Liquid Ring Pump

Series 2 Design

Installation, Operation & Maintenance Manual

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GRAHAM
ENGINEERING ANSWERS

Table of Contents

Section 1 - General Information

1.1 Introduction

This manual will provide assistance in the installation, operation, and maintenance of your Graham Liquid Ring Pump. Please read this manual completely prior to operating your Liquid Ring Pump. If you need to contact the Pump Service Department for assistance, please have available the pump serial number and model number. The Pump Service Department may be reached by contacting Graham Corporation in Batavia, NY by phone (585) 343-2216, Fax (585) 343-1097, or e-mail at service@graham-mfg.com. Refer to the Graham web site at www.graham-mfg.com for other information on our Liquid Ring Pumps.

Graham has an extensive stock of spare parts and replacement pumps. Stocked parts and pumps can be shipped from our warehouse in Batavia, NY by a carrier of your choice.

For your convenience, use our toll free number (1-800-828-8150) ***only*** when ordering spare parts and replacement pumps. Please have the model number, serial number and part number of the items required when placing an order. Refer to Graham web site www.graham-mfg.com for Liquid Ring Vacuum Pump spare parts information. Normal business hours are 8:00 a.m. to 5:00 p.m. (E.S.T.), Monday through Friday.

Factory rebuilding service is available for pumps returned to our factory in Batavia, New York. Before a pump is returned to the factory for repairs, please drain and flush the pump and include a Material Safety Data Sheet (MSDS) for the process in which the pump was used. A Return Material Authorization (RMA) Number, issued by Graham, is required before returning a pump. Refer to our web site for this form or contact Graham for this information. Field Service Technicians are also available for travel to the jobsite for troubleshooting and repair or rebuilding of pumps. Contact Graham for service rates.

1.2 General Description and Principle of Operation

Graham Vacuum Pumps and Compressors are of the liquid ring type. Single and two stage pumps are available in a wide range of sizes and materials. These options are listed in the Graham Sales Bulletin available on our web site. The major component of the Graham pump is a multi-bladed rotating assembly positioned eccentrically in a cylindrical casing. (See Figure 1) This assembly is driven by an external source, normally an electric motor. Service liquid (usually water) is introduced into the pump. As the impeller rotates, centrifugal force creates a liquid ring which is concentric to the casing. At the inlet, the area between the impeller blades (buckets) increases in size, drawing gas in. As the impeller continues to rotate toward the discharge, the impeller bucket area decreases in size, compressing the gas. This gas, along with the liquid from the pump, is discharged through the outlet nozzle. The service liquid is separated from the gas and cooled for reuse in the pump or sent to a drain. In addition to being the compressing medium, the liquid ring performs two other important functions:

1) It absorbs the heat generated by compression, friction, and condensation of the incoming vapor.
2) It absorbs and washes out any process contaminants entrained in the gas.

A continuous supply of service liquid is necessary to limit the temperature rise in the pump caused by the heat of compression, friction, and condensation. Any excessive rise in temperature will have a detrimental effect on performance, reducing the capacity and degree of vacuum attainable. Installation schematics for the supply of the service liquid and for the separation of the gas and liquid discharged from the pump are shown in Section 2.

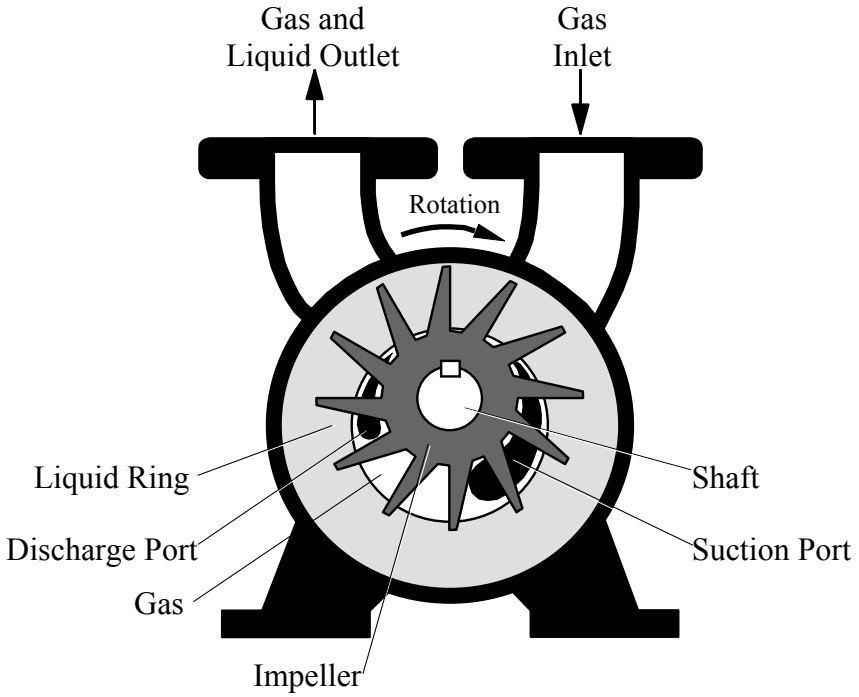


FIGURE 1

Service liquid quantities are a function of the particular model and the intended application. Check the data sheet for your specific pump model or see Table 1 of Section 3 which lists typical service liquid requirements for Graham Model Pumps.

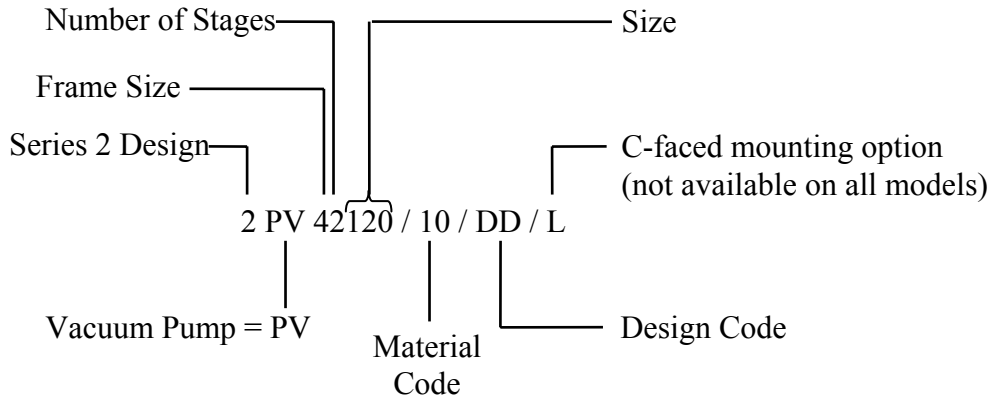
The normal operating ranges of Liquid Ring Pumps when using water at 59 °F (15 ºC) for the service liquid are:

Single Stage Pumps	dependent on model, down to 25 mmHgA
Two Stage Pumps	down to 25 mmHgA
Two Stage Pumps w/Air Ejector	down to 3 mmHgA
Single Stage Compressors	20 psi (1.4 bar) max. differential
Two Stage Compressors	30 psi (2.1 bar) max. differential

The standard materials of construction are suitable for handling air and other non-corrosive gases, while using water as the service liquid. Other materials can be supplied for special applications.

1.3 Description of Pump Model Codes

Each pump is designated by a model code which describes the materials of construction, size, type of shaft seals, and any special features. An example of a typical pump is shown below.



Note: Graham Pump Models LXP30 & LXP55 are replacements for models 2PV31020 and 2PV31040 respectively.

Section 2 - Installation Instructions

2.1 Handling

Carefully unpack the pump. Bare pumps may be lifted with a sling placed around the bearing housings or under the flanges.

Lift pump-motor assemblies by the baseplate only. Do not attach slings or hooks to the motor or the pump as this can cause misalignment. Do not attach slings or hooks to the motor or the pump as this can cause misalignment. Do not attempt to run the pump until the installation work is complete.

CAUTION: **DO NOT RUN THE PUMP WITHOUT SERVICE LIQUID AND SHAFT SEAL FLUID.**

2.2 Preservation

Cast Iron and Steel pumps are protected internally with a preservative solution applied at the factory before shipping. The preservative solution should be flushed from the pump prior to use. An MSDS form is included in the back of this manual (Appendix A).

The preservative solution is petroleum based and must be disposed of in accordance with all Local, State, and Federal regulations.

2.3 Mounting

Before operation, the pump package should be carefully set, leveled, and securely bolted in place. It is recommended that shims and grout be used as necessary under all structural members of the base.

Graham vacuum pumps supplied with an adapter for mounting a NEMA C-faced motor should be bolted to a floor, a cement pad or an existing framework. Support bracket located under motor lantern should contact but not be anchored to the floor or mounting base.

Baseplates supplied with a pump and drive motor mounted at the factory should be leveled, shimmed as required, and firmly anchored.

2.4 Installation

All piping to the pump should be adequately supported to eliminate any stress at the pump connections. All piping joints should be tested for leaks prior to start-up. A temporary start-up strainer in the process inlet piping may be used to keep large contaminates from entering the pump at start-up.

Install the piping for the service liquid and process, as required. Refer to Section 2.7 for details.

The location of the installation or the storage of the pump should be in an area that will not subject the pump to freezing.

Verify the pump's rotation direction by checking the arrow on the shaft end casing. Refer to Section 2.10 concerning the electrical requirements.

2.5 Coupling Alignment

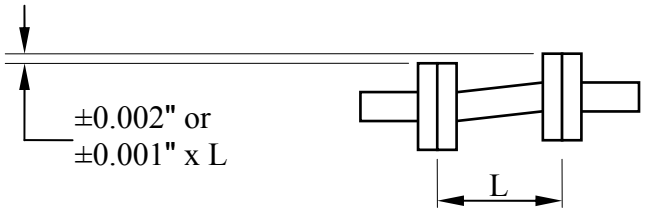
CAUTION: **TO PREVENT PERSONAL INJURY, DO NOT OPERATE THE PUMP WITHOUT PROPERLY GUARDING THE DRIVE COUPLING(S).**

Pumps supplied from the factory packaged with a motor on a baseplate have had the shafts aligned prior to shipment. This ensures that alignment can be done in the field. It is required that the shaft alignment be rechecked after mounting on a level foundation and prior to start-up.

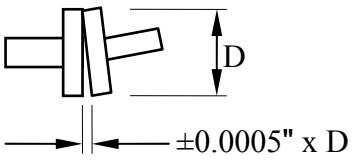
When a gear reducer is supplied between the pump and motor, they are aligned at the factory and must be realigned after installation. The gear reducer should be aligned to the pump first and then the motor should be aligned to the gear reducer.

For smoother operation and longer life of the coupled equipment, the following maximum misalignment tolerances are recommended:

The maximum allowable parallel shaft misalignment for standard couplings is ±0.002" (0.05 mm) and for spacer couplings is ±0.001" per inch (0.025 per mm) of spacer length.



The maximum allowable angular shaft misalignment is ±0.0005" per inch (0.013 per mm) of coupling diameter.



Pumps provided with a C-faced mounted motor do not require alignment, however, the coupling should be checked prior to start-up.

2.6 Belt Drives

CAUTION: **TO PREVENT PERSONAL INJURY, DO NOT OPERATE THE PUMP WITHOUT PROPERLY GUARDING THE DRIVE BELTS.**

When pumps are supplied with belt drives, follow the belt manufacturer's instructions to set the tension.

2.7 Service Liquid Piping Arrangements

The operating principle of a liquid ring pump depends on a continuous supply of clean service liquid, which is normally water. The liquid enters the pump through a connection on the casing and is discharged from the pump along with the gas. There are two basic piping arrangements that can be used for liquid ring pump applications. A once-through method with no recovery of the service liquid and a recirculation method which re-uses the service liquid.

Both of these arrangements have four basic elements:

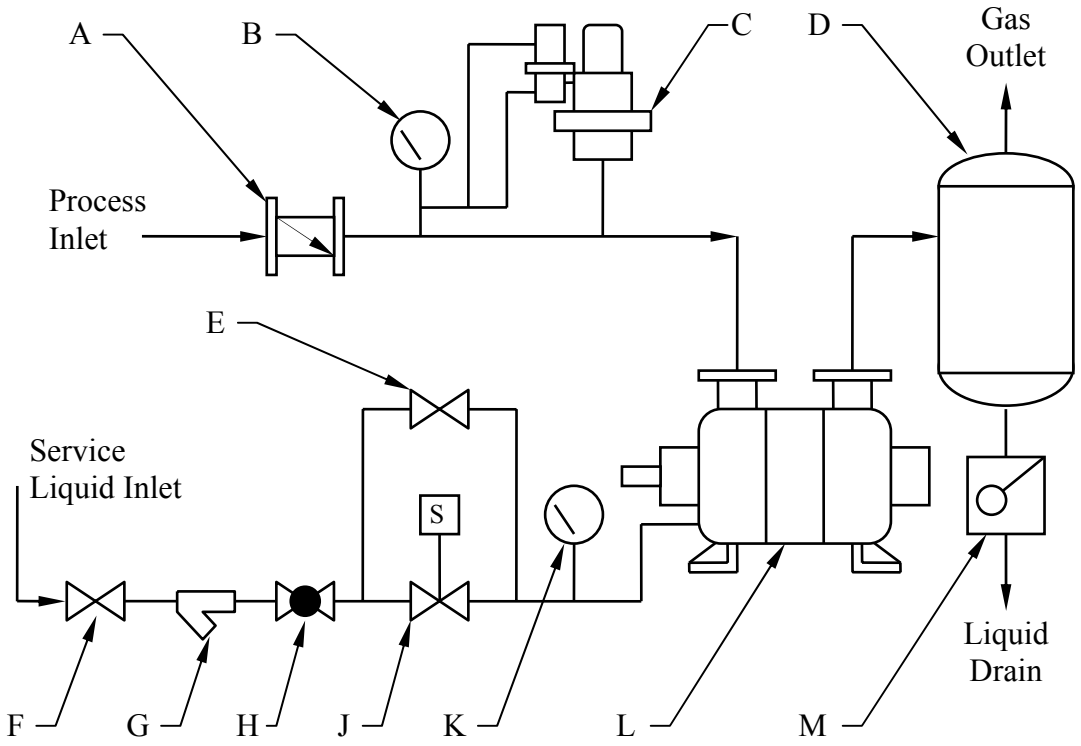
1) A supply of service liquid.
2) A means to control flow of service liquid.
3) A means of stopping the flow of service liquid when the pump is off.
4) A means of separating the gas / liquid exhaust mixture.

It is recommended to use a strainer to ensure that foreign matter does not enter the pump with the service liquid supply or make-up source. See Diagrams 1 and 2 for the proper piping arrangement scheme.

CAUTION: **COMPLETE ALL PIPING INSTALLATION AND MAKE SURE A SUPPLY OF SERVICE LIQUID IS AVAILABLE BEFORE STARTING THE PUMP.**

A) Typical Installation of Once Through with No Recovery

The service liquid is piped directly from a supply source to the pump. The liquid is separated from the gas in the separator and discharged to a drain. No recirculation nor recovery takes place. This is the most basic arrangement and can be used when service liquid conservation or contamination is not a concern. A solenoid operated valve provides for flow of the liquid simultaneously with the pump/motor operation. When the motor stops, the valve closes to prevent the pump casing from filling with fluid. The by-pass valve is used to pre-fill the pump at initial start-up only. It also can be used should the solenoid fail. When a manual valve is used, it must be opened immediately after starting the motor and closed immediately before turning the motor off.



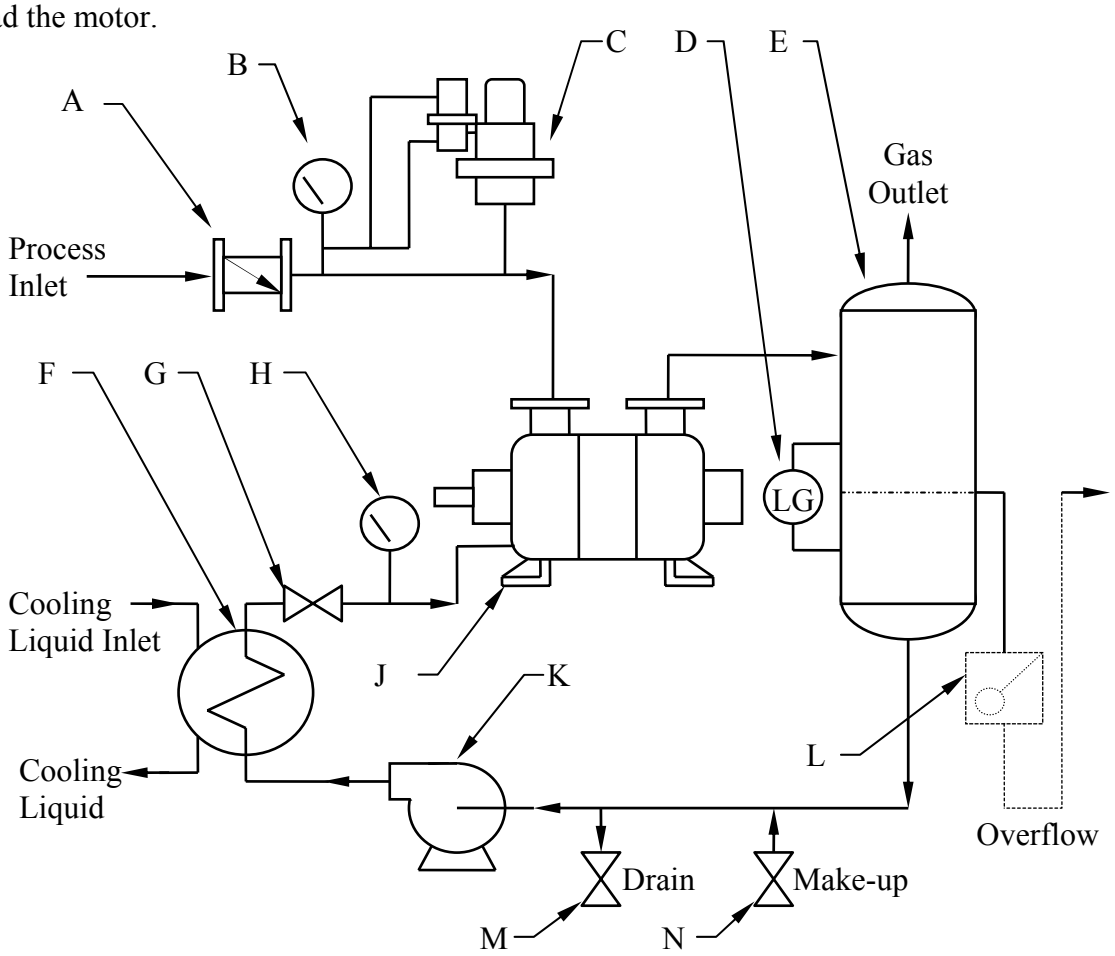
A. Inlet Check Valve
B. Pressure Gauge (vacuum gauge for vacuum service or compound gauge for compressor service)
C. Vacuum Relief Valve (not required for compressor service)
D. Discharge Separator
E. By-Pass Valve
F. Shut-off Valve
G. Strainer
H. Regulating Valve
J. Solenoid Valve
K. Compound Gauge
L. Liquid Ring Pump
M. Trap (required if discharge pressure is above atmospheric pressure)

ONCE THROUGH WITH NO RECOVERY
DIAGRAM 1

B) Typical Installation of Closed Loop with Total Recovery

This arrangement provides for the total recirculation of the service liquid. A heat exchanger is added to the system to remove the heat of compression, friction, and condensation from the service liquid before it is re-introduced to the pump.

The service liquid level in the separator of a total recovery system should be at, or slightly below, the centerline of the pump shaft. A provision should be made for a high level overflow. This will prevent starting the pump while it is full of liquid, which will damage the pump or overload the motor.



A. Inlet Check Valve
B. Pressure Gauge (vacuum gauge for vacuum service or compound gauge for compressor service)
C. Vacuum Relief Valve (not required for compressor service)
D. Level Gauge
E. Discharge Separator
F. Service Liquid Cooler
G. Shut-off or Throttling Valve
H. Compound Gauge
J. Liquid Ring Pump
K. Recirculation Pump (if required)
L. Trap or Loop Seal (required if discharge pressure is above atmospheric pressure)
M. Drain Valve
N. Make-Up Valve

CLOSED LOOP-TOTAL RECOVERY
DIAGRAM 2

C) Draining Before Start-Up

CAUTION: **DO NOT START THE PUMP WITH THE CASING FULL OF LIQUID.**

A Liquid Ring Pump should not be started with the casing full of liquid. Damage to the impeller(s) or the shaft will result. The normal liquid level should be no higher than the shaft centerline. The pump may be started with a low liquid level as long as a supply of service liquid is available immediately after start-up.

2.8 Shaft Seal Coolant Piping Arrangement

The Graham model Liquid Ring Vacuum Pumps incorporate internally flushed mechanical seals as a standard. Models that have been supplied fitted with special seal arrangements may require external flushing. Consult the factory for details.

2.9 Piping Requirements

A) Suction and Discharge Piping

The suction and discharge flanges on the pump are arranged vertically and are marked with arrows on the pump casing. The suction and discharge piping should be the same nominal size as the pump flanges. The elevation of the discharge separator above the discharge flange should be limited to an elbow turning horizontally.

If necessary, a discharge leg can be used with a maximum of 24 inches (610 mm) above the pump discharge flange. Too high an elevation in this line will cause excessive backpressure on the pump, overload the motor, and reduce the pump capacity.

Remove the protective coverings from the pump openings just before attaching the piping. Check that all foreign matter such as weld slag, nuts, bolts, rags, and dirt has been cleaned out of the piping before connecting to the pump. The piping flanges must fit easily and without strain on the pump flanges and the flange bolt holes must be in alignment. The flange gaskets must not protrude into the bore of the piping or pump flanges. All piping must be supported independently on each side of the pump without transmitting any strain to the pump casing. A temporary suction strainer fitted at the suction inlet is recommended during the first 100 hours of operation.

B) Service Liquid Piping

In a once-through arrangement, the nominal pipe size should be the same size as the service liquid connection. In a total recirculation package with no recirculation pump, use one nominal pipe size larger than the service liquid connection of the pump. Also, use the least number of fittings to minimize the pressure drop. When a recirculation pump is used, the piping should be the same size as the service liquid connection.

2.10 Electrical Requirements

All electrical wiring and installation must comply with local safety codes. After the electrical work is complete, the motor should be jogged to check for proper rotation. First, turn the pump by hand to see that it rotates freely. On packed gland pumps, it may be necessary to loosen the gland packing rings (see Section 3.2) to allow the shaft to turn easily. The direction of rotation is marked on the pump. Second, jog the motor momentarily to check the rotation. It is recommended to use a non-reversing motor controller to prevent the pump from turning in the wrong direction.

Section 3 - Operating Instructions

3.1 Start-up Procedures

Read all instructions before proceeding.

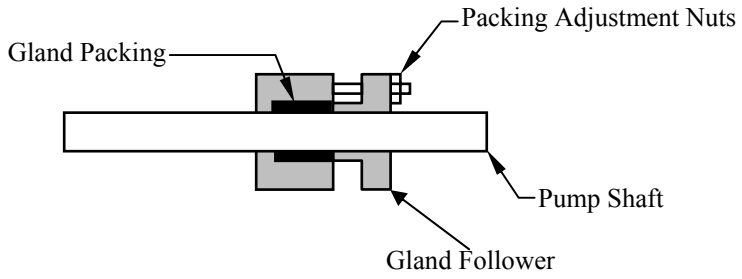
1) Turn the shaft manually to ensure it rotates freely. If the pump is binding or seized, refer to the troubleshooting chart in Section 5.
2) Fill the pump with service fluid to the shaft centerline, but do not overfill.

CAUTION: **DO NOT RUN THE PUMP WITHOUT SERVICE LIQUID AND SHAFT SEAL FLUID.**

3) The normal service liquid level should be no higher than the shaft centerline. The pump may be started with a low service liquid level as long as a supply is available immediately after start-up.
4) Open any valves in the suction and discharge lines.
5) Confirm the pump rotation with the arrow on the casing by jogging the motor.
6) Start the motor, ensure service liquid supply, and set regulating valve, when used, for optimum pump performance. Open and adjust the shaft seal cooling liquid valve, when used.

3.2 Pump Packing Adjustment (where applicable)

The packing adjustment nuts should be loosened before running to prevent damage to the shaft. With the gland follower loosened, the liquid pressure in the glands will force the packing rings against the gland follower. The pump can be run for several hours in this manner. Tighten the gland follower to allow the cooling fluid to drop from the gland at a rate of about 20 drops per minute from each end while the pump is running at a steady state.



ONE END OF PUMP SHOWN

3.3 Service Liquid Requirements

A) Flow Rates

Sealant water flow rate will vary based on what conditions the liquid ring pump is operating under. Table 1 provides information for most operating conditions. Sealant flow is considered acceptable when the required vacuum level is at design, motor amps are at design, and cavitation is not evident during pump operation.

Graham Liquid Ring Pump Sealant Water Flow Rates

Pump Frame Size	Sealant Water Flowrate USGPM	Sealant Water Flowrate m3/hr
LX Series	Range 0.5 to 2.0 Nominal 1.0	Range 0.1 to 0.5 Nominal 0.3
Series 3	Range 1.5 to 3.0 Nominal 2.0	Range 0.3 to 0.7 Nominal 0.5
Series 4	Range 2.0 to 4.0 Nominal 3.0	Range 0.5 to 0.9 Nominal 0.7
Series 5	Range 5.0 to 11.0 Nominal 9.0	Range 1.1 to 2.5 Nominal 2.0
Series 6	Range 8.0 to 17.0 Nominal 12.0	Range 1.8 to 3.8 Nominal 2.7
Series 7	Range 25.0 to 40.0 Nominal 30.0	Range 5.7 to 9.0 Nominal 6.8
Series 8	Range 45.0 to 80.0 Nominal 60.0	Range 10.2 to 18.1 Nominal 13.6
Series 9	Range 50.0 to 70.0 Nominal 65.0	Range 11.3 to 15.9 Nominal 14.8
Series 10	Range 50.0 to 85.0 Nominal 75.0	Range 11.3 to 19.3 Nominal 17.0
Series 11	Range 70.0 to 110.0 Nominal 100.0	Range 15.9 to 25.0 Nominal 22.7
Series 12	Range 100.0 to 170.0 Nominal 150.0	Range 22.7 to 38.6 Nominal 34.0
Series 13	Range 150.0 to 230.0 Nominal 210.0	Range 34.0 to 52.2 Nominal 47.7

TABLE 1

B) Flow Control

If a flow device is not used to measure the service liquid quantity to the pump, a regulating valve and compound gauge in the service liquid line can be used to approximate the flowrate. For pump operating pressures between atmospheric and 400 mmHgA, the reading on the compound gauge should be in the range of 2" HgV to 5 psig (709 mmHgA to 0.35 barg). For operating pressures below 400 mmHgA, the compound gauge reading should be in the range of 15" HgV to 2 psig (379 mmHgA to 0.14 barg). This method is only an approximation of the service liquid quantity. The actual operating conditions will dictate the amount of sealant liquid required and also the compound gauge reading.

Another procedure used to establish minimum service liquid flow is to slowly reduce the flow until the suction pressure fluctuates from the desired level. Gradually increase the flow until the suction pressure stabilizes. This flow setting can be used as long as the temperature rise through the pump remains reasonable (e.g., 10-20 ºF maximum for water sealant) and all other operating conditions remain constant.

C) Hard Water

If hard water is used as the service liquid, scale deposits caused by the precipitation of mineral salts will occur. This will vary with the temperature of the water. Scale deposits on the internal surfaces of the pump will cause an increase of the operating horsepower, wear on moving parts, and may cause the pump to seize.

If the hardness of the water is excessive, consider using a water softening treatment or a descaling compound. If no alternatives are possible, it may be necessary to periodically dismantle the pump to strip off the encrusted salts.

3.4 Cavitation

Cavitation is identified by a characteristic metallic or grinding noise inside the pump. It is caused when the pump suction pressure is too close to the vapor pressure of the service liquid. If the service liquid temperature inside the pump rises such that the vapor pressure closely approaches the total suction pressure of the pump, cavitation will occur.

When cavitation takes place, vapor bubbles form and collapse within the liquid ring. This will damage the surfaces of the impeller, side plates, and casing. The cavitation shock force causes damage by tearing away metal particles and deforming soft materials. The damage can be more severe in a corrosive situation.

Cavitation is prevented by bleeding air into the pump to raise the suction pressure. Vacuum relief valves can be fitted in the suction piping for this purpose.

If the problem is not caused by a low flow of non-condensable gases, the service liquid temperature should be checked. With the proper temperature, the operating vacuum can be increased. Ultimately, the vacuum at which the pump can be operated is governed by the vapor pressure of the service liquid inside the pump.

3.5 Shut-Down Procedures

1) Shut off the service liquid supply, and if used, the shaft seal coolant, and immediately stop the drive motor.
2) If necessary, close all suction and discharge valves.
3) If necessary, drain the pump to protect it from freezing by removing all drain plugs by draining.
4) Disconnect power from the motor if maintenance is to be performed.

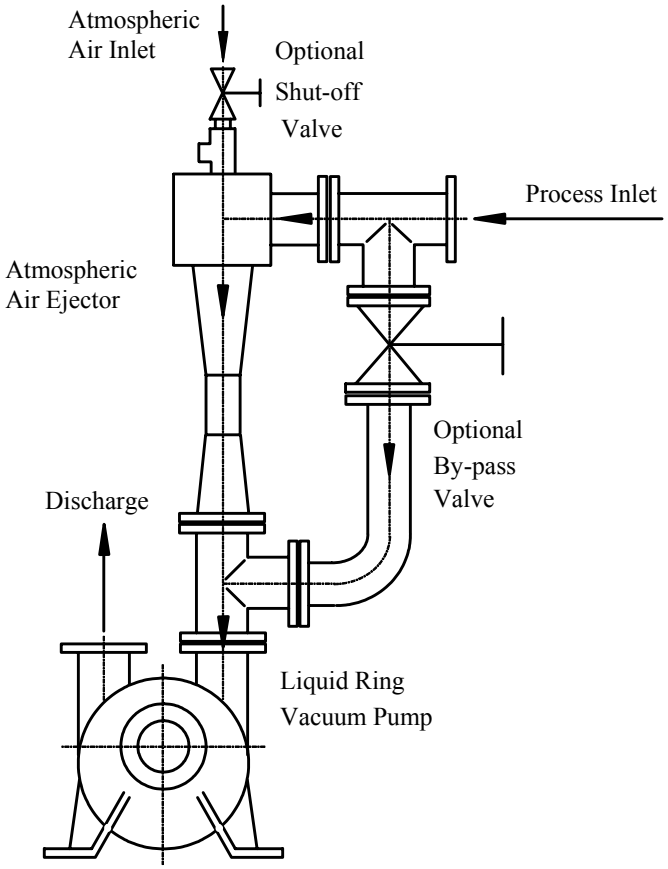
Section 4 - Accessory Items

4.1 Accessories

There are many accessory items associated with Liquid Ring Vacuum Pumps and Compressors. They can be supplied by Graham and shipped from the factory or can be supplied by others and installed in the field. The particular requirements, mode of operation, and type of control scheme desired dictate the necessity of various items. The following is a list of common accessories.

Inlet Check Valve	Used to prevent a back flow of gas into the process when the pump is stopped. Check valves are normally installed in a horizontal line. An elbow can be provided to adapt the vertical pump inlet to accept a horizontal check valve.
Vacuum Relief Valve	Used to protect the pump from cavitation and control the pump suction pressure. When the pump capacity exceeds the system's flow requirements at a pre-determined level, the valve will open and bleed in atmospheric air or process gas.

Flexible Connector	Used to compensate for minor misalignment or expansion between the pump connections and the process piping.
Vacuum Gauge	Used to indicate vacuum at the pump inlet. Normally mounted directly ahead of the pump suction.
Shut-off Valve	Used to manually stop the flow of service liquid to the pump.
Strainer	Used to filter out solid particles that will damage the pump.
Flow Regulator	Used to control the service liquid flow rate to the pump. A manual valve, a fixed orifice, or a flexible element orifice may be used depending on the application.
Compound Gauge	Used to indicate pressure in the service liquid piping.
Discharge Separator	Used to separate the service liquid from the discharged gas as it comes out of the pump. The liquid can be piped to a drain or recovered for re-use.
Solenoid Valve	Used to automatically stop or start the flow of service liquid to the pump. Normally interlocked to the pump motor.
By-pass Valve	Used to initially fill the pump with service liquid or for bypass in case the solenoid coil fails.
Recirculation Pump	Used to circulate the service liquid recovered from the discharge separator in some total recovery systems.
Heat Exchanger	Used to remove heat from the recirculated service liquid.
Atmospheric Air Ejector	Used to provide a suction pressure lower than the pump is capable of when operating alone. It may be added to a two stage pump to provide an inlet pressure as low as 3 mm HgA. The operation of the air ejector is similar to that of a steam ejector. Atmospheric air or recycled gas from the discharge separator is used as the motive force for compressing the process gas from the system design pressure up to the inlet pressure of the pump. To enhance pumping capacity at a higher suction pressure, an optional motive air shut-off valve or by-pass valve can be added. (See Figure 2)



Typical Atmospheric Air Ejector

FIGURE 2

Section 5 - Maintenance

5.1 Performance

Optimum performance and long service life are dependent upon good maintenance procedures and periodic inspections. When preparing to dismantle a pump, make provisions for the safe handling of heavy parts.

5.2 Pump Estimated Weights

Refer to table in Appendix D for estimated pump weights.

5.3 Shaft Bearings

The standard bearings used in Graham model pumps are rated for a L10h life of 80,000 hours. The temperature of the bearings should not exceed 140 °F (60 °C). Overheating may be due to excess grease, misalignment of the shafts, or a bad bearing. Refer to Appendix C for bearing information.

5.4 Gland Packings

Some large Graham pump models are available with gland packing. Refer to Appendix C for gland packing information.

Adjustment: If the glands leak air into the pump or excessive leakage of service liquid occurs, tighten the gland follower slightly. (See Section 3.2) If further tightening becomes impossible, replace the packing.

5.5 Mechanical Seals

Graham pumps are fitted with single acting mechanical shaft seals manufactured to DIN24960 standard. They should be reconditioned or replaced when worn, scratched, cracked, or when the rotating segment no longer grips the shaft. Seal elastomers should also be inspected and replaced as appropriate. Refer to Appendix C for seal size information.

As an option, Graham model pumps are available with double mechanical seals as well as single and double cartridge mechanical seals. The more elaborate seals of this style are utilized when the pump is used in severe, corrosive or hazardous service. External seal flushing arrangements are normally required for this type of service, as well as API Seal Flush plans and vessels using barrier fluids. Contact the factory for specific information.

5.6 Storage

If a pump is to be out of service, it should be protected internally from rusting by using a rust inhibitor. The pump should be drained completely by removing all the lower plugs. Install the plugs and fill with Oakite Ryconox 20M (or equal) preservative solution. Remove the manifold(s) and spray the insides with preservative. Rotate the pump manually to circulate the solution. Drain the pump to below the shaft centerline and replace the manifold(s). This procedure may be disregarded for pumps made of stainless steel, bronze, Monel, or other corrosion resistant materials.

Seal the flanged openings to prevent foreign material from entering the pump.

The pump shaft should be rotated each week to distribute the preservative and to prevent flat spots on the bearings. Document the time, date, and by whom this procedure was performed.

The manifold(s) should be re-sprayed monthly and the pump checked to see that the preservative is maintained. This will protect the pump for up to 12 months.

Pumps stored at low temperatures may need to be protected from freezing either by draining completely or by using an anti-freeze solution.

Pumps with V-belt drives should have the belts loosened to relieve the belt tension during storage. Do not store near running electric motors as ozone produced is detrimental to the rubber in the belts.

5.7 Removal from storage

The pump should be drained and flushed if necessary to remove the preservative solution. Refer to Section 3.1 of this manual for the recommended start-up procedure.

CAUTION: **THE OAKITE PRESERVATIVE SOLUTION IS PETROLEUM BASED AND MUST BE DISPOSED OF IN ACCORDANCE WITH ALL LOCAL, STATE, AND FEDERAL REGULATIONS.**

A MSDS form can be found on the Graham web site at www.graham-mfg.com

5.8 Troubleshooting Chart

Problem	Cause	Solution
Reduced Capacity	• Speed too low • Leak in suction line • Service liquid temperature too high • Insufficient or excess service liquid • Excessive back pressure	• Check power supply and transmission • Repair • Check coolant flow & heat exchanger • Provide correct flow rate • Eliminate cause of back pressure
Excessive Noise	• Excessive or insufficient service liquid • Shaft misalignment • Defective bearing • Cavitation • Back pressure	• Adjust flow rate • Realign shafts • Replace bearing • Open attenuation valve or adjust vacuum relief valve • Eliminate cause of back pressure
High Power Consumption	• Excessive service liquid • Shaft misalignment • Excessive back pressure • Defective bearing • Gland follower too tight • Improperly mounted pump • High temperature process load	• Reduce flow rate • Realign shafts • Eliminate cause of back pressure • Replace bearing • Loosen gland follower • Make sure surface is level and all feet touch the surface, shim if necessary. • Check conditions upstream of pump
Overheating	• Service liquid temperature too high • Insufficient service liquid • Shaft misalignment • Defective bearing • Gland ring too tight	• Check coolant flow & heat exchanger • Provide correct flow rate • Realign shafts • Replace bearing • Loosen gland ring, check packing coolant flow
Vibration	• Shaft misaligned • Pump or baseplate not properly anchored • Defective bearing • Improperly mounted pump • Cavitation • Back pressure • Excessive service liquid	• Realign shafts • Anchor • Replace bearing • Make sure surface is level and all feet touch the surface, shim if necessary. • Open attenuation valve or adjust vacuum relief valve • Eliminate cause of back pressure • Provide correct flow rate
Excessive Gland Leakage	• Worn packing • Loose gland • Gland coolant pressure too high	• Replace packing • Tighten gland follower • Reduce pressure
Abnormal Bearing Wear or Failure	• Shaft misalignment • Piping load on pump flange • Mechanical seal leakage • Shaft flinger missing	• Realign shafts • Support connecting pipe work • Replace seals • Replace flinger
Shaft Will Not Turn or Partially Seizes	• Scale build-up • Foreign object in pump • Piping load on pump flange • Improperly mounted pump • Soft foot	• Descale pump • Remove foreign object • Support connecting pipe work • Make sure surface is level and all feet touch the surface, shim if necessary. • Correct pump/motor mounting

TABLE 3

Section 6 – Rebuild Information

6.1 General

Graham Corporation has a fully staffed Service Department available to repair or rebuild your liquid ring vacuum pump. Prior to returning any equipment for service, a RMA number (Return Material Authorization Number) must be obtained. Go to www.graham-mfg.com for information. All instructions on the form must be followed prior to returning the unit to Graham.

Complete disassembly of the pump is seldom necessary and it only may need to be disassembled to the point required for repair or service. Before any servicing takes place, it is recommended that you obtain the necessary factory parts. To make the selection process complete, Graham offers a "Pump Rebuild Kit" for most pump models. The items in this kit will enable you to replace the normal wear items in the pump, such as the mechanical seals, lip seals, bearings and gaskets. The kit also includes the necessary bearing and impeller locknuts, as well as an impeller spacer. Consult Graham web site for details.

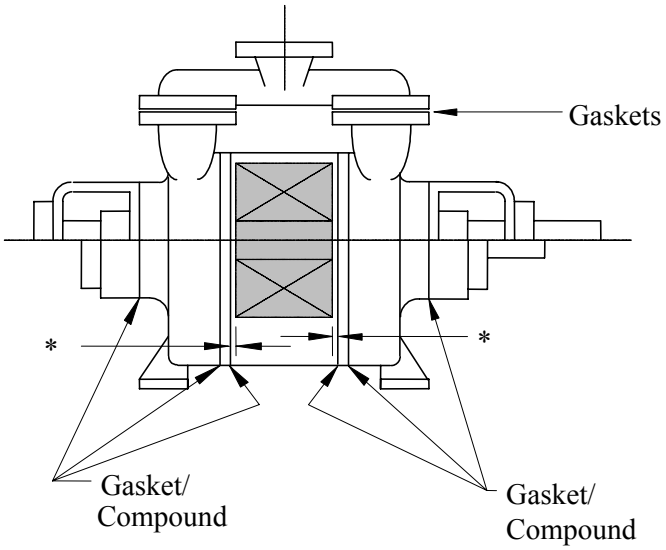
6.2 Impeller End Clearances

Refer to Appendix C for pump internal clearance information. These values are for each side of the impeller in each stage. These clearances are extremely important for optimum pump performance. Also refer to the dismantling and reassembly procedures that were provided with the documentation sent with your pump.

A) Gasketed Pumps

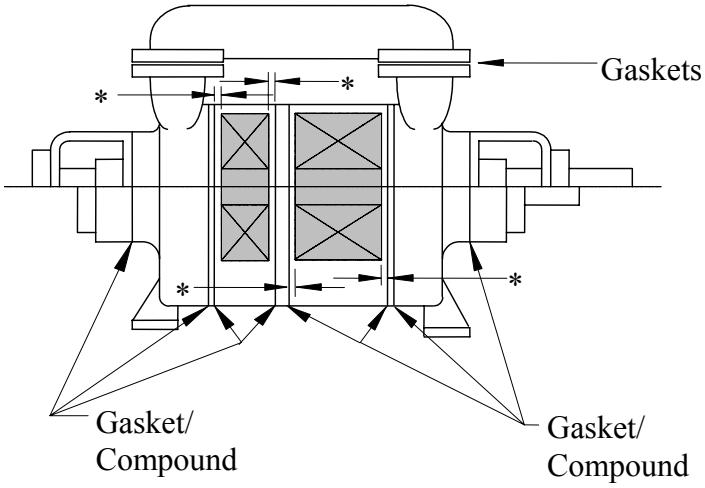
The critical impeller end clearance locations and typical gasket locations are shown in Figures 3 and 4. The gaskets between the impeller casings and end plates determine the impeller end clearances. Check and record the thickness and quantity of these gaskets at each joint when dismantling. The gaskets may be held in place with grease during re-assembly.

Do not use joint sealing compound to replace a gasket, as the clearances in the pump will be affected.



Single Stage

FIGURE 3



Two Stage

FIGURE 4

B) Non-Gasketed Pumps

Certain Graham pumps do not require gaskets, but use a joint sealing compound between the impeller casings and the end plates. They are machined to accommodate the same impeller end clearances as a gasketed pump.

6.3 Tie Rod Torque Values

Refer to Appendix C for bolting torque values.

6.4 Bearing Data

Refer to Appendix C for pump bearing information.

Section 7 - Warranty

THE FOLLOWING IS IN LIEU OF ALL WARRANTIES OF GRAHAM EXPRESSED OR IMPLIED AND ALL IMPLIED WARRANTIES, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, AND/OR ANY OTHER OBLIGATION ON THE PART OF GRAHAM ARE HEREBY EXCLUDED:

Graham, except as otherwise provided, warrants goods of its own manufacture against faulty workmanship or the use of defective materials, under normal use and service, and that such goods will conform to mutually agreed upon written specifications, drawings, and is guaranteed to meet specified performance requirements, for a period of twelve (12) months from date of shipment of the goods from the factory.

Graham assumes no responsibility for deterioration of the equipment due to corrosion, erosion, or flow induced tube vibration, or for fouling, maintenance problems or any other causes not specifically covered under the foregoing warranty. The sole remedy of Buyer with respect to any part not conforming to any warranty of Graham shall be the repair or, at Graham's option, replacement of any defective part at the point of manufacture, Buyer assuming all costs of removal, shipping, and reinstallation, provided that immediate written notice of the defect has been given to Graham, and Graham shall not be liable for any other expenses incurred because of failure of any part to meet Graham's warranty, nor for any special, indirect or consequential damages. Material returned to Graham's factory without its written consent will not be accepted. No back charges will be honored without Graham's advance approval of the work to be performed. Graham's liability on any claim of any kind, including negligence, for any loss or damage arising out of, connected with, or resulting from this transaction, or the design, manufacture, sale, delivery, resale, installation, technical direction of installation, inspection, repair, operation, or use of any equipment covered by or furnished hereunder shall in no case exceed the price paid by Buyer for the equipment. Graham also disclaims all liability, whether in contract, tort, warranty, or otherwise, to any party other than the Buyer.

In the event the pumps are altered or repaired by any person or entity other than Graham, without written approval by Graham, all warranties are void. Bearings and shaft seals are warranted only to the extent of, and pursuant to, the original manufacturer's warranty

Appendix A
MATERIAL SAFETY DATA SHEET

Chemetall Oakite 7870

MATERIAL SAFETY DATA SHEET

PRODUCT CODE: 7870
RYCONOX 20M
200-430-002

HMIS 1 1 0 C

SECTION I - PRODUCT IDENTIFICATION

TRADE NAME	RYCONOX 20M	**EMERGENCY TELEPHONE NUMBER:**
CHEMICAL NAME AND SYNONYMS	NA; Mixture	(800) 424-9300 (CHEMTREC)
MANUFACTURER'S NAME AND TELEPHONE NO.	OAKITE PRODUCTS INC. (908) 464-6900 (8am-5pm) A Member of The CHEMETALL Group	
ADDRESS	50 Valley Road Berkeley Heights NJ 07922	
DATE OF PREPARATION	06-23-2004	

SECTION II - HAZARDOUS INGREDIENTS

	CAS NO.	% BY WT	ACGIH TLV (TWA)	OSHA PEL (TWA)	UNITS
Mineral seal oil (as oil mist, mineral)	0064742467	70-80	5	5	mg/m^3
Hydrotreated naphthenic oil (as oil mist, mineral)	0064742525	5-15	5	5	mg/m^3
Sodium alkylaryl sulfonate (as oil mist, mineral)	Trademark	1-10	5	5	mg/m^3
Petrolatum (as oil mist, mineral)	0008009038	1-5	5	5	mg/m^3
Non-hazardous ingredients		Bal.			

Unidentified ingredients are considered not hazardous under Federal Hazard Communication Standard (29CFR 1910.1200).

All components of this material are on the US TSCA Inventory.

CARCINOGENICITY: No substance in this product is listed by IARC, NTP, or regulated by OSHA as a carcinogen.

SECTION III - PHYSICAL DATA

NA - Not Applicable **NE - Not Established**

Chemetall Oakite 7870

MATERIAL SAFETY DATA SHEET

BOILING POINT (F)	NE	SPECIFIC GRAVITY (H20=1)	0.859
VAPOR PRESSURE (mm Hg)	NE	Bulk Density	7.16 lbs/gal
VAPOR DENSITY (Air=1)	NE	PERCENT VOLATILE	
SOLUBILITY IN WATER	Insoluble	BY WEIGHT(%) Excludes H2O	0
EVAPORATION RATE (BuAc=1)	<1	PH	
APPEARANCE AND ODOR	Brown liquid; bland odor.	PH (concentrate)	NA

SECTION IV - FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (Method Used): 265F (TCC)
FLAMMABLE LIMITS: LEL: NA UEL: NA

EXTINGUISHING MEDIA: Carbon dioxide, dry chemical, foam, water spray.

SPECIAL FIRE FIGHTING PROCEDURES: Wear Self-Contained Breathing Apparatus (SCBA). Use water spray to cool fire-exposed containers.

UNUSUAL FIRE AND EXPLOSION HAZARDS: See Section VII.(WHMIS)
See Section VI.(U.S.)

SECTION V - HEALTH HAZARD INFORMATION

ROUTE(S) OF ENTRY:	INHALATION:	SKIN:	INGESTION:
	X	X	X

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: None known
SYMPTOMS/EFFECTS OF OVEREXPOSURE:
If material is heated, the vapors/fumes may cause respiratory irritation. Prolonged inhalation of high vapor concentrations may cause headache, dizziness or drowsiness. Prolonged skin contact may cause irritation. Direct contact with eyes may cause irritation.

FIRST AID

EYES: Immediately flush eyes with plenty of water for at least 15 minutes. If irritation persists get medical attention.

SKIN: Wash affected area with large amounts of water. If irritation persists, get medical attention.

INGESTION: Contact local poison control center or physician IMMEDIATELY!

NA - Not Applicable **NE - Not Established**

Chemetall Oakite 7870

MATERIAL SAFETY DATA SHEET

INHALATION: Move victim to fresh air. Treat symptomatically.

SECTION VI - REACTIVITY DATA

STABILITY: NORMALLY STABLE
Avoid extreme heat.
INCOMPATIBLE MATERIALS: Strong oxidizers.
HAZARDOUS DECOMPOSITION PRODUCTS: Carbon monoxide, Carbon dioxide, Sulfur oxides.

SECTION VII - SPILL OR LEAK PROCEDURES

PROCEDURES: Wear personal protective equipment (See Section VIII). Ventilate area. Remove all heat and ignition sources. Clean up with noncombustible absorbant material. Store in dry container for disposal.

WASTE DISPOSAL METHOD: Dispose of in accordance with Local State and Federal regulations.

SECTION VIII - SPECIAL PROTECTION INFORMATION

RESPIRATORY: Respirator not normally required. For symptoms of overexposure, wear a NIOSH-approved respirator for organic vapors.

EYEWEAR: Wear chemical safety goggles.

CLOTHING/GLOVES: Wear chemical-resistant gloves and clothing as needed to prevent skin contact.

VENTILATION: Local exhaust may be necessary for some handling/use conditions. Specific needs should be addressed by supervisory or health/safety personnel.

SECTION IX - SPECIAL PRECAUTIONS

Store in closed container in cool well-ventilated area.

APPROVAL Michael Chang Mgr. Health & Environmental Dept. 06/23/2004

NA - Not Applicable **NE - Not Established**

Appendix B

For Return Material Authorization visit the Graham web site at www.graham-mfg.com.

SAMPLE FORM

RETURN MATERIAL AUTHORIZATION FORM

(This section completed by authorized Graham personnel only. Use Tab Key or Cursor to complete areas.)

TO: _____ Date: _____

(Customer's Name & Company Name)

FROM: _____ Fax No.: _____

(Originator -- Auth. Graham Personnel) E-Mail: _____

RMA Number: _____

(current date, auth. Graham personnel initials,01, 02, etc. as applies for that date)

RMA Number Assigned by Authorized Graham Batavia Personnel Only

Sections A, B, & C to be completed by the customer and RETURNED VIA FAX to the Graham Service Department. For E-mailed form, use Tab Key or Cursor to complete areas. An additional copy must also be included with the returned equipment. No work will be started on the equipment being returned until the Service Department has the completed form.

MSDS (Material Safety Data Sheet) **must be included for all material(s) handled by the equipment. Work on the equipment will not begin until MSDS sheets are received. This is to ensure the safety of all Graham employees who may come in contact with this equipment.**

The equipment must be cleaned, drained and DECONTAMINATED prior to shipping back to Graham. Equipment returned in an unsatisfactory condition will be returned to the sender.

A. Customer Data

Customer: _____ Contact Person: _____

Mailing Address: _____ Phone Number: _____

_____ Fax Number: _____

_____ E-Mail: _____

B. Graham Equipment Information

Graham Serial No.: _____

ASME Unit?: NO [ ] YES [ ] - Engineering Procedure EP-006 applies

Type of Equipment / Model No: _____

Material Handled by Equipment: _____

Reason for Return: _____

_____

_____

_____

C. Authorized Customer Signature _____

Send equipment, RMA form and MSDS sheets to the address shown above, Attn: Service Dept.
Graham Corporation is not responsible for any freight charges.
(Units must be returned with freight prepaid or they will not be accepted.)

Appendix C
Pump Information

Frame Size	D.E. Bearing	N.D.E. Bearing	Packing (mm)	Side Clearance 0.000" /10 & /13	Side Clearance 0.000" /20	Mechanical Seal Size DN (mm)
LXP30	6305-2Z		N/A	3-4	6-7	30
LXP55						55
PV31060	6306-2Z		N/A	3.5-5	6-7.5	43
PV31080						
PV31110						55
PV32000				6-8	8-10	38
PV41000	6308-2Z		N/A	4-5	6-8	55
PV42000	6306-2Z			6-8	8-10	38
PV51160	6308-2Z		N/A	4-5	6-8	55
PV51200	6310-2Z					
PV52000	6308-2Z			8-10	10-12	43
PV61000	6310-2Z		N/A	8-10	10-12	55
PV62000						
PV71000	NJ313 EC	6313	N/A	8-10	10-12	75
PV72000	21314-CC					
PV81000	22320-C		N/A	10-12	12-14	120
PV82000	22320-C					
PV91540	NU222	(2) 30222	13x13x530	11-13	13-15	*
PV91305						
PV91670	NU226	(2) 30226	16x16x633	13-15	13-15	*
PV91335						
PV10100	32230	(2) 32230	19x19x710	14-18	18-20	*
PV11100	32234	(2) 32234	19x19x820	16-20	20-24	*
PV12100	32238	(2) 32238	19x19x890	20-24	24-28	*
PV13100	32244	(2) 32244	19x19x980	22-26	26-30	*

* Consult Factory

Bolting Torque Values						
	M6	M8	M10	M12	M16	
N-M	10	25	50	85	205	
ft-lb	7.4	18.5	37.0	63.0	151.9	

Note: Values are subject to change without notice.

Appendix D

Two Stage Pumps		
Frame Size	Avg Dry Weight (kg)	Avg Dry Weight (lbs)
32000	75	165
42000	120	265
52000	150	330
62000	300	670
72000	650	1440
82000	1600	3520

Single Stage Pumps		
Frame Size	Avg Dry Weight (kg)	Avg Dry Weight (lbs.)
LXP	20	45
31000	75	165
41000	120	270
51000	150	340
61000	250	550
71000	600	1325
91000	1800	4000
101000	3500	7800
111000	5000	11000
121000	8000	17700
131000	12000	26500