INSTALLING NES COMPANY INC. LIQUID RING VACUUM PUMPS

The first step towards operation of a liquid ring vacuum pump is proper installation.

The liquid ring vacuum pump is one of many kinds of rotary positive displacement gas transfer pumps that utilize liquid as the principal physical element to perform gas compression and pressure manipulation. The compression is performed by the liquid ring, which is formed by the centrifugal force of a rotating multi-bladed impeller that is positioned eccentrically relative to the pump's casing.

The eccentricity results in the near-complete filling and emptying of the rotor chambers, creating an effect similar to that of a piston within each set of rotor or impeller blades.

The pump's parts are assembled to intake gas as the pump empties liquid, allowing the gas to discharge after complete compression with simultaneous suction. Sealing areas between the suction and discharge close the rotor areas and separate the flow between the inlet and outlet.

IN THE BEGINNING

Proper installation of the liquid ring vacuum pump directly and significantly affects the results of its operation and the frequency of its maintenance. The following guidelines are recommendations that apply generally across liquid ring vacuum pump technology. Users should defer to the specific recommendations of each manufacturer to ensure optimal performance.

Unpacking the pump with caution prevents damage or assembly misalignment. For baseplate-mounted units, lifting should only be done by the base. Slings and hooks cannot be attached to the pump or motor without resulting misalignment. The pump should not be run until properly installed and given sealing liquid.

Pump components are typically protected with water-soluble preservatives. These should be flushed out if a non-water sealing fluid is being used in a closed-loop system. Stainless steel or other non-ferrous materials of construction may be shipped without preservative ("dry"). The unit should be stored and installed in a place where any liquid that is present will not freeze.

SETTING UP

Liquid ring vacuum pumps operate smoothly at slow speeds, providing some level of assurance, but it is nonetheless important to firmly secure, level, and anchor the pump's frame or baseplate.

Pumps greater than or equal to 50 hp should be placed on a concrete pad. Smaller units can be mounted on floors and skids. All pipe joints, flanged or screwed, should be checked for strain and leaks before startup.

Direct-coupled pumps that are supplied with motors are typically aligned and factory-tested prior to shipment. During shipment and installation, undefined forces and moments cause the alignment to become askew, requiring inspection and realignment before startup. The coupling manufacturer guidelines should be followed closely for the best results.

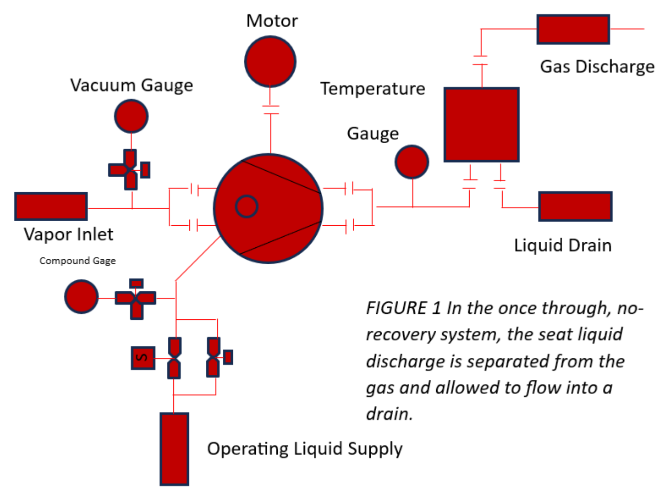


FIGURE 1 In the once through, no-recovery system, the seat liquid discharge is separated from the gas and allowed to flow into a drain.

V- belt driven pumps require inspection of sheaves and installation, as well as realignment before any tensioning of the drive. The V-belts are to be placed over the sheaves in the grooves without forcing the fit.

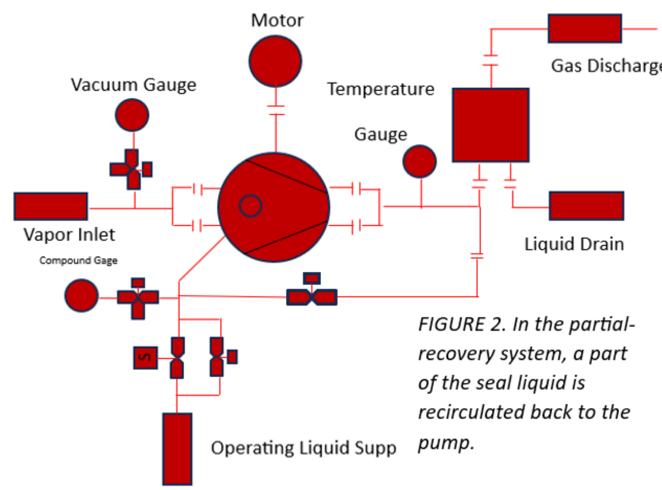


FIGURE 2. In the partial-recovery system, a part of the seal liquid is recirculated back to the pump.

After belt-groove alignment, adjusting needs to take place on the centers to remove slack, yielding a taut belt. During operation, the slack side should bow marginally. A few days after operation, the belts may require re-tensioning. Slipping ("squealing") upon startup indicates a need for re-tensioning. Excessive tensioning shortens bearing life. If the pump unit is to be idle for extended periods of time, the tension should be released.

Heat above 140°F over-cures the rubber and significantly shortens belt life. Belts should never switch from one groove to another on the sheaves and should only be replaced with a matched set. Oil, grease, and belt dressing must never come into contact with the belt.

PIPING THE SEAL FLUID

The effectiveness of the liquid ring depends on the continuous flow of clean seal fluid. Water is commonly used, but many suitable fluids are available and commercially used as well. The pump's casing has dedicated connections for the operating fluid to enter and form the ring before discharge along with the process gas. The seal liquid can be used in vacuum pump applications in three distinct configurations: once-through, partial recovery, and closed loop. All three of these arrangements feature four common elements:

- Sealing fluid source (tower, reservoir, etc.)
- A flow control device
- A device to cease flow when the pump is shut down.
- A means of separating the gas-liquid exhaust mixture.

Once-through, no recovery. Seal fluid flows from a main directly to the pump [Figure 1]. No fluid is recycled or recovered. Liquid discharge is filtered from the gas and wasted via drain. Conservation and contamination are of no concern for those who utilize once-through configurations. An automatic solenoid valve controls the flow of the seal fluid. When the motor stops running, the solenoid is set to shut. When a manual shut-off valve is used instead, care must be taken, flashing cautions to open the valve immediately after motor startup, as well as shutting the valve immediately before motor shutdown.

Partial recovery. Seal fluid enters and leaves the pump similar to that of the once-through arrangement [Figure 2]. Some of the seal fluid is recirculated from the separator tank back to the pump; the rest is discharged from the separator and wasted via drain. Fresh makeup seal fluid is incorporated in a controlled manner according to the proper operating temperature that contributes greatly to optimal pump efficiency and conservation. The partial-recovery arrangement is utilized in situations where sealing fluid conservation is an important consideration. A maximum 50% reduction in water consumption is possible. If a fluid other than water is used, consumption can be reduced beyond 50% depending on the physical properties of the fluid, such as vapor pressure and operating temperature.

Closed loop. This configuration completely recirculates the seal fluid. The system uses a heat exchanger to help remove any heat generated by operation, such as compression and condensation [Figure 3]. After heat removal, the fluid is recirculated through the pump. At high suction pressures and excessive pressure drops for extended periods of time, a recirculation pump is likely to be necessary. In partial and total recovery configurations, the seal fluid level in the separator tank should be level with or slightly below the pump shaft centerline. Level controls must be incorporated (high-level overflow and low-level makeup) to prevent pump startup with overfilled casing. This overloads the motor and damages the pump.

Any liquid ring vacuum pump arrangement should never be started with a full casing, so draining is always implemented in the case of flooding. The technical specificities depend on the manufacturer.

It is typically unnecessary to drain the pump if the seal liquid intake is shut off simultaneously. This can be done via automatic valve.

Liquid ring vacuum pumps with a standard shaft seal packing or gland arrangement are often fitted additionally with lantern rings and cooling liquid gland connection.

Cooling liquid at approximately 5 psig above operating pressure must be provided. A common supply for both seal fluid and gland cooling is normally used.

A supply of cooling and flush liquid is additionally required in the case of pumps that utilize mechanical seals. A separate, clean supply of seal fluid should be used for these mechanical seals. Double mechanical seals require a device for leak detection around the inboard seal.

PIPING

The suction and discharge flanges are usually marked by arrows on the casing. The lines should be the same size as the pump connections.

The discharge line to the separator should be as low in height as possible. If necessary, a discharge leg can be used with minimum elevation above the pump discharge flange. Excessive height on the discharge line causes back pressure, overloading the motor and causing detriment to pump capacity.

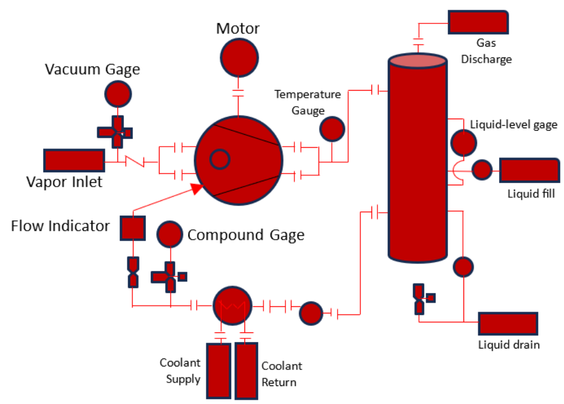


FIGURE 3. In this design, the seal fluid is totally recirculated.

The seal-fluid supply piping should be the same size as that of the pump connection. For full-recirculation systems without a recirculation pump, the pipe is up-sized to reduce pressure drop.

The pump openings' protective coverings are to be removed right before connecting pipework. All foreign matter must be thoroughly removed before any connections are made on piping.

The flanges must be inspected to fit without strain, and the flange holes must be in perfect alignment. The flange gaskets must not protrude into the interior bore of the pipe or flange. All pipework needs to be supported independently on each side and must fit easily without transferring strain onto the casing of the pump. During the first three weeks of operation, a protective mesh would be greatly beneficial if fitted on the pump inlet.
Piping and connections must be regulated to keep forces and moments transferred to the pump to a minimum. There should be no exerted forces or moments on the pump casing, as the piping support should be complete. The line sizes should be the same size as the pump connections to eliminate unwanted pressure drops, if not larger.

ELECTRICAL CONNECTIONS

Standard induction motors sufficiently drive liquid ring pumps. Across-the-line operation is typically employed, as the starting loads are usually quite low.

A motor controller with overcurrent protection over the heater or fuse is recommended. The full-load current rating that is stamped on the motor nameplate should be taken into consideration when selecting proper protection ratings. A disconnect switch should be installed between the motor controller and the power supply.

The pump should be turned by hand after the completion of all electrical work. The gland rings may need to be slackened for free rotation of the shaft, which rotates according to the direction of the arrow marked on the pump. Prime the system, introduce the seal fluid, turn the motor on and off, check the pump rotation, and turn off the seal fluid. Should the pump rotate in the wrong direction, reverse any two of the three motor leads and repeat the procedure.

A single-phase 115V supply should be used for the control circuits. All components, including solenoid valve, vacuum switches, and alarms should be supplied only with 115V to comply with the standards and regulations of the electric safety code.

ACCESSORIES

Liquid ring vacuum pump systems are capable of holding many essential, beneficial, or convenient accessories. Depending on the application, the necessity of each accessory is determined.

- **Isolation valves** separate the pump from the system when it is shut down for extended lengths of time, such as in the situations of maintenance procedures. For pressure drop reduction in 3-inch lines or larger in size, gate valves or full-port valves are the optimal choices. Butterfly valves are the more inexpensive of the selection.
- **Inlet check valves** prevent the process material and seal fluid from back-flowing through the process when the pump is stopped. Valves such as swing-check, double flexible-seal, and equal-type valve require horizontal installation.
- **Inlet vacuum relief valves** prevent pump cavitation. The valve opens and bleeds in atmospheric air (or process material if it is connected to the pump's discharge side) when the pump's vacuum is below the valve setting. Most of the economical of these valves are based on atmospheric pressure; they need to be calibrated at regular intervals.
- **Flexible connectors** are used when slight misalignments occur between pump and process, or if expansion is expected within the capabilities of the connector.
- **Inlet vacuum control valves** control the system's vacuum level by bleeding in a similar way to the relief valves. To control this to a finer degree, pneumatic diaphragms mounted on globe valves are necessary.
- **Seal liquid shut-off valves** stop the seal fluid flow manually.
- **Strainers** filter solid particulates from seal fluid.
- **Seal liquid flow-control valves** control the seal fluid flowrate to the pump. Globe valves are most common.
- **Compound pressure gages** indicate the seal fluid inlet connection pressure. Maintaining the connection point's pressure properly will result in the establishment of an approximate flowrate.
- **Discharge separator tanks** separate liquids from the discharge gas. These tanks can be mounted on the floor (or a baseplate) or supported by discharge piping like in once-through systems.
- **Solenoid valves** automatically stop and start the seal fluid flow to the pump.
- **Circulating pumps** are used in fluid recovery systems when the pump operates for long periods of time with high suction or excessive pressure drops.
- **Heat exchangers** remove heat from recirculated seal fluid.

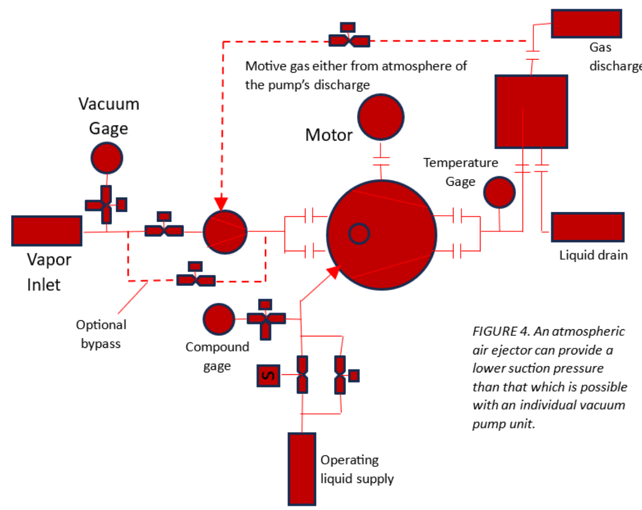


FIGURE 4. An atmospheric air ejector can provide a lower suction pressure than that which is possible with an individual vacuum pump unit.

- **Atmospheric air ejectors** extend the suction pressure capabilities of a lone liquid ring vacuum pump unit. The ejectors can be added to a pump to yield vacuum levels down to 3 torr. Atmospheric air or recycled gas is used as the motive gas that compresses the process material from the system design pressure up to the liquid ring pump suction pressure. A bypass can be added for full pump capacity above 30 torr.

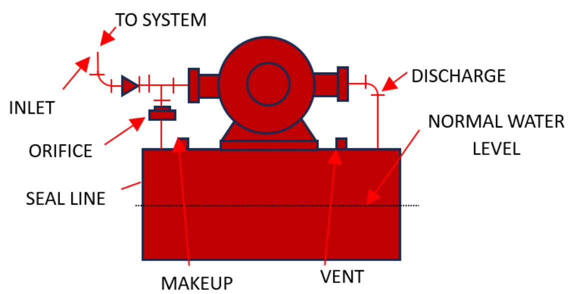
BASIC RECIRCULATED SYSTEMS

There are two encompassing instances where systems of recirculated seal fluid may be advantageous:

1. Contained water or water shortage, i.e. shipboard applications
2. Non-water seal fluid. Mineral oils, synthetic oils, and various solvents can be used to create the liquid seal. The use of a once-through system with non-water seal fluid will result in a cost that is multiples times larger than the pump itself.

NES Company Recirculated Systems come in three kinds.

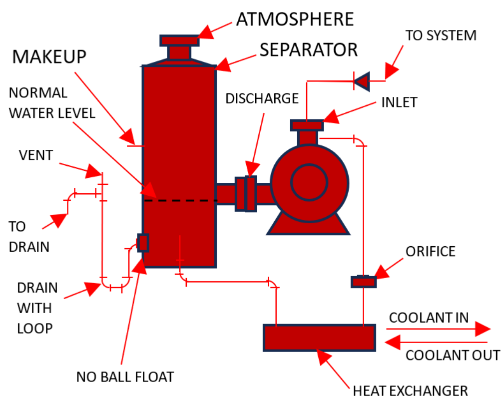
1. Tank Mounted, Self-Contained.



These units do not need heat exchangers or circulating pumps, as natural heat transfer occurs through the walls of the tank and piping, and the fluid flow is controlled via orifice in the seal fluid line. Tank mounted units are typically limited to pumps of 5 bhp or less.

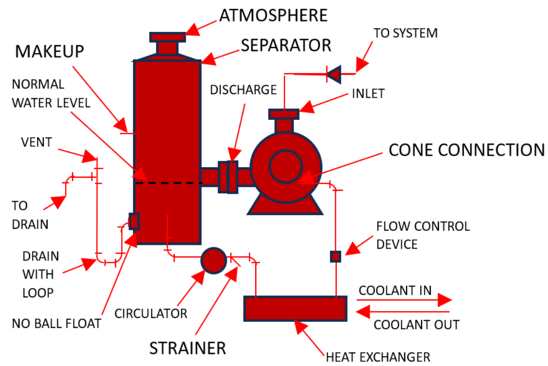
2. Full Recirculation with Heat Exchanger

STANDARD – NO CIRCULATOR – VACUUM



a. Standard units without a circulator can only be used on inlet-sealed vacuum pumps and compressors. Like with the tank-mount, an orifice controls the flow. A heat exchanger is used to cool the fluid.

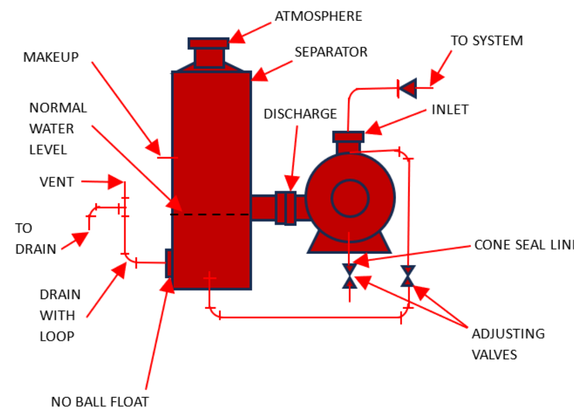
STANDARD – WITH CIRCULATOR – VACUUM



b. Cone or shroud seal pumps require a system with a circulator. An orifice, flow control valve, or adjusting valve controls the flow. The circulator creates positive pressure by which the flow control is achieved when the inlet seal is not recommended. All systems should be completely primed before startup, and a sufficient water level must be maintained to prevent carryover of air into the pump.

3. Partial Recirculation

PARTIALLY RECIRCULATED SYSTEM



The seal fluid savings may reach 10-50% depending on the fluid temperature. Heat transfer is achieved through the partial renewal of seal fluid, so no heat exchanger is incorporated. The temperature of the seal fluid will still rise, so caution is advised: the pump efficiency will be affected, and the water vapor content of the process material discharged from a compressor will increase.

Basic design requirements for recirculated system:

a. Method of moving water from the separator to the pump.
b. Water level control.
c. Sufficient heat transfer.

Recirculating the water from separator to pump takes two generic forms:

1. Use the discharge pressure as the driving force, piping back to seal connections in the cone at a discharge pressure greater than or equal to 20 psig. For values between 10 and 20 psig, a third of the water is sent to the cones, with the remainder sent to the inlet. An orifice is needed at the gas outlet to quickly create separator pressure upon startup, regardless of the discharge pressure values.
2. Use a circulating pump to create motive force, the easiest method when discharge pressure is less than or equal to 10 psig. This pump is typically a centrifugal pump rated for 110-125% of normal sealing requirements. TDH requirements are usually between 20-40 feet, but this varies.

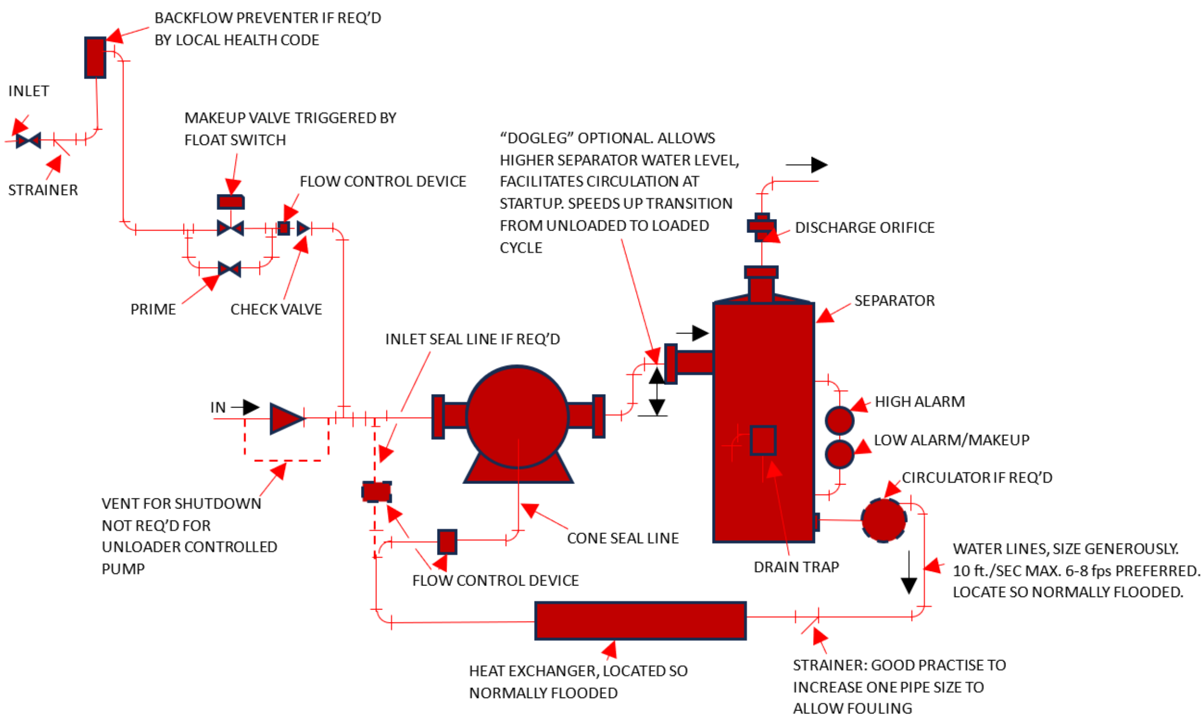
There are two methods equally capable of controlling water level.

1. Continuous duty systems should have a high-level drain that allows more gpm than the makeup device and a low-level alarm switch.
2. Unattended operation should have a high-level alarm switch and automatic makeup with a capacity less than the high-level drain. The low-level alarm can be combined with this makeup device if need be.

The typical ways of dissipating heat generated by compression are as follows:

1. A water-to-water heat exchanger is most common, usually of the shell-and-tube type. A good estimation technique would be to allow no more than 3 psi of pressure drop in the seal fluid with a 0.0015 minimum fouling factor. Dirty fluid, usually the cooling fluid, should be put through the tubes, and the compressant should be cooled by the shell.
2. Closed type air-to-water heat exchangers (radiators) are used when water is scarce. The issue with this method is that the fluid temperature is not usually lowered to the desirable degree, only within approximately 20 degrees of ambient air temperature. More often than not, the capacity must be de-rated in this case.
3. Open type air-to-water heat exchangers like cooling towers cool within 5 degrees of ambient wet bulb temperature. They occupy much space and are expensive. In most cases it is more practical to tap into the plant's main cooling tower, despite the piping complications and poor quality of water that follows. Consider using the plant main tower cooling water as coolant in a shell-and-tube heat exchanger.
4. Systems without exchangers, the most common of which are tank mounts, are best suited for cyclical processes in which idle periods give the fluid time to cool.

RECIRCULATED SYSTEM



System Layout

For the initial priming of systems, especially ½" or ¾" pipe-to-pump inlet, the following provisions are required:

- Cooling and circulating fluid lines need to be below the pump so that they are normally flooded. If they cannot be below, additional valves are needed.
- When financially possible, use corrosion-resistant material for piping to hinder the buildup of foreign material such as scale and sludge.

Case and Feeding of Recirculated Systems

The most significant issue to note is the cleanliness of the circulated fluid. Sludge and scale naturally build up within the system, and dirt and dust are scrubbed from ambient air into the system. Corrosion inhibitors, such as chromates, can be added to mediate the effects of buildup, but only if they are compatible with the process material such that there are no resulting hazardous chemical products. The most accessible and effective practice is system blowdown every twenty-four hours. This allows the separator to drain fluid until the system runs clean and clear circulating fluid.

TROUBLESHOOTING

LIQUID RING VACUUM PUMPS

Troubleshooting is just as important to extending service life as with proper installation. Only qualified personnel with proper equipment should be authorized for testing.

It is good practice to inspect the equipment upon arrival onsite. Make sure the equipment is installed properly and that all valves and flow switches are according to installation drawings, including direction of installation. Confirm the proper rotation direction and freedom of the pump, and properly prime the system before startup. The aforementioned checks make troubleshooting simpler.

Malfunction of the vacuum system could be due to utility or process conditions, or both, or the equipment, and it is important to determine the cause. A malfunction due to external influences can be determined as follows:

1. Compare original design conditions with existing conditions, particularly chemical composition and cooling fluid temperature, as these will have definitive impact on the system performance. An increase in condensable load will raise the temperature of the seal fluid. A change in condensable or non-condensable composition will affect the seal fluid composition, causing detriment to vacuum. High seal fluid temperatures do the same.
2. Inspect all areas for excessive air leakage, determined in one way through the drop test from the Heat Exchange Institute Standards for Steam Jet Vacuum Systems.
3. Verify that system backpressure is within design conditions, as excess causes increase on brake horsepower and negatively affects pump capacity.

Beyond these steps, troubleshooting a malfunction is as follows:

1. The seal fluid temperature rise across the pump should be comparable to that of design; even if cooling water temperature and gas composition are of design, a plugged strainer or partially closed valve in the recirculation line could cause reduced sealing. The recirculating pump performance should be reviewed, and the heat exchanger should be checked for fouling. All said issues affect the vacuum performance.
2. Using a tachometer, compare pump speed against design specifications. For V-belt drive, check for proper tension and no slipping.
3. Test the vacuum pump against the Heat Exchange Institute's Performance Standards for Liquid Ring Vacuum Pumps and manufacturer performance curves. Need may arise to readjust internal clearances to meet the same performance as that of the manufacturer's curves.

It is of utmost importance to develop and adhere to a maintenance routine with the following considerations:

1. A vacuum pump with packing will drip, but excessive leakage means improper adjustment. Readjust packing and check dripping to provide proper cooling. Mechanical seal vacuum pumps should not leak. Flush seals with clean fluid that is compatible with the material of construction of the mechanical seals.
2. Verify that the bearings do not exceed their rated temperatures. Normal temperatures are approximately 140°F. Misaligned couplings, piping stress, over-greasing, and contaminated lubricant all contribute to temperature rise.
3. Coupling misalignment, high seal-fluid flow, high discharge pressure, improper pump anchoring, bearing failure, overflooding during startup, or lack of air flow to the vacuum pump are all issues that can be diagnosed with excessive noise and vibration from the pump.
4. High amperage is caused by issues such as high discharge pressure, seal-fluid overflow, and motor malfunction.