

KINNEY[®] KTC[™] SERIES

Two Stage, Triplex Rotary Piston Pumps

Models KTC-60 KTC-112

INSTALLATION
OPERATION
MAINTENANCE
REPAIR
MANUAL



WARNING

DO NOT OPERATE BEFORE
READING MANUAL.



02/2006

ADVANCING THE STANDARDS IN VACUUM TECHNOLOGY



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NOTICE

The above safety instruction tags were permanently affixed to your pump prior to shipment. Do not remove, paint over or obscure in any manner.

Failure to heed these warnings could result in serious bodily injury to the personnel operating and maintaining this equipment.

SAFETY PRECAUTIONS FOR ROTARY PISTON PUMPS

Please read the following safety information on this page before operating your vacuum pump.

- Do not operate the pump without the belt guard properly attached. Disconnect the pump motor from the electrical supply at the main disconnect before removing the belt guard. Replace the belt guard before reconnecting the power supply to the pump motor. Operating the pump without the belt guard properly installed exposes personnel in the vicinity of the pump to risk from rotating drive components.
- Do not operate the pump with oxygen-enriched gas (greater than 20% by volume) in the suction line, unless the pump has been prepared with an inert fluid suitable for the application.
Pumping oxygen-enriched gases with mineral oil or other non-inert fluids can cause fire or explosion in the pump, resulting in damage or serious bodily injury.
- Take precautions to avoid prolonged or excessive exposure to oil mist or process materials emanating from the discharge of the pump.
- Do not allow the pump to discharge into a closed, or inadequately ventilated room. Always use a discharge oil mist eliminator unless the pump discharge is discharged to outside atmosphere. Laws and ordinances may pertain to your local area regarding discharge of oil mist or vapor to atmosphere. Check local laws and ordinances prior to operation of the pump with discharge to outside atmosphere. Venting of the discharge of an oil mist eliminator to outside atmosphere is highly recommended.
- Do not restrict the pump discharge in any way, or place valves in the discharge line. The vacuum pump is a compressor and will generate high pressures without stalling the motor when operated at low suction pressures.
Excessive pressure could cause damage or serious bodily injury.
- Disconnect the pump motor from the electrical supply at the main disconnect before disassembling or servicing the pump. Make sure pump is completely reassembled, the belt guard is properly installed, and that all fill and drain valves are installed and closed before reconnecting the power supply. **Accidental starting or operation of the pump while maintenance is in progress could cause damage or serious bodily injury.**
- Lift pump only by the lifting lugs supplied with the pump. DO NOT lift equipment attached to pump by the pump lifting lugs.
- Do not touch hot surfaces on the pump. In normal operation at low pressures, surface temperatures will not normally exceed 180° F (82° C). Prolonged operation at 200 Torr (267 mbar a) may cause surface temperatures as high as 220° F (104° C)

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INTRODUCTION

CONGRATULATIONS on your purchase of a new KINNEY® KTC™ Single-Stage, Tri-plex Rotary Piston Vacuum Pump from Tuthill Vacuum & Blower Systems. Please examine the pump for shipping damage, and if any damage is found, report it immediately to the carrier. If the pump is to be installed at a later date make sure it is stored in a clean, dry location and rotated regularly. Make sure covers are kept on all openings. If pump is stored outdoors be sure to protect it from weather and corrosion.

KINNEY KTC vacuum pumps are built to exacting standards and if properly installed and maintained will provide many years of reliable service. We urge you to take time to read and follow every step of these instructions when installing and maintaining your pump. We have tried to make these instructions as straightforward as possible. We realize getting any new piece of equipment up and running in as little time as possible is imperative to production.

WARNING: Serious injury can result from operating or repairing this machine without first reading the service manual and taking adequate safety precautions.

IMPORTANT: Record the pump model and serial numbers in the OPERATING DATA form below. You will save time and expense by including this reference identification on any replacement part orders, or if you require service or application assistance.

OPERATING DATA

It is to the user's advantage to have the requested data filled in below and available in the event a problem should develop in the blower or the system. This information is also helpful when ordering spare parts.

Model No. _____	V-Belt Size _____ Length _____
Serial No. _____ (Recorded from nameplate on unit)	Type of Lubrication: _____
Startup Date _____	_____
Pump RPM _____	Operating Vacuum _____
Pump Sheave Diameter _____	Any other special accessories supplied or in use:
Motor Sheave Diameter _____	_____
Motor RPM _____ HP _____	_____

NOTES: _____

KINNEY® KTC™ SERIES MANUAL 1845-2

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This manual applies to Kinney Vacuum models KTC-60 and KTC-112. You should be thoroughly familiar with these instructions before attempting to install, operate or repair this unit. Consult Kinney when problems arise that cannot be resolved after reading this manual. Always include pump nameplate information when ordering parts or components.

Specifications

		KTC-60	KTC-112
Free Air Displacement	cfm	60	107
Pump Speed	rpm	972	1055
Motor Speed	rpm	1725	1725
Motor Power	hp	3	7-1/2
Total Oil Capacity	gal	2	4
Cooling Water @ 60°F	gpm	Not req'd	1-1/2
Cooling Water Connections		-	1/4 NPT
Suction, 150# ASA Flange	in.	3	3
Discharge	In.	1-1/2	2 NPT
Height	In.	37	43
Floor Space	In.	24 x 19	26 x 21
Weight	Lbs.	515	765
Ultimate Pressure	Torr	2×10^{-4}	2×10^{-4}

Description

The Kinney KTC, oil-sealed, compound rotary piston pumps, produce the lowest pressures achievable with mechanical pumps. Two pumping chambers in parallel are backed by a third pumping chamber in series and produce an ultimate pressure 0.2 microns as indicated by a McLeod Gauge (2×10^{-4} Torr). The pumps are simple to operate and require straightforward maintenance without special tools.

The moving parts in the triplex pumps are inherently dynamically balanced so that the pumps run smoothly and quietly. The standard vibramounts virtually eliminate vibration transmitted to the floor.

Adjustable gas ballast valves can reduce or prevent the contamination of the oil, and can be used to clean oil that has become contaminated with vapors. The gas ballast can also be cracked open to quiet the pump when operating at blank-off.

The KTC-60 is air-cooled and oil is circulated by vacuum generated by the pump itself; two solenoid valves control the oil flow.

The KTC-112 an oil pump circulates oil through a water-cooled heat exchanger. Solenoid valves and a pressure switch control the oil flow.

Pump Components

The pumps have three cylinders with rotary pistons, two of which operate in parallel as a single high vacuum stage and have a common inlet and discharge. The discharge of this stage is connected in series to the inlet of the backing stage cylinder, which discharges into the oil-gas separator.

A check valve is provided between the inter-stage connection (high vacuum stage discharge) and the oil reservoir. When the pump is operating at pressures above 200 Torr, some air is discharged from the inter-stage through the check valve(s) and into the separator housing.

The cylinder has an end cover called a head at each end. The end through which the drive shaft extends is called the open head and the non-drive end is called the closed head. The heads contain the main sleeve bearings and external piping or oil flow. The open head also contains a vacuum tight rotary shaft seal to prevent leakage along the shaft.

KTC pumps have two oil reservoirs, one for the high vacuum stage and one for the backing stage. The sight glass on the side of the separator housing indicates the oil level in the backing stage. The oil level should be near the mid-point of the sight glass when operating at low inlet pressures and will rise and fall with changes in the inlet pressure. The separator housing contains a discharge baffle to separate oil from the exhaust gas. There is a discharge valve on the backing stage below the baffle. There are no discharge valves on the high vacuum stage.

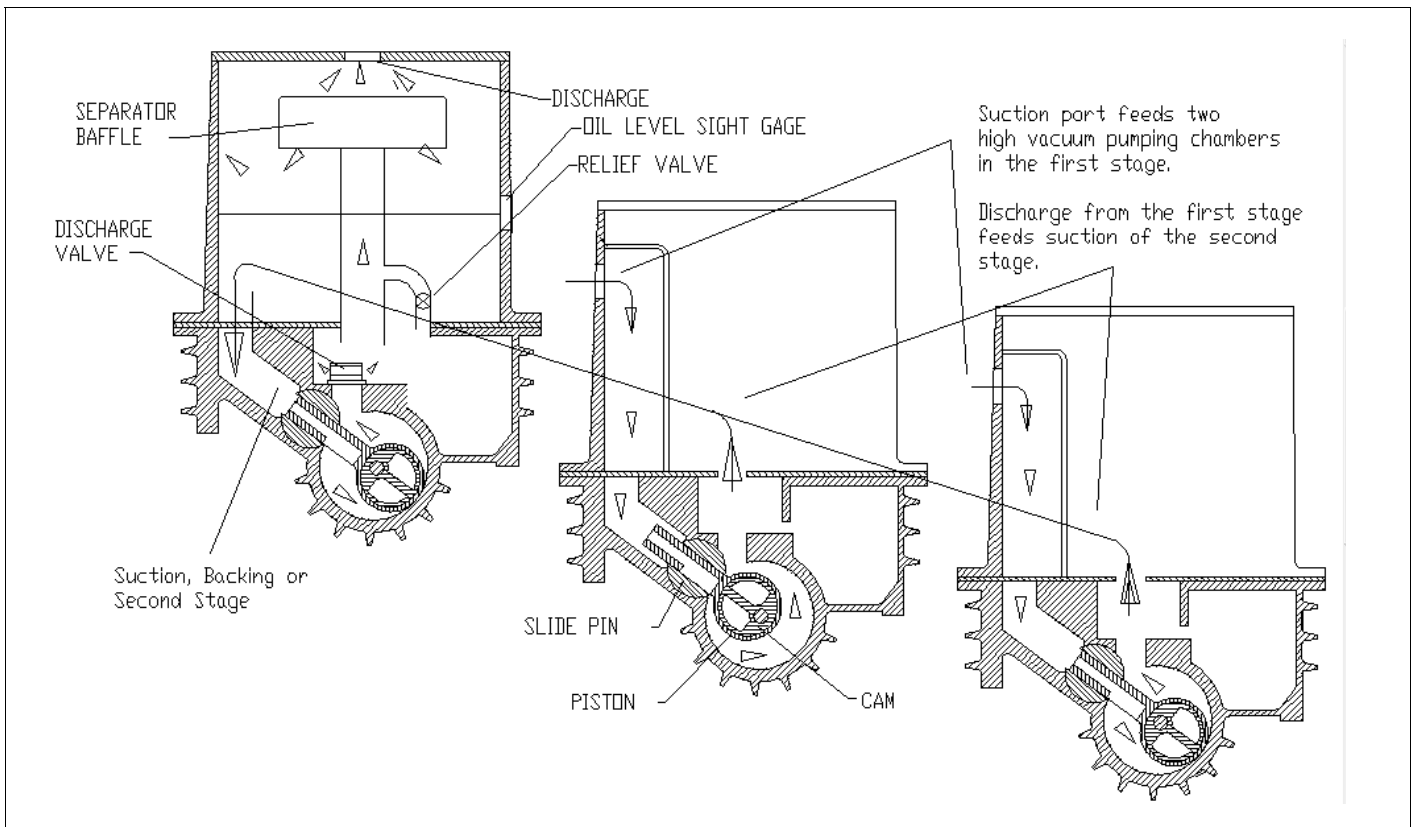


Figure 1. Operating Cycle

Operating Cycle

Gas from the system enters the pump suction and passes through the hollow piston slide and out into the space being created between the piston and cylinder wall. This space increases and more gas is drawn in as the piston rotates. At the same time, the gas taken in and trapped on the previous revolution is discharged into the inlet of the backing stage.

The high vacuum pumping cycle is repeated in the backing stage. The gas is compressed and forced out through the discharge valves along with a small amount of oil, and then into the oil separator where oil is separated from the gas. This gas is discharged into the atmosphere and the oil drains back to the oil reservoir. Oil from the reservoir does not normally enter the pump when stopped under vacuum, however, stopping the pump under vacuum is not recommended.

Sealing and Lubrication

The pump components are lubricated and sealed against backflow of gas by a film of oil, which fill the running clearances. When the pump is in operation the cylindrical part of the piston almost touches the pump cylinder at a line along the length of the piston. An effective wave of oil is pushed ahead of this moving line. Oil is also being squeezed through the clearances of the other working parts. The seal and bearings are lubricated and washed by the flow of intake oil. There are two oil reservoirs, one for each stage, and at the end of the compression stroke the oil is forced out with the discharged gas and returned to their respective reservoirs.

Figure 2 shows the oil flow for KTC-112 pumps. It circulates oil from the backing (second) stage reservoir through a water-cooled heat exchanger and back to the reservoir. When the pump is at a pressure above 100 Torr, some of the oil leaving the heat exchanger is admitted through solenoid valve (A) into the high vacuum (first) stage via the bearing located on the non-drive side of the pump. Below 50 Torr, the pressure switch closed solenoid valve (A) and opens solenoid valve (B) and the high vacuum (first) stage is then supplied with degassed oil from the first stage reservoir. The oil supply pressure is provided by interstate pressure and the reservoir oil head. A solenoid valve located on the drive side of the pump, which is open when the pump is running controls oil to the backing (second) stage. Oil is delivered into the backing stage by differential pressure.

On the KTC-60, there is no oil pump, heat exchanger, or pressure switch. Oil is fed from the backing stage reservoir to the drive-end of the pump, and from the high vacuum reservoir to the non-drive end of the pump. Solenoid valves close both lines when the pump is stopped.

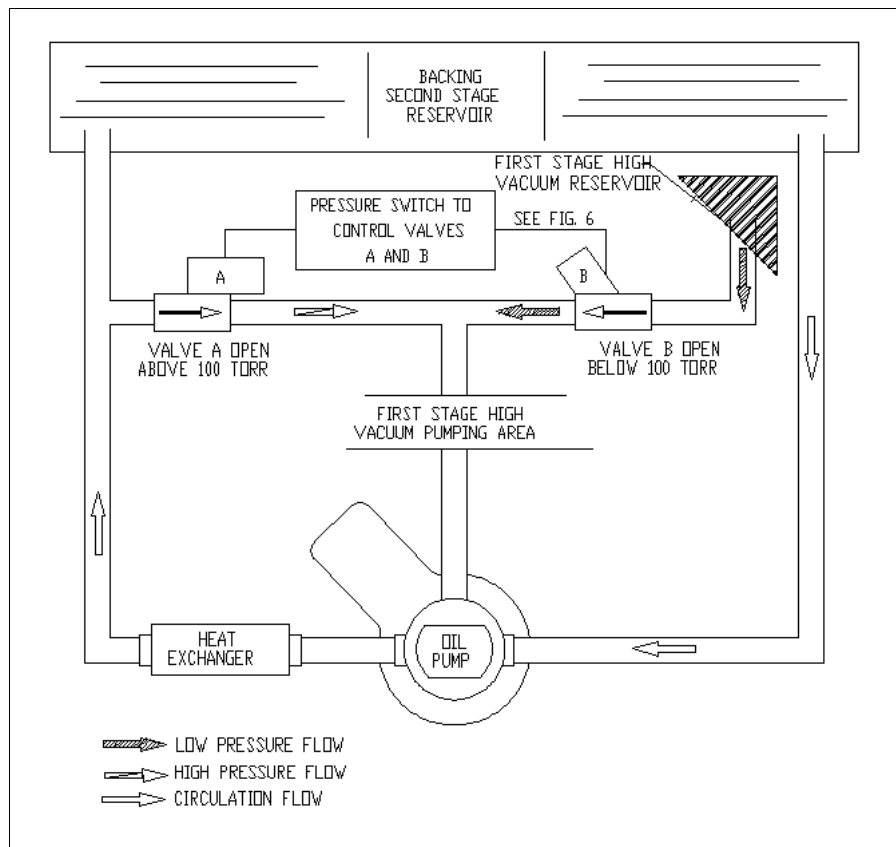


Figure 2. Oil Flow KTC 112

INSTALLATION

Vibramounts

KTC pumps are supplied with vibramounts that enable them to run quietly and vibration free. The pump can be operated on any floor that will support its weight. The pump must be installed on the vibramounts and flexible connectors fitted in suction, discharge, water and electrical connections. It is not necessary to bolt the pump to the floor.

Bolt the vibramounts to the four holes in the feet. On the KTC-112 all four vibramounts are the same. On the KTC-60, install two green vibramounts at the beltguard end and two red vibramounts at the other end.

Care must be taken to set the pump down squarely on the mounts when installing the pump in operating position.

Suction Manifolding

Inlet manifolding should be sized and designed with three objectives in mind:

- 1) To avoid gas flow restrictions
- 2) To prevent pump fluids from entering the process chamber
- 3) To protect the pump from the ingestion of particulate matter

Under normal conditions, the diameter of the manifolding should not be less than the diameter of the pump connection and the pipe length should be kept to a minimum.

Oil may splash from inside the pump through the suction port. Therefore, the suction line must be designed to prevent oil from collecting there, and draining back to the system or process.

A flexible connection should be installed in the suction manifold to provide freedom for the vibramounts. The vacuum piping must be well aligned with the pump connections as not to place a strain on the piping.

Provisions for gauge installation and any other drilling in the piping must be made prior to piping installation; otherwise, drilling particles entering the piping could be entrained into the pump.

A vacuum isolation valve should be installed adjacent to the suction port to be used for leak checking, shutting down the system, or blanking off the pump.

Before connection the suction manifolding, distribute 4 quarts of oil over the two high vacuum slide pins. This will necessitate reaching through the suction port with a container and pouring oil directly onto the slide pins. Then rotate the pump by hand a minimum of two revolutions to distribute the oil throughout the pump interior.

Discharge Manifolding

During the initial operation and as long thereafter as necessary, a fine mesh screen should be installed across the inlet connection to prevent abrasive or solid particles left in the line from being sucked into the pump. This screen can be removed when particles no longer accumulate. If particles continue to accumulate, a filter should be installed in the line.

Discharge manifolding should be sized and designed to prevent the following:

- A. Return of oil mist condensate to the pump
- B. Oil loss
- C. Oil mist in the discharged gas

Under the normal conditions, the diameter of the manifolding should not be less than the diameter of the pump connection and the pipe length should be kept to a minimum.

The installation of a Kinney oil mist eliminator on the discharge is recommended for all applications. Oil that collects in the eliminator should be returned to the pump. The optional oil return kit will allow oil to drain back into the separator housing when the pump is operating a low pressure or when the pump is stopped. If the pump is to operate continuously, or normal operating pressure is 10 Torr or higher consult Kinney for special recommendations on oil return.

It may be necessary to pipe the pump exhaust fumes away from the pump area, such as out of doors. If this is done, the piping must be arranged to prevent line condensation from returning to the pump. A flexible connector should be fitted in the discharge line to provide freedom for the vibramounts.

Cooling Water

The KTC-60 is air-cooled and does not require cooling water.

On the KTC-112 the lubricating oil is cooled by a shell and tube heat exchanger mounted adjacent to the oil pump on the KTC-112.

DO NOT ALLOW THE COOLING WATER TO FREEZE IN THE HEAT EXCHANGER.

Connect a water supply line with "on-off" valve to the water inlet, and an open drain to air the water outlet. The inlet

line should have a flow-regulating valve. If the water supply is unreliable, it is advisable to install a flow switch to stop the pump or signal when the flow is interrupted. Normally the cooling water will be off when the pump is not running. Standard cooling water rates are for up to 80°F (26°C), supply temperature and operation within the design continuous operating pressure range below 10 Torr. For sustained operation above 10 Torr consult Kinney for recommendations.

Filling the Pump with Oil

Use oil recommended by Kinney and see the **Specifications** for the quantity of oil required to fill the pump. There are two oil reservoirs in Kinney KTC pumps, the main reservoir is at atmospheric pressure and feeds oil to the high-pressure stage, and the other is between the two stages and feeds oil to the low-pressure stage. Both must be filled before starting the pump. An oil sight glass is provided in the atmospheric reservoir only, oil level in the interstage reservoir is maintained automatically by normal operation of the pump.

To fill the main reservoir, remove the filler cap from the fill elbow on the separator housing and add oil until the level reaches the top of the sight gauge. The level will drop to below mid-center of the gauge once the pump is operated at blank off and the oil is distributed. Add or drain oil as necessary, to keep the oil level at blank off 3/8 inch (1cm) up from the bottom of the glass. The oil level changes with operating pressure, reaching the lowest level at blank off. To fill the interstage remove the filler cap from the fill elbow mounted on the pump cylinder and add the following quantity of oil.

Interstage

KTC-60	2 quarts
KTC-112	1 gallon

Replace the interstage filler cap and make sure the cap seals. The interstage reservoir is under vacuum when the pump is in operation and any leakage will cause loss of performance.

CAUTION: Do not overfill the pump, as excess oil will be blown out during the high-pressure operation of the pump.

Electrical Connections

WARNING

Disconnect pump from source electrical power prior to making repairs or adjustments to any electric component of the unit.

Wire the motor in accordance with the wiring diagram located on the motor. Oil control solenoid valves and switches are factory wired. If the pump has been disassembled, rewire the solenoid according to the diagram located on the solenoid valve.

When wiring is completed, turn the pump by hand to ensure that the pump is free to turn and then momentarily jog the motor to check that the pump rotation direction is clockwise when facing the drive end. If the pump rotates in the wrong direction, reverse any two of the three motor leads. If a flow switch is proved it should be wired into the motor circuit with a relay so as to stop the motor, in the event the cooling water flow is interrupted.

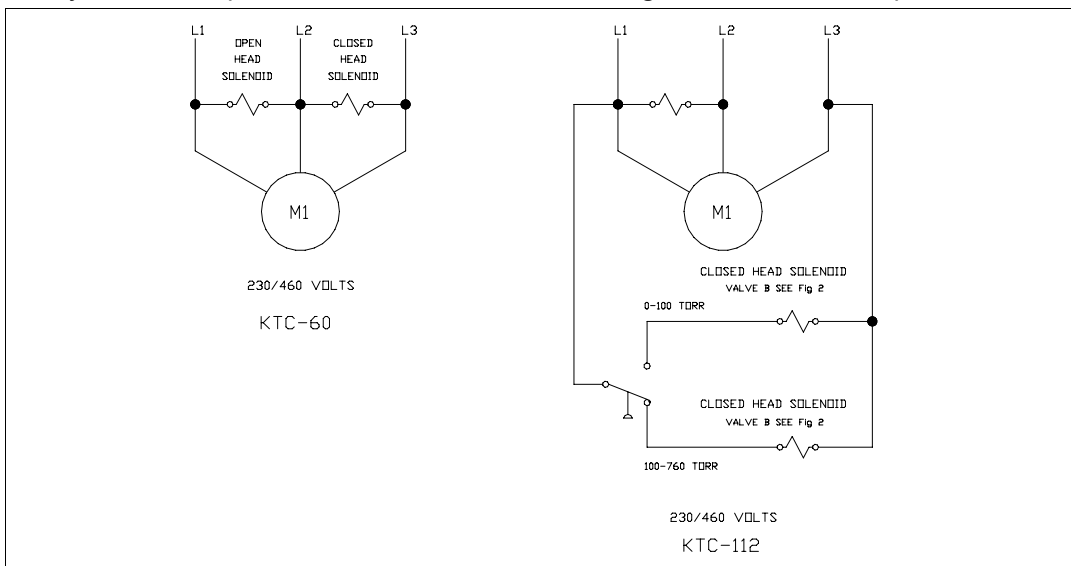


Figure 3. Wiring Diagram

Vacuum Gauges

The vacuum gauge(s) to be installed on the pump must be selected to meet the requirements of the particular pump application. Two general types of vacuum gauges are used for the testing of vacuum equipment, total pressure reading, such as thermocouple gauges, and partial pressure reading McLeod gauges.

The McLeod gauge indicates the partial pressure of permanent gasses. It does not indicate the component of pressure due to vapor such as water vapor. It is not greatly affected by vapor contamination unless the contamination pressure is quite high. It is most useful in confirming pump performance and for determining the absence or presence of leaks. A high thermocouple gauge reading may indicate that the pump is contaminated or that it leaks, or both. A high McLeod gauge reading means that a leak is present.

OPERATION

General



WARNING

Do not operate the pump in an enclosed area unless the pump discharge is filtered or piped to open air. Prolonged inhalation of oil mist or vapors is a health hazard.

Do not block or restrict the flow of gas from the pump discharge. Backpressure within the pump could cause severe damage.

The belt guard must be properly secured to the pump at all times while the pump is running.

Prestart Checks

Before starting the pump check the following items:

- 1) The installation has been made in accordance with the installation section of this manual.
- 2) The pump has been filled with oil, in accordance with the installation section of this manual.
- 3) If the pump has been idle for a month or more, turn the pump by hand two or more revolutions to distribute oil internally through the pump.
- 4) The temperature of the pump oil is 60°F (16°C) or above. Special heaters may be required for starting at lower temperatures. Consult Kinney for recommendations.
- 5) Cooling water is available (for KTC-112 only). Do not start the cooling water flow until the pump has operated a few minutes.
- 6) Drive belts are correctly tensioned. (See V-Belt Drive in Maintenance Section).

Direction of rotation is correct.

Starting the Pump

- 1) Close inlet isolation valve.
- 2) Close the vent valve if one is used.
- 3) Start the pump.
- 4) Open and adjust the cooling water flow as shown in the specifications.
- 5) Adjust the gas ballast (See "Gas Ballast").
- 6) Maintain oil level 3/8" up from bottom of sight glass when running at blank off.

Run the pump at blank off for 5-10 minutes and then with full gas ballast for 10-15 minutes before opening the suction of the pump to a higher air pressure.

Stopping the Pump

- 1) Close the isolation valve.
- 2) Vent pump to atmosphere through vent (air admittance) valve.
- 3) Close gas ballast valve.
- 4) Stop the pump.
- 5) Shut off cooling water.
- 6) Close vent valve.

Handling Large Quantities of Water

Use of the gas ballast valve enables Kinney pumps to handle small to moderate amounts of water and other vapors in the suction gas stream. See the Gas Ballast section below.

In applications where large quantities of water vapor are encountered, water will condense in the backing stage oil reservoir. If it is not drained, water will enter the lubrication system instead of oil and the pump may be seriously damaged.

KTC Series pumps can accumulate some water in the reservoir before it reaches the oil line pickup where it could circulate through the pump. If water or other condensate collects in the oil reservoir, the water should be drained before the level reaches the oil line pickup. To drain water from the pump, crack the oil drain valve and leave it open until any water accumulation has drained out. Drain the water as often as necessary.

Gas Ballast

The gas ballast valve is shown in Figure 8. Gas ballast is used while the pump is running, to prevent internal condensation of oil insoluble vapors such as water, alcohol or acetone and to quiet the hydraulic noise when running pump at blank off conditions.

The setting of the gas ballast valve is not critical on compound pumps, as full gas ballast does not seriously affect the base pressure. Compound pumps are eminently suitable for handling vapors at low pressure.

Continuous use of gas ballast is recommended where the process pressure requirements can be met with the gas ballast valve open; otherwise, intermittent use of gas ballast between process cycles is suggested. If use of gas ballast at neither of these times is tolerable, it is advisable to run the pump using gas ballast when process work is not being done, such as overnight.

Use the gas ballast valve as follows:

- A. Continuous gas ballast: With the pump operating, open the gas ballast valve until the ultimate pressure is slightly below that needed for the process. Operate the pump in this manner continuously to aid in preventing oil contamination.
- B. Intermittent gas ballast during processing: With the pump operating, fully open the gas ballast valve during periods when this will not affect the process (work preparation, recycling, etc.) This will aid in cleaning the oil.
- C. Continuous gas ballast when not processing: With the pump operating, but isolated from the process, fully open the gas ballast valve. If convenient, operate the pump overnight in this manner to clean badly contaminated oil. Gas ballast will remove vapor contamination, but will not remove solids such as varnish.

If it is necessary to clean the oil using gas ballast in the short period, the time needed can be estimated as follows:

Open the gas ballast valve fully and operate the pump for a short period (15 to 20 minutes). Close the gas ballast valve for 1 to 2 minutes and observe the pressure change. Use the "pressure change versus time", as a rough guide to estimate the total time required to obtain the desired blank-off pressure.

MAINTENANCE

General

Pump repair services are available at Tuthill Vacuum & Blower Systems Authorized Service Centers and at our Springfield, MO factory. Call TVBS (800)825-6937 or your nearest sales office for the location nearest you.

Periodic Maintenance

There is no fixed interval for changing pump oil, since applications vary widely. This can be determined only by experience and/or by deterioration of pump performance. As a minimum, the pump oil should be changed after each six month logged period of operating.

At high pressures, or with a gas ballast flow the oil level should be higher than it is when operating at low pressures near blank off. If there are no changes in the oil level, check for obstructed oil passages. Check the condition of the oil periodically by draining a small quantity of oil into a clean container and visually inspecting it for solid or liquid contaminants.

Oil Contamination

When the pump has operated satisfactorily for some time and then gradually the vacuum becomes poor, clean the oil by applying gas ballast, or change the oil as directed in "Changing the Oil". A change in the color of the oil does not necessarily mean that it is not satisfactory for use. On the other hand, vapors may contaminate the oil and not show any color change.

The following factors may cause the pump oil to deteriorate:

- water and solvents will lower viscosity
- solid accumulation will increase viscosity and "feel gritty"
- polymerization and chemical attack on oil will increase viscosity and odor

As a “Rule of Thumb” change the oil if:

- the oil “feels gritty”
- viscosity changes more than 100 SSU @ 100°F (38°C)
- oil color becomes opaque
- smells burnt or acrid smell occurs
- total Acid Number increases to 0.3

If oil contamination is suspected, change the oil and operate the pump for 15 to 30 minutes. Repeat this procedure as required to flush out all contaminants from the pump or operate the pump with gas ballast as explained under “Gas Ballast”. See gas ballast and water handling instructions under OPERATION.

Oil filtration systems are available for filtering solid, water, and acids continuously or periodically.

Changing the Oil

Run the pump until the oil reaches normal operating temperature 145 to 165°F, (63 to 75°C), below 100 Torr (130 mbar), and then stop the pump. There are two oil reservoirs to be drained. Place a container under each oil drain valve and open the valves until the oil is removed from the pump, then close the valves.

If the oil is being drained due to oil contamination it is advisable to drain the oil from the discharge valve well. The well is located between the pump cylinder and separator housing. Removing the pipe plug from the cylinder located above the open head can drain the oil trapped there.

When the oil has drained from the pump close all drains and fill the pump with the quantity and type of oil shown in the Specification Table. The oil level will show above the center of the sight gauge until the pump is started and the oil is distributed through the pump.

Lubricating the Pump

An oil pump is installed on the KTC-112 to circulate oil through the heat exchanger. It is mounted on the closed head and is driven directly by the vacuum pump shaft. Failure of the gear pump may be detected by high oil temperature and consequently, deteriorating performance and noise. The tubing attached to the pump should be nearly the same as the oil temperature or 145 to 165° F (63 to 75°C). See “Sealing and Lubrication”.

Stalling

If the pump stalls at any time, it may be due to loose belts, lack of lubrication caused by failure of the oil circulating pump, badly contaminated oil, coating build up, or foreign matter in the pump. If the pump cannot be turned over freely by hand after cooling, there is foreign matter in the pump and the inside of the pump must be cleaned.

Sometimes a process related coating build up can be removed by soaking the pump with proper solvent (turning by hand) - check with Kinney Service Department. Inspecting the inside of the pump is covered under “Disassembly”.

Pump Leaks

If the pump is suspected of having an air leak, after eliminating oil contamination as the causes of poor performance, use a plastic sealing compound to seal over suspected areas, such as joints, connections plugs, and any penetrations into the vacuum area. Check the pump blank off performance before making permanent repairs with Kinseal. If gasketed connections are suspected, remake the connections. Plastic sealing compound may be used to make temporary gaskets; these should not be made too thick since the material may be squeezed into the pump. Check the shaft seal for mechanical defects, such as a cracked carbon washer or hardened rubber components. For checking leaks, a fast acting total pressure gauge used with acetone or a sensitive freon leak detector can be used. A helium leak detector is the most convenient to use if available.

Checking Pump Performance

If the processing time or the ultimate pressure becomes poor with no recent changes in the process or in system configuration, test the pump to determine if the trouble is in the pump or the connected process equipment. To check the condition of the pump, measure the blank off pressure as directed below using a McLeod gauge. If possible, also read the blank off pressure with a thermocouple gauge.

To read blank off pressure, close the pump inlet by means of a vacuum valve or blank off plate. Connect a vacuum gauge to the suction side and position the gauge tube, facing downward into the higher area of the manifold so that the tube will not become flooded and blocked by splashing pump oil. If the pump is disconnected from the process equipment, connect a 90-degree elbow, extending upward, to the inlet flange and bolt the blank off plate, with gauge connection, the open elbow flange. Operate the pump for a minimum of 15 minutes and record the lowest pressure reached. Average blank off reading is .0001 to .0005 microns with a McLeod gauge, and 1 to 10 microns with a thermocouple gauge. The specification pressure is 0.2 microns, McLeod gauge reading. If the McLeod gauge reading is low and the thermocouple gauge reading high, the pump oil is contaminated, (see "Oil Contamination"). A high reading of both the McLeod and thermocouple gauges indicates that an air leak is present.

Checking Process Equipment

Attach a vacuum gauge (See INSTALLATION, Vacuum Gauges) to connection on the system side of the isolation valve. For this test, the system should be clear of any process work, which might give off vapors and change the reading. Run the pump to obtain the best vacuum possible with the valve open, then close the valve and observe the pressure rise. If the pressure rise is greater than desired, the leaks should be eliminated. Check the system carefully for loose joints and obvious leaks. Use a leak detector if available. The trouble can be isolated further by applying the following procedures:

- A. Isolate each segment by valves or blank off plate at convenient location. Pump down each segment of the process equipment individually, starting at the segment closest to the vacuum pump.
- B. Check the lowest pressure attainable when each segment is added. If the pressure is close to that obtained previously, add the next segment. If the pressure is not close to the previous reading, leak test the last segment.
- C. When leak checking process chambers, start at the air and gas inlet valves, doors, sight ports, electrical and mechanical feedthroughs, gauge tube fittings, and any other gasketed penetrations and O-Ring connections. After a suspected leak has been found, cover it with plastic sealing compound, such as Apiezon Q, and check the equipment performance before sealing the leak permanently. Thus, all permanent repairs can be made at the same time.

If a leak detector is not available, use the following methods to locate leaks:

- 1) Cover suspected leaks with a low vapor pressure sealing compound (such as Apiezon-Q, James Biddle Company or Shell Company; or Duxseal, Mansville Corp). Do this while pumping on the equipment and monitoring the pressure. A sudden decrease in pressure indicates that a leak has been covered. Repair leaks permanently as necessary.
- 2) If the leak is large, causing pressures over 1 Torr, (1 mbar), pressurize the process equipment with one psig (70 mbar) of clean compressed air and paint a soap solution on suspected leak areas and bubbles will indicate leaks.

If the leak is small causing pressures less than 1 Torr (1 mbar), use a fast acting medium such as acetone, alcohol, freon or helium. Position the vacuum gauge head downstream from the suspected leak area, between the leak and pump. When the pressure has been reduced so that the gauge may be used, apply the probing medium to suspected leak areas using a squirt gun or brush. If the probing fluid is directed at the leak or an area

- 1) close to it, a sudden change in pressure will occur. Cover suspected leak with plastic sealing compound and continue leak checking until desired pressure is obtained.
- 2) If leak checking fails, disassemble and remake all demountable joints and connections using new gaskets or vacuum sealing compound such as Kinseal. Temporary gaskets may be fabricated from sealing compound but these should not be made too thick since the material may be squeezed into the equipment.

Discharge Valves

If the cause of poor pump vacuum is not due to leaks or oil contamination, the next step is to inspect the discharge valves. The discharge valves are located at the exhaust port of the backing stage chamber. They should not cause trouble unless they are mechanically damaged or are prevented from sealing properly due to foreign matter on the valve seat. Under normal pump usage, the valves should be replaced annually. When the pump is operating at blank off without gas ballast, a sharp hydraulic noise (click) indicates proper valve operation.

The poppet type valve has six flat, washer-like springs, which press against a sealing disk. The disk fits against a seal forming a tight seal. The springs are maintained in place by a lift stop and the entire valve is held together by a capscrews. The valves are attached to the cylinder by means of screws and a hold-down plate.

To inspect the discharge valves, remove the valve as described in the “Disassembly” section. Inspect the valves by snapping the valve disk or lower valve spring away from the valve seat to check for spring tension and mechanical defects. Inspect the sealing surfaces for dirt or other foreign material. Check that the disk or lower valve spring has not warped (dish shape), as they must be flat for full contact. If a more careful inspection is required, remove the cap screw(s) holding the valve together. When reassembling the valve, replace valve components in exactly the same position as before.

Reassemble the valves as described in the “Assembly” section.

Shaft Seal Assembly

Under normal conditions, the shaft seal (See Figure 4) has a long trouble-free life. It may become worn or scratched on the sealing face by dirty sealing oil, which also lubricates the shaft seal, or it may be damaged by excessive heat due to poor lubrication.

If oil drips from the shaft seal and bearing housing, it is an indication that the shaft seal should be inspected and replaced as necessary. The drain plug of the shaft seal and bearing housing should be removed as long as oil is leaking past the shaft seal. If oil, which has leaked from the shaft seal, is allowed to drain through the bearing, it will wash the grease from the bearing and cause it to fail.

To inspect the seal, proceed as follows:

- 1) Remove the belt guard and belts.
- 2) Remove the pump pulley and drive key from the shaft.
- 3) Remove the shaft bearing and housing:
 - a) Remove the outboard bearing retainer nut from the shaft.
 - b) Remove the cap screws holding the bearing housing and remove it.

Inspect the face of the running surface for dirt, scratches, or grooves that might cause leaks into the pump. A smooth shining carbon face indicates a good seal. A crease across the sealing ring, a dent, or scratch in the running face makes a direct leak through the seal. Cracks or hardening of the rubber parts indicate that the shaft seal was exposed to excessive operating temperatures and needs to be replaced.

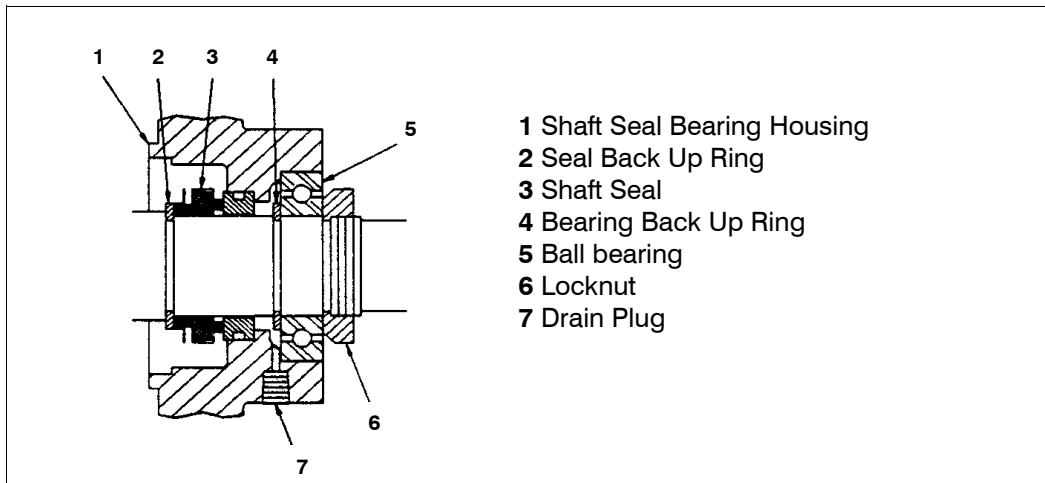


Figure 4. Shaft Seal Assembly

V-Belt Drive

Before attempting to tension the V-belt it is imperative that the sheaves be properly aligned. V-belts should be replaced in sets and the sheaves should be positioned so as to allow the belts to be placed in the grooves without rolling them onto the sheaves. The following tensioning steps can be safely followed for all belt types, cross sections, number of belts per drive, or type of construction.

- 1) With the belts properly in their grooves adjust the sheaves until all slack has been taken up.
- 2) Start the drive and continue to tension the V-belt(s) until only a light bow on the slack side of the drive appears while operating under load conditions as shown in Figure 5.
- 3) After 24 to 48 hours of operation the belts will seat themselves in the sheave grooves. Further tensioning is then necessary as described in Step 2.

The belts should not slip if they are correctly adjusted and the correct starting procedure is used. A screeching noise at start-up may indicate the belts are too loose. Belt dressing should not be used on V-belts. Sheaves and V-belts

should remain free of oil and grease. Tension should be removed from belts if the drive is to be inactive for an extended period of time.

DISASSEMBLY

The following steps are for complete disassembly of the pump, however the pump should be disassembled only to the extent necessary for servicing. Refer to the illustrations and parts list as needed. Note that the open head is the head through which the shaft extends, and the closed head is the head on which the oil pump is mounted.

- 1) Disconnect the pump from the power supply.
- 2) Drain the oil as described in "Changing the Oil".
- 3) Remove the belt guard.
- 4) Disconnect all leads from solenoid valves, pressure switch and motor junction box.
- 5) Loosen the jam nuts and release the belt tension and remove the V-belts.
- 6) Remove the pump sheave and key, spacer and locknut.
- 7) Remove the oil piping to the shaft seal housing.
- 8) Remove all the screws securing the shaft seal/bearing housing and use two screws to jack the housing and bearing off the shaft. Remove the O-ring.
- 9) Pull the seal head assembly (the rotating part of the shaft seal) off of the shaft, this may require a heavy pull if the unit has heat bonded to the shaft. In extreme cases it may be necessary to break the bond by removing the open head from the cylinder. Remove the shaft seal backup ring. If necessary press the seal seat (the stationary part of the shaft seal) from the bearing housing.

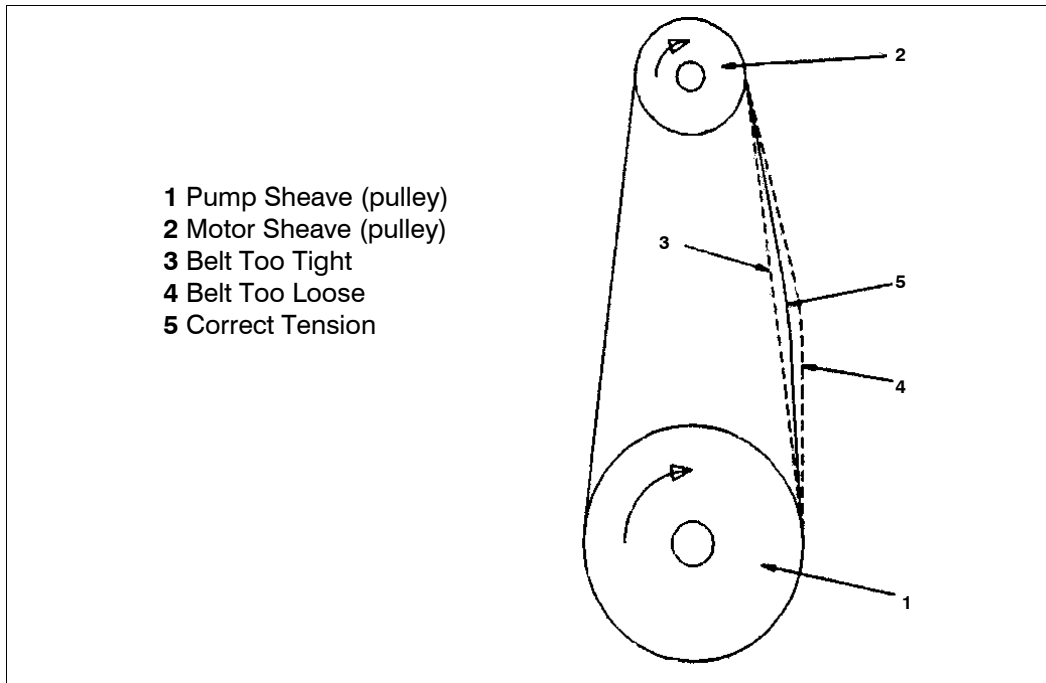


Figure 5. V-Belt Drive

- 10) Disconnect the oil piping between the separator housing and the oil pump, the closed head and the heat exchanger. Remove the piping between the cylinder and the closed head.
- 11) Remove the separator housing cover. On the KTC-112 remove the valve deck cover complete with umbrella. On the KTC-60 remove the umbrella from the top of the separator housing, the nipple from the valve deck cover and then the valve deck cover itself. Remove the relief valve(s) then drain the discharge valve chamber (if not already done), and remove the discharge valve retainers and discharge valves.
- 12) Remove all the screws from the open head and using three or four screws in threaded holes in the head to break the seal jack the head off of the cylinder. Remove the open head.
- 13) Pull the open head slide pin and piston from the cylinder. Mark the parts to insure that they can be replaced in the same location.
- 14) Pull the open head cam off the shaft.
- 15) Replace the open head and dowel pins using four screws to hold the head. This will support the shaft while the closed end of the pump is dismantled.

- 16) Remove four screws securing the oil pump housing and pull off the housing complete with the pump.
- 17) Remove the closed head in the same way as the open head was removed, by jacking the head off of the cylinder
- 18) Pull the closed head slide pin and piston from the cylinder and again mark them so that they can be replaced in the same location.
- 19) Remove the closed head cam from the shaft.
- 20) Loosen the socket head self-locking screws in the floating wall to release the pins securing the wall to the cylinder. Withdraw the wall from the cylinder, taking care not to tilt the wall. Two 3/8-16 tapped holes in the face of the wall can be utilized in conjunction with a bar (two 1/2" holes on 3-1/2" center) placed across the face of the cylinder and two draw bolts to aid in the wall removal.
- 21) Pull out the center slide pin and piston.
- 22) The shaft and cam can now be removed from the closed head end. Disassembly of the center cam and shaft is not recommended unless either part has to be replaced. The cam is a press fit onto the shaft and a press is required to remove it.
- 23) Remove the oil seal from the fixed wall, it is advisable to replace this.
- 24) If the bearings are to be replaced, press them out of the heads.
- 25) If disassembly has proceeded this far, it is advisable to perform a complete cleaning of the oil reservoirs as follows.
- 26) Remove separator housing from the cylinder complete with motor attached. Remove gaskets and compound plate.
- 27) Remove discharge pipes and relief valves. Flush and clean both oil reservoirs with solvent and remove all solid particles.

ASSEMBLY

- 1) Thoroughly clean all parts and remove harmful rough or sharp areas before reassembling. Do not use solvents such as kerosene or carbon tetrachloride for cleaning unless facilities are available to evaporate them by vapor degreasing or washing with acetone or alcohol. When reassembling, all parts must be coated with vacuum oil.
- 2) Replace the Woodruff keys in the close head end of the shaft. If the center cam has been removed from the shaft, press the cam onto the shaft. Do not install keys in the open head end of the shaft, these may damage the center wall seal during assembly.
- 3) Install a new centerwall shaft seal in the cylinder, with the lip towards the open head of the cylinder.
- 4) If new bearings are to be installed, press them into the heads.
- 5) Attach the open head to the cylinder with dowels, place and secure it with four screws.
- 6) Insert the shaft with the center cam attached into the cylinder from the open head side.
- 7) Place the center slide pin over the center cam with the flat edges of the slide pin facing the flats along the side of the piston tang. If the slide pin is assembled upside down the pump will not be able to rotate correctly. Make sure the inlet port in the piston is facing down and slide the cam and piston into the cylinder and over the center cam. If the piston is installed upside down the pump will rotate but will not pump.
- 8) Renew the locking screws in the removable wall. Insert the rounded ends of the locking pins into the holes on the outside edge of the wall and turn the locking screws until the head of the locking pin is just below the surface of the wall. Put a dab of grease on the top of the locking pin to prevent it from falling out. Carefully clean all foreign matter from the floating wall seating shoulder. Slide the wall into the cylinder from the closed head side and press it tightly against the shoulder in the bore of the cylinder. Place two pieces of .005 shim stock two inches apart, between the center slide pin OD and the floating wall cut out, to ensure adequate clearance.
- 9) Tighten the socket head screws to drive the locking pins out against the cylinder, thus securing the wall in place. The tightening torque for these screws is 80 inch pounds. This is as much torque that can be applied with one hand, over-tightening may result in the wall becoming cocked and cause the pump to bind. To ensure that the wall is correctly seated, check dimensions from cylinder face to wall face with a depth micrometer. Correct dimensions should be as follows:

KTC-60	2.500 to 2.504
KTC-112	2.9995 to 3.0035

When the floating wall is secured, remove the two pieces of shim stock from the pump and install the retaining ring to the shaft.

- 10) Install the closed head cam, and slide the closed head slide pin and piston into place, making sure that the slide pin and piston are correctly positioned as described for the center piston.
- 11) Install the closed head and dowel pins securing the head with four screws. Although the head could be

- sealed at this point it is best to check that the pump does not bind before sealing the head.
- 12) Remove the open head by jacking it off the dowel pins, and install the open head slide pin and piston; again making sure that the slide pin and piston are correctly positioned as described for the center piston.
 - 13) The open head could now be sealed, but it is best to check that the pump does not bind before sealing the head. Install the open head with dowel pins and four screws.
 - 14) Turn the pump to ensure that there is no binding. If binding does occur it is necessary to dismantle the pump and correct the cause.
 - 15) Remove the closed head and make sure the sealing surfaces on the head and cylinder are clean. Apply a thin coat of Kinseal to these surfaces. Allow the surfaces to become tacky before joining them.
 - 16) CAUTION: If too thick an application of sealing compound is used, it will squeeze into the pump during assembly and cause parts to stick or even clog the oil piping.
 - 17) Install the closed head on the cylinder, tap the dowel pins home and tighten the screws securing the head. Rotate the head to ensure there is no binding.
 - 18) Repeat this process for the open head.
 - 19) Install the oil pump housing and O-ring to the closed head. Install oil pump and O-ring to housing. Apply vacuum oil or grease to O-rings before installing.
 - 20) Install the shaft seal as follows:
 - a) Remove sharp edges and burrs from the shaft seal to prevent damage to the shaft seal.
 - b) Lubricate the shaft and seal head assembly with vacuum grease.
 - c) Replace the seal backup ring and slide the rotating portion of the seal against the ring with the carbon face outwards. Be extremely careful not to damage or cut the rubber.
 - d) Coat the seal seat with vacuum grease and press it by hand into the shaft seal bearing housing. Assemble the bearing housing and seat to the open head.
 - e) Insert the bearing backup ring against the shaft shoulder and tap the outer race of the bearing into its housing. Tighten the bearing locknut and rotate the shaft to check for binding.
 - f) Reconnect all external lines except to the separator housing.
 - 21) Install the discharge valve(s).
 - a) Place the compound plate with its top and bottom gaskets in position, and install the interstage relief valve. Install the valve deck cover and fasten it in place. Install the discharge baffle assembly. (On the KTC-60 the umbrella is fastened to the separator housing.)
 - b) Lower the separator housing into place and tighten the retaining screws inside, then the outside screws. Go back and re-tighten the inside screws.
 - 22) Connect the oil line to the separator housing.
 - 23) Reconnect the wiring.
 - 24) Install the sheaves and belts. The V-belts should be adjusted as described in the MAINTENANCE section.
 - 25) Install the belt guard.
 - 27) Fill the pump with oil as described in the OPERATION section.

REPLACEMENT PARTS

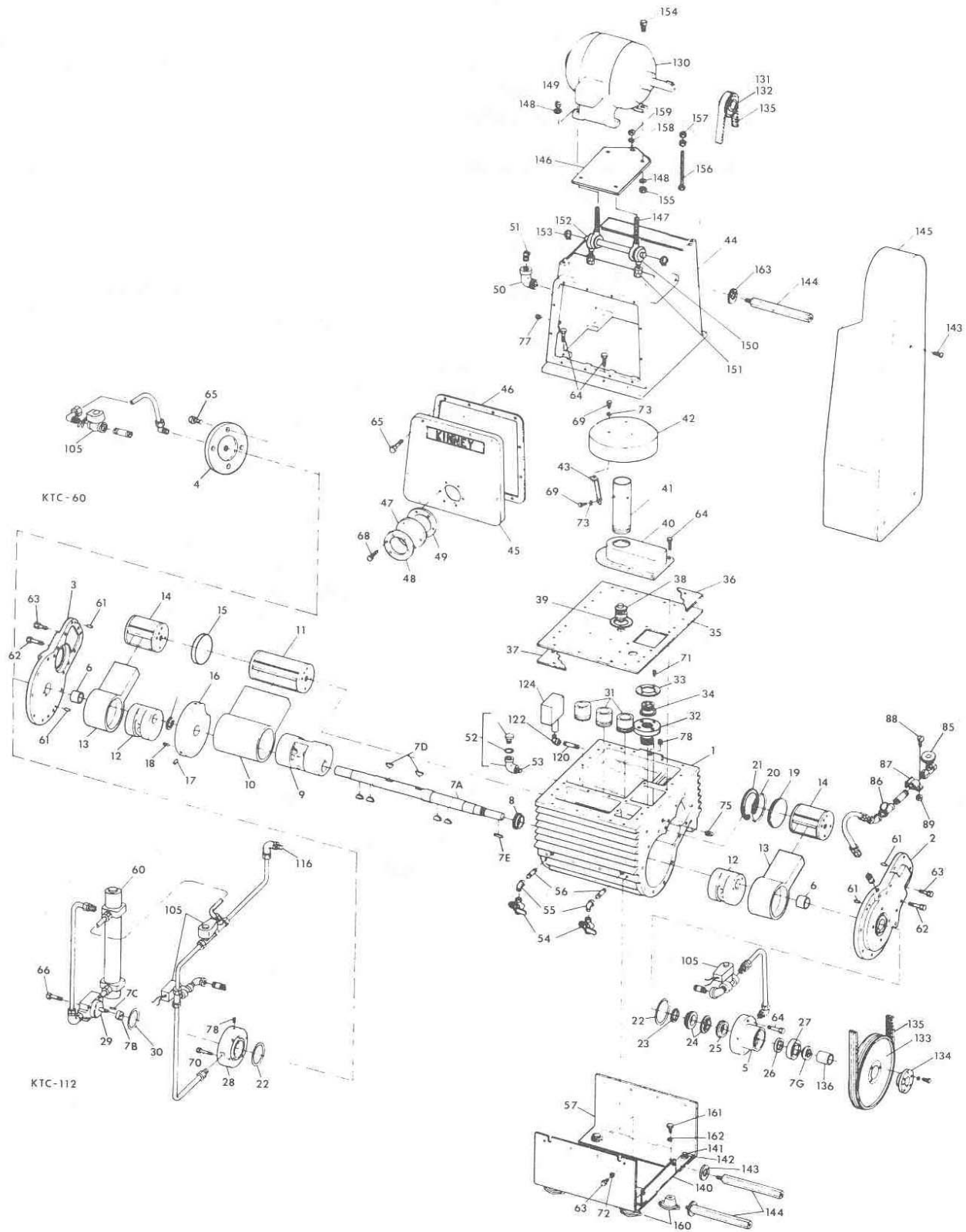
Various parts, particularly internal components for earlier versions of KTC series pumps are different and cannot be interchanged. Many pumps are ordered and equipped with special modifications and accessories, or adaptations for special fluids. Therefore, when ordering spare parts the pump model and nameplate serial number must always be provided to ensure verification and shipment of the correct parts.

RECOMMENDED OIL

KINNEY AX Oil is recommended for the KTC pumps and it is available from the factory and Distributors under the following item numbers:

55 Gallons	203082 0000
5 Gallons	203080 0000
1 Gallon	203079 0000

KTC 60 & KTC 112 Exploded View



Ref		Description	KTC-60 Qty	KTC-112 Qty
1		Cylinder	1	1
2		Head,open end	1	1
3		Head, closed end	1	1
4		Cap, closed end	1	
5		Housing, shaft seal and brg	1	1
6		Sleeve bearing, heads	2	2
7		Shaft & coupling assy		1
	A	Shaft	1	1
	B	Drive coupling		1
	C	Rollpin		2
	D	Key Woodruff	4	6
	E	Key, drive	1	1
	F	Retaining ring, cam	3	1
	G	Bearing locknut	1	1
8		Oil Seal	1	1
9		Cam, center	1	1
10		Piston, center	1	1
11		Slidepin. center	1	1
12		Cam, outer	2	2
13		Piston, outer	2	2
14		Slidepin, outer	2	2
15		Spacer, slidepin	1	1
16		Removable wall	1	1
17		Pin, wall locking	3	3
18		Setscrew, wall locking	3	3
19		Separator, slidepin	1	1
20		O-ring, slidepin sep	1	1
21		Retaining ring		1
22		O-ring, SS hsg & OP hsg	1	2
23		Ring, shaft seal backup	1	1
24		Shaft seal head assy	1	1
25		Shaft seal seat	1	1
26		Ring, bearing backup	1	1
27		Ball bearing	1	1
28		Housing, oil pump		1
29		Oil pump		1
30		O-ring, oil pump		1
31		Pipe, discharge	2	3
32		Valve adapter	1	1
33		Hold down plate	1	1
34		Discharge valve assy	1	1
35		Compound plate assy	1	1
36		Gasket, top plate	1	1
37		Gasket, bottom plate	1	1
38		Relief valve	1	1
39		Gasket, relief valve	1	1
40		Valve deck cover	1	1
41		Nipple, baffle	1	1
42		Baffle	1	1

Ref		Description	KTC 60 Qty	KTC-112 Qty
43		Baffle Support	1	1
44		Seperator Housing	1	1
45		Cover, Separator Housing	1	1
46		Gasket, Sep hsg cover	1	1
47		Sight Glass	1	1
48		Ring, Sight Glass	1	1
49		Gasket, Sight Glass	1	1
50		Street Elbow, 90 deg	1	1
51		Pipe Plug, sq hd	1	1
52		Oil Fill Assembly	1	1
	A	Elbow	1	1
	B	Cap	1	1
		*Oring	1	1
53		Nipple, 3/4 x 1-3/8	1	1
54		Ball valve	2	2
55		Street Elbow	2	2
56		Nipple	2	2
57		Base	2	2
58		Air Diverter	1	-
59		Coupling, 1/8	-	1
60		Heat Exchanger	-	1
61		Dowel Pin	4	4
62		Hexhd capscr, heads	12	18
63		Hexhd capscr, heads	38	51
64		Hexhd capscr, sep hsg	20	16
65		Hexhd capscr, sep hsg cv	10	-
66		Hexhd capscr, oil pump	-	4
67		Hexhd capscr, sep hsg	-	4
68		Hexhd capscrg	6	6
69		Hexhd capscr, baffle	3	6
70		Sockhd capscr, op hsg	-	4
71		Sockhd Capscr, dis valve	4	4
72		Lockwshr, reg spr 5/16	26	8
73		Lockshr, reg spr 1/4	3	6
74		Face bushing 3/4 x 3/8	2	-
75		Pipe Plug, sq hd 1/4	2	1
76		Pipe plug, sq hd 1/8	1	1
77		Pipe plug, sockhd 1/2	-	2
78		Pipe plug, hexs 1/4	-	3
79		Mach Screw 10-32 x 3/4	4	-
80		HMSN 10-32 x 3/8	4	-
85		Needle Valve, Gas Ballast	1	1
86		Check Valve, Swing	1	1
87		Hanger, 1/2 conduit	1	1
88		Mach scr, 1/4-20 x 3/4	1	1
89		Nut 1/4-20	1	1
90		Mach Scr, 1/4-20 x 1/2	1	1
91		Lockwshr, reg spring 1/4	2	2
94		Male elbow, 3/8 x 1/4	2	-

Ref	Description	KTC 60 Qty	KTC 112 Qty
95	Female, Conn 3/8 x 1/8	-	1
96	Nipple 1/8 x 1 1-2	-	1
97	Nipple	1	1
98	Nipple, 1/4 close	-	1
99	Elbow, 1/4 x 45 deg	-	1
105	Solenoid Valve	2	3
106	Tubing, 3/8 od x .035 w	2ft	3ft
107	Tubing, 1/2 od x 0.35w		1ft
108	Male conn, 3/8 x 1/8	1	2
109	Male conn, 3/8 x 1/4	2	4
110	Male conn, 1/2 x 3/8	-	1
111	Male elbow, 1/2 x 1/2	-	1
112	Male conn, 3/8 x 3/8	-	1
113	Male conn, 3/8 x 1/4	-	1
114	Male br tee, 3/8 x 1/4	-	1
115	Female Elbow, 3/8 x 1/4	1	1
116	Orifice Nipple	-	1
117	Nipple, 1/2 x 2-1/2	-	1
118	Hexhd Bushing, 1/2 x 3/8	-	1
119	Hexhd Bushing, 1 x 1/4	-	2
120	Nipple, 1/4 x 1-1/2	3	3
121	Street Elbow, 90 x 1/8	1	1
122	Street Elbow, 90 x 1/4	1	3
123	Nipple, 1/4 x 1-3/4	1	-
124	Pressure Switch	-	1
130	Motor	1	1
131	Motor Sheave	1	1
132	QD Bushing	1	1
133	Pump Sheave	1	1
134	QD Bushing	1	1
135	V-Belt	1	1
136	Spacer Sheave	1	1
137	Fan Ass'y	1	-
138	Sockhd Capscr 10-24 x 1/2	3	-
139	Lockwshr, #10 reg spring	3	-
140	Beltguard Bracket	1	1
141	Hexhd Capscr	4	2
142	Lockwshr, reg spring 5/16	4	2
143	THMS, 3/8-16 x 3/4	1	3

Ref	Description	KTC 60 Qty	KTC 112 Qty
144	Standoff, beltguard	-	3
145	Beltguard	1	1
146	Motor plate	1	1
147	Rod end, motor	2	2
148	Lockwshr, reg spring 3/8	4	4
149	Hex nut 3/8-24	2	2
150	Rod end, sep hsg	2	2
151	Jam nut	4	4
152	Hinge pin	1	1
153	Retaining ring	2	2
154	Hexhd Capsr	2	2
155	Hex nut, 3/8-16	2	2
156	Jacking Screw	1	1
157	Jam nut, 5/8-11	2	2
158	Lockwashr, reg spr 5/8	1	1
159	Hex nut, 5/8-11	1	1
160	Vibration mounts	2	4
161	Hexhd caspr	4	4
162	Plain washer	4	4
163	Lockwshr 1/2	-	3

WARRANTY – VACUUM PRODUCTS

Subject to the terms and conditions hereinafter set forth and set forth in General Terms of Sale, Tuthill Vacuum & Blower Systems (the seller) warrants products and parts of its manufacture, when shipped, and its work (including installation and start-up) when performed, will be of good quality and will be free from defects in material and workmanship. This warranty applies only to Seller's equipment, under use and service in accordance with seller's written instructions, recommendations and ratings for installation, operating, maintenance and service of products, for a period as stated in the table below. Because of varying conditions of installation and operation, all guarantees of performance are subject to plus or minus 5% variation. (Non-standard materials are subject to a plus or minus 10% variation).

THIS WARRANTY EXTENDS ONLY TO BUYER AND/OR ORIGINAL END USER, AND IN NO EVENT SHALL

Product Type	Warranty Duration
New	15 months after date of shipment or 12 months after initial startup date, whichever occurs first
Repair	6 months after date of shipment or remaining warranty period, whichever is greater
Remanufactured	9 months after date of shipment or 6 months after initial startup date, whichever occurs first

THE SELLER BE LIABLE FOR PROPERTY DAMAGE SUSTAINED BY A PERSON DESIGNATED BY THE LAW OF ANY JURISDICTION AS A THIRD PARTY BENEFICIARY OF THIS WARRANTY OR ANY OTHER WARRANTY HELD TO SURVIVE SELLER'S DISCLAIMER.

All accessories furnished by Seller but manufactured by others bear only that manufacturer's standard warranty.

All claims for defective products, parts, or work under this warranty must be made in writing immediately upon discovery and, in any event within one (1) year from date of shipment of the applicable item and all claims for defective work must be made in writing immediately upon discovery and in any event within one (1) year from date of completion thereof by Seller. Unless done with prior written consent of Seller, any repairs, alterations or disassembly of Seller's equipment shall void warranty. Installation and transportation costs are not included and defective items must be held for Seller's inspection and returned to Seller's Ex-works point upon request.

THERE ARE NO WARRANTIES, EXPRESSED, IMPLIED OR STATUTORY WHICH EXTEND BEYOND THE DESCRIPTION ON THE FACE HEREOF, INCLUDING WITHOUT LIMITATION, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS OF PURPOSE.

After Buyer's submission of a claim as provided above and its approval, Seller shall at its option either repair or replace its product, part, or work at the original Ex-works point of shipment, or refund an equitable portion of the purchase price.

The products and parts sold hereunder are not warranted for operation with erosive or corrosive material or those which may lead to build up of material within the product supplied, nor those which are incompatible with the materials of construction. The Buyer shall have no claim whatsoever and no product or part shall be deemed to be defective by reason of failure to resist erosive or corrosive action nor for problems resulting from build-up of material within the unit nor for problems due to incompatibility with the materials of construction.

Any improper use, operation beyond capacity, substitution of parts not approved by Seller, or any alteration or repair by others in such manner as in Seller's judgment affects the product materially and adversely shall void this warranty.

No employee or representative of Seller other than an Officer of the Company is authorized to change this warranty in any way or grant any other warranty. Any such change by an Officer of the Company must be in writing.

The foregoing is Seller's only obligation and Buyer's only remedy for breach of warranty, and except for gross negligence, willful misconduct and remedies permitted under the General Terms of Sale in the sections on CONTRACT PERFORMANCE, INSPECTION AND ACCEPTANCE and the PATENTS Clause hereof, the foregoing is BUYER'S ONLY REMEDY HEREUNDER BY WAY OF BREACH OF CONTRACT, TORT OR OTHERWISE, WITHOUT REGARD TO WHETHER ANY DEFECT WAS DISCOVERED OR LATENT AT THE TIME OF DELIVERY OF THE PRODUCT OR WORK. In no event shall Buyer be entitled to incidental or consequential damages. Any action for breach of this agreement must commence within one (1) year after the cause of action has occurred.

December, 2002



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