

Installation, Operation & Maintenance

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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.



## Introduction to SIHI Close Coupled Vacuum Pumps

SIHI's LEM series, close coupled, multi-service, liquid ring vacuum pumps offer the ultimate in robust simplicity.

SIHI LEM series pumps feature cavitation protection, single North American mechanical seal, single casing drain, continuous solids purge connection, ultimate vacuum approaching 29" HG. (25 Torr), and minimum space requirements.

SIHI LEM pumps are close coupled to North American motors of NEMA design. Motors are supplied in compliance with 'UL' and 'CSA' requirements. The close coupled design eliminates the need for baseplates, couplings, coupling guards, and on-site alignment of pump and motor.

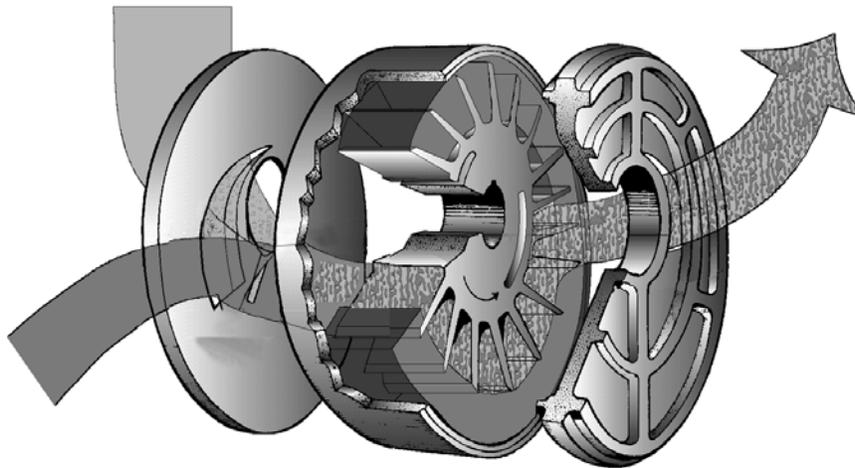


Figure 1

## 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/operator prior to installation, start-up & 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** Indicates a hazardous situation which, if not avoided, will result in death or serious injury.



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



**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.



**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. 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.**

## 2.1 Loading and unloading

With equipment located in a safe area capable of supporting equipment weight, visually inspect shipping carton or skid 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 figure 2 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.

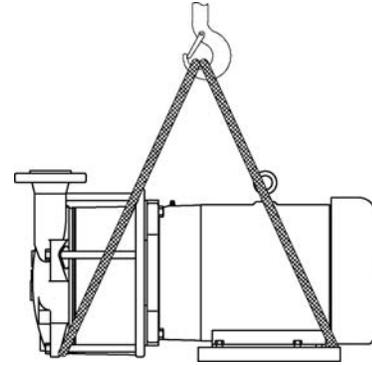


Figure 2

## 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.

**2.2.4** Remove plastic shipping plugs from the inlet/discharge and service liquid connections. Refer to Figure 4 for location.

## 2.3 Mounting

**2.3.1** Mount the pump on supporting equipment or firm foundation. In most instances, the pump unit is mounted with gas inlet and discharge connections vertically up. However, pump head can be rotated 90° to the right (or left), if desired.

**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. Mounting surface must be flat and level.

**2.3.3.** Remove knock-out plug from the motor fan shroud and rotate motor shaft by hand, using a screwdriver inserted through the shroud, and engaging the slotted end of the motor shaft. No undue binding or scraping noises should be heard from inside the pump. Pump size (rotor inertia) and friction of seals may make hand rotation difficult.

**NOTE: Call the factory for information if rotation cannot be accomplished.**

## 2.4 Piping Installation:

### WARNING

**Service liquid supply and system integration with USER'S process is the responsibility of the USER 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.**

## 2.4.1 General:

Minimally, all liquid ring pumps should be fitted with a low pressure drop inlet check valve, 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.

## 2.4.2 Inlet piping

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

**2.4.2.1** 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.

**2.4.2.2** 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.

**2.4.3 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.

**2.4.3.1** 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 from the pump flange to the separator, to twelve inches (12") or less.

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

**FIGURE 3 – PRESSURE AND TEMPERATURE LIMITATIONS (STANDARD)**

**Maximum Gas Temperatures:**

Dry Gas: 212°F, 100°C  
Saturated Gas: 212°F, 100°C

**Service Liquid:**

Max. Temperature: 60°C (140°F)  
Max. Viscosity: 1.15 cts.  
Max. Specific Gravity: 1.0  
Max. Discharge Pressure: 0.5 PSIG

**Casing Pressures:**

Casing Design Pressure: 30 PSIG  
Casing Test Pressure: 45 PSIG

**Max. Dissolved Solids:**

200 ppm

**2.4.3.3** 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.

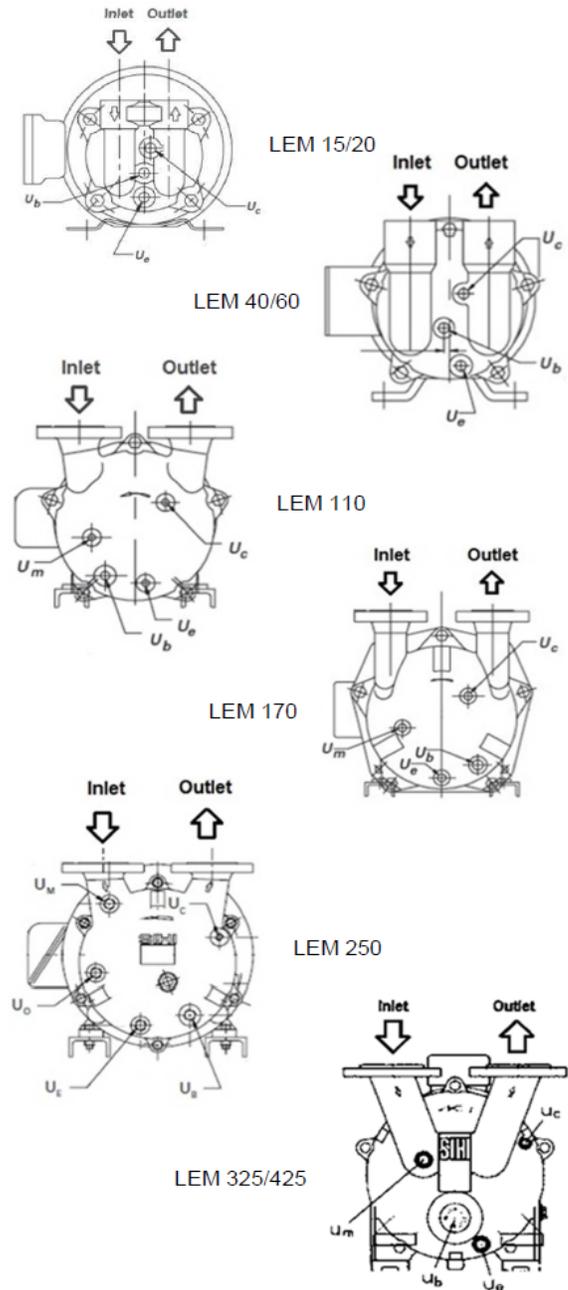
**2.5 Service liquid:**

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

**2.5.2** Connect service liquid to the service liquid connection as shown using suitable pipe sealant on connections.

**Piping Connections**

FIGURE 4



U<sub>b</sub> is Service Liquid  
U<sub>c</sub> is Anti-Cavitation  
U<sub>o</sub> is Overfill  
U<sub>m</sub> is Gauge

FIGURE 5 – Piping Arrangement Table

Pump Models	Inlet and Outlet Size/Rating	Service Liquid Size/Rating
LEM 15/20	3/4"/npt	1/4"/npt
LEM 40/60	1-1/4"/npt	1/4"/npt
LEM 110/170	1-1/2"/150 RF	1/2"/npt
LEM 250	2"/150 RF	1/2"/npt
LEM 325/425	2-1/2" 150 RF	1"/npt

### 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.**

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

### 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 are not damaged by dry operation, and unit is ready for liquid priming if installed in a recirculation system, refer to Chapter 4

Connect electrical supply in accordance with the motor label and electrical connection details in the motor terminal box. Wire any electrically controlled accessories such as service liquid solenoid valves as required.

**3.2.** Ensure motor speeds, voltages and frequencies agree with the supply and the pump requirements.

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

**3.4.** 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

Liquid ring pump operation depends on the continuous supply of cool, clean service liquid, to the pump via the service liquid supply port which is then discharged along with the compressed gas from the pump discharge connection. The volume supplied to the pump needs to 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:** The actual temperature rise experienced 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 needed.

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

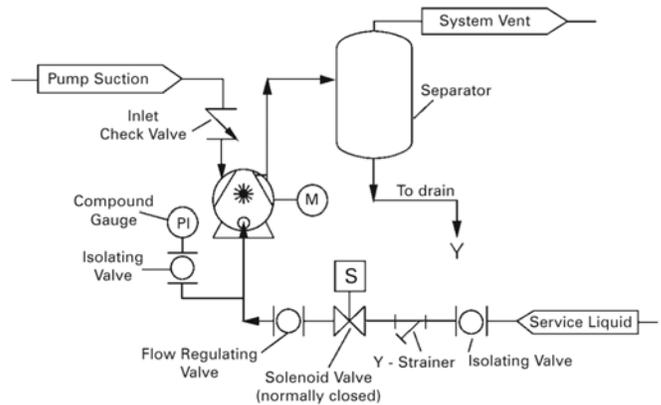
### **WARNING**

**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.**

Refer to [Figure 5 for pipe sizes](#) and [Figure 4 for piping locations](#), [Appendix 1 for the effects of service water vapor pressure](#), and [Appendix 2 for recommended service liquid flow rates for each pump model](#).

#### 4.1 System 1 – Once Through



**Once Through System - Figure 6  
(or flow control orifice)**

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, 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 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 adjust the inlet pressure (vacuum), to the normal operating level. Adjust the liquid flow using the manual, flow regulating valve until the compound gauge shows approximately 0 psig max. 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.

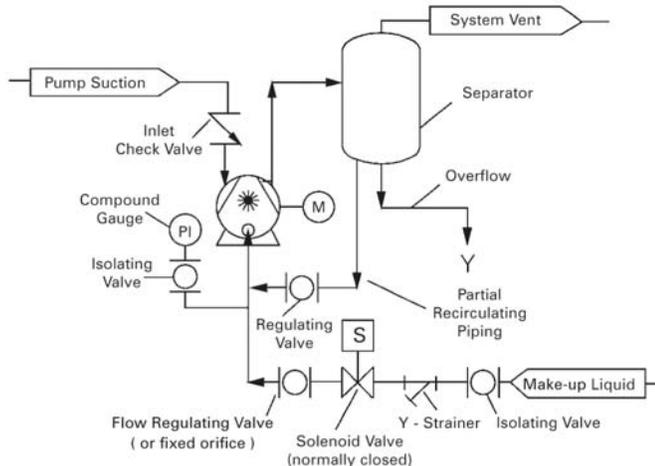
**4.1.1.6** Monitor the service liquid pressure routinely to ensure variations are not occurring and pump operation is satisfactory.

If in the course of normal operation it is necessary to shut the unit off, ensure the solenoid 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 starting torques leading to pump failure or to motor shut down from overload. Contact your local SIHI Agent or the factory for assistance if necessary.

## 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. In operation 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 mixed with the cool make up liquid and the cooled mixture at the design temperature returned to the pump.

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 overflow.

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 with automatic fixed flow control orifice in the make up line

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

**4.2.1.2** Ensure service fluid is available to the make up line.

**4.2.1.3** Close regulating valve approximately half way.

**4.2.1.4** 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.

**4.2.1.5** Start the unit and adjust to the normal operating pressure. 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 the 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.

### 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 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 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.

### NOTICE

Separators used are small hence SIHI recommends a minimum of 10% fresh make-up-be used. Should it be desired to reduce make-up liquid rates further, consult the factory, or consider installing a complete recirculation system.

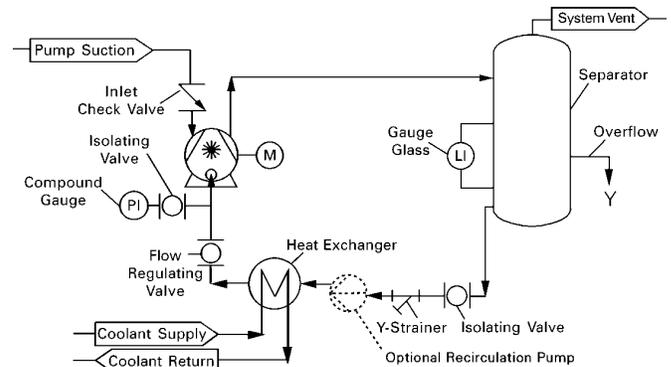
**4.2.2.5** Start the pump and monitor the system inlet pressure until pump operates at the desired vacuum. Reduce the liquid make-up setting until the pump is just capable of maintaining system vacuum with a stable service liquid temperature.

**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 pump is performing satisfactorily, that temperatures are stable and equipment is operating normally (no objectionable change in vibration or noise levels). Service liquid make up rate increase may be necessary if: water temperatures increase, vacuum requirements increase, or supply pressure changes to the control valves.

### 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 gases and/or liquids are handled or processed or where cost or disposal concerns will be high.

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 for 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 to ensure minimum 10" hg is maintained to the pump, or a recirculation pump should be employed to positively supply liquid. 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. Note with LEM pumps this can be done by rotating motor fan by hand

### 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 and that compound gauge pressure fluctuates. If compound gauge does not vary, system is not properly filled. Should this occur readdress points 4.3.1.1 through 4.3.1.4 until pressure fluctuates.

**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 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 5 in. Hg vacuum.

**4.3.1.11** Check service liquid supply temperature from the heat exchanger. Temperature should stabilize at the design temperatures. Check compound gauge which should read up to approximately 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 vacuum pump, recirculation system and/or recirculation pump is not filled with fluid and must be filled. Should this be seen readdress points 4.3.2.1 through 4.3.2.6 until pressure fluctuates.

**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 approximately 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 0 to 5 in. Hg vacuum.

### NOTICE

Ensure service liquid temperature stabilizes at the design temperature required at the pump. If the temperature continues to rise or is above design temperature check coolant supply, temperature and other operating parameters for compliance with design. Contact SIHI for assistance as necessary if variations are found.

**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. Motor Lubrication**

This is a ball bearing motor. Lubrication prior to startup is not required. The bearings have been lubricated at the factory.

**Relubrication Intervals:**

The following intervals are suggested as a guide:

Hours of Service per Year	H.P. Range	Suggested Relube Interval
6,000	1/8 to 7 – ½	6 years
Continuous Normal Applications	10 to 15	1 year
Seasonal Service Motor is idle for 6 Months or More	All	1 year (beginning of season)
Continuous High Ambients, Dirty or Moist Locations, High Vibrations, or Where Shaft End is Hot (Pumps-Fans)	1/8 to 40	6 months

Insulation Class	Consistency	Type	Typical Grease
A/B/F & H	Medium	Polyurea	Polyrex EM Texaco Polystar Rykon Premium #2 Pennzoil Pen 2 Lube Chevron SRI

**Procedure:**

If motor is equipped with zirk fitting, clean tip of fitting and apply grease gun. Use 1 to 2 full strokes on motors in NEMA 215 frame and smaller. On motors having drain plugs, remove grease drain plug and operate motor for 20 minutes before replacing drain plug.

**Explosion Proof motors must only be regreased by UL approved repair shops.**

**NOTICE**

Keep grease clean. Lubricate motors at standstill. Remove and replace drain plugs at standstill. 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.

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 erosion damage are not covered by warranty.

**WARNING**

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

SIHI LEM pumps are fitted with provisions for a cavitation reducing air bleed. Should it be necessary to utilize this feature, refer to Figure 4 and remove plug denoted as Uc. Connect a bleed line with manual regulating valve to the connection, and to the separator vent piping.

Operate the pump at the design conditions and open the bleed valve until the cavitation noise subsides. Leave the air bleed open at this setting.

### **WARNING**

Do not open plug Uc to atmosphere, since in some operating conditions, water and/or gas may be vented from the Uc connection.

If liquid or gases handled are toxic, be certain to follow accepted procedures when draining or disassembling equipment. Safety Regulations must take precedence over any procedure noted in this manual. Failure to do so may result in serious personal injury, environmental damage, and/or premature pump failure.

### 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. Pump failures resulting from cavitation and abrasion damage are not covered by warranty.

SIHI LEM pumps are fitted with a central drain for the impeller cavity (Ue) refer to Figure 4. If solids are carried over from the system evacuated, this drain should be opened from time to time with the pump idle to drain solids trapped in the pump casing. Frequency required will depend on the quantity of foreign matter carryover experienced.

In extreme cases, the drain connection in the pump casing can be piped via a manual or orifice type flow valve to continuously drain carried over solids. However, in these instances, service liquid flows or make-up flows must be increased by the liquid quantity drained.

### **NOTICE**

If continuous drain is utilized, drain piping should be piped from the connection up to approximately the midpoint of the casing, and then down to drain, to prevent complete casing drain when the pump is idle.

For complete recirculation systems, the continuous drain should be piped to the discharge separator, not to an open drain, unless make-up is continuously used.

### 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.

In these applications, 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.

### **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

## 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 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 2.3.3

**6.2.2** Cap connections securely to prevent leakage.

**6.2.3** 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 and fill the pump completely with the chosen preservative. Close all connections securely.

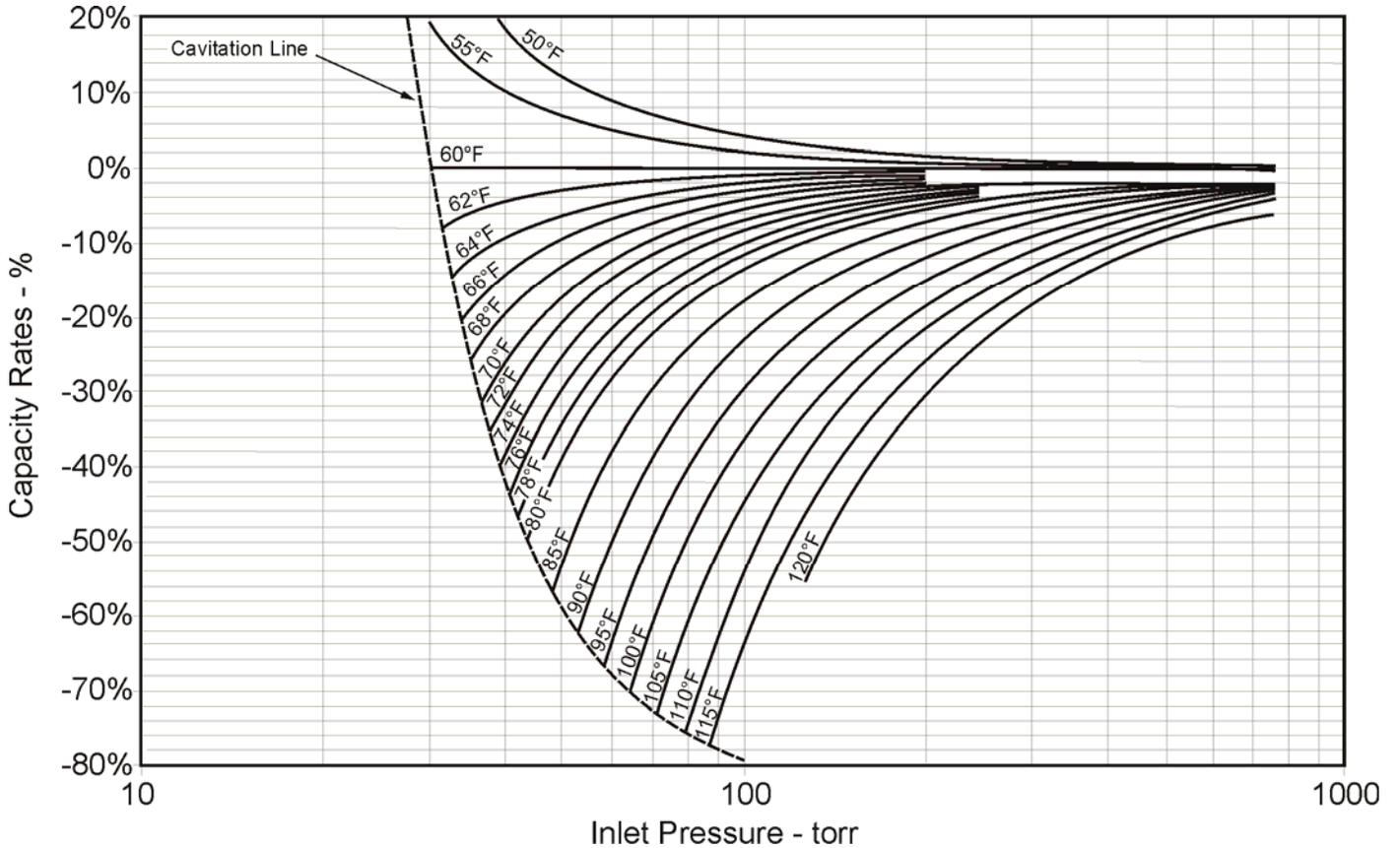
**6.3.6** Grease bearings if possible to ensure they are adequately sealed and prevented from exposure to the atmosphere.

**6.3.7** Rotate shaft by hand weekly to prevent possible bearing damage.

**APPENDIX 1**

**EFFECTS OF SERVICE WATER TEMPERATURE**

**Single Stage Liquid Ring Vacuum Pumps**



**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.

## SERVICE LIQUID RATES (USGPM)

PUMP MODEL	Pump Speed	12" HG 455 torr			16" HG 345 torr			20" HG 252 torr			24" HG 150 torr			28" HG 49 torr		
		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
LEM 15	3500	0.8	0.2	0.1	0.8	0.2	0.1	0.8	0.2	0.1	0.8	0.2	0.1	0.8	0.2	0.1
	2900															
LEM 20	3500	1.0	0.3	0.2	1.0	0.3	0.2	1.0	0.3	0.2	1.0	0.3	0.2	1.0	0.3	0.2
	2900		0.3	0.2		0.3	0.2		0.3	0.2		0.3	0.2		0.3	0.2
LEM 40	3500	1.5	0.5	0.3	1.5	0.5	0.3	1.5	0.5	0.3	1.5	0.5	0.3	1.5	0.4	0.2
	2900															
LEM 60	3500	1.5	0.7	0.5	1.5	0.8	0.5	1.5	0.8	0.5	1.5	0.7	0.5	1.5	0.7	0.5
	2900		0.6	0.4		0.6	0.4		0.6	0.4		0.6	0.4		0.6	0.3
LEM 110	1750	1.8	1.1	0.7	2.3	1.2	0.8	3.1	1.5	1.0	3.5	1.5	1.0	3.9	1.3	0.8
	1450															
LEM 170	1750	3.1	1.7	1.2	3.8	1.9	1.3	3.8	2.0	1.3	4.4	2.0	1.3	4.4	1.8	1.1
	1450		1.4	0.9		1.6	1.0		1.7	1.1		1.7	1.1		1.4	0.8
LEM 250	1750	3.3	1.7	1.3	3.8	2.0	1.4	4.3	2.2	1.5	4.7	2.4	1.6	5.2	2.2	1.4
	1450		1.0	0.6		1.7	1.1			1.9		2.0	1.3		1.7	1.0
LEM 325	1750	5.1	3.0	2.2	5.1	3.0	2.2	5.1	3.0	2.2	6.2	3.4	2.3	6.6	3.3	2.2
	1450		2.6	1.8		2.6	1.8		2.6	1.8		2.9	1.9		2.2	1.8
LEM 425	1750	4.0	3.0	2.3	4.0	3.0	2.3	4.8	3.3	2.5	7.0	4.3	3.1	8.3	4.4	3.0
	1450		2.6	2.0		2.6	2.0		2.9	2.1		3.7	2.5		3.6	2.5

**Column A** is the flow in USGPM required - once through.

**Column B** is the make-up flow required when make-up water is 5°C (9°F) cooler than service water.

**Column C** is the make-up flow when make-up water is 10°C (18°F) cooler than service water.

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

## Appendix 3 - 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 (approximately 15 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 leading 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.

**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**

**Cause 1:** Most SIHI equipment operates at less than 85 dba at 3 to 5' when installed depending on pump size. 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 2, and adjust accordingly.

Compare service water temperature with the data in Appendix 1, Figure 9.

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.

Install anti cavitation line per 5.3.1. If cavitation persists, added bleed in suction may be required. **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).**

**Problem 4 Vibration**

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

Vibration in close coupled pumps is usually the result of installation concerns caused by improper pump and motor support, piping miss-alignment improper suction or discharge piping.

Other sources of vibration in close coupled units are operational concerns including cavitation, liquid slug carryover, service liquid supply and mechanical failures

**Solution:** Check pump installation per Chapter 2. Pay particular attention to line sizes, discharge piping heights and inlet piping slopes to the equipment. Ensure piping is properly supported and any expansion or contraction issues dealt with in the piping before connection to the pump.

If inlet slug conditions exist, install a knockout or flow equalizer system as required. Refer to cavitation issues Trouble Shooting Problem 3 Noise.

Check motor bearings for noise and vibration and contact SIHI for information.

## Installation, Operation & Maintenance

# LEM – Close Coupled Vacuum Pumps

SIHI – An International Company Serving Industry Since 1920

### Global Locations

Australia	Columbia	Italy
Austria	France	Netherlands
Belgium	Germany	Spain
Canada	Great Britain	Switzerland
Chile	Greece	United States

### North American Locations

#### **SIHI Pumps, Inc.**

303 Industrial Drive  
Grand Island, NY 14072  
Tel: (716) 773-6450  
Fax: (716) 773-2330

#### **SIHI Pumps Limited**

225 Speedvale Avenue W.  
Guelph, Ont. Canada N1H 6L8  
Tel: (519) 824-4600  
Fax: (519) 824-7250

#### **SIHI Pumps, Inc.**

5757 Genoa-Red Bluff Road  
Pasadena, Texas 77507-1044  
Tel: (281) 991-3100  
Fax: (281) 991-3101



[www.sihi-pumps.com](http://www.sihi-pumps.com)

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