

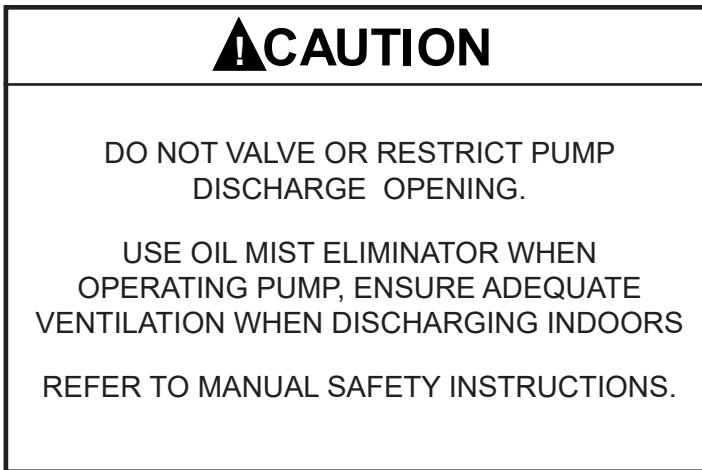
WARNING: Do Not Operate Before Reading Manual

KTC OPERATOR'S MANUAL

Models

21B





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 beltguard properly attached.
- Disconnect the pump from the electrical supply at the main disconnect before removing the beltguard. Replace the beltguard before reconnecting the power supply. Operating the pump without the beltguard secured in place exposes people in the vicinity of the pump to risk from rotating drive parts.
- Do not operate the pump with oxygen enriched gas in the suction line, where the proportion of oxygen exceeds 20%, 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 an explosion in the pump, resulting in damage or injury.
- Take precautions to avoid prolonged or excessive exposure to oil mist or process materials from the discharge of the pump. Do not allow the pump to discharge into a closed room, or a room without adequate ventilation. Always use a discharge oil mist eliminator unless the pump discharge is vented to the open air. Venting the outlet of the oil mist eliminator to the open air is highly recommended.
- Do not restrict the pump discharge line in any way, or place any valves in the discharge line. The vacuum pump is a compressor and will generate high pressures without the motor stalling when operated at low suction pressures. Excessive pressure build up could cause damage or injury.
- Disconnect the pump from the electrical supply at the main disconnect before dismantling or servicing the pump. Make sure the pump is completely reassembled, the beltguard is replaced, and all drain and fill valve and plugs are closed before reconnecting the power supply.
- Accidental starting or operation of the pump while maintenance is in progress may caused injury or damage.
- Lift only with the lifting eyebolts supplied with the pump. Do not lift equipment attached to the pump with the eyebolts supplied.
- Do not touch hot surfaces on the pump. In normal operation at low pressures surface temperatures will not normally exceed 180°F. Prolonged operation at 200 torr may cause surface temperatures up to 220°F.

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DESCRIPTION

GENERAL

A direct-coupled motor drives Vacuum Pump Model KTC-21B. Oil is used for both lubrication and sealing and is controlled, on-off, by two solenoid valves. The pump has an adjustable gas ballast valve, which increases the vapor handling capacity of the pump. The cylinder is air-cooled and contains three rotary pistons, two of which make up the high vacuum stage, which is located at the suction end of the pump. The third piston forms the backing stage, which draws the gas from the high vacuum stage and exhausts it through the discharge valve, along with the excess oil, into the oil/gas separator. When the oil and gas are separated the oil is returned to the reservoir for recirculation and the gas is released through the breather filter to atmosphere. The pistons are driven by cams arranged on the drive shaft to dynamically balance the moving parts. The effect of this balancing principle renders the pump virtually vibrationless when running. Mounting pads are provided to absorb the starting force plus the residual vibrations and prevent their transmission to the support. The pump can operate on any structure capable of supporting the weight.

PUMP COMPONENTS

Each pump consists basically of three rotary piston pumping members, and each member is made up of a cam, piston and slide pin. Two of these members operate in parallel to form the High Vacuum Stage and have a common inlet and discharge. This HV-Stage discharge is connected to the inlet of the backing stage so that the two stages operate in series. The backing stage discharges to atmosphere through the breather filter.

A check valve is provided between the high vacuum stage and the backing stage. Since the HV-Stage has three times the capacity as the backing stage, when the pump is operating at inlet pressures above 250 torr, some air is discharged from the high vacuum stage through the check valve and into the oil separator.

The cylinder has an open head, through which the shaft extends, and a closed head. Each head contains a sleeve bearing and the necessary oil ducts and solenoid valves for lubrication of the internal parts. In addition, the open head contains the stationary part of the drive shaft mechanical seal, and the gas ballast valve.

An oil baffle assembly contained within the separator housing separates the oil from the exhaust gases at the pump discharge.

Sealing/lubricating oil is contained in two reservoirs, one for the high vacuum stage and one for the backing stage. A sight glass on the side of the separator housing indicated 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 large changes in inlet pressure. The sealing/lubricating oil inlet is positioned above the bottom of the reservoir to allow a space for sedimentation of foreign materials, including water.

OPERATING CYCLE

The operating cycle is shown in Figure 1. As the piston moves, gas enters the pump inlet where it is drawn into the cylinder through the openings in the piston slides. The space behind the piston continues to fill with gas as the piston moves, and the gas on the other side of the piston is compressed and forced through the interconnecting channel to the backing stage.

The pumping cycle is repeated in the backing stage, as gas is

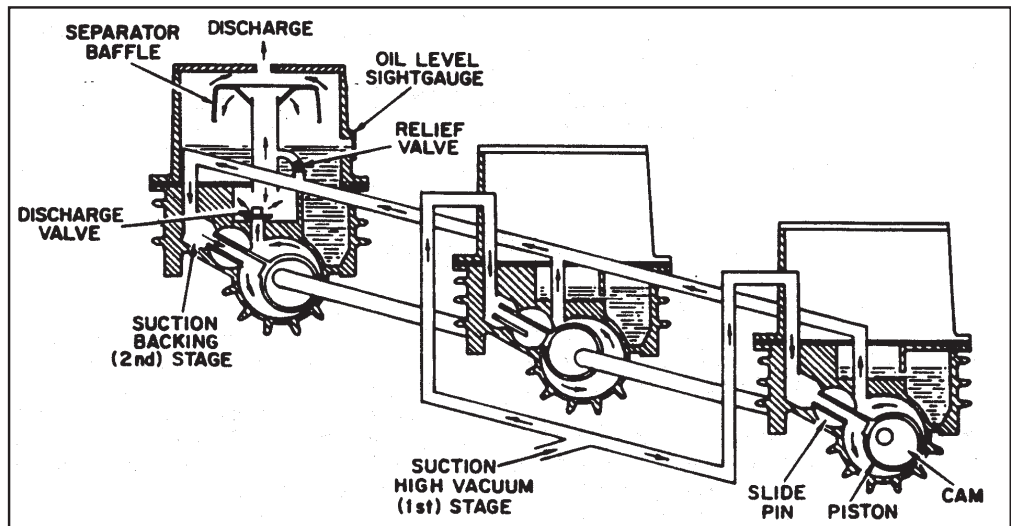


Figure 1. Operating Cycle

compressed and forced out through the discharge valve along with a small amount of oil and then into the oil separator where the oil is separated from the gas. The gas is discharged to atmosphere either through the breather filter or through an optional oil mist eliminator and the oil drains back into the oil reservoir.

OIL TYPES

The ability of the KTC-21B pump to obtain and hold pressure in the low micron range depends greatly on the use of proper sealing/lubricating oil. AX Vacuum Oil is recommended for use with this pump under normal operating conditions. This oil was developed to maintain a dry, low, vapor pressure with suitable viscosity for effective pumping at either high pumping speed or at low pressure. Typically, the vapor pressure of this oil is 1 millitorr at 100°F pump temperature.

Other fluids may have to be used for special applications. If varnishing is a problem high detergency oils may be used. Where low temperature starting is required, other more suitable fluids may be used [ie. inert fluids]. Heaters may be used for cold starting with viscous fluids. Kinney can recommend fluids to fit most special applications.

SEALING AND LUBRICATING

The pump components are lubricated, and sealed against the backflow of gas by a film of oil, which fills the close running clearances. When operating, the cylindrical part of the piston almost touches the pump cylinder at a line along the length of the piston. At this moving line, an effective wave of oil is pushed ahead of the piston and cylinder as well as between all other moving components.

The oil flows through the oil passages by means of differential pressure. Because of the higher pressure at the discharge and lower pressure at the inlet of each stage, oil is drawn from the high vacuum and backing stage reservoirs through channeling to each pumping stage. At the end of the compression stroke the excess oil is forced out with the discharged gas where it returns to either the HV or backing stage oil reservoir. Oil flow is controlled by two normally closed solenoid valves, which open when the motor is energized. This arrangement prevents oil from flooding the cylinder when the pump is stopped.

CAUTION: Because the flow of lubricant is activated by differential pressure, prolonged operation near atmospheric pressure could result in damage to the pump.

INSTALLATION

MOUNTING

The KTC-21B Vacuum Pump can be mounted and operated on any near level floor that will support the weight of the pump. Vibration mounts are standard with each pump to absorb and minimize the force transmitted to the floor or pump support.

DISCHARGE PIPING

The standard KTC-21B Vacuum Pump is supplied with a breather filter. A mist eliminator is available as an accessory, which virtually eliminates oil mist from the pump discharge. If it is necessary to install discharge piping, a flexible connector such as rubber hose should be used as a vibration insulator and serve as a convenient disconnect between piping and pump. If exposed to the elements, the outer end of the piping should turn downward to prevent a backflow into the pump.

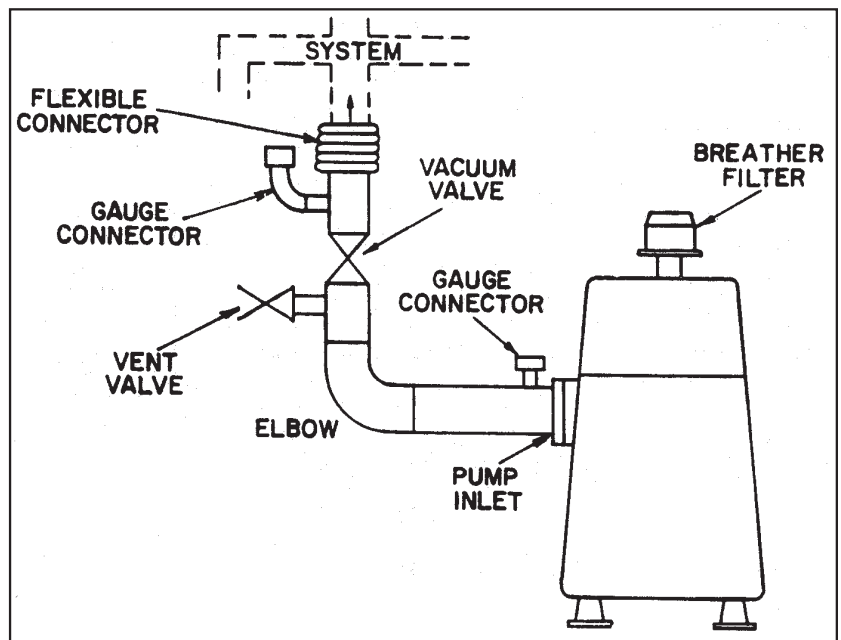


Figure 2. Typical Inlet Piping Arrangement

INLET PIPING

The inlet piping to the pump should be as short as possible and no smaller in diameter than the pump inlet. The piping should have an isolation valve and a flexible connector adjacent to the inlet to prevent rigidity between the piping and pump. If oil spitting back into the system becomes a problem, a trap with a drain can be installed. Before connecting the piping to the pump, pour two or three ounces of lubricant, the same as used in the pump, into the pump inlet to provide lubrication on initial starting.

CAUTION: Piping must be free of foreign matter that could be entrained into the pump. An inlet filter or screen is suggested for initial start-up.

Make all connections vacuum tight by sealing demountable joints with O-rings or equivalent method. If threaded connections are used, clean the threads and turn them together about two turns. Cover the remaining exposed threads with a sealing compound such as Loctite 567 or PTFE tape, for piping up to 1" in diameter, and tighten the connection. Use Tite Seal (Radiator Specialty Company, North Carolina) on larger pipe sizes.

Install a vacuum isolation valve between the system and the pump with fittings for connecting vacuum gauges on both sides of the valve and an air admittance valve on the pump side of the isolation valve. See Figure 2 for a typical piping arrangement. With such an arrangement, it is possible to check both the system and the pump for leaks without disconnecting the piping. The system can be kept under vacuum while the pump is not running or the pump can be operated while the system is open to atmosphere.

ELECTRICAL CONNECTIONS

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

Check the nameplates on the motor and solenoid valves for the electrical power required and refer to Figure 3 for the correct wiring. Connect the pump motor and solenoid valves to the proper power source through necessary switches and fuses or relays. After wiring is complete, momentarily start the motor to check the direction of rotation against the arrow cast on the pump by checking the motor rotation through the slots in the motor end. If the pump rotates in the wrong direction, interchange two connections from the motor to the power line on three-phase installations. On single phase installations carefully re-check the lead connections per the wiring diagram. Note that the KTC-21B should rotate clockwise when facing the pump open head.

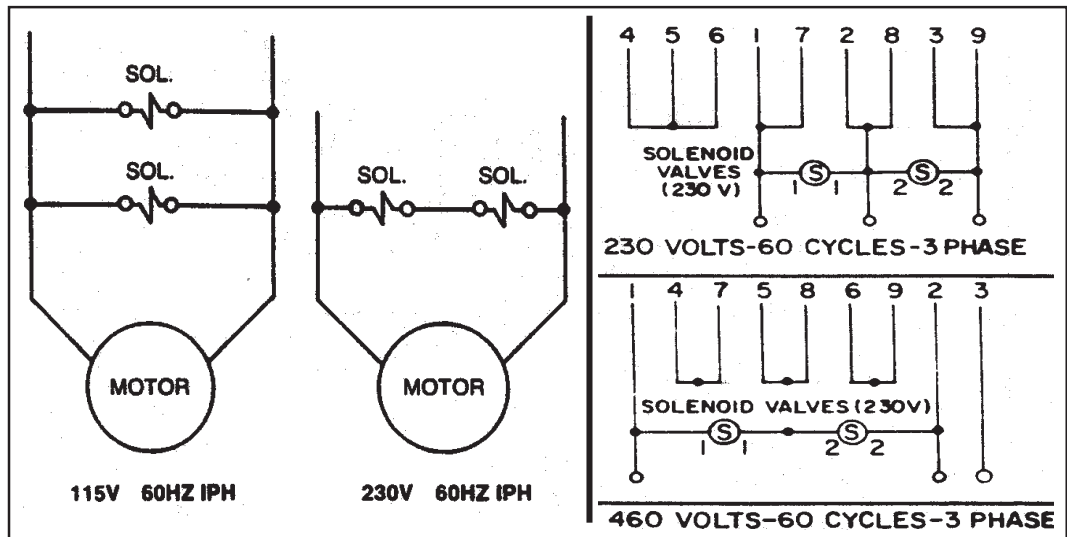


Figure 3. Wiring diagrams for motor and solenoid valves

VACUUM GAUGES

Two general types of vacuum gauges are used for testing vacuum equipment. Themistor or thermocouple gauges give a total pressure reading while the McLeod gauge registers only the pressure of the permanent gases and is not normally affected by the presence of condensable water vapor. The McLeod gauge is particularly useful for leak checking when used in conjunction with a themistor or thermocouple gauge. A high reading on both types of gauges indicates that a leak is present. If the McLeod gauge reading were considerably lower than the other gauge it would indicate contamination such as water in the oil.

OPERATION

WARNINGS:

- Do not block or restrict the flow of gas from the pump discharge. Backpressure within the pump could cause severe damage.
- Exhaust fumes in a confined space could cause breathing discomfort and under extreme prolonged conditions could be injurious to health. The discharge should be piped out-of-doors should this condition exist.

GENERAL

The model KTC-21B pump is designed for low-pressure operation and prolonged periods of operation at high pressure MUST be avoided. Each pump is thoroughly tested and ready for operation as soon as it is installed and filled with oil. If the vacuum system is tight, including the connections to the pump, the ultimate system pressure should be close to that obtained with the pump inlet closed off.

FILLING THE PUMP WITH OIL

Remove the filler plug from the top of the separator housing and pour in 3 pints of oil. With the pump running, open the valve on the drain that has the hose connected and submerge the hose in one pint of oil and operate the pump long enough to draw the oil into the high vacuum stage oil reservoir. Close the drain valve and replace the filler plug.

After the pump has been in operation for a few minutes with the pump inlet closed, check the oil level, which should be near the center of the sight gauge on the separator housing. If necessary add more oil, but do not raise the oil level beyond the top of the sight gauge since this may cause noisy pump operation. Note that the oil level should change when operating the pump at high and low inlet pressures. This indicates proper oil flow through the pump. When the pump is first started, the oil level will rise in the backing stage. When the inlet pressure is reduced to the micron (10 -3 torr) range, the oil level will drop to about the center of the sight gauge.

PRESTART CHECKS

- a. Check that the suction lines are tight free of foreign matter.
- b. Check that the oil is midway on the sight gauge.
- c. Check that all wiring is complete and correct.
- d. Drain accumulated water from oil separator as necessary.

STARTING THE PUMP

- a. Perform the prestart checks indicated previously. Warm the pump to the minimum starting temperature of 45°F.
- b. Start the pump. It is recommended that the pump be warmed up before beginning process work. This requires operation for about 10 minutes with the pump isolated from the process equipment.
- c. Open the pump isolation valve, if one is provided, allowing the pump to evacuate the process equipment.
- d. Open the gas ballast valve if condensable vapors are encountered, This is a preferred method of operation since it helps to keep the oil free of condensate and quiets pump operation.

STOPPING THE PUMP

- a. If a vacuum valve is provided between the pump and the process equipment, close this valve.
- b. Vent the pump suction to atmospheric pressure by opening a vent valve if provided, otherwise, open the gas ballast valve. Note that if the system does not have a pump isolation valve; vent the system to atmospheric pressure to prevent oil from being drawn from the pump into the process equipment.
- c. Stopping the pump under vacuum is not recommended.

HANDLING LARGE QUANTITIES OF WATER

In applications where large quantities of water vapor are encountered, drain all water from the backing stage oil reservoir often enough to prevent accumulation of water. The pump may be damaged if water is allowed to accumulate above the level of the oil inlet in the oil separator. Check for excess water each time before starting the pump. Water may separate out of the oil when it is allowed to sit for a period of time.

GAS BALLAST

Gas bled into the pump during the compression stroke is referred to as gas ballast, and is used to prevent the condensation of vapor in a vacuum pump. Vapor present in the gas being pumped can condense during the vacuum pump compression cycle and mix with the vacuum pump oil, collecting in the backing stage oil reservoir. Since this oil is recirculated through the pump, the condensate is carried with the oil where it will re-evaporate, causing poor pump performance and making frequent oil changes necessary.

By using gas ballast, most vapors can be passed through a vacuum pump without condensing and then discharged with the pump exhaust. In addition to preventing water vapor condensation, the use of gas ballast also reduces discharge valve noise. It is generally possible to eliminate valve noise using a small gas ballast flow with only a slight increase in ultimate pressure. If the ultimate pressure is tolerable, this is a preferred method of operation since it also helps to keep the oil clean. The motor power consumption and the ultimate pressure increase in proportion to the gas ballast airflow increase. To use gas ballast proceed as follows:

- 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 prevent oil contamination.
- Intermittent gas ballast. 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 removing oil contamination. If convenient, operate the pump in this manner overnight to clean badly contaminated oil.

If it is necessary to clean the oil in the shortest period, the time needed can be estimated as follows: Observe the pump's blank-off pressure with the gas ballast valve fully closed. Open the gas ballast valve fully and operate the pump for 15 to 20 minutes. Close the gas ballast valve fully and observe the pressure change in that time period. Use this as a rough guide to estimate the total time required to obtain the desired blank off pressure.

MAINTENANCE

PERIODIC

Check the oil level daily for the first week of operation and weekly thereafter. The oil level should be about midway on the sight gauge when operating at low inlet pressures. However, it will rise and fall with large inlet pressure changes. 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. Change the oil when contaminated with foreign matter. There is no fixed interval for changing the pump oil, since applications vary widely. The user, for his particular operation can best determine the period between oil changes. As a minimum the pump oil should be changed after logging three months operating time.

Inspect the discharge valve once every two years or more often if the pump is used on a process where chemical or mechanical damage can occur.

CHANGING THE OIL

To change the pump oil, first operate the pump long enough to warm the pump oil to normal temperature then stop the pump and open both drain valves until the oil is drained. Close the drain valves.

Fill the pump with oil as directed under the OPERATION section per "Filling the Pump with Oil." Note that if the oil is badly contaminated, it may be necessary to flush the pump by changing the oil several times, with a short period of operation between each change to check the pump's blank off pressure.

If frequent oil changes are necessary to maintain proper pump performance, note that the proper use of gas ballast will minimize the amount of oil contamination and reduce the frequency of oil changes. Refer to the "Gas Ballast" paragraph for details.

If varnish deposits occur, use a high detergent oil. Kinlube 220 may be used provided the seal (elastomer) components are compatible with this lubricant. Contact the factory or a district sales office for modification details.

CHECKING PUMP PERFORMANCE

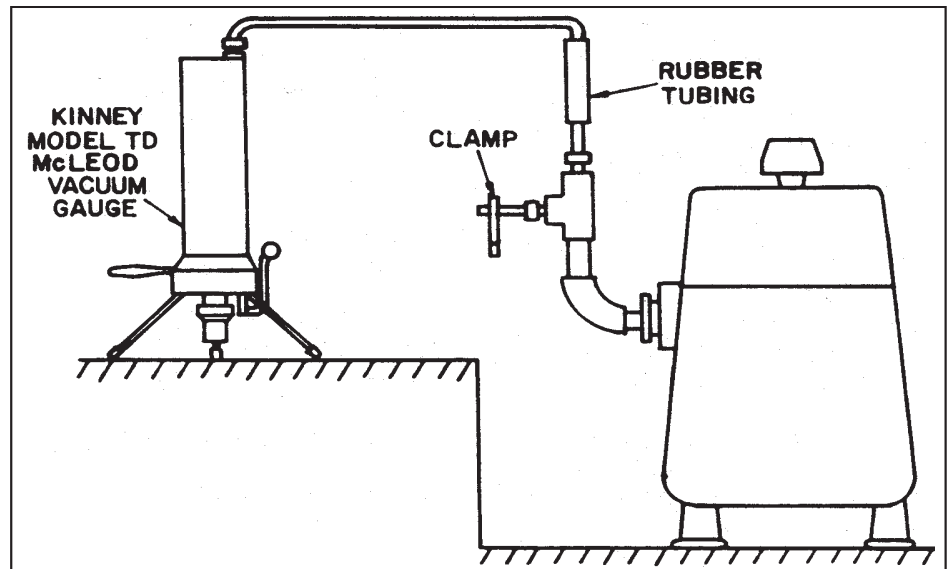


Figure 5. Pump test manifolding

If the processing time increases or the ultimate pressure becomes poor with no recent change 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 illustrated in Figure 5 using a McLeod Gauge. If possible, also read the blank-off pressure with a thermistor or thermocouple gauge. Refer to Figure 4 for a listing of common faults in vacuum systems.

To read the pump blank-off pressure:

1. Close the pump inlet by means of the isolation valve or a short segment of manifolding as shown in Figure 5.
2. Connect a vacuum gauge to the manifolding with the gauge connection positioned so that it will not become flooded or blocked by splashing pump oil.
3. Operate the pump for about 15 minutes or until the lowest pressure is reached and note the reading obtained.

The reading obtained should be between the pump specification blank-off pressure (low end) and the pressure needed for the process (high end). Average blank-off readings are 0.5 to 2.0 microns with a McLeod gauge, and 1 to 15 microns with a thermocouple gauge. The specification pressure is 0.2 microns (2×10^{-4} torr) McLeod Gauge reading. Due to gauge variances, a 10% tolerance in pressure reading should be allowed. If the McLeod gauge reading is low and the thermocouple gauge reading is high, the pump oil is contaminated. Change the oil and re-check the pump blank-off pressure. In some instances it is necessary to change the oil several times to flush all traces of contamination from the pump. Note that if a thermocouple gauge is not available and the pump oil has been in service for an appreciable period, it is best to change the pump oil to eliminate pump oil contamination as a possible cause of poor pump performance. After changing the oil, re-check the blank-off pressure. If both the McLeod and thermocouple gauge readings are high, indicating that the oil is not contaminated, the pump is leaking. Proceed as directed in "Pump Leaks".

STALLING

If the pump stalls at any time, it may be due to a broken shaft coupling, motor failure, damaged pump components, or foreign matter in the pump. Remove the motor to check the shaft coupling. If the pump cannot be turned over by hand with the pump inlet open to atmosphere, refer to the "Disassembly" section for pump disassembly, cleaning and inspection.

PUMP LEAKS

If the pump is suspected of leaking (after eliminating oil contamination as the cause of poor performance), use plastic sealing compound, such as Apiezon Q, or equal to seal suspected areas, and check pump blank-off performance before making permanent repairs with Loctite 515. If gasketed connections are suspected, replace.

Check carefully around the head-to-cylinder joints, securing bolts, plugs, oil valves, and generally any penetration into the vacuum pumping portion of the pump. Check the shaft seal for mechanical defects, such as cracked carbon sealing washer or hardened rubber components.

TROUBLESHOOTING

SYMPTOM	PROBABLE CAUSE	REMEDY
System ultimate pressure excessively high	Process equipment faulty. Vacuum pump improperly operated or malfunctioning.	Check pump performance. See "Checking Pump Performance".
	Process equipment contaminated by high vapor pressure material.	Clean equipment with Acetone, Alcohol, or Ether. Pump down with vacuum pump overnight.
	Process equipment leaks.	Leak check process equipment. See "Process Equipment Leaks".
	Improper vacuum pump oil flow.	Check oil solenoid valves. Check for obstructed oil passages.
	Vacuum pump oil contaminated.	Change pump oil. See "Changing the Oil" and "Oil Contamination".
	Discharge valve malfunctioning.	Check valves per "Discharge Valve".
	Vacuum pump leaks.	Leak check pump per "Pump Leaks".
	Vacuum pump shaft seal malfunctioning.	Check shaft seal per "Shaft Seal".
	Vacuum pump internal parts worn or damaged	Disassemble pump and inspect internal parts. See "Disassembly".
Excessive pump noise at low pressures.	Hydraulic noise of pump discharge.	Open gas ballast valve
	Oil level above sight glass.	Drain oil to reach proper level.
Pump stalls.	Electrical power interrupted.	Check power at pump.
	Shaft coupling damaged.	Replace coupling.
	Pump malfunctioning. Pump oil contaminated or pump is insufficiently lubricated.	See "Stalling"
	Pump discharge line blocked.	Clear pump discharge line. Check oil separator for blockage.
Pump will not start.	Electrical failure.	Check for power at pump. Check motor start controls and motor.
	Temperature excessively low.	Heat pump to minimum starting Temperature of 30°F.

CHECKING PROCESS EQUIPMENT

If the blank-off test shows that the vacuum pump is functioning properly but that the process equipment is faulty, the trouble can be isolated further by pumping down each segment of the process equipment separately, starting at the segment closest to the vacuum pump. Check the lowest pressure obtainable when each segment is added. If the pressure is close to that obtained previously, add the next segment. If the pressure is too high, leak test the last segment. 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 penetrations, especially threaded, gasketed, and O-ring connections. After suspected leak has been found, cover it with plastic sealing compound such as Apiezon -Q or Duxeal and check the equipment performance before sealing the leak permanently. Thus, all permanent repairs can be made at the same time.

PROCESS EQUIPMENT LEAKS

Attach a vacuum gauge to the connections of the system side of the isolation valve. For this test, clear the system of any process work, which might give off vapors and affect the reading. Run the pump to obtain the lowest possible pressure, close the valve, and observe the pressure rise. If the pressure rise is greater than desired, or if the ultimate pressure is too high, check and eliminate all leaks. Check the system carefully for loose joints and obvious leaks. Use a leak detector if available, otherwise, proceed as directed in "Leak Checking Techniques".

LEAK CHECKING TECHNIQUES

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 Plasticine, F.W. Woolworth Company). 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 in the torr range, pressurize the process equipment with one psig of clean compressed air and paint a soap solution on suspected leak areas and watch for bubbles which indicate leaks. De-energize and isolate the pump during the leak checking. Repair leaks as required.
3. If the leak is small, causing pressures in the sub-torr range, use a fast acting thermocouple or thermistor gauge in conjunction with a probing medium such as acetone or alcohol. Position the vacuum gauge head downstream from the suspected leak area, between the leak and the pump. When the pressure has been reduced so that the gauge will register, apply probing medium to suspected leak area. A squirt bottle or brush may be used for applying liquid probing media. If the probing fluid is directed at the leak or an area close to it, a sudden increase in pressure will occur. Vacuum oil can also be used as a probing media; however, the gauge pressure will decrease when oil covers a leak. CAUTION: Damage to paint may occur when using vacuum oil as a probing media.
4. Cover suspected leaks with plastic sealing compound and continue leak checking until the desired pressure is obtained.
5. If leak checking fails, disassemble and remake all demountable joints and connections using new gaskets or vacuum sealing compound such as Loctite 515.

OIL CONTAMINATION

Oil contamination is indicated by an increase in the ultimate pressure of the pump, by a significant difference in McLeod and thermocouple gauge readings, and sometimes by a change in the color of the pump oil. This is caused most often by vapors, which have been introduced into the pump along with the gases being pumped, and have contaminated the pump oil. Water vapor and other oil-insoluble vapors are common contaminants and can be readily cleaned from the pump oil by using gas ballast as indicated in "Gas Ballast." Low level water contamination (PPM range) can be detected by the "crackling" method. Heat a few drops of oil, in aluminum foil, with a match. If the oil smokes the oil is dry; if it spits and crackles water is present. Other vapors which are soluble in oil or which have a low vapor pressure are not readily cleaned from the pump oil by using gas ballast. If these contaminants are encountered, it may be necessary to use an oil reclaimer or to increase the frequency of oil changes. If contamination by solid particles is encountered, an inlet filter and/or an oil filter should be used.

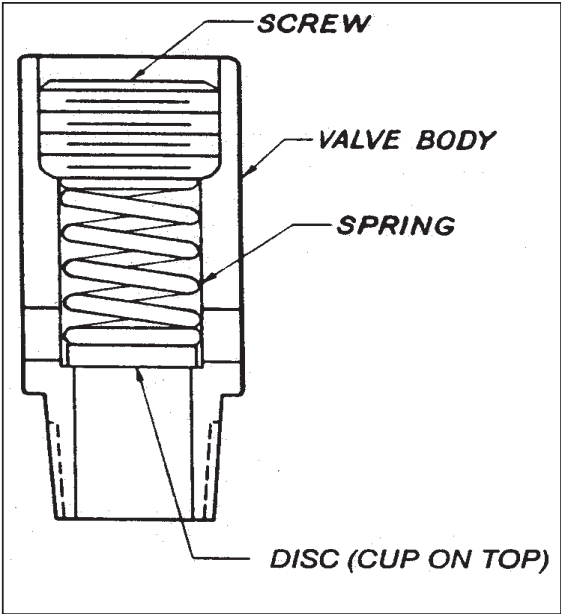


Figure 6. Discharge Valve

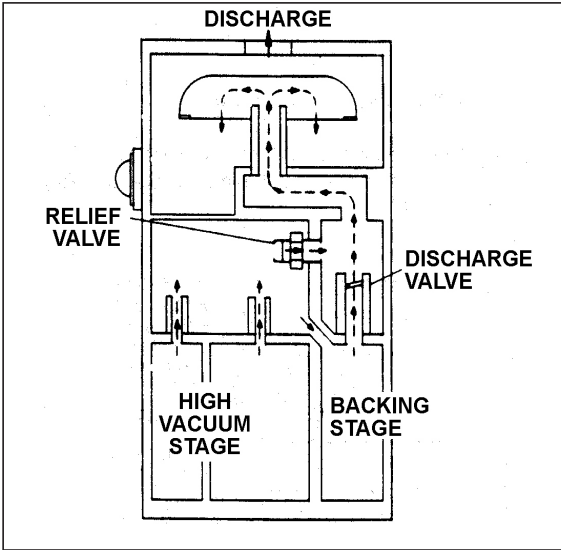


Figure 7. Schematic of Relief and Discharge Valve in Gas Stream

DISCHARGE VALVE

If poor pump performance was not due to leaks or oil contamination, inspect the discharge valve and the pressure relief valve. The discharge valve, Figure 6, is located at the exhaust port of the backing stage and the pressure relief valve is located between the backing and high vacuum stages, see Figure 7. When the pump is operating at pressures below 50 microns (50×10^{-3} torr), a sharp valve noise (clicking) indicates proper valve closing. Poor valve performance can be due to spring weakening or breakage, disc damage, or seat damage.

To inspect the discharge and relief valves follow steps 1 through 3 of "Disassembly".

1. Check the pressure relief valve by pushing a small outside diameter rod against the valve disc to check for adequate spring tension and proper valve closing. Inspect the O-ring visibly in the valve disc.
2. Check the discharge valve for adequate spring tension and proper valve closing. Inspect the disc for wear or damage by pushing it clear of the valve seat. Replace the discharge valve if it shows signs of wear, chemical or mechanical damage, or a weakened spring.
3. Replace the discharge and pressure relief valves. Apply vacuum oil to both sides of the separator housing gasket and install the gasket and separator housing.
4. Apply a thin coat of sealant, such as Loctite 515, to the oil separator cover. Position the cover on the housing and tighten the securing cap screws.
5. Fill the pump with oil per "Filling the Pump with Oil." Test the pump per "Checking Pump Performance."

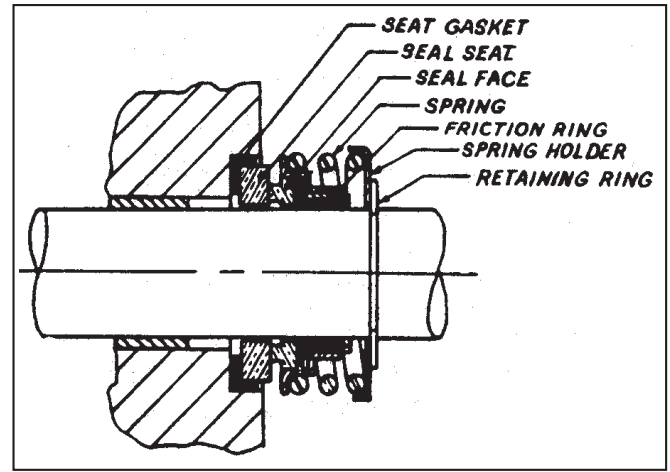


Figure 8. Shaft Seal

SHAFT SEAL

Under normal conditions the shaft seal (Figure 8) has a long and trouble-free life. It may become worn or scratched on the sealing faces by contaminated oil, or it may be damaged by excessive heat due to poor lubrication. To inspect the seal, proceed as follows:

1. Remove the motor by loosening the V-ring clamp, which supports the motor. Remove the coupling, fan, and key from the pump shaft.
2. Remove the shaft seal as follows: (a) Remove the rotating portion of the shaft seal, which may require a heavy pull if the unit has heat or vacuum bonded to the shaft. In extreme cases it may be necessary to break the bond by removing the open head. (b) Remove the stationary portion of the shaft seal.

Install the shaft seals as follows:

1. Remove all sharp edges and burrs from the pump shaft to prevent damage when installing the shaft seal.
2. Lubricate the shaft and shaft seal components with a thin coating of vacuum grease (not oil) to allow axial movement of the seal (pumping action).
3. Press the stationary portion of the shaft seal into position on the open head.
4. Slide the rotating portion of the shaft seal over the shaft with face inward and press it into position on the shaft. When pressing the shaft seal into position, check that the carbon sealing ring does not slip out of position in its metal housing. Be careful not to damage the seal faces or cut the rubber. Check that the seal faces are flush against each other and not cocked.
5. Place the spring and spring holder in position on the shaft and install the retaining ring. Insert the drive key in the pump shaft.
6. Reassemble the fan and coupling on the pump shaft, install coupling to motor shaft and tighten the setscrews. Place the interconnecting rubber coupling section in position.
7. Align the motor and pump segments of the shaft coupling and move the motor into position. Install the v-ring clamp, which supports the motor, and tighten it securely.

SOLENOID VALVES

The KTC-21B is equipped with two solenoid valves that control pump oil flow. If the valves fail to open, pump oil will not flow, thus causing high ultimate pressures and possibly mechanical failure. After operating the pump for some time, it will also cause the separator housing to remain cool while the pump cylinder temperature rises. Another indication is that the oil level will not change with large changes in inlet pressure. To check for proper solenoid operation, check for magnetic attraction with a piece of iron or other magnetic material. To service the solenoid valve, remove the coil by unscrewing the top nut after being sure that the electrical power is turned "OFF." The plunger, spring, seat and O-ring can be removed by removing the screws that hold the base plate. Clean and replace worn or damaged parts and coat the O-ring with vacuum oil when reassembling.

DISASSEMBLY

These instructions are for complete disassembly; however, the pump should be disassembled only to the extent necessary to repair it. Reference is made to the open head and closed head ends of the cylinder. The open head is the end adjacent to the motor. Refer to Figure 9 and the parts list for reference numbers.

1. Drain the oil as directed in "Changing the Oil".
2. Disconnect suction and discharge piping, and disconnect pump from electrical source.
3. Remove the discharge and pressure relief valves as follows: (a) Remove the separator housing cover, separator housing and separator housing gasket. If necessary, unscrew the oil baffle assembly from the separator housing. (b) Unscrew the pressure relief valve and the discharge valve.
4. Remove the motor by loosening the V-ring clamp, which supports the motor. Remove the coupling fan and key from the pump shaft.
5. Remove the shaft seal as follows: (a) Remove the shaft seal retaining ring. (b) Remove the rotating portion of the shaft seal; this may require a heavy pull if the unit has heat or vacuum bonded to the shaft. In extreme cases, it may be necessary to break the bond by removing the open head. (c) Remove the stationary portion of the shaft seal.
6. Remove the entire open head securing cap screws. Insert two cap screws in the threaded jackscrew holes in the head and tighten the screws to break the seal between the head and the cylinder. Remove the open head.
7. If necessary, remove the open head bearing by pressing it out of the head.
8. Remove the open head piston and slide pin. Mark the piston and slide pin so that they can be reassembled in the same location. Although the open and closed head pistons and slide pins are interchangeable, it is advisable to replace the piston and slide pin as a set once the parts have worn in.
9. Remove the entire closed head securing cap screws. Insert two cap screws in the threaded jackscrew holes to break the seal between the head and the cylinder. Remove the closed head.
10. To remove the closed head bearing, press out or cut lengthwise along the oil groove with a chisel, overlap the two edges to reduce the diameter of the bearing, and pull from the head.
11. Remove the closed head piston and slide pin. Mark the piston and slide pin so that they may be reassembled in the same location.
12. Attach a puller to the closed head cam using the tapped holes in the end of the cam. Pull the cam from the shaft and remove the cam key and slide pin separator.
13. Attach two long bolts or a puller to the removable wall using the tapped holes in the wall and remove wall and O-ring.
14. Remove the center piston and slide pin.
15. Remove the open head cam by using a puller. Remove the shaft and attached center cam and press the center cam from the shaft if replacement is required. Remove the shaft oil seal between the center cylinder and open head cylinder. Replacement is recommended prior to assembling.
16. Remove the cap screws holding the cylinder to the base. Remove the cylinder from the base and unscrew the two oil drain lines.
17. Remove additional parts as required to complete pump disassembly.
18. Inspect all parts for wear and damage and replace components as required.

REASSEMBLY

Before starting to reassemble the pump, inspect all parts to make sure that they are clean, smooth, and free of nicks and old sealing compound. Replace all worn or damaged parts. The recommended cleaning solvent is Trichloroethylene.

Do not use solvents such as kerosene or carbon tetrachloride for cleaning unless facilities are available to evaporate them by vapor degreasing or washing in acetone or alcohol. Avoid leaving excessive solvent on the pump parts and as the pump is reassembled, coat the cylinder and internal moving parts with AX Vacuum Oil to facilitate assembly and to ensure that all parts are lubricated when the pump is first started.

1. Reassemble the oil drain lines. Position the pump cylinder on the base and tighten cap screws. Reassemble the mounting pads, if removed.
2. Replace the bearings in the open and closed heads, if removed.
3. Check the oil seal in the wall between the stages and replace if damaged. It is recommended that this seal be replaced each time the pump is disassembled. Install the slide pin wall and O-ring.
4. Install the center cam key in the shaft and press the center cam on to the shaft until it is against the shaft shoulder. The cam should fit tight on the shaft.
5. Place the center slide pin over the center piston with the scalloped edges up and the capped end of the slide pin to the left when facing the inlet suction of the pump.
6. Slide the center piston and slide pin into position on the center cam so that the piston slide inlet ports will face downward toward the pump base when installed in the pump.
7. Insert the shaft, center cam, piston, and slide pin as an assembly into the cylinder from the closed head end with the cam in the down position. Use caution to avoid damaging the oil seal on the wall between the stages.
8. Place the O-ring on the removable wall and screw two $\frac{1}{4}$ -20 threaded bolts into the tapped holes in the center wall. After lubricating the pump cylinder, carefully insert the center wall into position leaving a small amount of space to avoid binding against the center cam. Remove bolts from wall.
9. Install the slide pin separator in the slide pin bore above the center wall.
10. Insert the closed head cam key in the shaft. Tap the closed head cam into position on the shaft; if the cam is too loose on the shaft, use Loctite 515 to improve the fit.
11. Install the closed head slide pin in the cylinder with the capped end outward and the flat edge down toward the piston bore. Insert the piston into the cylinder with the inlet ports facing downward.
12. Check that the closed head and cylinder sealing areas are clean. Apply a thin coat of Loctite 515 to the sealing faces of the cylinder and closed head. CAUTION: If too thick an application of sealing compound is used, it will squeeze into the pump during assembly and cause the working parts to stick or clog the oil ducts.
13. Position the closed head on the cylinder with the locating pins, and install the securing cap screws. Tighten the cap screws and rotate the shaft to check that there is no binding.
14. Insert the open head cam key in the shaft and tap the cam onto the shaft. Rotate the shaft to check that there is no binding. If the cam is too loose on the shaft, use Loctite 515 to improve the fit.
15. Install the open head slide pin in the cylinder with the capped end inward and the flat edge down toward the piston bore. Insert the piston into the cylinder with the inlet ports facing downward.
16. Check that the open head and cylinder sealing faces are clean. Apply a thin coat of Loctite 515 to both faces.
17. Position the open head on the cylinder and install the securing cap screws. Tighten the cap screws and rotate the shaft to check that there is no binding.
18. Install both solenoid valves and the gas ballast valve.
19. Install the shaft seal as follows: (a) Remove all sharp edges and burrs from the pump shaft to prevent damage when installing the shaft seal. (b) Lubricate the shaft and shaft seal components with a thin coating of vacuum grease. (c) Press the stationary portion of the shaft seal into position on the open head. (d) Slide the rotating portion of the shaft seal over the shaft and press it into position using a pipe sleeve that is slightly larger than the shaft. When pressing the shaft seal into position, check that the carbon sealing ring does not slip out of position in its metal housing. Be careful not to damage the seal faces or cut the rubber. Check that the seal faces are flush against each other and not cocked. (e) Place the spring and spring holder in position on the shaft and install the retaining ring. Insert the drive key in the pump shaft.
20. Install the discharge valve and pressure relief valve. Note that the arrow on the pressure relief valve should point toward the open head when the valve is installed.
21. Close the oil drains and pour one pint of AX Vacuum oil into the high vacuum stage reservoir (around the discharge nipples) to ensure lubrication at start up.
22. Apply the bottom plate gasket, the compound plate and the top plate gasket on the cylinder. Install the separator housing and replace the oil baffle assembly if removed.
23. Install the separator housing cover gasket and cover, and secure them in place. Reassemble the oil sight guage if removed.

KTC-21B VACUUM PUMP — COMPOUND TRIPLEX ROTARY PISTON TYPE

ITEM #	DESCRIPTION	QTY
1	Cylinder	1
2	Head, open	1
3	Head, closed	1
3A	Cover, closed	1
4	Cam, center	1
5	Cam, outer	2
6	Piston, center	1
7	Piston, outer	2
8	Slide pin, center	1
9	Slide pin, outer	2
10	Wall, slide pin	1
11	Separator, slide pin	1
12	Wall, removable	1
13	Housing, separator	1
14	Cover, sep. Housing	1
15	Gskt, cyl./Sep. Hsg.	
15A	Gskt. Upper comp. Plte.	1
15B	Gskt. Cover comp. Plte.	1
15C	Plate, compound	1
16	Shaft	1
17	Valve, discharge	1
18	Seat, solenoid valve	1
19	Adapter, 1/4 x 1/4	2
20	Valve, drain	1
21	Base	1
22	Oil baffle ass'y.	1
23	Key, cam	3
24	Shaft seal ass'y.	1
25	Bearing, shaft	2
26	Seal, centerwall	1
27	Sight glass	1
28	Valve, relief	1
29	Valve, gas ballast	1
30	Elbow t. 1/4 X 1/4, 45°	1
31	Ring, retaining .75 Ext.	1
32	O-ring	1
33	O-ring	1
34	O-ring	2
35	O-ring	2

ITEM #	DESCRIPTION	QTY
36	Pin, dowel 1/4 x 3/4	4
37	Tubing, oil drain	1
38	Nipple, 3/8 x 2	3
39	Plug, pipe, 3/4	
40	Plug, pipe, hex s. 1/2	2
41	Reducer bushing 3/8 x 1/4	2
42	Gasket, sep. Hsg. Cover	1
43	O-ring	1
44	Nipple 1/4 x 2	1
45	Elbow, st. 1/4 X 90°	1
46	Body, sol. Vlve	1
47	Operator, sol. Vlve.	2
48	Male connector 3/8 x 1/4	1
49	Oil line tubing	1
50	Male elbow 3/8 x 1/4	1
51	Ring, retaining, rew. (used 2/86 thru 11/09)	1
52	Sockhd capscr	17
53	Sockhd capscr	11
54	Sockhd capscr	4
55	Sockhd capscr	4
56	Hexhd capscr	8
57	Sockhd capscr	6
58	Lkw 1/4 reg spr	6
59	Hose clip 7/32	1
80	Motor, 230/460, 3ph, 60hz	1
81	Coupling, shaft	1
82	Adapter, motor	1
83	Clamp, v-band	1
84	Fan	1
85	Key, shaft coupling	2
86	Reducer bushing 1 x 3/4	1
87	Breather filter	1
88	Vibration mount, black	2
89	Vibration mount, blue	2
90	Hexhd capscr 5/16-18 x 3/4	4
91	Sockhd setscr #10-32 x 1/4	4
92	Hexhd capscr 3/8-16 x 1	4
93	Butthd machscr #8-32 x 1/4	3
94	Lkw #8	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).

PRODUCT TYPE	WARRANTY DURATION
New	15 months after date of shipment or 12 months after initial startup date, whichever occurs first
Piston Pumps	30 months after date of shipment, on all units sold after June 1, 2014.
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

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

June 2014

OPERATING DATA FORM / PRODUCT REGISTRATION

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.	_____	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:

IMPORTANT

All blowers manufactured by Tuthill Vacuum & Blower Systems are date coded at time of shipment. In order to assure you of the full benefits of the product warranty, please complete, tear out and return the product registration card, or register online at tuthillvacuumblower.com.



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