Pipe
LPHR 95367 [1]	1450	8" - 150# R.F	3" Pipe
LPHR 10534 [1]	8489	8" - 150# R.F	3" Pipe
LPHR 11535 [1]	12789	10" - 150# R.F	4" Pipe

1 Drilled to 150# RF standards or supplied with companion flanges at manufacturer’s discretion.

F.



Pump Models Applicable	Estimated Weight	Inlet/Outlet Size/Rating	Service Liquid Size/Rating
LPHR 3404	100	11/2" - 150# R.F	1/2" NPT
LPHR 3408	115	11/2" - 150# R.F.	1/2" NPT
LPHR 3704	130	11/2" - 150# R.F.	1/2" NPT
LPHR 3708	140	11/2" - 150# R.F.	1/2" NPT

APPENDIX 2

EFFECTS OF SERVICE WATER TEMPERATURE

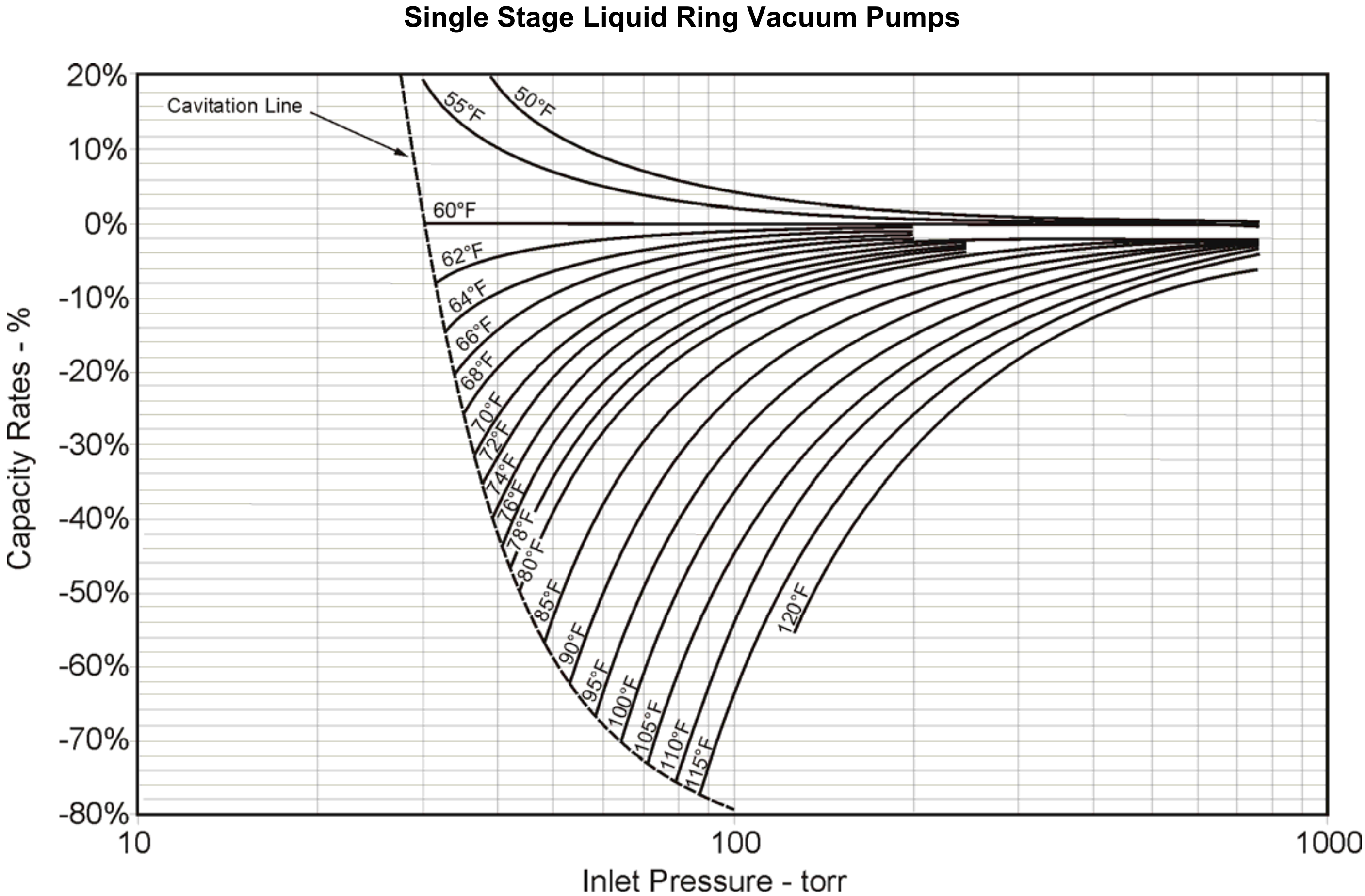


FIGURE 9

SERVICE LIQUID TEMPERATURES

Service liquid temperatures affect pump performance. Increasing temperatures result in higher vapor pressures and reduction in effective pump performance.

SIHI standard capacity data is based on water @ 59°F (15°C). Corrections for higher temperatures are obtained from the curves above.

If liquids with vapor pressures different than water are used, effects are obtained by finding the temperature at which water has the same vapor pressure as the liquid used and applying the water correction factor for that temperature.

EFFECTS OF SERVICE WATER TEMPERATURE - continued

Two Stage Liquid Ring Vacuum Pumps

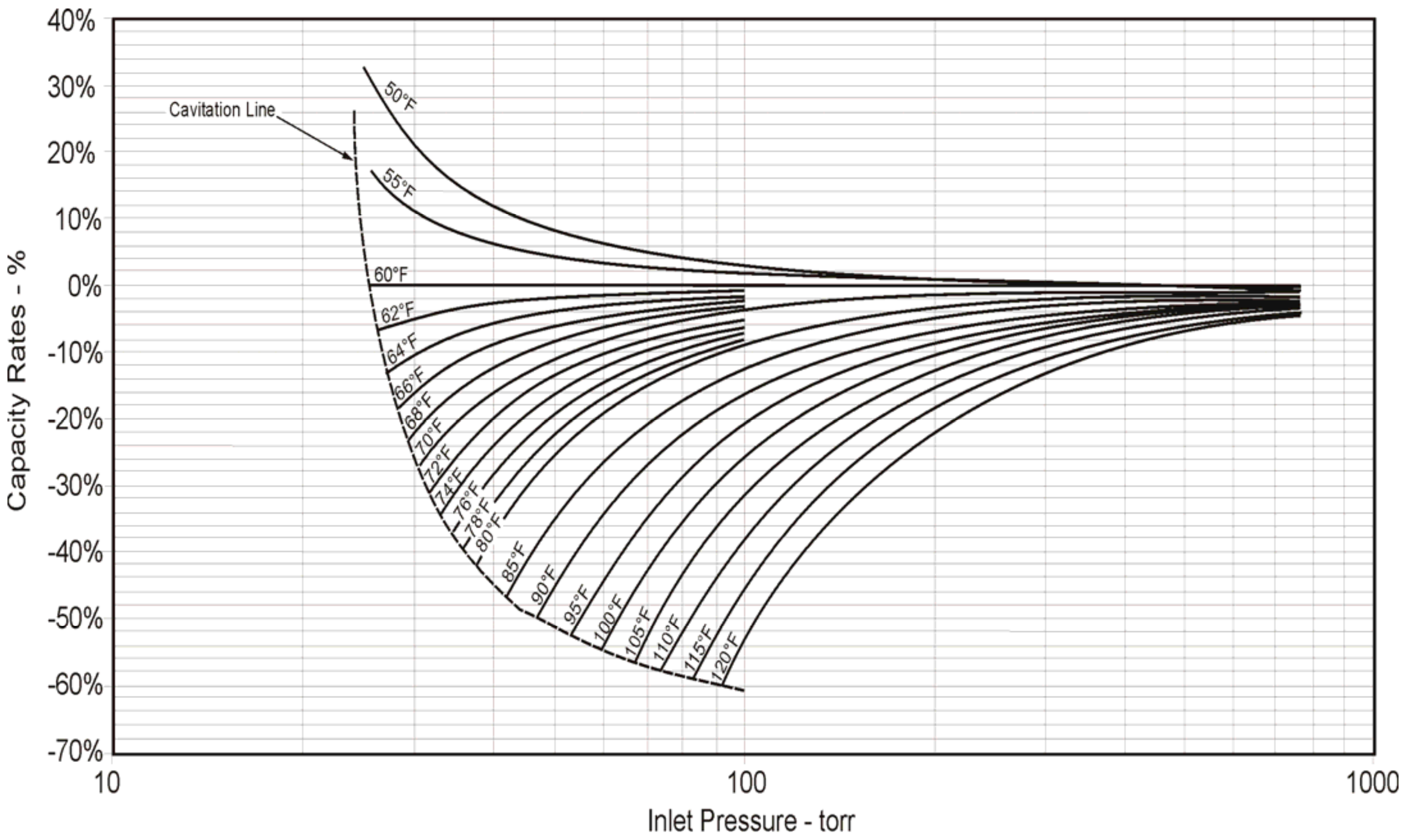


FIGURE 10

SERVICE LIQUID TEMPERATURES

Service liquid temperatures affect pump performance. Increasing temperatures result in higher vapor pressures and reduction in effective pump performance.

SIHI standard capacity data is based on water @ 59°F (15°C). Corrections for higher temperatures are obtained from the curves above.

If liquids with vapor pressures different than water are used, effects are obtained by finding the temperature at which water has the same vapor pressure as the liquid used and applying the water correction factor for that temperature.

APPENDIX 3 – SERVICE LIQUID REQUIREMENTS

NOTE: For all tables in this appendix, refer to the end of each section for description of columns A, B, and C.

SINGLE STAGE PUMP TABLES

		4" Hg 658 torr			16" Hg 354 torr			20" Hg 252 torr			24" Hg 150 torr		
Model	**RPM**	A	B	C	A	B	C	A	B	C	A	B	C
LPHR 3404	1750	1.0	0.5	0.3	3.0	0.8	0.5	3.8	1.0	0.5	4.4	1.0	0.6
	1450		0.4	0.2		0.7	0.4		0.8	0.4		0.9	0.5
LPHR 3408	1750	1.0	0.6	0.4	3.0	1.2	0.8	3.8	1.4	0.9	4.4	1.5	0.9
	1450		0.5	0.4		1.1	0.7		1.3	0.8		1.4	0.8

		8" Hg 557 torr			16" Hg 354 torr			20" Hg 252 torr			25.4" Hg 115 torr		
Model	**RPM**	A	B	C	A	B	C	A	B	C	A	B	C
LPHR 20103	3500	0.7	0.3	0.2	1.0	0.4	0.3	1.2	0.4	0.3	1.3	0.5	0.3
	2900		0.2	0.1		0.3	0.2		0.3	0.2		0.4	0.2
LPHR 20105	3500	0.7	0.4	0.2	1.0	0.5	0.3	1.2	0.5	0.3	1.3	0.6	0.4
LPHR 20107	3500	0.7	0.4	0.3	1.0	0.5	0.3	1.2	0.6	0.4	1.5	0.7	0.4
	2900		0.3	0.2		0.4	0.3		0.5	0.3		0.5	0.3

		8" Hg 557 torr			16" Hg 354 torr			20" Hg 252 torr			24" Hg 100 torr		
Model	**RPM**	A	B	C	A	B	C	A	B	C	A	B	C
LPHR 40412	1750	1.4	0.9	0.7	2.5	1.4	1.0	3.2	1.6	1.1	3.9	1.8	1.2
	1450		0.8	0.6		1.2	0.8		1.4	0.9		1.5	1.0
LPHR 40517	1750	2.0	1.3	0.9	6.0	2.5	1.6	7.0	2.7	1.7	7.3	2.7	1.7
	1450		1.2	0.8		2.2	1.3		2.3	1.4		2.4	1.4
LPHR 50518	1750	4.8	2.7	1.7	7.8	3.7	2.4	9.0	4.0	2.6	10.5	4.3	2.7
	1450		2.3	1.3		3.1	1.9		3.4	2.7		3.5	2.7

SINGLE STAGE PUMP TABLES – SERVICE LIQUID RATES (Cont.)

		8" Hg 577 torr			16" Hg 354 torr			20" Hg 252 torr			26" Hg 100 torr		
Model	**RPM**	A	B	C	A	B	C	A	B	C	A	B	C
LPHR 50523	1750	3.1	2.2	1.7	6.5	3.8	2.6	8.4	4.3	2.9	10.2	4.6	3.0
	1450		2.0	1.4		3.2	2.1		3.7	2.4		3.9	2.4
LPHR 60520	1750	4.8	3.1	2.3	6.4	4.0	2.9	8.0	4.7	3.4	10	5.5	3.8
	1450		2.7	1.9		3.5	2.4		4.1	2.8		4.7	3.1
LPHR 60527	1750	5.2	3.6	2.7	7.5	4.9	3.7	8.6	5.5	4.0	11	6.4	4.5
	1450		3.3	2.4		4.4	3.1		4.9	3.4		5.6	3.8
LPHR 70123	1150	5.0	3.7	3.0	9.3	6.2	4.7	13	7.8	5.6	14	8.2	5.8
	975		3.5	2.7		5.6	4		6.9	4.7		7.2	4.9
	880		3.3	2.5		5.4	3.8		6.6	4.4		6.8	4.5
LPHR 70530	1150	8.5	6.0	4.6	15	9.2	6.7	19	11	7.5	22	12	8.2
	975		5.4	3.9		8.2	5.6		9.5	6.4		10	6.7
	880		5.1	3.6		7.7	5.2		9.0	5.9		9.7	6.2
LPHR 70540	1150	9.0	6.8	5.5	17	11	8.3	21	13	9.4	24	14	10
	975		6.1	4.6		9.9	6.9		11	7.8		12	8.3
	880		5.9	4.3		9.5	6.6		11	7.4		12	7.9
LPHR 80540	880	16	11.0	8.5	27	16.0	11.5	33	18.5	13.0	38	20.0	13.5
	735		10.0	7.5		14.5	10.0		16.5	11.0		17.0	11.0
	700		9.5	7.0		14.0	9.5		16.0	10.5		17.0	11.0
LPHR 80553	880	19	13.5	10.5	32	20.0	14.5	38	22.5	16.0	42	24.0	17.0
	735		12.0	9.0		18.0	12.5		20.0	14.0		21.5	14.5
	700		11.5	8.5		17.5	12.0		19.5	13.0		21.0	14.0

SINGLE STAGE PUMP TABLES – SERVICE LIQUID RATES (Cont.)

		8" Hg 577 torr			16" Hg 354 torr			20" Hg 252 torr			26" Hg 100 torr		
Model	**RPM**	A	B	C	A	B	C	A	B	C	A	B	C
LPHR 80557	735	14	10.5	8.5	22	15.5	12.0	27	18.0	13.5	33	20.5	15.0
	680		10.0	8.0		15.0	11.0		17.0	12.5		19.5	14.0
	575		9.5	7.0		13.5	10.0		15.5	11.0		17.5	12.0
LPHR 90554	700	21	20.0	15.0	48	29.0	20.0	56	32.0	22.0	66	35.0	24.0
	600		17.5	13.0		26.0	18.0		29.0	19.0		32.0	21.0
	465		14.0	9.0		21.0	13.0		23.0	14.0		25.0	16.0
LPHR 90567	700	43	30.0	24.0	72	45.0	32.0	86	51.0	36.0	104	56.0	39.0
	600		28.0	21.0		40.0	28.0		46.0	31.0		51.0	33.0
	465		24.0	18.0		35.0	23.0		40.0	25.0		44.0	28.0
LPHR 10054	565	72	48.0	36.0	106	67.0	48.0	123	72.0	52.0	144	78.0	55.0
	490		44.0	30.0		61.0	41.0		67.0	46.0		73.0	49.0
	420		36.0	24.0		50.0	33.0		56.0	36.0		62.0	39.0
LPHR 11055	475	35	23.0	17.0	52	33.0	23.0	60	36.0	26.0	70	39.0	28.0
	415		21.0	15.0		29.0	20.0		32.0	22.0		35.0	24.0
	335		18.0	12.0		25.0	16.0		28.0	17.0		29.0	18.0

Column A (Once through) shows the amount of service liquid required by the pump, in U.S. gallons per minute. When installed with partial recirculation, part of this water is reused. The amount of make-up liquid for this kind of operation is shown in columns B and C.

Column B amount of make-up when service liquid at pump is approximately 9°F (5°C) warmer than the make-up temperature.

Column C amount of make-up when service liquid at pump is approximately 18°F (10°F) warmer then the make-up temperature.

Note: The service liquid supply pressure may vary with pump speed and vacuum level. Please consult factory engineering department for additional information.

TWO STAGE PUMP TABLES – SERVICE LIQUID RATES

		20" Hg 252 torr			25" Hg 125 torr			27" Hg 75 torr			28.9" Hg 25 torr		
Model	**RPM**	A	B	C	A	B	C	A	B	C	A	B	C
LPHR 25003	3500	1.2	0.5	0.3	1.35	0.5	0.3	1.4	0.6	0.4	1.5	0.6	0.4
	2900		0.4	0.2		0.4	0.2		0.4	0.2		0.4	0.2
LPHR 25007	3500	1.2	0.6	0.4	1.35	0.6	0.4	1.4	0.7	0.4	1.5	0.7	0.4
	2900		0.5	0.3		0.5	0.3		0.6	0.4		0.6	0.4

TWO STAGE PUMP TABLES – SERVICE LIQUID RATES (Cont.)

		20" Hg 252 torr			25" Hg 125 torr			27" Hg 75 torr			28.9" Hg 25 torr		
Model	**RPM**	A	B	C	A	B	C	A	B	C	A	B	C
LPHR 3704	1750	3.7	1.2	0.8	4.4	1.3	0.8	4.7	1.4	0.8	5.0	1.4	0.8
	1450		1.0	0.6		1.1	0.7		1.2	0.7		1.2	0.7
LPHR 3708	1750	4.7	1.7	1.1	5.5	1.7	1.0	5.7	1.7	1.0	6.0	1.7	1.0
	1450		1.4	0.9		1.5	0.9		1.5	0.8		1.4	0.8
LPHR 45312	1750	3.2	1.7	1.2	3.4	1.6	1.1	3.5	1.6	1.0	3.5	1.5	1.0
	1450		1.4	0.9		1.4	0.9		1.3	0.8		1.3	0.8
LPHR 45317	1750	3.3	1.9	1.4	3.8	2.0	1.4	3.9	2.0	1.4	4.1	2.0	1.3
	1450		1.6	1.1		1.7	1.1		1.7	1.1		1.6	1.0
LPHR 55312	1750	8.5	4.2	2.7	9.0	4.0	2.5	9.8	4.0	2.5	12.0	4.2	2.6
	1450		3.2	1.9		3.2	1.9		3.2	1.9		3.3	1.9
LPHR 55316	1750	9.0	4.4	2.9	10.0	4.5	2.9	10.9	4.4	2.8	13.5	4.7	2.8
	1450		3.7	2.0		3.7	2.3		3.5	2.1		3.7	2.7
LPHR 55320	1750	10.0	4.9	3.2	12.0	5.3	3.4	13.2	5.4	3.4	16.0	5.6	3.4
	1450		4.2	2.7		4.4	2.7		4.4	2.7		4.4	2.5

TWO STAGE PUMP TABLES – SERVICE LIQUID RATES (Cont.)

		20" Hg 252 torr			25" Hg 125 torr			27" Hg 75 torr			28.9" Hg 25 torr		
Model	**RPM**	A	B	C	A	B	C	A	B	C	A	B	C
LPHR 65320	1750	7.3	4.7	3.5	8.8	5.4	3.9	9.4	5.3	3.7	10.2	5.6	3.8
	1450		4.3	2.9		4.6	3.1		4.5	3.0		4.7	3.0
LPHR 65327	1750	7.3	5.1	3.9	8.8	5.8	4.3	9.4	5.7	4.1	10.2	6.0	4.2
	1450		4.5	3.3		4.9	3.4		4.9	3.3		5.0	3.3
LPHR 75320	1150	14	8.8	6.5	18	10	7.3	20	10.7	7.3	23	11	7.5
	975		7.7	5.4		8.6	5.6		9.1	5.9		9.0	5.6
	880		7.4	5.1		8.3	5.4		8.4	5.3		8.8	5.4
LPHR 75330	1150	16	11	7.8	19	12	8.3	21	12.2	8.6	24	13	8.8
	975		9.6	6.8		10	7.2		10.7	7.2		11	7.2
	880		8.7	5.9		9.5	6.3		9.8	6.4		10	6.5
LPHR 75340	1150	16	11	8.7	20	13	9.8	23	14.1	10.3	26	15	11
	975		9.9	7.2		11	7.8		11.9	8.0		12	8.0
	880		9.7	6.9		11	7.5		11.4	7.6		12	7.7
LPHR 85340	880	27	18	14	41	22	16	45	24.3	16.7	49	25	17
	735		17	12		21	14		20.2	13		20	13
	700		17	12		20	13		19.6	12.5		19	12
LPHR 85353	1150	37	24	18	53	30	21	58	30	21	62	31	21
	975		22	16		25	17		25	16		25	16
	880		21	15		24	16		24	15		23	15
LPHR 95354	700	84	55	42	113	66	46	121	65	48	132	70	46
	600		50	36		55	37		56	37		55	35
	465		42	29		46	30		46	28		43	26
LPHR 95367	700	100	78	55	165	91	62	179	92	62	194	93	62
	600		72	50		80	53		81	53		80	48
	465		56	39		65	42		63	38		62	36

TWO STAGE PUMP TABLES – SERVICE LIQUID RATES (Cont.)

		20" Hg 252 torr			25" Hg 125 torr			27" Hg 75 torr			28.9" Hg 25 torr		
LPHR 10534	590	58	34	23	79	46	32	86	47	32	93	46	31
	490		30	18		40	24		40	26		39	25
	400		22	13		30	18		30	18		28	17
LPHR 11535	470	57	37	29	75	43	29	80	42	28	84	42	28
	415		33	24		37	26		35	23		35	22
	335		27	18		23	19		27	16		26	16

Column A shows the amount of service liquid required by the pump, in U.S. gallons per minute.
When installed with partial recirculation, part of this water is reused. The amount of make-up liquid for this kind of operation is shown in columns B, C, and D.

Column B shows amount of make-up when service liquid at pump is approximately 9°F (5°C) warmer than the make-up temperature.

Column C shows amount of make-up when service liquid at pump is approximately 18 °F (10°C) warmer than the make-up temperature.

Note: The service liquid supply pressure may vary with pump speed and vacuum level. Please consult factory engineering department for additional information.

Appendix 4 - Troubleshooting Liquid Ring Pumps and Process Systems

Problem 1 Insufficient Vacuum (too high inlet pressure)

General Description: Liquid ring pumps are normally useful at vacuum levels said to be in the rough vacuum field. Technically the rough vacuum field is defined as absolute pressures between 1 and 760 torr. Of this range liquid ring pumps by themselves are theoretically possible of operation from 0 in. Hg V, (760 torr) to 29 in. Hg V, (25 torr) with water as service liquid at 60°F or theoretically to 29.5 in. Hg V (approximately15 torr) with very low vapor pressure service fluids.

Failure to reach the required operating vacuum levels in a process can be further split into three major areas of concern: 1) Measurement equipment inaccuracies, 2) Process or design concerns, and 3) Pump wear.

Cause 1: Incorrect gauges, or low atmospheric pressure when using vacuum gauges.

Solution: Calibrate gauges and measure the absolute pressure at the site. Use one gauge as the reference gauge for all positions.

Cause 2: Insufficient pump capacity due to process conditions, leading to pump under-sizing. Process difficulties could include: excessive non-condensable carryover or leakage, pre-condenser condensable carryover due to high coolant temperature, improper coolant flows, fouled heat transfer surfaces, and or fouled condensate drains from condenser lading to hot condensate carryover.

Solution: Check design conditions especially gas and liquid temperatures at the pump. Perform dry sealed system leak test after tightening all flanges and threaded connections. Check for proper gasket installation and condenser drain conditions.

Cause 3: Inlet line plugs or excessive pressure drop.

Solution: Measure vacuum at the pump casing and compare to other monitoring points in the system. Remove or reduce excessive pressure drops (plugs, valves, check valves, improper piping, etc.)

Cause 4: Service liquid vapor pressure too high due to insufficient cooling, contamination and/or wrong service liquid.

Solution: Check design conditions and rectify cooling problem as required.

Cause 5: High discharge pressure caused by plugged or fouled lines, improper installation of separator (vertical rise between separator and pump discharge too high) or poor plumbing practices.

Solution: Check discharge lines for causes of discharge pressure. Contact SIHI if discharge pressure cannot be changed (have design data available when calling). Check installation details per Chapter 4, figures 6, 7 and 8.

Cause 6: Low rotational speed.

Solution: Check motor details. Check rotational speed and direction.

Cause 7: Pump damage or shaft not turning (contact SIHI for information).

Solution: Listen for improper noise or monitor vibration levels. Check internal clearances. Check to ensure pump inlet shaft rotates.

Problem 2 High motor amperage

Cause 1: High motor speed – wrong motor installed.

Solution: Check motor nameplate and confirm proper selection with SIHI representative and/or with purchase order or specifications.

Cause 2: Improper discharge piping installation (too small, or too much vertical rise from discharge connection to separator or plugged separator vent connections).

Solution: Check piping details, refer to installation notes in Chapter 2.

Cause 3: High discharge pressure caused by plugged vents, flooded separators, or high vent pressures.

Solution: Check for properly opened vent lines, open overflow from separators and or proper vented drain connection from separator drain and overflow.

Remove the offending condition. If pressure cannot be lowered, check design conditions with SIHI. Replacement motor may be required.

Cause 4: Excessive service liquid or carryover from the system.

Solution: Reduce service liquid flow and/or install knockout system prior to the pump. Attach continuous drain connections to drain or to separator. When possible, reduce excess liquid. If carryover is continuous from the system, note rates and contact SIHI for information on required motor sizing.

Cause 5: Improper motor sizing as a result of service liquid viscosity or density.

Solution: Determine design conditions and contact SIHI for information and proper selection details.

Problem 3 Noise

Most SIHI equipment operates at less than 85 dba at 3 to 5’ when installed depending on pump size.

Cause 1: Cavitation (or grinding noises) in the pump casing caused by insufficient non-condensable flow. This can result from operation at too high vacuum, too high service liquid temperature, too little service flow, or too much condensable vapor.

Solution: Compare operating service flow rate with data in Appendix 3, and adjust accordingly.

Compare service water temperature with the data in Appendix 2, figure 9 and 10.

Regulate inlet pressures and/or decrease service water temperatures as required. If partially recirculated service liquid is being used increase the make-up rate.

If pump is pulling from condenser, check condenser discharge temperature and pressure. Reduce condenser discharge gas temperature if possible by increasing coolant flow or cleaning condenser as applicable. Increase condenser pressure if lower than design.

In two stage pumps install air bleed valve in center intermediates or crossover manifold cover plug and bleed air into pump to reduce cavitation noise. **NOTE: it is suggested air be piped from the discharge separator vent not from atmosphere and care must be taken to ensure bleed does not result in problems due to increased oxygen content).** In single stage pumps bleed air in the suction as required or as possible.

Cause2: Slipping belts on V-belt drive-units or bearing problems (described usually as high pitched noises such as squealing).

Problem 4 Vibration

Typical vibration levels should be less than 2-3 mils displacement on any plane.

Cause: Vibration is usually caused by misalignment in direct driven units. Other sources are bearing failures, internal mechanical failures or inlet slug conditions.

Solution: Properly align pumps per Chapter 2.4 Alignment of pump and motor. Check and replace bearings as required, check shaft run out with dial gauge if necessary.

If inlet slug conditions exist, install a knockout or flow equalizer system as required. Contact SIHI for information.

Notes

Notes

General Instructions

for

Liquid Ring Vacuum Pumps

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