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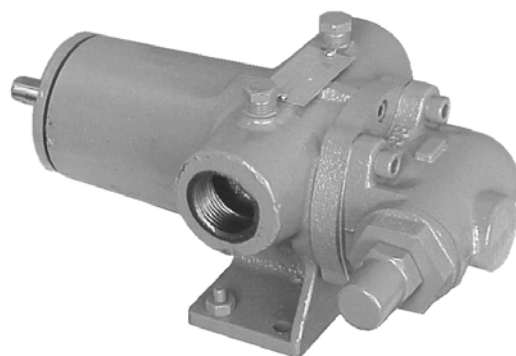
INTRODUCTION

The illustrations used in this manual are for identification purposes only and cannot be used for ordering parts. Obtain a parts list from the factory or a VIKING representative. Always give complete name of part, part number and material with model number and serial number of pump when ordering repair parts. The pump model number and serial number are on the nameplate.

In the VIKING model number system, basic size letters are combined with series number.

UNMOUNTED PUMP	UNITS
GG-190	Units are designated by the unmounted pump model numbers followed by "Arrangement" indicating drive style.
HJ-190	
HL-190	
AS-190	
AK-190	
	13-Direct Connected
	53-V-Belt
	70-Commercial Speed Reducer

This manual deals only with Series 190 Heavy Duty Pumps. Pump specifications and recommendations are listed in Catalog Section 3, series 190 Heavy Duty pumps.



GG-190



AK-190

DANGER

BEFORE OPENING ANY VIKING PUMP LIQUID CHAMBER (PUMPING CHAMBER, RESERVOIR, RELIEF VALVE ADJUSTING CAP FITTING ETC.) BE SURE:

1. THAT ANY PRESSURE IN CHAMBER HAS BEEN COMPLETELY VENTED THROUGH SUCTION OR DISCHARGE LINES OR OTHER APPROPRIATE OPENINGS OR CONNECTIONS.
2. THAT THE DRIVING MEANS (MOTOR, TURBINE, ENGINE, ETC.) HAS BEEN "LOCKED OUT" OR MADE NON-OPERATIONAL SO THAT IT CANNOT BE STARTED WHILE WORK IS BEING DONE ON PUMP.
3. THAT YOU KNOW WHAT LIQUID THE PUMP HAS BEEN HANDLING AND THE PRECAUTIONS NECESSARY TO SAFELY HANDLE THE LIQUID. OBTAIN A MATERIAL SAFETY DATA SHEET (MSDS) FOR THE LIQUID TO BE SURE THESE PRECAUTIONS ARE UNDERSTOOD.

FAILURE TO FOLLOW ABOVE LISTED PRECAUTIONARY MEASURES MAY RESULT IN SERIOUS INJURY OR DEATH

ROTATION: Rotary gear pumps operate equally well in a clockwise or counterclockwise rotation. The shaft rotation determines which port is suction and which is discharge. Port in area where pumping elements (gear teeth) come out of mesh is suction port.

PRESSURE RELIEF VALVES:

1. Rotary gear pumps are positive displacement and must be provided with some sort of pressure protection. This may be a relief valve mounted directly on the pump, an inline pressure relief valve, or a torque limiting device or a rupture disk.
2. There are relief valve options available on pump models. Options may include a return to tank relief valve and a jacketed relief valve. Pumps equipped with a jacketed head are not available with a relief valve.
3. If pump rotation is reversed during operation, pressure protection must be provided on *both* sides of pump.
4. Relief valve bonnet (see page 12) must *always* point towards suction side of pump. If pump rotation is reversed, remove pressure relief valve and turn end for end. Figures 2 and 3 show 2 possible configurations, both have side suction and top discharge. A right-hand pump turns in the opposite direction to the left-hand pump.
5. Pressure relief valves cannot be used to control pump flow or regulate discharge pressure.

MAINTENANCE

Series 190 pumps are designed for long, trouble-free service life under a wide variety of application conditions with a minimum of maintenance. The points listed below will help provide long service life.

LUBRICATION: All 190 pumps have sealed ball bearings, and carbon bushings which do not require lubrication.

CLEANING PUMP: Keep pump as clean as possible. This will facilitate inspection, adjustment and repair work and help prevent overlooking a dirt covered grease fitting.

STORAGE: If pump is to be stored, or not used for six months or more, pump must be drained and a light coat of lubricant and rust preventative suitable to the application must be applied to all internal pump parts. Lubricate fittings and apply grease to pump shaft extension. Rotating the pump shaft by hand, one complete revolution every 30 days to circulate the oil.

SUGGESTED REPAIR TOOLS: The following tools must be available to properly repair Series 190 pumps. These tools are in addition to standard mechanics' tools such as open-end wrenches, pliers, screwdrivers, etc. Most of the items can be obtained from an industrial supply house.

1. Soft Headed hammer
2. Allen wrenches (some mechanical seals and set collars)
3. Internal and external snap ring plyers.



Figure 1,



Figure 2, Right Hand Pump



Figure 3, Left Hand Pump

4. Mechanical seal installation sleeve.
6. Spanner wrench, adjustable pin type for use on end caps (Source: #482 J. H. Williams & Co. or equal) or hammer and punch.
7. Brass bar.
8. Arbor press.

Strainers: Use a strainer on the suction side of the pump to prevent foreign material from entering the pump causing damage to the gears, and casing or lock-up the pump. Keep the strainer on the suction side of the pump clean and free of debris. A blocked strainer will not allow sufficient liquid to reach the pump. The lack of liquid reaching the pump will create cavitation. Cavitation is when the liquid vaporizes on its way to the pump, then returns to a liquid form on the surfaces of the pump. This is very noisy, damaging to a pump, and seriously affects the output.



Figure 4, Pressing idler bushing



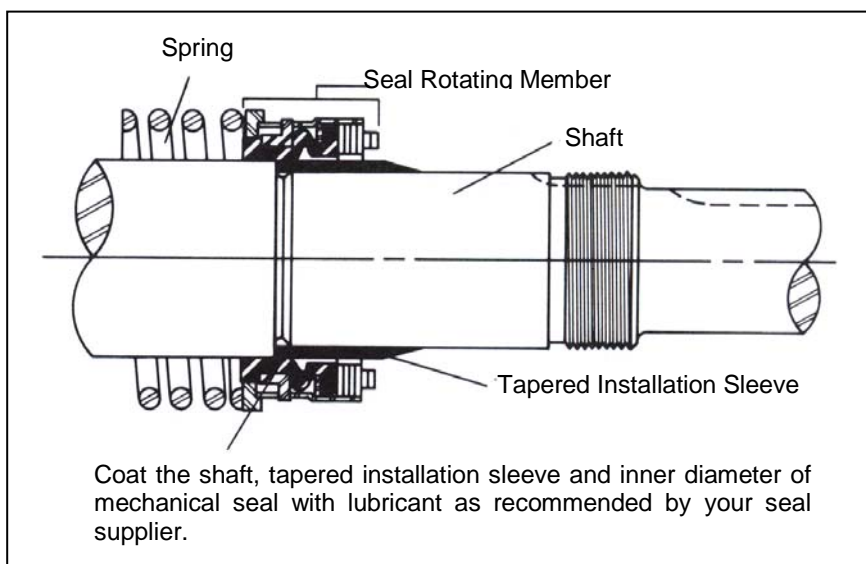
Figure 5, Pressing the idler pin



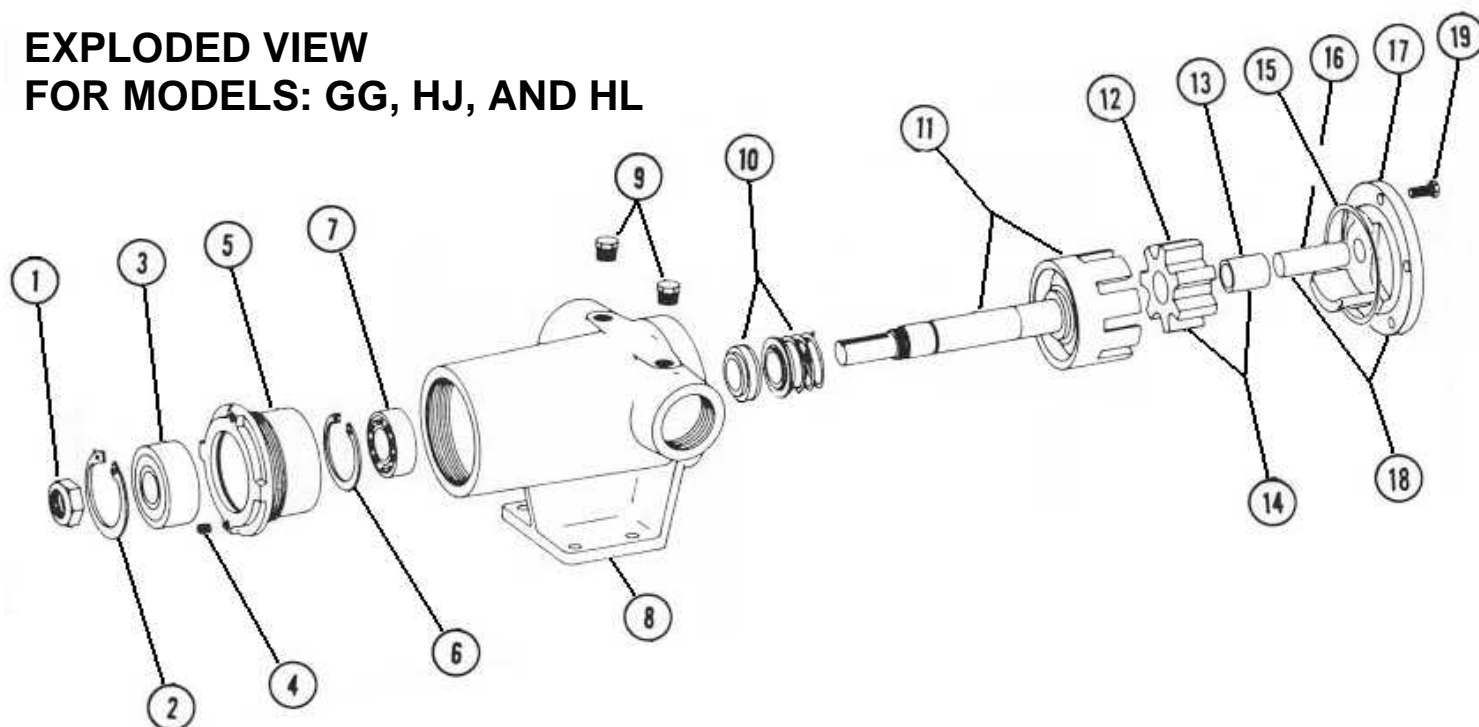
Figure 6, Inner bearing & snap ring



Figure 7, Bearing housing ass'y

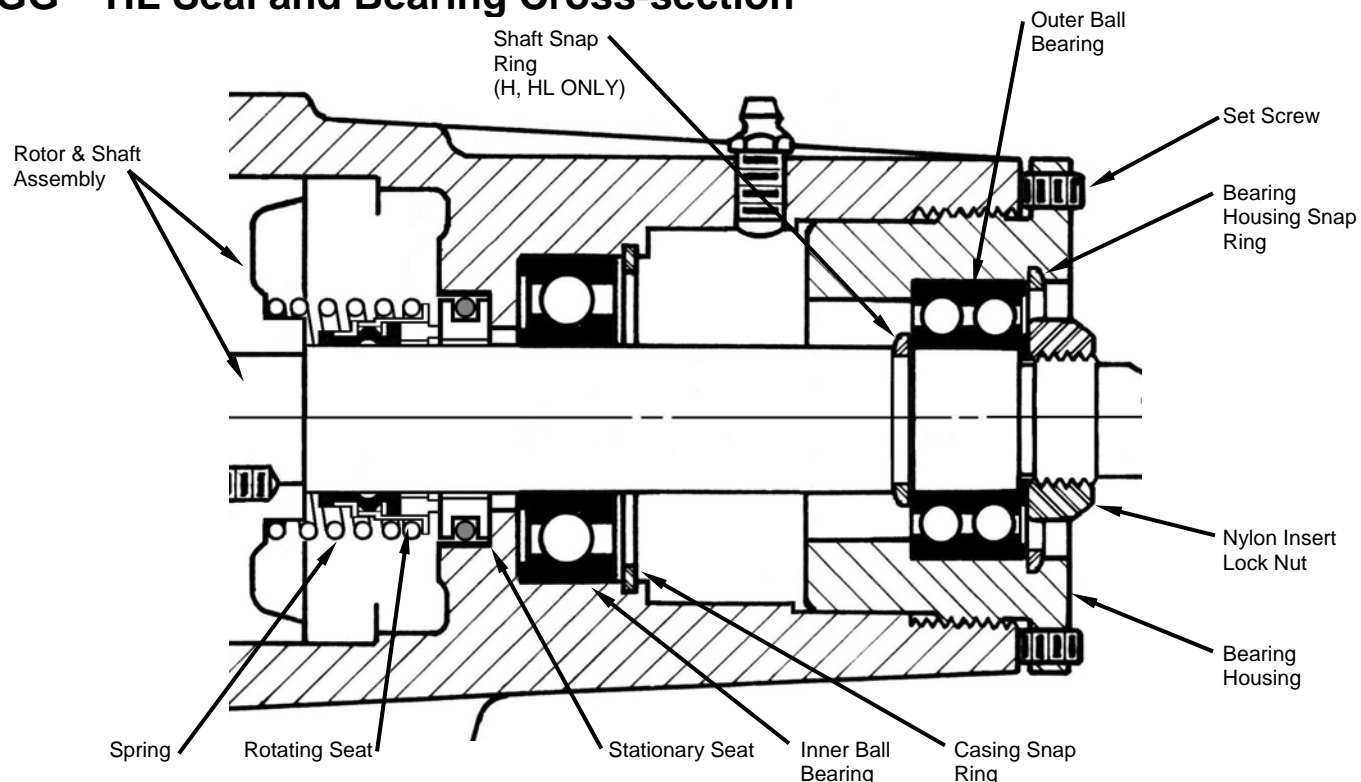


EXPLODED VIEW FOR MODELS: GG, HJ, AND HL



ITEM	NAME OF PART	ITEM	NAME OF PART	ITEM	NAME OF PART	ITEM	NAME OF PART
1	Nylon lock nut	6	Inner snap ring	11	Rotor and shaft assembly	16	Idler pin
2	Internal snap ring	7	Ball bearing (inner)	12	Idler	17	Head
3	Ball bearing (outer)	8	Casing	13	Idler bushing	18	Head and pin assembly
4	Set screw	9	Pipe plug	14	Idler and bushing assembly	19	Head bolts
5	Bearing housing	10	Mechanical seal assembly	15	O-ring		

GG – HL Seal and Bearing Cross-section



DISASSEMBLY OF MODELS GG, HJ AND HL

Before disassembling a pump determine why it needs to be disassembled, with the aid of the troubleshooting chart on page 13. Do not disassemble further than necessary, and look for sign of wear or damage throughout the process.

1. Mark head and casing before disassembly to insure proper reassembly. The idler pin, which is offset in pump head, must be positioned toward and centered between the port connections to allow for proper flow of liquid through pump. Figure 1, page 2.

Remove head from pump. *Do not allow idler to fall from idler pin.* Tilt top of head back and down when removing to prevent this. If pump is furnished with pressure relief valve, remove it from the head and refer to Pressure Relief Valve Instructions, page 11.

Be careful not to damage the o-ring seal between the head and casing.

2. Remove idler and bushing assembly from the idler pin.
3. Insert a plate between rotor teeth to keep shaft from turning, Figure 12, page 6. Remove the lock nut from the shaft. Remove the plate from the rotor.
4. Loosen the setscrews in the casing at the shaft end, and in the end of the bearing housing. Figure 24 & 25, page 10.
5. Remove the bearing housing from the casing.
6. Remove the shaft snap ring and tap the shaft forward with a soft headed hammer. Then pull the shaft out of the inner ball bearing being careful not to damage the mechanical seal.
7. Remove the stationary element of the seal from the casing, and the rotating element from the rotor and shaft assembly.
8. Using snap ring pliers remove the inner snap ring through the shaft end of the casing.
9. To remove the inner ball bearing, support the casing on the shaft end and press the bearing out from the rotor side.
10. Remove the snap ring from the bearing housing and press the ball bearing out from the side opposite to the snap ring.
11. Clean all parts thoroughly and examine for wear and damage. Check idler bushing, idler pin, gears and head. Replace if necessary. Check all other parts for nicks, burrs, excessive wear and replace if necessary.
12. Check the ball bearing for signs of roughness. Roughness can be determined by turning the inner and outer race opposite directions by hand. Note if the motion is smooth and free or rough and stiff. Smooth and free is desired. Replace if necessary.
13. Check the casing for wear or damage. Most wear occurs between the suction and discharge ports at the top side of the bore where the rotor spins.



Figure 8, Stationary seal element



Figure 9, Installing the rotating element



Figure 10, shaft snap ring

ASSEMBLY OF MODELS GG, HJ AND HL

1. Coat the idler bushing with soapy water, and carefully press the idler bushing into the idler with an arbor press. Be sure to press the bushing straight and with constant force. Starting and stopping the operation will result in cracking. Figure 4, page 3.
2. Press the idler pin into the head, using the idler and bushing assembly for alignment. Figure 5, page 3.
3. Put the inner ball bearing into the casing, and install the inner snap ring. Figure 6, page 3.
4. For models HJ and HL only; install the shaft snap ring. Figure 10, page 5
5. Install the outer ball bearing, and the snap ring into the bearing housing. Figure 7, page 3.
6. Coat the counter bore in the casing and the stationary seal seat with a lubricant as recommended by your seal supplier.
7. Carefully press the stationary seal seat into the casing while protecting the seal face with a clean piece of cardboard. Figure 8, page 5.
8. Coat the shaft, installation sleeve, shaft and inside diameter of the rotating seal seat with seal lubricant.
9. Place the spring on the rotor hub, and with the seal installation sleeve carefully slide the seal seat onto the shaft and into the spring. Figure 9, page 5.
10. Remove the seal installation sleeve.
11. Start the end of shaft into the inner ball bearing, slowly push the shaft through the bearings. Continue until there is pressure applied to the seal spring.
12. Turn the bearing housing into the casing by hand until the flange is about 1/16 inch away from the casing. Because of the size of these threads and the minimum clearance allowed between these threads, the installation of this component may be difficult. To aid installation, tap the casing around the diameter of the bearing housing threads with a hammer while turning the bearing housing.
13. Place a plate into the rotor teeth to hold the rotor and shaft assembly from turning. Tighten the nylon lock nut onto the shaft. Figure 12, page 6.
14. Turn the bearing housing out until the head can be installed without applying pressure to the rotor teeth.
15. Install the head and idler assembly on the pump with the o-ring seal, on the head, figure 13, page 6. If the pump head and casing were marked before disassembly simply match up the markings. If not, be sure the idler pin, which is offset in pump head, is positioned directly above the center of the crescent on the head, figure 1, page 2. Tighten head capscrews evenly.
16. Adjust pump end clearance. Refer to "END CLEARANCE ADJUSTMENT", page 10.

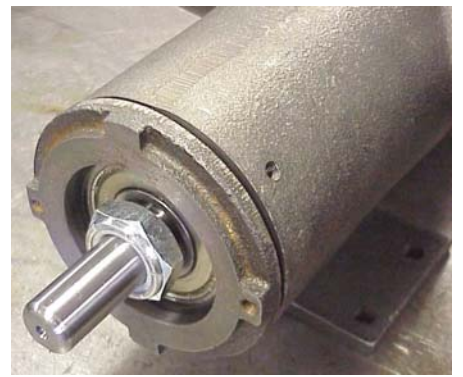


Figure 11, Lock nut ready to tighten

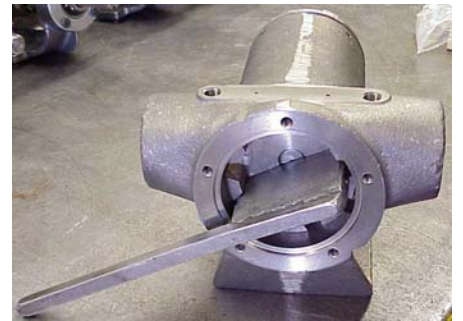


Figure 12, Locking the shaft for tightening



Figure 13, Head ass'y ready to install

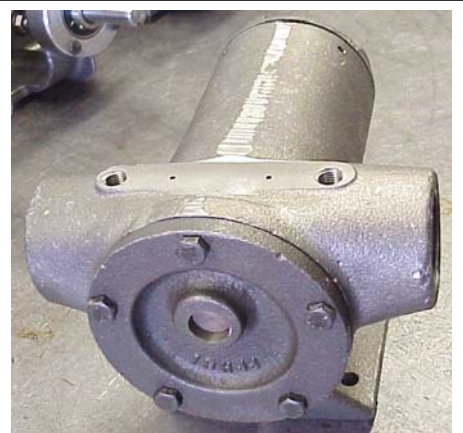
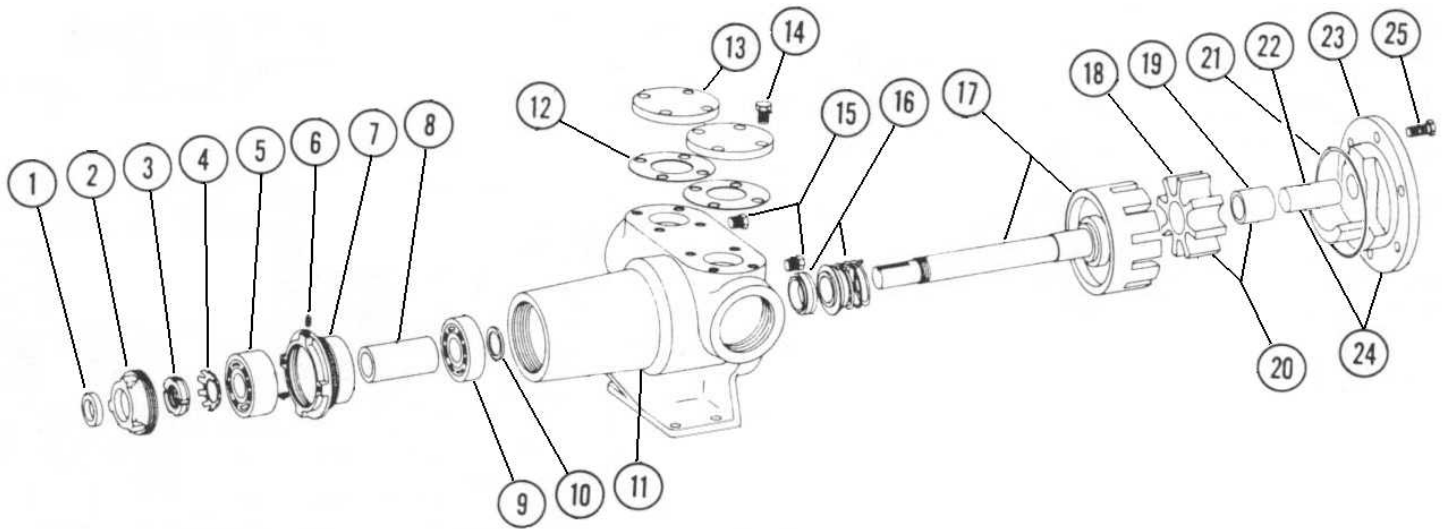


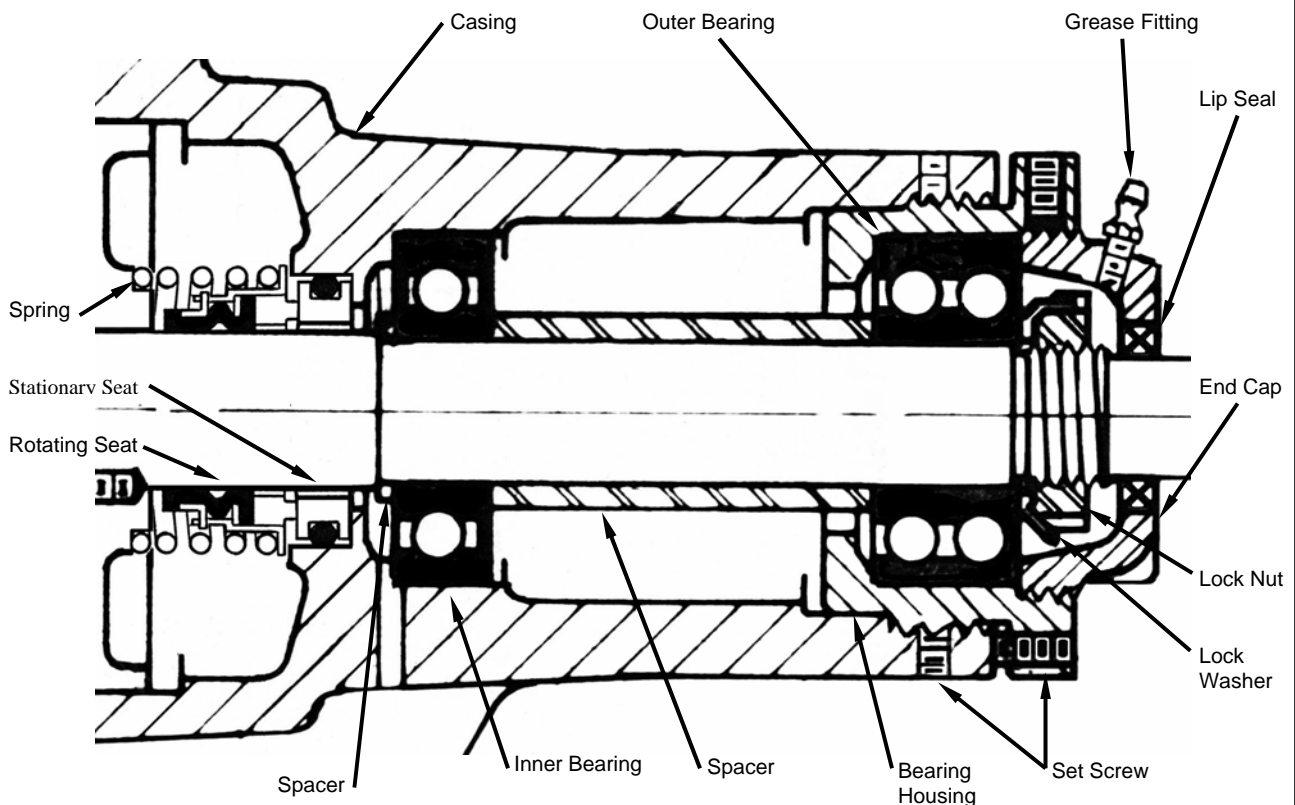
Figure 14, Pump ready for adjustment

EXPLODED VIEW FOR MODELS: AS and AK



ITEM	NAME OF PART	ITEM	NAME OF PART	ITEM	NAME OF PART	ITEM	NAME OF PART
1	Lip seal	8	Bearing spacer	15	Pipe plug	22	Idler pin
2	End cap	9	Ball bearing (Inner)	16	Mechanical Seal	23	Head
3	Nylon Lock nut	10	Shaft snap ring	17	Rotor and shaft assembly	24	Head and pin assembly
4	Lock washer	11	Casing	18	Idler	25	Head bolt
5	Ball Bearing	12	Relief valve port gasket	19	Idler bushing		
6	Set screw	13	Blanking plate	20	Idler and bushing assembly		
7	Bearing housing	14	R/V bolt	21	O-ring		

AS & AK Seal and Bearing Cross-Section



DISASSEMBLY OF MODELS AS AND AK

Before disassembling a pump determine why it needs to be disassembled, with the aid of the troubleshooting chart on page 13. Do not disassemble further than necessary, and look for sign of wear or damage throughout the process.

1. Mark head and casing before disassembly to insure proper reassembly. The idler pin, which is offset in pump head, must be positioned toward and centered between the port connections to allow for proper flow of liquid through pump. Figure 1, page 2.

Remove head from pump. *Do not allow idler to fall from idler pin.* Tilt top of head back and down when removing to prevent this. If pump is furnished with pressure relief valve, remove it from the head and refer to Pressure Relief Valve Instructions, page 11.

Be careful not to damage the o-ring seal between the head and casing.

2. Remove idler and bushing assembly from the idler pin.
3. Remove the end cap with the lip seal.
4. Bend the tab on the lock washer out of the notch in the lock nut.
5. Insert a plate between rotor teeth to keep shaft from turning, Figure 12, page 6. Remove the lock nut and lock washer from the shaft. Remove the plate from the rotor teeth.
6. Push the shaft out of the pump while supporting the casing on the head-mounting surface. Be careful not to damage the seal or let the rotor and shaft assembly drop.
7. Remove the stationary element of the seal from the casing, and the rotating element from the rotor and shaft assembly.
8. Loosen the setscrews in the casing at the shaft end, and in the end for the bearing housing. Figure 24 & 25, page 10.
9. Remove the bearing housing from the casing.
10. Remove the snap ring from the bearing housing and press the bearing out of the housing.
11. Remove the bearing spacer from the casing.
12. Stand the casing on the bearing end and press the inner bearing out.
13. Clean all parts thoroughly and examine for wear and damage. Check idler bushing, idler pin, gears and head. Replace if necessary. Check all other parts for nicks, burrs, excessive wear and replace if necessary.
14. Check the ball bearing for signs of roughness. Roughness can be determined by turning the inner and outer race in opposite directions by hand. Note if the motion is smooth and free, or rough and stiff. Smooth and free is desired. Replace if necessary.
15. Check the casing for wear or damage. Most wear occurs between the suction and discharge ports at the topside of the bore where the rotor spins.



Figure 15, Bearing washer



Figure 16, Inner ball bearing



Figure 17, Bearing spacer

ASSEMBLY OF MODELS AS AND AK

1. Press the lip seal into the endcap, figure 20 page 9 (lip facing away from the threads).
2. Coat the idler bushing with soapy water and carefully press the idler bushing into the idler with an arbor press. Be sure to press the bushing straight and with constant force. Starting and stopping the operation will result in cracking. Figure 4, page 3.
3. Press the idler pin into the head, using the idler and bushing assembly for alignment. Figure 5, page 3.
4. Coat the counter bore in the casing and the stationary seal seat with a lubricant as recommended by your seal supplier.
5. With the lapped face of the stationary seal seat facing out, carefully press the stationary seal into the casing while protecting the seal face with a clean piece of cardboard. Figure 8, page 5.
6. Coat the shaft, installation sleeve and inside diameter of the rotating seat with the seal lubricant.
7. Place the spring on the rotor hub, and with the seal installation sleeve carefully slide the rotating seat onto the shaft and into the spring. Figure 9, page 5.
8. Start the end of shaft into the stationary seat of the seal, slowly push the shaft through the casing. Continue until there is pressure applied to the seal spring.
9. Place the head and idler assembly in the casing temporarily, to support the rotor and shaft assembly while pressing the bearings into the casing.
10. Place the bearing washer on the shaft and press the inner ball bearing onto the shaft, and into the casing, figure 15 & 16, page 8.
11. Place the bearing spacer on the shaft, figure 17, page 8.
12. Turn the bearing housing into the casing until the flange is about 1/16 inch away from the casing.
13. Press the outer ball bearing into the bearing housing, and onto the shaft. Figure 18.
14. Remove the head and idler assembly from the casing and place a plate into the rotor teeth to hold the rotor and shaft assembly from turning. Figure 12, page 6.
15. Place the lock washer on the shaft and tighten down the lock nut. Bend the tab on the lock washer, into the closest notch in lock nut, and remove the plate from the rotor teeth. Figure 19.
16. Install the end cap into the bearing housing and tighten down.
17. Turn the bearing housing out so that the head and idler assembly can be installed without applying pressure to the rotor teeth.
18. Install the head and idler assembly on the pump with the o-ring seal on the head as shown in figure 13, page 6. If the pump head and casing were marked before disassembly simply match up the markings. If not, be sure the idler pin, which is offset in pump head, is positioned directly above the center of the crescent on the head, figure 1, page 2. Tighten head capscrews evenly.
19. Adjust pump end clearance. Refer to End Clearance Adjustment, page 10
20. Pneumatic test the pump.
21. Return the pump to service.



Figure 18, Outer ball bearing



Figure 19, Lock nut & lock washer



Figure 20, Lip seal instalation



Figure 21, End cap & lipseal

END CLEARANCE ADJUSTMENT

Note: Cone point setscrews are to be installed in the diameter of the casing. The cone does less damage to the threads than the cup point setscrews. Figure 23

1. Loosen setscrews in the face of the end cap and on the diameter of the casing. Figure 24 and 25.
2. Turn the bearing housing clockwise until the rotor and shaft assembly rubs the head when turned.
3. Turn the bearing housing counter clockwise about $\frac{1}{4}$ of a turn.
4. Check the shaft rotation for rubbing.
5. Turn each setscrew in until the tip touches the bottom.
6. Evenly tighten all setscrews, and check the shaft rotation for any rubbing or binding.
7. Re-adjust the setscrews until the shaft turns freely.

Note: If the setscrews are loose, the end clearance will change during operation. This will seize the pump or cause the pump to not move any liquid.

PNEUMATIC TESTING

1. Seal the ports with pipe plugs or plates and gaskets. Be sure to provide a male air line connection to one of the ports.
2. Apply air pressure to the pump.
3. Spray or brush the externals with soapy water and watch for growing air bubbles around the seal, fitting, and gaskets.
4. Relieve the pressure from the pump.
5. Carefully disconnect the air supply.
6. Remove the plugs or covers from the ports.
7. Return the pump to service.



Figure 22, Check rotation



Figure 23, Cone and cup point setscrews



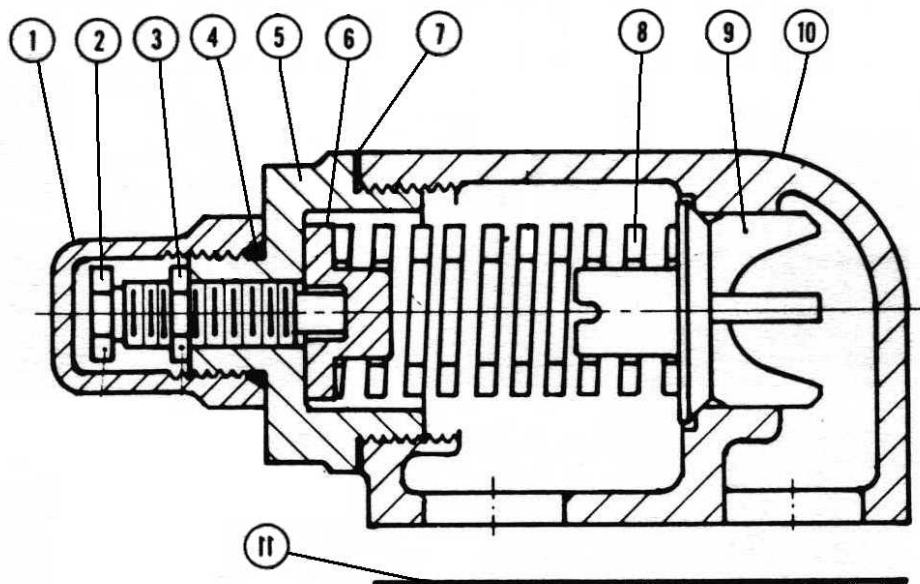
Figure 24, Tightening cone point setscrew



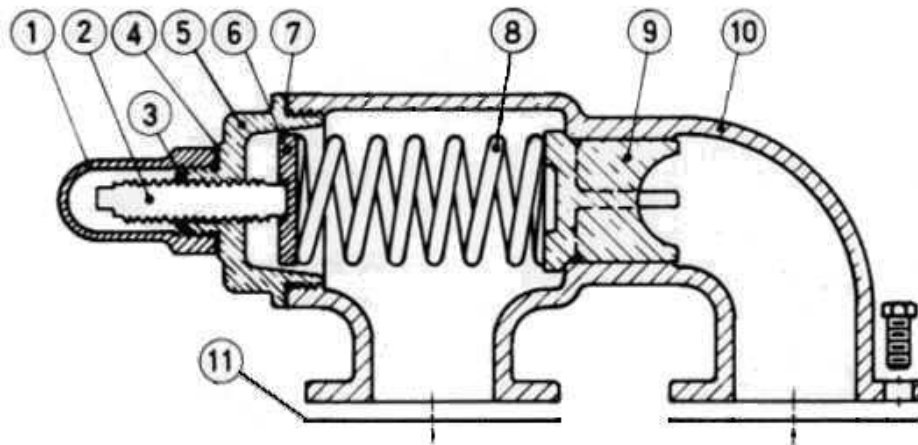
Figure 25, Tightening cup point setscrew

PRESSURE RELIEF VALVE INSTRUCTIONS

“G” & “A” Size



“B” Size



ITEM	NAME OF PART	ITEM	NAME OF PART	ITEM	NAME OF PART	ITEM	NAME OF PART
1	Bonnet	4	Bonnet o-ring	7	Cap Gasket	10	Poppet
2	Adjusting Screw	5	End cap	8	Spring	11	Relief valve port gasket
3	Lock nut	6	Spring Guide	9	Casing		

DISASSEMBLY

Mark valve and head before disassembly to insure proper reassembly.

1. Remove bonnet.
2. Measure and record length of adjusting screw protruding out of the end cap.
3. Loosen locknut and back out adjusting screw until spring pressure is released.
4. Remove relief valve cap, spring guide, spring and poppet from valve body. Clean and inspect all parts for wear or damage and replace as necessary.

ASSEMBLY

1. Place the poppet inside the relief valve body. The fingers should pass through the hole in the middle of the body.
2. Place the spring on the poppet.
3. Place the spring retainer on the spring with the protruding step inside the spring.
4. With 2 gaskets on the face of the body turn the cap into the body and tighten down.
5. Install the adjusting screw in the threaded hole in the endcap and turn in until the remainder of the screw sticking out is equal to the measurement taken during the disassembly.
6. Lock the adjusting screw into position by turning the locknut onto the adjusting screw and tightening it against the endcap.
7. Place the oring over the threads of the endcap.
8. Put the poppet on the endcap
9. Remount the relief valve onto the pump with 2 gaskets. Be sure to replace in the same position as it was removed from. The Bonnet must *always* point towards suction side of pump. If pump rotation is reversed, remove relief valve and turn end for end. Refer to Figures 2, 3, page 2.

PRESSURE ADJUSTMENT

If a new spring is installed or if pressure setting of pressure relief valve is to be changed from that which the factory has set, the following instructions must be carefully followed.

1. Carefully remove the bonnet, which covers the adjusting screw.
2. Loosen the locknut, which locks the adjusting screw so that the pressure setting will not change during operation of pump.
3. Install a pressure gauge in discharge line for actual adjustment operation.
4. Turn adjusting screw in to increase pressure and out to decrease pressure.
5. Closing a valve in the piping stopping all flow, the pressure gauge on the discharge port of the pump will show the maximum pressure that the relief valve will allow while pump is in operation.

IMPORTANT

In ordering parts for pressure relief valve, always give model number and serial number of pump as it appears on nameplate and name of part wanted. When ordering springs, be sure to give pressure setting desired.



Figure 21, Poppet, spring, & spring retainer



Figure 22, Spring & Retainer



Figure 23, End cap, screw, & nut



Figure 24, Bonnet

Troubleshooting

No Discharge:	Pump priming may be required
	Suction lift is too great
	Relief valve is stuck open
	Strainer needs cleaning
	Wrong direction of rotation
Insufficient Discharge Volume	Air leaks in suction
	Speed is too slow
	Relief valve is set too low
	Suction lift too high for liquid handled. This is very important on hot or volatile fluids
	Suction line is not submerged
	Suction piping too small in diameter, or foot valve is too small
	Wrong rotation
	Pump internals worn
	Air or gases in suction piping
Insufficient Pressure	Viscosity is higher than expected
	Relief valve set too low
	Air or gases in the fluid
	Pump internals are worn
	Insufficient volume being pumped
	Wrong rotation
Loss of suction after a period Of operation	Improper clearances in the internals
	Suction line is leaking (letting air into the pump)
	Packing is too loose or the mechanical seal is leaking
Excessive power requirement	Leaking Gaskets
	Viscosity too high
	Discharge pressure is too high
	Insufficient lubrication
Noisy operation with good Performance	Shaft or rotor bent, misalignment or packing gland is too tight
	Misalignment of coupling
Noisy operation with poor or No performance	Worn bearings
	Cavitation – Not enough fluid getting to the pump
Leaking around the shaft	Worn bearings or bushings
	Packing is loose, or needs replacement
	Mechanical seal is damaged or misaligned
	Shaft is scored
	Shaft is bent

PUMP INSPECTION REPORT

DATE: _____

PUMP MODEL: _____ SERIAL NUMBER: _____

CUSTOMER: _____

SALES ORDER NUMBER: _____ OTHER REFERENCE: _____

APPLICATION AND/OR PROBLEM: _____

DESCRIPTION	STANDARD DIMENSIONS	EX. CL. (IF ANY)	ACTUAL	WEAR
ROTOR O.D.				
ROTOR I.D.				
ROTOR TOOTH LENGTH				
IDLER O.D.				
IDLER (BUSHING) I.D.				
IDLER TOOTH LENGTH				
IDLER PIN O.D.				
SHAFT O.D.				
SHAFT BUSHING I.D.				
CRESCENT LENGTH				
CASING I.D.				
END CLEARANCE				

COMMENTS & RECOMMENDATIONS: _____

NOTES

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WARRANTY

Viking warrants all products manufactured by it to be free from defects in workmanship or material for a period of one (1) year from date of startup, provided that in no event shall this warranty extend more than eighteen (18) months from the date of shipment from Viking. If, during said warranty period, any products sold by Viking prove to be defective in workmanship or material under normal use and service, and if such products are returned to Viking's factory at Windsor, Ontario, transportation charges prepaid, and if the products are found by Viking to be defective in workmanship or material, they will be replaced or repaired free of charge, FOB. Windsor, Ontario.

Viking assumes no liability for consequential damages of any kind and the purchaser by acceptance of delivery assumes all liability for the consequences of the use or misuse of Viking products by the purchaser, his employees or others. Viking will assume no field expense for service or parts unless authorized by it in advance.

Equipment and accessories purchased by Viking from outside sources which are incorporated into any Viking product are warranted only to the extent of and by the original manufacturer's warranty or guarantee, if any.

THIS IS VIKING'S SOLE WARRANTY AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, WHICH ARE HEREBY EXCLUDED, INCLUDING IN PARTICULAR ALL WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. No officer or employee of IDEX Corporation or Viking Pump Canada is authorized to alter this warranty.



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GENERAL

Before installation is started a few items of a general nature should be considered.

1. Location - always locate the pump as close as possible to the supply of liquid to be pumped. Locate it below the liquid supply if at all practical. Viking pumps are self priming but the better the suction conditions the better the performance.
2. Accessibility - the pump should be located where it is accessible for inspection, maintenance, and repair. For large pumps, allow room to remove the rotor and shaft without removing the pump from the base.
3. Port Arrangement - since the pumps have different port arrangements depending on the model, port location should be checked before starting the installation. The ports may be upright, opposite or at right angles to each other, see Figure 1. The right angle ports are normally right-hand, see Figure 2; some models are available with left-hand arrangements; still other models are available with the right angle ports located in any one of eight positions including right-hand and left-hand.

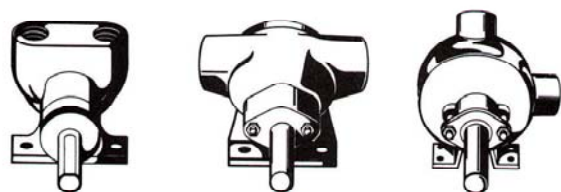


FIGURE 1

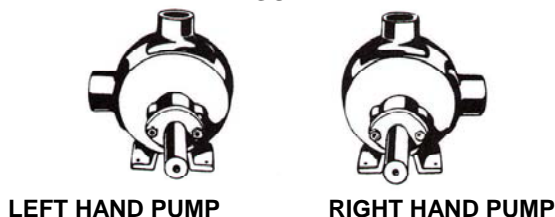


FIGURE 2

4. Suction/Discharge - shaft rotation will determine which port is suction and which discharge. A look at Figure 3 will show how rotation determines which port is which; as the pumping elements (gears) come out of mesh, point "A" on Figure 3, liquid is drawn into the suction port; as the gears come into mesh, point "B", the liquid is forced out the discharge port. Reversing the rotation reverses the flow through the pump. When determining shaft rotation, always look from the shaft end of the pump. Unless otherwise specified, rotation is assumed to be clockwise (CW), which makes the suction port on the right side of the pump. The idler pin, which is offset in the pump head, should be properly positioned toward and an equal distance between the port connections.

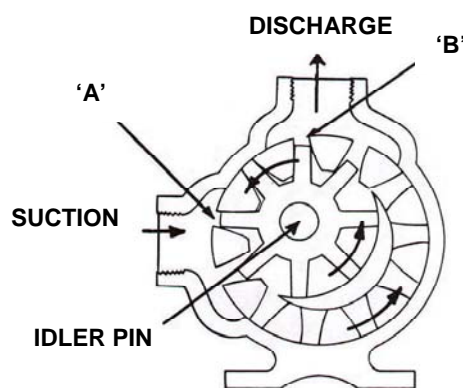
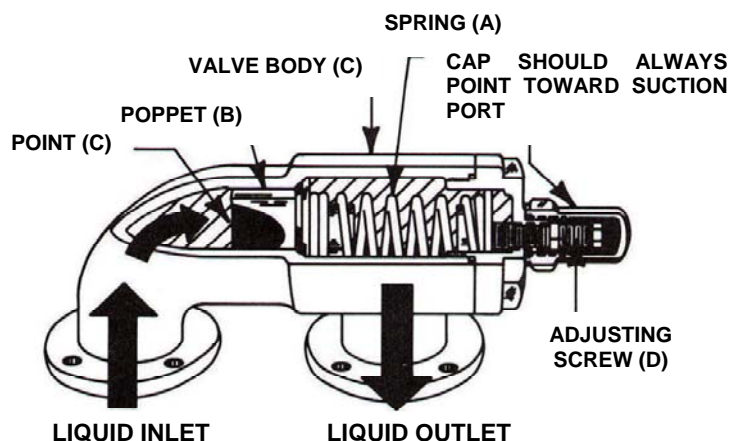


FIGURE 3

5. Pressure Protection - Viking pumps are positive displacement. This means that when the pump is rotated, liquid will be delivered to the discharge side of the pump. If there is no place for this liquid to go - discharge line is blocked or closed - pressure can build up until the motor stalls, the drive equipment fails, a pump part breaks or ruptures, or the piping bursts. Because of this, some form of pressure protection must be used with a positive displacement pump. This may be relief valve mounted directly on the pump, an inline relief valve, a torque limiting device or a rupture disk.

The pressure relief valve mounted on Viking pumps and most in-line valves are of the spring loaded poppet design See Figure 4. The spring (A) holds poppet (B) against the seat in the valve body (C) with a given force determined by the spring size and by how tightly it is compressed by the adjusting screw (D). The pump discharge pressure pushes against the underside of the poppet at point (E). When the force exerted by the liquid under the poppet exceeds that exerted by the spring, the poppet lifts and liquid starts to flow through the valve.



CUT-AWAY OF MAGNUS INTERNAL RELIEF VALVE FIGURE 4

CAUTION

INTERNAL TYPE RELIEF VALVES MOUNTED ON VIKING PUMPS SHOULD ALWAYS HAVE THE CAP OR BONNET POINTED TOWARD THE SUCTION SIDE OF THE PUMP. RETURN-TO-TANK-TYPE RELIEF VALVES SHOULD ALWAYS BE MOUNTED ON THE DISCHARGE SIDE OF THE PUMP. IF PUMP ROTATION IS REVERSED, CHANGE THE RELIEF VALVE. TURN THE INTERNAL TYPE END FOR END; MOVE THE RETURN-TO-TANK TYPE TO THE OTHER PORT. IF, ON A PARTICULAR INSTALLATION ROTATION IS REVERSED, e.g., USING ONE PUMP TO FILL A TANK AND THEN BY USE OF A REVERSING SWITCH OR OTHER MEANS CHANGING THE ROTATION TO PERMIT THE SAME PUMP TO CIRCULATE THE LIQUID THROUGH A HEATER OR TO LOAD OUT) THEN PRESSURE PROTECTION MUST BE PROVIDED ON BOTH SIDES OF THE PUMP OR FOR BOTH ROTATIONS. THIS MAY BE A COMBINATION OF RELIEF VALVES, TORQUE LIMITING DEVICES OR RUPTURE DISKS.

PUMPS OR SYSTEMS WITHOUT RELIEF VALVES SHOULD HAVE SOME FORM OF PRESSURE PROTECTION, E.G., TORQUE LIMITING DEVICES OR RUPTURE DISKS.

Viking pumps can be furnished with either an internal relief valve - one which directs the flow from the valve back to the suction side of the pump - or a return-to-tank valve which directs the flow through piping back to the supply tank. See Figure 5. An inline relief valve mounted in the discharge piping also directs the flow back to the supply tank. This type of valve should be mounted close to the pump so that the pressure drop through the piping between the pump and the valve is at a minimum. Be sure there are no shutoff valves between the pump and relief valve. Piping from a return-to-tank or an in-line valve to the supply tank should also be as short and large as possible.

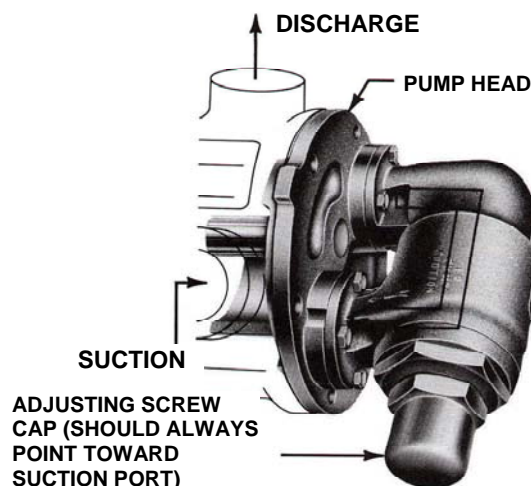


FIGURE 5A
INTERNAL RELIEF VALVE

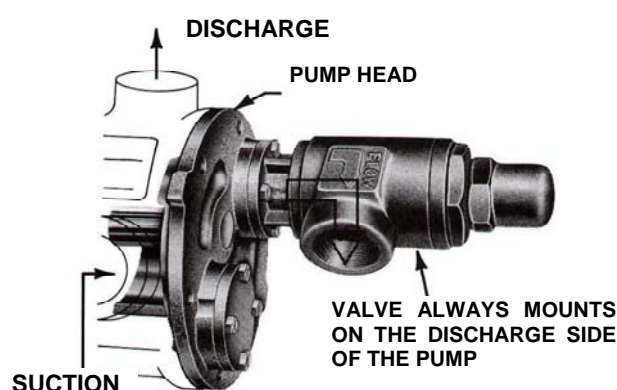


FIGURE 5B
RETURN-TO-TANK RELIEF VALVE

NOTE: on some models the relief valve is mounted on the pump casing instead of the pump head.

The spring loaded poppet-type valve is strictly a differential valve, sensing only those pressures on each side of the poppet. It should **not** be used as a pressure or flow control device. **It is intended strictly as a relief valve.**

The pressure at which either the return-to-tank or internal relief valve bypasses can be changed by turning the adjusting screw. Do not back the adjusting screw all the way out. Stop when spring tension is off the screw (the screw starts to turn easily).

For details on maintenance of the relief valve see Technical Service Manual covering your model series.

6. Motor - follow local electrical codes when booking up motors.

FOUNDATION

Every pump should have a solid foundation. It may be any structure sufficiently strong to hold the pump rigid and to absorb any strain or shock that may be encountered.

A certified print of the pumping unit should be used in preparing the foundation. If a separate foundation is provided, make it at least four inches wider and longer than the base of the unit.

When the unit is placed on the foundation it should be leveled and checked for position against the piping layout and then fastened down.

ALIGNMENT

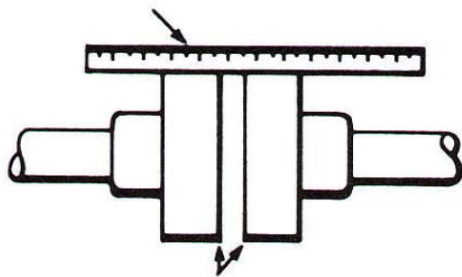
CHECK ALIGNMENT AFTER MOUNTING

For detailed coupling alignment procedures see Viking service bulletin ESB-61.

The pump, drive, and motor were properly aligned at the time they were assembled. During shipping and mounting the alignment is often disturbed. **BE SURE TO RECHECK ALIGNMENT AFTER THE PUMP UNIT IS INSTALLED!**

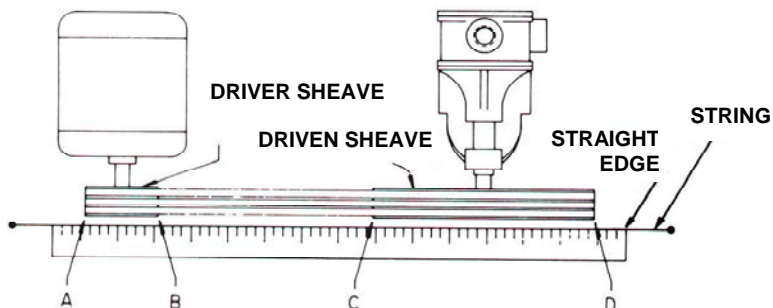
1. Check pump ports to be sure they are square and in proper position; shim or move pump as required. Do not force piping to line up with the ports.
2. If the pump is driven by a flexible coupling(s) either direct connected to the motor or through a reducer, remove any coupling guards or covers and check alignment of the coupling halves. A straightedge (a piece of key stock works nicely) across the coupling must rest evenly on both rims at the top, bottom, and sides. See Figure 6.
3. If the pump is driven by V-belts, check the alignment by using a long straightedge or tightly drawn string across the face of the sheaves. See Figure 6A.
4. Make a final check on alignment after piping is hooked up.
See item 13 under "Installation - Piping".
Figures 7, 8, and 9 show typical units - direct, gear reducer and V-belt drive.
5. For high temperature applications (those above 300°F) allow pump to reach operating temperature, then recheck alignment.

USE A STRAIGHT EDGE. THESE SURFACES MUST BE PARALLEL.



CHECK WIDTH BETWEEN THESE SURFACES WITH INSIDE CALIPERS TO BE CERTAIN THE FACES ARE EQUAL DISTANCE APART AND PARALLEL.

FIGURE 6



WHEN SHEAVES PROPERLY ALIGNED ALL POINTS A, B, C, D WILL TOUCH STRING OR STRAIGHTEDGE.

FIGURE 6A

PIPING

The cause of many pumping problems can be traced to suction piping. It should always be as large and short as practical. For help in selecting the proper size piping, both suction and discharge, refer to Viking General Catalogue.

Before starting layout and installation of your piping system, consider the following points:

1. Never use piping smaller than the pump port connections.
2. Be sure the inside of the pipe is clean before booking it up.
3. Foot valve - When pumping a light liquid with a suction lift, a foot valve at the end of the suction piping or a check valve in the first horizontal run will hold the liquid in the line and make it easier for the pump to prime. Be sure the foot or check valve is big enough so that it doesn't cause excessive line loss.

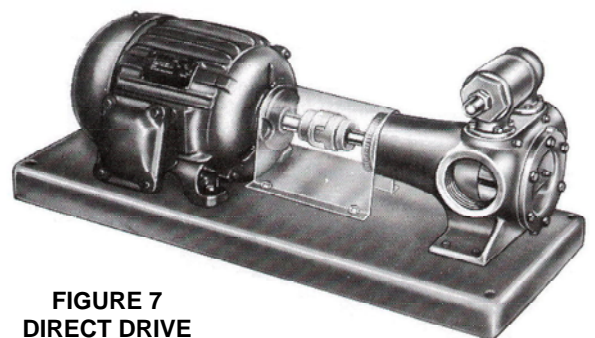


FIGURE 7
DIRECT DRIVE

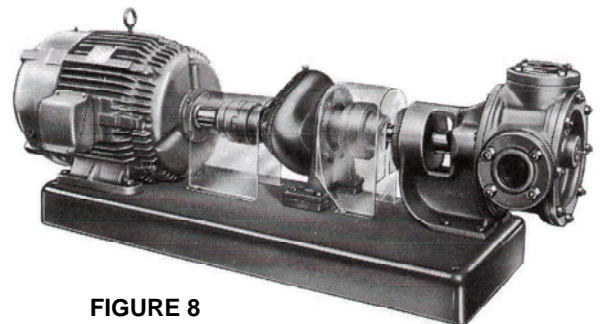


FIGURE 8
GEAR REDUCER DRIVE

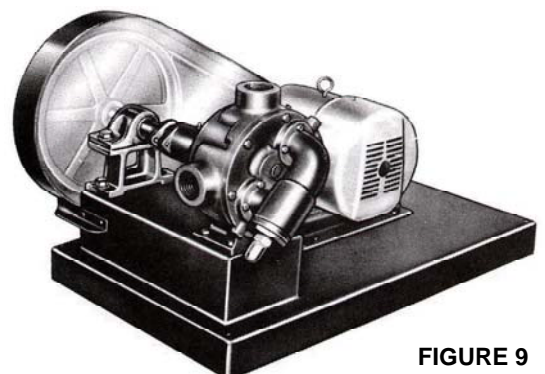


FIGURE 9
V-BELT DRIVE

4. When approaching an obstacle in the suction or discharge line, go around the obstacle instead of over it. Going over it creates an air pocket. See Figure 10.

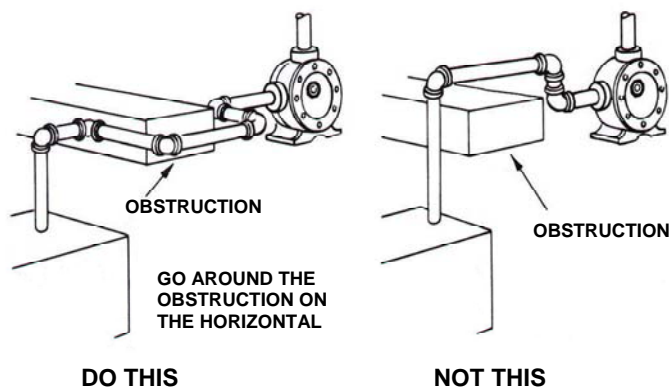


FIGURE 10

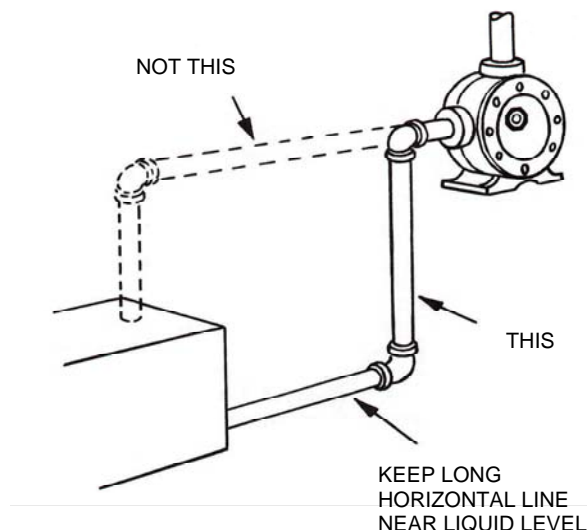


FIGURE 11

5. Where practical, slope the piping so no air or liquid pockets will be formed. Air pockets in the suction line make it hard for the pump to prime.
6. For a suction line with a long horizontal run keep the horizontal portion below the liquid level if possible. This keeps the pipe full so the pump does not have to remove so much air when starting; this is most helpful when there is no foot valve. See Figure 11.
7. When piping a hot or cold system (liquid being handled is at a temperature different from the air surrounding the pump), be sure allowance is made for expansion and contraction of the piping. Loops, expansion joints, or unsecured (this does not mean unsupported) runs should be used so the pump casing is not distorted or put into a bind.
8. **STRAINER** - It is always good practice to consider a strainer on the suction side of a positive displacement pump. The strainer will keep foreign objects from going into the pump; without a strainer some would go through; others would cause a jammed pump, a broken part, or a torn up drive. The strainer basket mesh or perforation size should be big enough so that it does not cause excessive pressure drop, but it should be fine enough to protect the pump. When in doubt as to the proper size, check with the manufacturer, giving him pipe size, flow rate, and viscosity involved. Provision should be made for cleaning the strainer. If the pump operates continuously, a bypass should be built around the strainer or two strainers should be put in parallel with proper valving so they can be isolated for cleaning. Use of a strainer is particularly important at start up to help clean the system of weld beads, pipe scale, and other foreign objects. If the pump is not equipped with a relief valve, consideration should be given to mounting one in the discharge line. See discussion on relief valves under START UP.
10. The pump should not be used to support the piping. The weight of the pipe should be carried by hangers, supports, stands, etc.
11. When fastening the piping to the pump it should not be necessary to impose any strain on the pump casing. "Springing" or "drawing" the piping up to the pump will cause distortion, possible misalignment, and probable rapid wear of the pump. Do not use the pump to correct errors in piping layout or assembly.
12. All joints of the piping system should be tight; pipe sealer or Teflon tape will help assure leak-free threaded joints. Leaks in the suction line permitting air to be drawn in may cause a noisy pump, or a reduction in capacity.
13. **ALIGNMENT** - Check the alignment of the drive after the piping is hooked up. As a final check on pump alignment remove the head of the pump and with a feeler gauge determine if there is clearance all the way around between the rotor and casing. Because of manufacturing tolerances, bushing clearances, etc., the rotor may not be centered in the casing, but it should not drag; dragging would indicate unit misalignment or casing distortion from piping strain. Making this check is most desirable on installations involving Q, M and N size standard duty pumps.
14. The auxiliary piping hooked to jackets, glands, etc. for heating, cooling, quenching, or for other purposes should receive the same attention as the piping handling the liquid pumped.
15. Provide a relief device in any part of a pump and piping system that can be valved off and, thus, completely isolated. This is particularly important:
 - a). When handling a cold liquid such as refrigeration ammonia that can warm up to ambient temperatures when the pump is shut off or
 - b). When handling a liquid such as asphalt or molasses that has to be heated before it can be pumped. The rise in temperature causes the liquid to expand; if there is no provision for pressure relief in the closed off section, there is a chance that the pump or piping will rupture.

START UP

Before pushing the "start" button, check the following:

1. Are there vacuum and pressure gauges on or near the pump? These gauges are the quickest and most accurate way of finding out what is happening in the pump.

2. Check alignment - See suggestions under "Installation - Alignment" in this manual.
3. Check piping to be sure there is no strain on the pump casing.
4. Rotate the pump shaft by hand to be sure it turns freely. **MAKE SURE THE PUMP DRIVER IS LOCKED OUT OR CANNOT BE ENERGIZED BEFORE DOING THIS.**
5. Jog motor to be sure it is turning in the right direction; see discussion on pump rotation under "Installation - General" item 4 in this manual.
6. Check any relief valves to be sure they are installed correctly. See discussion on relief valves under "Installation - General".
7. Check suction piping to be sure (a) it is all connected and tight, (b) valves are open, and (c) end of pipe is below liquid level.
8. Check discharge piping to be sure (a) it is connected and tight, (b) valves are open, and (c) there is a place for the liquid to go.
9. Lubricate any grease fitting on the pump using a good, general purpose #2 ball bearing grease. Check any gear reducer, motor, coupling, etc. for instructions and lubricate as recommended. See Engineering Service Bulletin ESB-515.
10. For packed pumps, loosen packing gland nuts so gland can be moved slightly by hand. Adjust gland to reduce leakage only after pump has run long enough to reach constant temperature. Packing should weep a little to keep it cool and lubricated.
11. Do **not** use the Viking pump to flush, pressure test or prove the system with water. Either remove the pump or run piping around it while flushing or testing. Pumping water, dirty or otherwise, can do more damage in a few minutes than months of normal service.
12. Check to be sure all guards are in place.
13. Now you are ready to push the "start" button - gently.

If the pump begins to deliver liquid within 60 seconds, you're in business. If it does not, push the "stop" button. Do **not** run the pump longer than one minute without liquid in it; you may damage it. Review the steps just outlined, consider what the suction and discharge gauges indicate, see page 6; if everything appears to be in order, put some liquid in the pump, a lubricating liquid is best. This will help it prime.

Push the "start" button again. If nothing is flowing within two minutes, stop the pump. The pump is not a compressor, it will not build up much air pressure; it may be necessary to vent the discharge line until liquid begins to flow.

If the pump still does not deliver, the cause may be one or more of the following:

1. Suction line air leaks; vacuum gauge reading should help determine if this is the problem.
2. End of suction pipe not submerged deep enough in liquid.
3. Suction lift is too great or the suction piping is too small.
4. Liquid is vaporizing in the suction line before it gets to the pump.

If after consideration of these points it still does not pump, suggest you review again all points given under START UP; read through Troubleshooting in this manual and try again. If it still does not pump, contact your Viking representative.

TROUBLESHOOTING

A Viking pump that is properly installed and maintained will give long and satisfactory performance.

NOTE: Before making any pump adjustment or opening the pump liquid chamber in any manner, make sure that:

- 1) Any pressure in the pumping chamber has been vented through the suction or discharge lines or other openings provided for this purpose,
- 2) The driver has been "locked out" so that it cannot inadvertently be started while work is being done on the pump and
- 3) The pump has been allowed to cool down to the point where there is no chance of anyone being burned.

If trouble does develop, one of the first steps toward finding the difficulty is to *install a vacuum gauge in the suction port and a pressure gauge in the discharge port*. Readings on these gauges often will give a clue as to where to start looking for the trouble.

Vacuum Gauge - Suction Port

1. High reading would indicate -
 - a). Suction line blocked - foot valve stuck, gate valve closed, strainer plugged.
 - b). Liquid too viscous to flow through the piping.
 - c). Lift too high.
 - d). Line too small.
2. Low reading would indicate -
 - a). Air leak in suction line.
 - b). End of pipe not in liquid.
 - c). Pump is worn.
 - d). Pump is dry - should be primed.
3. Fluttering, jumping, or erratic reading -
 - a). Liquid vaporizing.
 - b). Liquid coming to pump in slugs, possibly an air leak insufficient liquid above the end of the suction pipe.
 - c). Vibrating from cavitation, misalignment, or damage parts.

Pressure Gauge - Discharge Port

1. High reading would indicate -
 - a). High viscosity and small and/or long discharge line.
 - b). Gate valve partially closed.
 - c). Filter plugged.
 - d). Vertical head did not consider a high specific gravity liquid.
 - e). Line partially plugged from build up on inside of pipe.
 - f). Liquid in pipe not up to temperature.
 - g). Liquid in pipe has undergone a chemical reaction and has solidified.
 - h). Relief Valve set too high.
2. Low reading would indicate -
 - a). Relief valve set too low.

- b). Relief valve poppet not seating properly.
 - c). Bypass around the pump partially open.
 - d). Too much extra clearance.
 - e). Pump worn.
3. Fluttering, jumping, or erratic reading -
- a). Cavitation.
 - b). Liquid coming to pump in slugs.
 - c). Air leak in suction line.
 - d). Vibrating from misalignment or mechanical problems.

Some of the following may also help pinpoint the problem:

A). Pump does not pump.

1. Lost its prime - air leak, low level in tank, foot valve stuck.
2. Suction lift too high.
3. Rotating in wrong direction.
4. Motor does not come up to speed.
5. Suction and discharge valves not open.
6. Strainer clogged.
7. Bypass valve open, relief valve set too low, relief valve poppet stuck open.
8. Pump worn out.
9. Any changes in the liquid system, or operation that would help explain the trouble, e.g. new source of supply, added more lines, inexperienced operators, etc.
10. Too much end clearance.
11. Head position incorrect. See Fig. 3.

B). Pump starts, then loses its prime.

1. Supply tank empty.
2. Liquid vaporizing in the suction line.
3. Air leaks or air pockets in the suction line; leaking air through packing or mechanical seal.
4. Worn out.

C). Pump is noisy.

1. Pump is being starved (heavy liquid cannot get to pump fast enough). Increase suction pipe size or reduce length.
2. Pump is cavitating (liquid vaporizing in the suction line). Increase suction pipe size or reduce length; if pump is above the liquid, raise the liquid level closer to the pump; if the liquid is above the pump, increase the head of liquid.
3. Check alignment.
4. May have a bent shaft or rotor tooth. Straighten or replace.
5. Relief valve chatter; increase pressure setting.
6. May have to anchor base or piping to eliminate or reduce vibration.
7. May be a foreign object trying to get into the pump through the suction port.

D). Pump not up to capacity.

1. Starving or cavitating - increase suction pipe size or reduce length.
2. Strainer partially clogged.
3. Air leak in suction piping or along pump shaft.
4. Running too slowly; is motor the correct speed and is it wired up correctly.
5. Bypass line around pump partially open.
6. Relief valve set too low or stuck open.
7. Pump worn out.
8. Too much end clearance.
9. Head position incorrect. See Fig. 3.

E). Pump takes too much power.

1. Running too fast - Is correct motor speed, reducer ratio, sheave size, etc. being used?
2. Is liquid more viscous than unit sized to handle; heat the liquid, increase the pipe size, slow the pump down, or get a bigger motor.
3. Discharge pressure higher than calculated, check with pressure gauge. Increase size or reduce length of pipe, reduce speed (capacity), or get bigger motor.
4. Packing gland drawn down too tight.
5. Pump misaligned.
6. Extra clearance on pumping elements may not be sufficient for operating conditions. Check parts for evidence of drag or contact in pump and increase clearance where necessary.

F). Rapid Wear.

On most applications the pump will operate for many months or years before it gradually loses its ability to deliver capacity or pressure. Examination of such a pump would show a smooth wear pattern on all parts. Rapid wear, occurring in a few minutes, hours or days, shows up as heavy grooving, galling, twisting, breaking or similar severe signs of trouble. SEE CHART PAGE 7.

PREVENTATIVE MAINTENANCE

Performing a few preventative maintenance procedures will extend the life of your pump and reduce the overall cost of ownership.

A). Lubrication - Grease all grease nipples after every 500 hours of operation or after 60 days, whichever occurs first. If service is severe, grease more often. Do it gently with a hand gun. Use a NLGI #2 grease for normal applications. For hot or cold applications use appropriate grease. See Engineering Service Bulletin ESB-515.

B). Packing Adjustment - Occasional packing adjustment may be required to keep leakage to a slight weep; if impossible to reduce leakage by gentle tightening, replace packing or use different type. See Technical Service Manual on particular model series for details on repacking.

C). End Clearance Adjustment - After long service the running clearance between the end of the rotor teeth and the head may have increased through wear to the point where the pump is losing capacity or pressure. Resetting end clearance will normally improve pump performance. See TSM on particular model series for procedure on adjusting end clearance for pump involved.

D). Examine Internal Parts - Periodically remove the head, examine idler and bushing and head and pin for wear. Replacing a relatively inexpensive idler bushing and idler pin after only moderate wear will eliminate the need to replace more expensive parts at a later date. See TSM on particular model series for procedure in removing head of the pump. Be sure idler does not slide off idler pin as head is removed and drop and hurt someone or damage the part.

E). Cleaning the Pump - A clean pump is easier to inspect, lubricate, adjust, and runs cooler; plus, it looks better.

F). Storage - If pump is to be stored, or not used for six months or more, pump must be drained and a light coat of non-detergent SAE 30 weight oil must be applied to all internal pump parts. Lubricate fittings and apply grease to pump shaft extension. Viking suggests rotating pump shaft by hand one complete revolution every 30 days to circulate the oil. Retighten all gasketed joints before using the pump.

RAPID WEAR

CAUSE		EVIDENCE	POSSIBLE SOLUTION
1.	ABRASIVES	Gouges or marks made by large, hard particles; a rapid wearing away of bushings from very small abrasives similar to pumice; or anything in between.	Flush the system with the pump removed. Install strainer in suction line. Oftentimes after a system has run for a few cycles or a few days the dirt is pretty well cleaned out and if the pump is rebuilt into good condition it will then last for a long time.
2.	CORROSION	Rust, pitting or metal appears to be "eaten" away.	Check the Viking General Catalog Liquid List for materials of construction recommendation. Consider whether all of the materials used in pump construction were attacked; consider other materials used in the system to determine how they resisted the liquid. Check to see whether or not the liquid has been contaminated to make it more corrosive than anticipated.
3.	EXCEEDING OPERATING LIMITS	Noisy operation, broken bushings, twisted shaft, parts show evidence of high heat (discoloration).	Review General Catalog for operating limits on particular model involved.
4.	INSUFFICIENT EXTRA CLEARANCE	Pump may stall. Evidence of heavy contact between end of rotor teeth and head or other parts.	Increase end clearance and/or contact your distributor or the factory with details of the application so that information regarding proper extra clearance may be provided.
5.	LACK OF LUBRICATION	Noisy bearings, localized heating at bearings or lip seal, smoke, rapid bushing wear.	Be sure all grease fittings are greased before starting and instructions for lubrication of drive equipment are followed; consider use of auxiliary lubricating equipment.
6.	MISALIGNMENT	Wear on only one part of a surface, e.g., one side of the casing, one side of the packing gland, only a portion of the face of the head.	Double check alignment of drive equipment and piping. Check the alignment under conditions as close to operating conditions as possible.
7.	RUN DRY	Pump stalls because parts have uneven expansion caused by frictional heat; galling between surfaces having relative motion; seal seats and idler pins changing colour because of high heat.	Be sure there is liquid in the system at the time of start up. Provide some kind of automatic alarm or shut-off if supply tank runs dry.

DO'S AND DON'TS -

Do's and Don'ts for installation, operation, and maintenance of Viking pumps to assure safe, long, trouble-free operation.

INSTALLATION -

1. Do install pump as close to supply tank as possible.
2. Do leave working space around the pumping unit.
3. Do use large, short, and straight suction piping.
4. Do install a strainer in the suction line.
5. Do double check alignment after the unit is mounted and piping is hooked up.
6. Do provide a pressure relief valve for the discharge side of the pump.
7. Do cut out the center of gaskets used as port covers on flanged port pumps.
8. Do record pump model number and serial number and file for future reference.

OPERATION -

1. Don't run pump at speeds faster than shown in the catalogue for your model.
2. Don't require pump to develop pressures higher than those shown in the catalogue for your model.
3. Don't operate pumps at temperatures above or below limits shown in the catalogue for your pump.
4. Don't operate pumps without all guards being in place.
5. Don't operate pump without a relief valve on the pump or in the discharge piping; be sure valve is mounted and set correctly.
6. Don't exceed catalogue limits for temperature and pressures of fluids in jacketed areas of pump.
7. Don't use the pump in a system, which includes a steam blow or an air or vapour blow or purge **without** provision for over-speed shutdown in case the pump starts to act as a turbine and over-speeds the drive.
8. Don't operate the pump with all of the liquid bypassing through a pump mounted internal type relief valve or without any flow of liquid going through the pump for more than a couple of minutes. Operation under either of these conditions may result in a heat build-up in the pump, which could cause hazardous conditions or happenings.

MAINTENANCE -

1. Do make sure any pump that has residual system pressure in it or that has handled high vapour pressure liquids, e.g., LP-gas, ammonia, Freons, etc. has been vented through the suction or discharge lines or other openings provided for this purpose.
2. Do make sure that if the pump is still hooked to the driver while maintenance is being performed that the driver has been "locked out" so that it cannot be inadvertently started while work is being done on the pump.
3. Do make sure any pump that has handled a corrosive, flammable, hot, or toxic liquid has been drained, flushed, vented and/or cooled before it is disassembled.
4. Don't drop parts during disassembly, e.g., idler can slip from the pin as the head is removed from the pump; it may drop on your foot, plus, it may get nicked or gouged.
5. Don't stick fingers in the ports of a pump! Serious injury may result.
6. Don't spin the idler on the idler pin! Fingers may be jammed between teeth and crescent.
7. Do remember that a few simple preventative maintenance procedures such as periodic lubrication, adjustment of end clearance, examination of internal parts, etc., will extend the service life of your pump.
8. Do **obtain**, read and keep maintenance instructions furnished with your pump.
9. Do have spare parts, pumps or standby units available, particularly if the pump is an essential part of a key operation or process.

TECHNICAL SERVICE MANUAL

INSTALLATION, START-UP, TROUBLESHOOTING,
PREVENTATIVE MAINTENANCE, DO'S AND DON'TS

BULLETIN TSM-000-V
PAGE 9 of 9
ISSUE D



WARRANTY

Viking warrants all products manufactured by it to be free from defects in workmanship or material for a period of one (1) year from date of startup, provided that in no event shall this warranty extend more than eighteen (18) months from the date of shipment from Viking. If, during said warranty period, any products sold by Viking prove to be defective in workmanship or material under normal use and service, and if such products are returned to Viking's factory at Windsor, Ontario, transportation charges prepaid, and if the products are found by Viking to be defective in workmanship or material, they will be replaced or repaired free of charge, FOB. Windsor, Ontario.

Viking assumes no liability for consequential damages of any kind and the purchaser by acceptance of delivery assumes all liability for the consequences of the use or misuse of Viking products by the purchaser, his employees or others. Viking will assume no field expense for service or parts unless authorized by it in advance.

Equipment and accessories purchased by Viking from outside sources which are incorporated into any Viking product are warranted only to the extent of and by the original manufacturer's warranty or guarantee, if any.

THIS IS VIKING'S SOLE WARRANTY AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, WHICH ARE HEREBY EXCLUDED, INCLUDING IN PARTICULAR ALL WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. No officer or employee of IDEX Corporation or Viking Pump Canada is authorized to alter this warranty.



OPERATING AND MAINTENANCE INSTRUCTIONS FOR ACE COOLERS

IMPORTANT

Before start up, check set screws and bolts in the fan assembly and set screws in locking collars of all bearings and sheaves. These items should be checked again several days after start up.

FAN & DRIVE

Although the fan and drive are inspected before shipment, clearance between the fan blades and the fan ring and guard, and alignment of the fan shaft should be checked to assure that rough handling during shipment has not loosened bearing mounting bolts or caused misalignment.

V-belt drives should be adjusted until tight enough to prevent excessive belt slippage. The belt is generally tight enough when it can be twisted one-quarter of a turn with the thumb and fore-finger.

LUBRICATION

Bearings should be greased in accordance with normal maintenance practice. Over-lubrication is the most common cause of bearing failure. In general, about one cubic inch of grease in each bearing every 2 to 3 months is adequate. The operating temperature of the bearing may indicate how much lubrication is required.

Normal temperature may range from "cool to warm to touch" up to a point "too hot to touch for more than a few seconds" depending on bearing size and speed, and surrounding conditions. Unusually high temperature accompanied by excessive leakage of grease indicates too much grease. High temperature with no grease showing at the seals, particularly if the bearing seems noisy, usually indicates too little grease. Normal temperature and slight showing of grease at the seals indicates proper lubrication.

TUBE CLEANING

Operating conditions sometimes cause an accumulation of dirt on the outside fin surface. This can be removed by directing compressed air, or a greaseless solvent followed by a water spray through the fins in a direction opposite the normal air flow. The inside of the tubes will require periodic inspection and cleaning as necessary. Removal of access plugs allows visual inspection, and if necessary, the use of mechanical tube cleaners.

PLUG LEAKS

Should tapered plugs develop leaks, additional tightening is normally all that is required. Thread dope may be used if tightening alone is not sufficient. If shoulder type plugs develop leaks, the gaskets should be replaced. Tapered plugs that are removed for the tube inspection or cleaning should be replaced in the same hole.

TUBE LEAKS

Tube leaks can be of two types: (1) leaks in the tubewall itself (usually corrosion) and (2) leaks in the tube to tubesheet joint. In the first case, it is usually most practical to plug both ends of the tube with the resulting loss in heat transfer surface. When so many tubes have been plugged that performance is affected, retubing will be necessary. If leaks develop in the tube to tubesheet joints, re-rolling of the tube will be required. Care must be used in selection of the proper tube expander for the size and BWG of the tube being used. As with all rolled tube joints, over-rolling must be avoided.

GENERAL

If it is ever necessary to contact our plant for service or replacement parts, it is essential that our serial number or other identifying data be obtained from the metal nameplate attached to the cooler. This is the only way to positively identify the correct parts that may be required.

AIR COOLED HEAT EXCHANGER **SUGGESTED START UP PROCEDURE**

Before any start up procedure is begun, a thorough inspection of the Air Cooled Exchanger should be made.

- 1.) Be sure all bolted connections are properly tightened.
- 2.) After tube bundle and piping hydrotest, remove hydrotest connections. Be sure tube bundle is properly drained, and if required, dried. Connect process piping and any auxiliary connections.
- 3.) Inspect all process connection, as well as, vent drain, temperature and pressure, or any other auxiliary connections to be sure they are plugged or connected properly.
- 4.) Check mechanical equipment before starting process through the tube bundle(s).
 - a.) Thoroughly check the plenum and fan drive area to be sure all tools and construction materials are removed.
 - b.) Rotate the fan by hand and check fan tip clearance and alignment of belts and sheaves.
 - c.) Check belt tension.
 - d.) Check all fan drive bolts to be sure they are properly tightened. This includes bearing bolts, fan and sheave bushing bolts, set screws, motor bolts and fan blades attachment bolts.
 - e.) If air operated auto-variable pitch fans are used, check for proper pitch with the air off. Fans may go to either minimum or maximum pitch at air failure. Check specifications for requirements. If fan pitch is not satisfactory, set pitch per manufacturer's instructions (see Operation and Maintenance Instructions). If fan pitch is satisfactory, cycle fan through it's range, using plant air and an air regulator.

- f.) If air operated louvers are provided, it is advisable to disconnect the air motor linkage and cycle the louvers by hand to assure there is no binding or obstruction of the louvers blades. If binding occurs, check to be sure louver frames are square. Attaching bolts may have to be loosened and frames shifted to ease binding. If louvers operate smoothly, reconnect air motor. Cycle the air motor, using plant air and an air regulator.
 - g.) If manually adjusted pitch fans are provided, check fan pitch and re-pitch per manufacturer's instructions if required.
 - h.) If manual operated louvers are provided, check for binding of the blades, as in instruction (f). Operate louvers to be sure there is no linkage obstruction or binding.
 - i.) Remove condensate drain plugs, if provided, in electric motors and other electrical components to drain any condensation that might have occurred during storage. If space heaters are furnished in electric motors, louver actuators, controls, etc., activate the space heaters and allow approximately 24 hours before starting equipment.
 - j.) After all the applicable steps previously stated are completed, the mechanical equipment may be cycled.
 - k.) Be sure all personnel and equipment are away from the fan and fan drive area. For safety reasons, equipment guards should be installed. Activate the drive motor and let it reach speed. Check for vibration and excessive noise. If vibration or excessive noise occurs, immediately shut motor down, and check for loose connections or insufficient clearance between moving parts. If the system is running smoothly, replace any guards removed and move to the next drive and repeat above steps.
- 5.) Start the process through the tube bundle(s). Open the inlet valves slowly and let the process "Warm" the bundles slowly. This will allow the components of the tube bundle to expand at the same rate and lessen the thermal shock.



AXH air-coolers
air-x-limited

401 E. Lowry Road Phone (918) 283-9200
Claremore, OK 74017 Fax (918) 283-9229
info@axh.com www.axh.com

Proposal / Job No. 68007C
Date 3/12/2007
Page 1 OF 1

1	Purchaser	VAPORTECH	Ultimate User	
2	Inquiry / PO#	05252-T1	Destination	SASKATCHEWAN
3	# Units	1	Model	54EF
4	Assembly	PACKAGED	Draft	FORCED
			Overall Size (WxL), Ft	Est Wt 3900 LBS

THERMAL & MECHANICAL DESIGN

5	Service	JW	CCW	PC	AC
6	Flow	41GPM	5GPM	0.42MMSCFD	0.42MMSCFD
7	Fluid	50%GLY	50%GLY	1.517SPGR	1.517SPGR
8	Temp. In / Out, °F	180.0 / 168.4	146.5 / 122.0	176.0 / 122.0	300.0 / 122.0
9	Pressure, PSI			14.2PSIA	53.7PSIA
10	Pressure Drop, PSI	2.5	0.5	0.3	2.1
11	Heat Load, BTU/HR	220000	54350	30951	108534
12	True LMTD	52.6	28.8	42.4	73.1
13	Overall Rate, U	166.2	70.4	14.7	37.7
14	Fouling Factor	.0005	.0005	.0020	.0020
15	Surface, Tube / Total, Sq Ft	27 / 434	27 / 434	50 / 740	40 / 589
16	Sections, #	(1) - COMBINED	(1) - COMBINED	(1)	(1)
17	Design Temp, °F Max / Min	300 / -20	300 / -20	350 / -40	350 / -40
18	MWP / Test Press, PSIG	* 14 / 75	* 14 / 75	215 / 280	215 / 280
19	Pass Arrangement	CROSSFLOW	CROSSFLOW	CROSSFLOW	CROSSFLOW
20	# Tube Rows	3	3	3	3
21	# Tube Passes	2	4	1	3
22	Tubes, OD x BWG	5/8X16	5/8X16	3/4X16	3/4X16
23	Material	SA214 STEEL	SA214 STEEL	SA179 STEEL	SA179 STEEL
24	# Per Section / Length, Ft	29 / 6	29 / 6	44 / 6	35 / 6
25	Turbulators				
	Accelerators				
26	Fins, Type	HI-EFF	HI-EFF	HI-EFF	HI-EFF
28	Material	AL	AL	AL	AL
29	Nozzles, Rating / Type	150RF	CPLG	150RF	150RF
30	Material	SA105		SA350LF2	SA350LF2
31	# Inlets / Size In	(1) 2	(1) 1	(1) 6	(1) 3
32	# Outlets / Size In	(1) 2	(1) 1	(1) 6	(1) 3
33	Headers, Type	REC TUBE	REC TUBE	BOX	BOX
34	Material	A500	A500	SA516-70	SA516-70
35	Corrosion Allow, In			.1250	.1250
36	Grooved Tubesheet	SGL	SGL	DBL	DBL
37	Plugs, Type	TAPER	TAPER	SHOULDER	SHOULDER
38	Plugs Material	STEEL	STEEL	SA350LF2	SA350LF2
39	PWHT			YES	YES
40	ASME Code & Nat'l Board			YES	YES
41	CRN			AB, SK	AB, SK

Add'l Specs & Options

43	API				
44	Louvers / Hail Screen	MAN /	MAN /	AUTO /	AUTO /
45	Inspection / NDT			SX	SX

FX= 100% X-Ray of all header seam, attachment & nozzle butt welds. **SX=** Spot X-Ray of 1 long seam & 1 end closure, per header
BX= 100% X-Ray of all nozzle butt welds. **UT =** 100% UT of all header seam, attachment & nozzle butt welds. **H =** Hardness testing.

AIR-SIDE PERFORMANCE		FAN DATA		DRIVER DATA	STRUCTURAL
46	Ambient Air Temp, In °F	100	Fan(s) (1) MOORE-10K-24VT	Type	Guards FAN
47	Elevation, Ft	1968	Blade Material ALUMINUM	V-BELT BY OTHERS	AUTOMATIC WARM AIR
48	Air Flow, SCFM	24,701	HP / Fan 6		RECIRCULATION SYSTEM
49	Outlet Air Temp, °F	114.9	Dia, In / # Blades 54 / 4		SOFT BUGSCREENS
50	Min Air Temp, °F	-20	RPM 650		
51			Tipspeed, FPM 9189		
52	Est. Noise Data:	81 dBA @ 1m, 58 dBA @ 15m	Pitch, Deg 13		

Additional Info. *-BUILT TO STANDARD 150# DESIGN BUT DESIGNATED 14# TO AVOID THE NEED FOR PROVINCIAL REGISTRATION



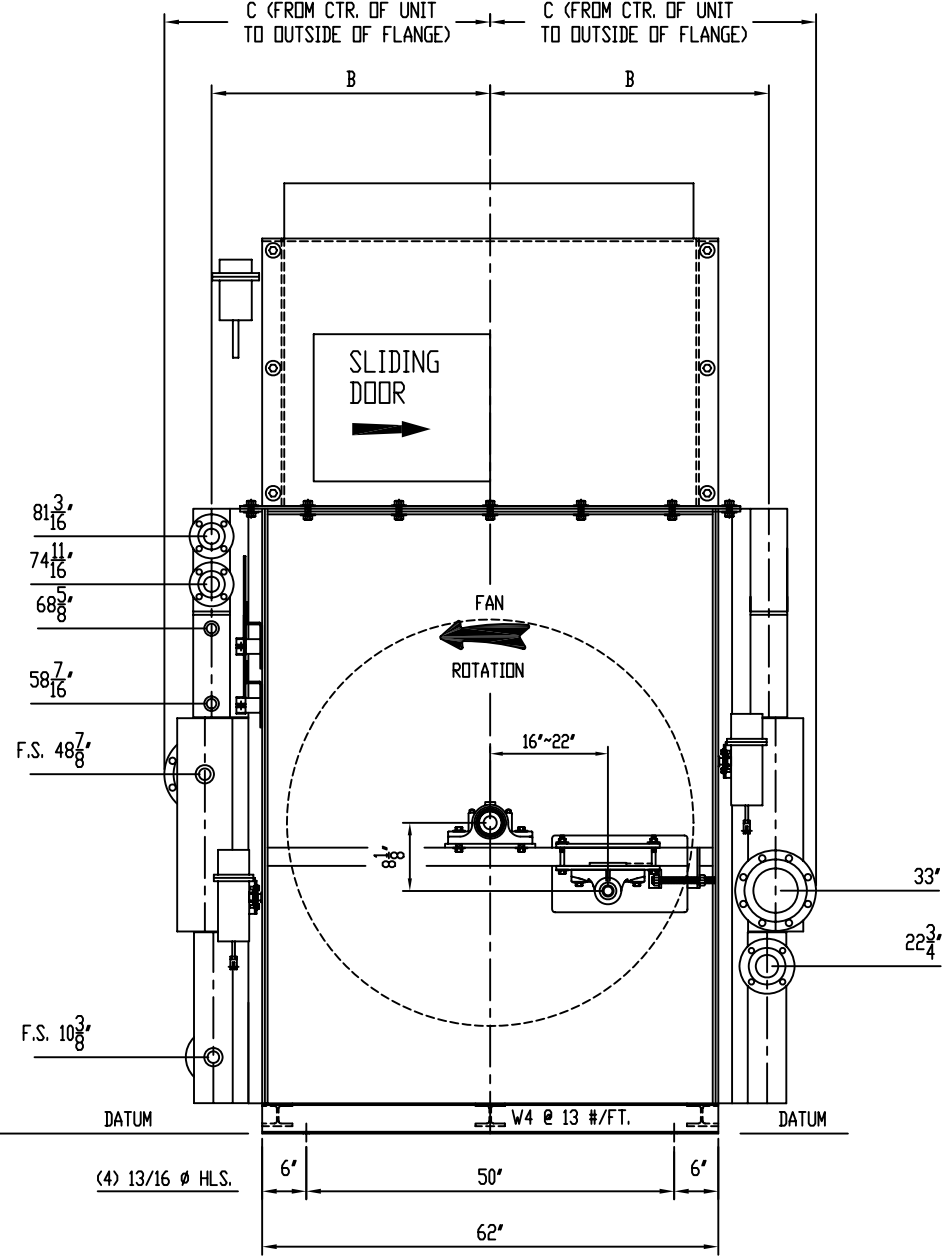
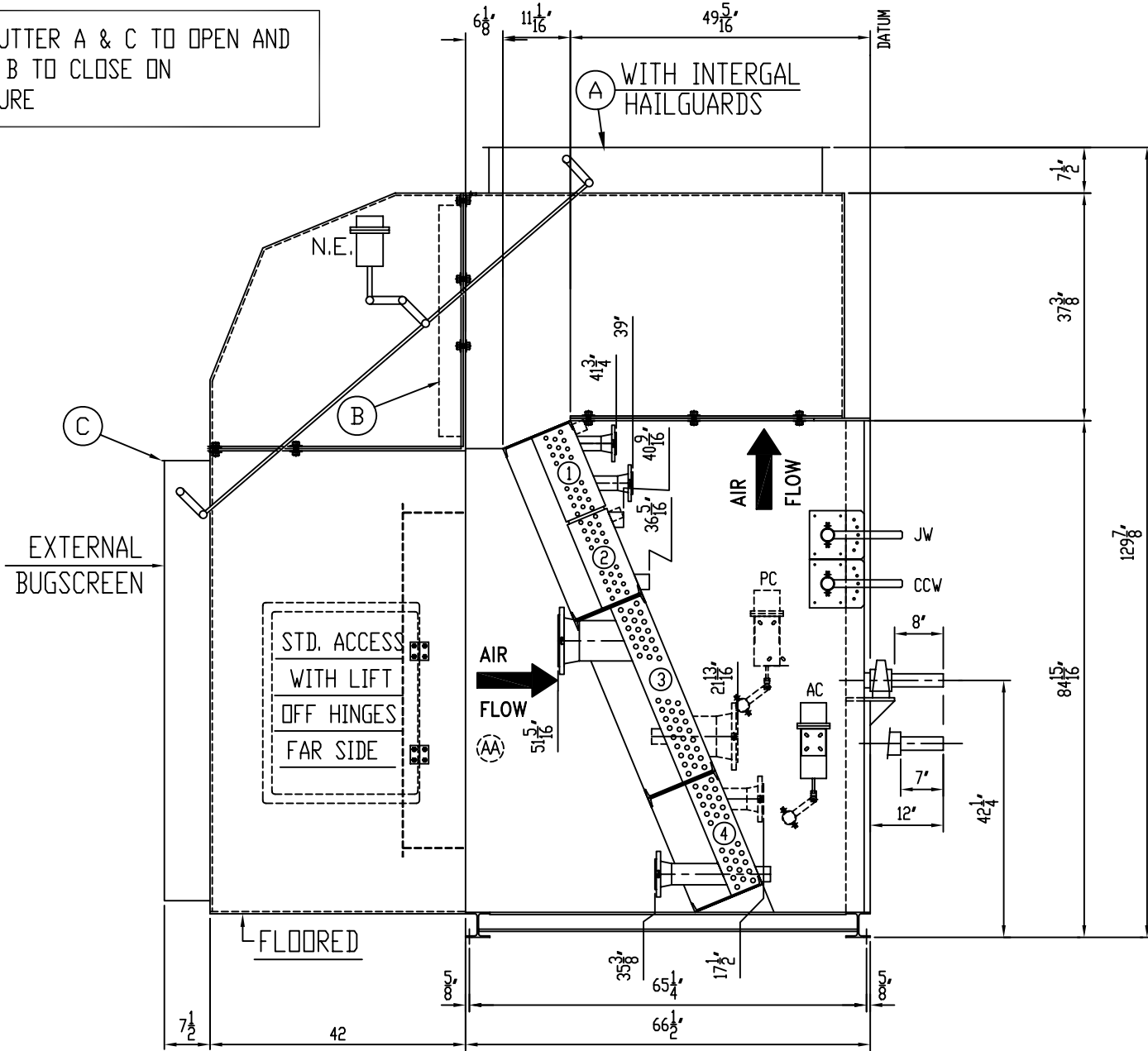
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Proposal / Job No. 68007C
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1	Purchaser VAPORTECH		Ultimate User	
2	Inquiry / PO# 05252-T1		Destination SASKATCHEWAN	
3	# Units 1	Model 54EF	Reference	
4	Assembly PACKAGED	Draft FORCED	Overall Size (WxL), Ft	Est Wt 3900 LBS
THERMAL & MECHANICAL DESIGN				
5	Service	JW	CCW	PC
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9	Pressure, PSI			14.2PSIA
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13	Overall Rate, U	166.2	70.4	14.7
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15	Surface, Tube / Total, Sq Ft	27 / 434	27 / 434	50 / 740
16	Sections, #	(1) - COMBINED	(1) - COMBINED	(1)
17	Design Temp, °F Max / Min	300 / -20	300 / -20	350 / -40
18	MWP / Test Press, PSIG	* 14 / 75	* 14 / 75	215 / 280
19	Pass Arrangement	CROSSFLOW	CROSSFLOW	CROSSFLOW
20	# Tube Rows	3	3	3
21	# Tube Passes	2	4	1
22	Tubes, OD x BWG	5/8X16	5/8X16	3/4X16
23	Material	SA214 STEEL	SA214 STEEL	SA179 STEEL
24	# Per Section / Length, Ft	29 / 6	29 / 6	44 / 6
25	Turbulators			
26	Accelerators			
27	Fins, Type	HI-EFF	HI-EFF	HI-EFF
28	Material	AL	AL	AL
29	Nozzles, Rating / Type	150RF	CPLG	150RF
30	Material	SA105		SA350LF2
31	# Inlets / Size In	(1) 2	(1) 1	(1) 6
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33	Headers, Type	REC TUBE	REC TUBE	BOX
34	Material	A500	A500	SA516-70
35	Corrosion Allow, In			.1250
36	Grooved Tubesheet	SGL	SGL	DBL
37	Plugs, Type	TAPER	TAPER	SHOULDER
38	Plugs Material	STEEL	STEEL	SA350LF2
39	PWHT			YES
40	ASME Code & Nat'l Board			YES
41	CRN			AB, SK
42	Add'l Specs & Options			
43	API			
44	Louvers / Hail Screen	MAN /	MAN /	AUTO /
45	Inspection / NDT			SX
FX= 100% X-Ray of all header seam, attachment & nozzle butt welds. SX= Spot X-Ray of 1 long seam & 1 end closure, per header BX= 100% X-Ray of all nozzle butt welds. UT = 100% UT of all header seam, attachment & nozzle butt welds. H = Hardness testing.				
AIR-SIDE PERFORMANCE		FAN DATA		DRIVER DATA
46	Ambient Air Temp, In °F	100	Fan(s) (1) MOORE-10K-24VT	Type
47	Elevation, Ft	1968	Blade Material ALUMINUM	V-BELT BY OTHERS
48	Air Flow, SCFM	24,701	HP / Fan 6	AUTOMATIC WARM AIR RECIRCULATION SYSTEM SOFT BUGSCREENS
49	Outlet Air Temp, °F	114.9	Dia, In / # Blades 54 / 4	
50	Min Air Temp, °F	-20	RPM 650	
51			Tipspeed, FPM 9189	
52	Est. Noise Data: 81 dBA @1m, 58 dBA @ 15m	Pitch, Deg 13		
53	Additional Info. *-BUILT TO STANDARD 150# DESIGN BUT DESIGNATED 14# TO AVOID THE NEED FOR PROVINCIAL REGISTRATION			
54				
55				
56				
57				
58				


ITEM	SERVICE	MAWP	CODE	NOZZLES		COUPLING VENT/TEMP	REF. DIMENSION		LOUVERS	BUG SCREEN	DRIVE	FAN	FINISH
				INLET	OUTLET		B	C					
1	JW COMBINED (5 GALS)	14 PSI @ 300/-20°F	NONE	2-150 RFWN	2-150 RFWN	1-3000	37.88	40.88	MANUAL	SOFT	ENGINE DRIVE SHEAVES, BELTS, AND GUARDS BY OTHERS Ø1.4375 IDLER SHAFT WITH .375 x .3125 KWY Ø1.9375 FAN DRIVE SHAFT WITH .5 x .25 KWY (AA)VIBRATION SWITCH (MTD)	54Ø MOORE 10K, SERIES 24,VT,HD 4-BLADE 13" PA. LH ROTATION 650 RPM @ 6.0 HP REQ'D Ø1.9375 BORE WITH .5 x .25 KWY.	STRUCTURE STD PRIMER W/ WARM GREY ENAMEL TOP COAT
2	CCW COMBINED (5 GALS)	14 PSI @ 300/-20°F	NONE	1-3000	1-3000	1-3000	37.88	-	MANUAL				
3	PC	215 PSI @ 350/-40°F	ASME	6-150 RFWN	6-150 RFWN	1-6000	38.75	44.25	AUTO				
4	AC	215 PSI @ 350/-40°F	ASME	3-150 RFWN	3-150 RFWN	1-6000	37.63	41.38	AUTO				

NOTE: SHUTTER A & C TO OPEN AND SHUTTER B TO CLOSE ON AIR FAILURE



P.O.# 001093,001095,001096,001097,001099

RELEASED
FABRICATION OF THIS
ORDER HAS BEGUN

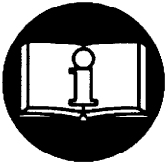
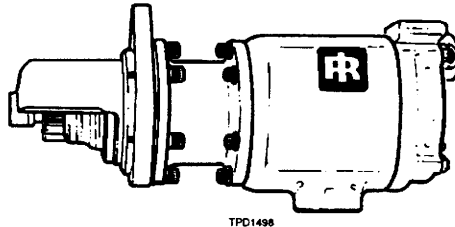
						FOR: VAPORTECH ENERGY SERVICES	ESTIMATED DRY WEIGHT 5,000#					
						P.O. NO: SEE ABOVE	<div> AXH air-coolers</div>					
						CUST. TAG: 5252-A/B/C/D/E						
						USER: -						
						JOBSITE: AB.,SK. CANADA						
3	MOVED IDLER AND AIR MOTOR			MIKE	L.W.	03/27/07	JOB. NO. 68007					
2	MOVED ACCESS, CHANGED PC NOZ TO 6" AND RELEASED.			J.J.	M.B.	03/13/07	WORK ORDER NO: -					
1	MOVED PC & AC NOZZLES PER CUSTOMER COMMENTS			J.J.	M.B.	02/19/07	DR: MJ	DATE: 2/9/07				
REV	REVISION DESCRIPTION			BY	CK	APP	DATE	CK: M.B.	DATE: 02/14/07	SCALE: FULL	DATE: 2/9/07	REV 3

INSTALLATION AND MAINTENANCE MANUAL

for

SERIES 3BMG STARTERS

(For Starters manufactured after September, 1983 with first three letters of the serial number: RHJ, RHK, RHL or higher)



⚠ WARNING

IMPORTANT INFORMATION CONTAINED IN OPERATION AND MAINTENANCE MANUAL FOR SAFE STARTER OPERATION.

THIS MATERIAL MUST BE READ PRIOR TO OPERATING THE STARTER.

FAILURE TO OBSERVE THE FOLLOWING WARNINGS COULD RESULT IN INJURY.

1. For safety, top performance, and maximum durability of parts, do not operate Series 3BMG Starters at pressure over the pressure rating stamped on the nameplate. Use supply lines of adequate size as directed in the installation instructions in this manual.
2. Always turn off the air or gas supply and disconnect the air or gas supply hose before installing, removing or adjusting any accessory on this Starter, or before performing any maintenance on this Starter.
3. Series 3BMG Starters are designed for gas operation. They are not totally sealed in dynamic operation since the exhaust must be vented or piped away and there is a possibility of leakage around the output shaft when rotating.
4. Caution should be taken when operating these starters on gas because of the danger of fire, explosion, or inhalation. After assembling a starter, always test it in accordance with the procedures outlined in this manual. Never install a reassembled starter that has not been tested in accordance with the procedures in this manual.
5. Operate this starter only when properly installed on the engine.
6. Do not lubricate starters with flammable or volatile liquids such as kerosene, diesel or jet fuel.
7. For personal protection, do not remove any labels. Replace any damaged label.
8. Use only recommended Ingersoll-Rand accessories.

NOTICE

The use of other than genuine Ingersoll-Rand replacement parts may result in safety hazards, decreased Starter performance and increased maintenance, and may invalidate all warranties.

Ingersoll-Rand is not responsible for customer modification of Starters for applications on which Ingersoll-Rand was not consulted.

Repairs should be made only by authorized, trained personnel. Consult your nearest Ingersoll-Rand Authorized Servicenter.

Specific Test Data, when applicable, can be found in the Special Instructions Section of this manual.

It is the responsibility of the employer to place the information in this manual into the hands of the operator.

Refer All Communications to the Nearest
Ingersoll-Rand Office or Distributor.

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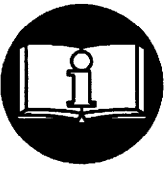

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INGERSOLL-RAND®
PROFESSIONAL TOOLS


WARNING LABEL IDENTIFICATION



WARNING

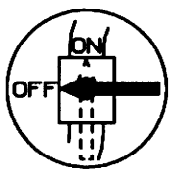

FAILURE TO OBSERVE THE FOLLOWING WARNINGS COULD RESULT IN INJURY.

	<p> WARNING</p> <p>Important information contained in Installation and Maintenance Manual for safe starter operation.</p> <p>This material must be read prior to installing or operating the starter.</p>
---	---

	<p> WARNING</p> <p>Always wear eye protection when operating or performing maintenance on this starter.</p>
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	<p> WARNING</p> <p>Always wear hearing protection when operating this starter.</p>
--	--

	<p> WARNING</p> <p>Do not use damaged, frayed or deteriorated air hoses and fittings.</p>
--	---

	<p> WARNING</p> <p>Always turn off the air or gas supply and disconnect the air or gas supply hose before installing, removing or adjusting any accessory on this starter, or before performing any maintenance on this starter.</p>
---	--

PLACING STARTER IN SERVICE

INSTALLATION

NOTICE

For maximum performance, read this manual prior to the installation or operation of Series 3BMG Starters.

General Information

1. It is strongly recommended that on all vehicular installations and on stationary engines subject to vibration, that hoses of the specified diameter be used instead of rigid pipe connections to the Starter. Vehicle and engine vibration will soon loosen rigid pipe connections, whereas hoses will absorb the vibration and connections will remain tight.
2. In the actual mounting of a Starter, it may be best to have the hose connections already made at the receiver and to have the Starter end of the hose handy for attaching to the Starter.
3. Engine design often demands that the Starter be mounted underneath in extremely close quarters, and even though two of the mounting bolt holes are easy to reach, the third one is often less accessible. To install a Starter, the following tools are required: regular ratchet wrench, sockets, universal joint, socket extension and a single or double-end box wrench.
4. The efficiency of an Air Starter can be greatly impaired by an improper hook-up. Hoses smaller than those recommended will reduce the volume of air to the motor and the use of reducers for piped-away applications in the exhaust port will restrict the exhaust causing back pressure to the motor resulting in reduced performance. The number of tees and elbows, and the length of the supply line should be kept to a minimum. Use 3/4" (19 mm) hose or pipe, or larger, for supply lines.
5. A leak in any of the connections in live air lines means that the system will drain overnight and will have to be re-pressurized the next morning by use of another vehicle or compressor. Make your connections bubble tight to avoid unnecessary costs and delays. On all threaded connections throughout the system, use Ingersoll-Rand No. SMB-441 Sealant, non-hardening No. 2 Permatex or Loctite®* Pipe Sealant.
6. Always run the air supply line from the side or top of the receiver, never at or near the bottom. Moisture in the air collects at the bottom of the receiver resulting in damage which could cause the valves to become inoperative. Periodically open the petcock at the bottom of the tank to drain the water.

Mounting the Starter

1. Study the Piping Diagram (Figure 1). We strongly recommend that the Starter be connected exactly as shown.
2. The air receiver tank for a Starter installation must have a working pressure capability equal to or greater than the maximum pressure at which the Starter will be operated.

⚠ WARNING

Bleed off the air pressure through a valve or petcock. Do not remove a plug from the tank while the tank is still pressurized.

3. If you are going to connect to a receiver tank that is already in service, bleed off the air pressure by opening the drain valve. Drain off any water that may have accumulated in the bottom of the tank.
4. Using a 1-1/4" short nipple, install the SRV100 Starter Relay Valve on the end of the receiver tank as shown in the Figure 1.

NOTICE

Make certain the connection between the SRV100 Starter Relay and the Receiver Tank is made to the inlet side of the Relay Valve indicated by the word "IN" cast on the valve body.

5. Install the No. SMB-618 Starter Control Valve on the dash panel (for vehicular installations) or some other appropriate panel (for stationary installations).
6. Attach No. TA-STR-100 Starter Instruction Label to the control panel adjacent to the Starter Control Valve.
7. Mount the No. 150BMP-1064 Air Pressure Gauge on or adjacent to the control panel. It should be located where it is readily visible to the operator of the Control Valve.
8. Connect the Starter Control Valve to the Relay Valve with 1/4" hose. Install a Tee in this line with a short feeder hose to the Pressure Gauge.

NOTICE

When connecting the Starter Control Valve to the Relay Valve make certain the hose is connected to the "SUP" side of the Starter Control Valve.

* Registered trademark of Loctite Corporation.

PLACING STARTER IN SERVICE

9. Using a piece of heavy duty garden hose, or some other similar large diameter hose, run it from the Relay Valve on the receiver to the Starter location on the engine to determine the exact length of 3/4" hose required.
10. Attach the 3/4" hose to the outlet side of the Relay Valve, and run the hose through the frame, etc. to its final position at the Starter location.
11. At this point, determine whether or not it is feasible or practical to attach the hose to the Starter before or after the Starter is actually mounted. In many cases, it may be necessary to attach the hose to the Starter before mounting.
12. If practical, liberally grease the teeth on the ring gear with a good, sticky gear grease or motorcycle chain lubricant. This will help promote the life of the ring gear and the Starter Pinion.
13. Place the Starter into position, and mount it on the flywheel bell housing. Tighten the mounting bolts to 55–60 ft–lb (75–81 Nm) of torque.
14. Install a 1/4" hose line from the "DEL" side of the Starter Control Valve to the "IN" port on the Starter Drive Housing.
15. Install a 1/4" hose line from the "OUT" port on the Starter Drive Housing to the small pipe tapped port on top of the Starter Relay Valve.
16. If the exhaust is not to be piped away, install a No. 3BM-WM07 Muffler in the exhaust port on the Motor Housing of the Starter.
17. Pressurize the complete starting system and check every connection with a soap bubble test. There must be no leaks.

Orientation of the Starter

If the factory orientation will not fit your engine due to radial location of the Drive Housing, or location of the inlet and/or exhaust ports, reorient the Starter as follows:

1. Look at the dimension illustration (Figure 2) and note that the Drive Housing (19) can be located in any one of six (6) radial positions relative to the Motor Housing (8). The inlet (Motor Housing Cover (1)) can be located in any one of four radial positions relative to the exhaust ports (Motor Housing).

NOTICE

When rotating the Drive Housing and/or the Motor Housing, do not allow them to separate.

2. Study the engine mounting requirements and determine the required orientation of the Drive

Housing relative to the Motor Housing. If the Drive Housing has to be reoriented, remove the six (6) Drive Housing Cap Screws (26) and rotate the Drive Housing to its required position. Reinstall the Drive Housing Cap Screws and tighten them to 9 ft–lb (12.2 Nm) of torque.

NOTICE

When rotating the Drive Housing and/or the Motor Housing Cover, do not allow them to separate.

3. Now that you have the Drive Housing properly oriented relative to the Motor Housing, notice whether or not the exhaust port will be at the bottom, and whether or not the inlet port will be favorably located for hose installation. If either or both of these members must be reoriented, remove either the six Drive Housing Cap Screws or four Motor Housing Cover Cap Screws and rotate the Motor Housing and/or Motor Housing Cover to the desired position. Reinstall the Motor Housing cover Cap Screws and alternately tighten them to 9 ft–lb (12.2 Nm) torque.

Barring over the Engine

Occasionally, for setting injectors and/or for timing purposes, it may be desirable to bar over the engine in such a manner that any given piston can be stopped at any given location. This is very easily done with a 3BMG Starter.

1. Disconnect the 1/4" hose at the "OUT" portion the Drive Housing, and plug the hole in the Drive Housing with a 1/4" pipe plug.
2. Remove the 3/8" pipe plug from the center of the Motor Housing Cover.
3. Engage the Drive Pinion with the flywheel by applying pressure to the "IN" port on the Drive Housing.
4. Insert a 5/16" hexagonal wrench through the hole in the Motor Housing Cover to engage the hexagonal recess at the rear of the Rotor.
5. Manually, rotate the Rotor until the engine is cranked to its desired position.

Air or Gas Supply and Connections

Low pressure (under 150 psig; 10.3 bar/1034 kPa) reduces the speed of air tools. Low pressure not only wastes time, but also costs money. High pressure (over 150 psig 10.3 bar/1034 kPa) raises performance beyond the rated capacity of the tool and could cause injury.

Make sure all hoses and fittings are the correct size and are tightly secured. See Figure 1 for a typical piping arrangement.

PLACING STARTER IN SERVICE

GAS OPERATED STARTERS

⚠ WARNING

When repairing a gas operated starter or when converting a starter from air operation to gas operation, it is necessary to use Ingersoll-Rand No. SMB-431 Plastic Gasket as directed and the following procedures for assembly and testing must be followed exactly.

1. Inspect the Rotor (4). If it does not have a plastic plug, order and press in a No. 3BMG-531 Rotor Plug (5) for gas sealing.
2. If the shaft seal is being replaced, it must be installed with sealant between the seal outside diameter and housing bore. The lip of the seal must be inward toward the ball bearing.

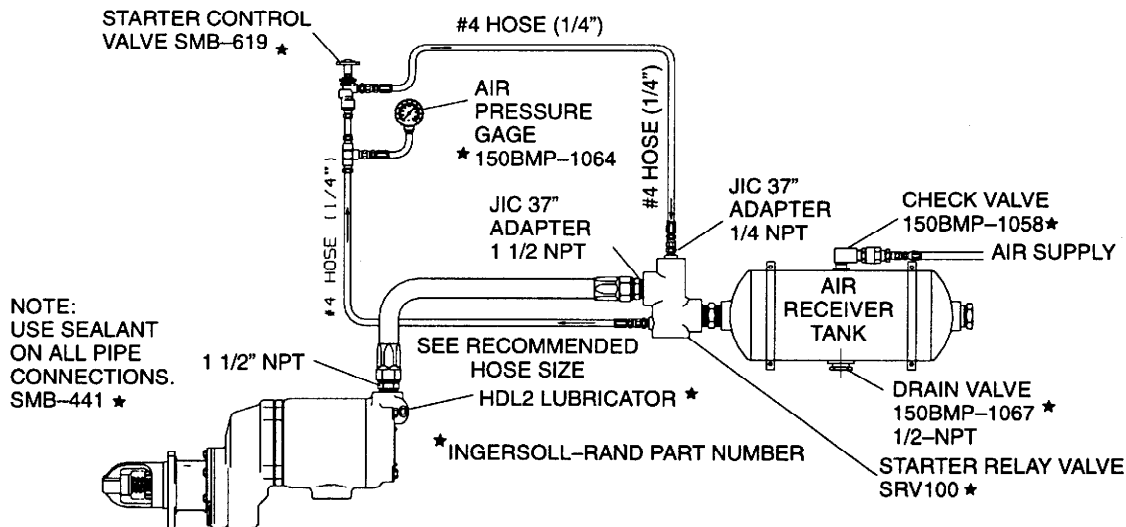
NOTICE

Do not allow the Plastic Gasket to get into the threaded holes.

3. Apply a thin film of Plastic Gasket between the Motor Housing Cover (1) and the Motor Housing (8). Apply the Cover to the Housing.

4. Apply Plastic Gasket to both sides of the copper sealing washers and under the head of the Motor Cover Cap Screws (28). Assemble, install and tighten to 100 in-lb (11.3 Nm) torque.
5. Plugs for the lubricator connection (2) will normally be supplied with sealant previously applied. When substitute plugs are used, Plastic Gasket must be applied to the threads.
6. Insert Plastic Gasket into each nameplate screw hole and install the Nameplate (30) and Screws (31).
7. Assemble the Drive Shaft (17), Starter Drive (16), Drive Shaft Key (15) and Drive Shaft Collar (14). Loctite the Drive Shaft Collar to the Drive Shaft after installing the Starter Drive.
8. Finish assembling using Plastic Gasket on the threads of the Drive Housing Cap Screws (26) and on both sides of the Housing Cap Screw Lock Washers (27).
9. Allow four hours drying time.
10. Screw a 1" pipe plug into the exhaust port.
11. Connect gas line to the inlet, regulate the air pressure to 40 psig (2.8 bar/280 kPa) and immerse the unit for 30 seconds in light oil or non-flammable solvent. If there are any bubbles, the unit is not safe for gas operation.

PIPING DIAGRAM



THE PERFORMANCE OF THE STARTER IS DEPENDENT ON THE PRESSURE AT THE INLET OF THE STARTER. THIS PRESSURE IS EFFECTED BY THE PRESSURE DROP BETWEEN THE AIR RECEIVER TANK AND THE STARTER. THE MOST SIGNIFICANT PRESSURE DROPS WILL OCCUR IN FITTINGS (VALVES, TEES, ELBOWS, ETC.). THE NEXT SIGNIFICANT SOURCE OF PRESSURE DROP IS THE HOSE. VALVES (SRV) SIZES FOR TYPICAL ONE STARTER INSTALLATIONS. SYSTEMS WITH MANY FITTINGS OR LONG HOSES SHOULD BE ANALYZED & SIZED INDIVIDUALLY.

STARTER	HOSE LGTH.	HOSE SIZE	SRV SIZE
3BMG	0-30'	#12 (3/4")	SRV100

Figure 1

(Dwg. TPC597)

PLACING STARTER IN SERVICE

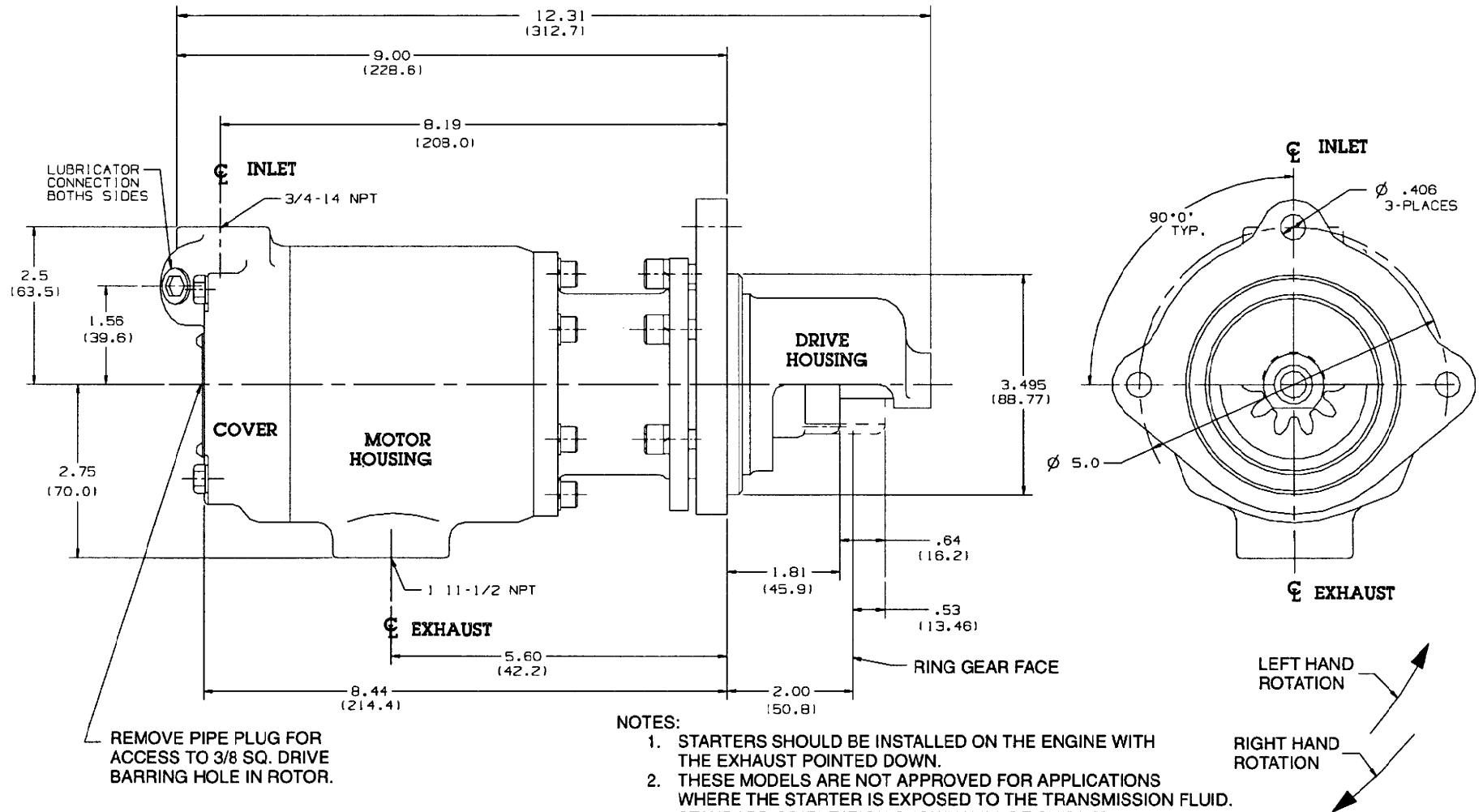
Series 3BMG Starters are designed for air or gas operation in off-highway, marine, and stationary applications.

HOW TO ORDER A STARTER

SERIES 3BMG STARTER

Model	Teeth/Blank	Pinion Drive		
		D.P./Module	P.A.	Rotation
3BMGA11RH-1F	12/13	8/10	20	R
3BMGA11RH-12F	12/13	8/10	20	R
3BMGA11RH-34F	10/11	8/10	20	R
3BMGA11RH-6F	9/10	8/10	20	R

3BMG MOUNTING DIMENSIONS

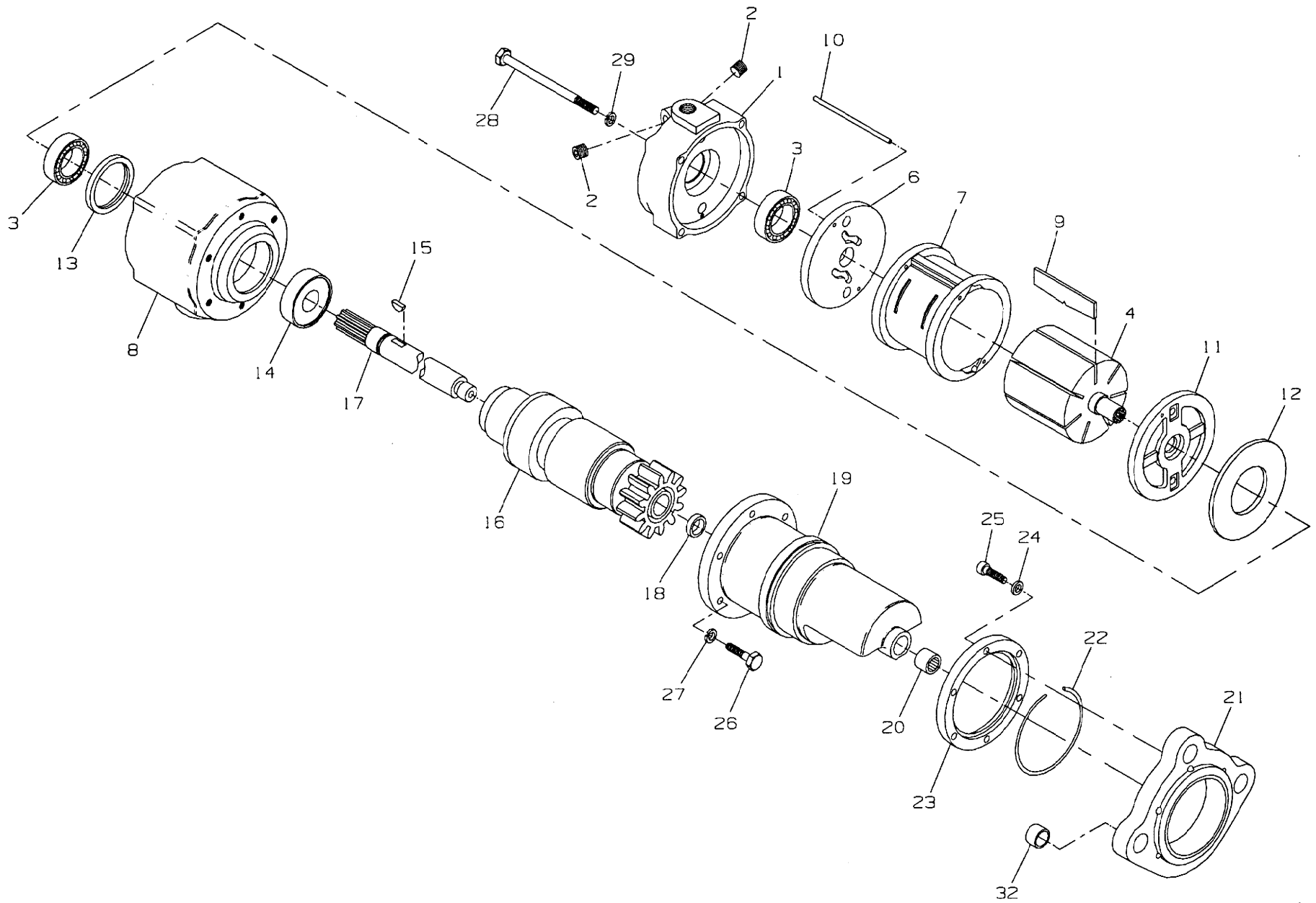


DUAL IN
DIMENSIONS (MM)

Figure 2

(Dwg. TPA1371-1)

SERIES 3BMG AIR AND GAS STARTERS



(Dwg. TPA497-4)

MAINTENANCE SECTION

WARNING

Always wear eye protection when operating or performing maintenance on this starter.

Always turn off air or gas supply and disconnect supply hose before installing, removing or adjusting any accessory on this starter, or before performing any maintenance on this starter.

LUBRICATION

Each time the Series 3BMG Starters are disassembled for maintenance, repair or replacement of parts, lubricate the starter as follows:

For temperatures above 32° F (0° C), use a good quality SAE 20 non-detergent motor oil.

For temperatures below 32° F (0° C), use diesel fuel.

CAUTION

When an HDL2 Lubricator is used, make certain that the oil supply line pressure is no greater than 5 psi. If there is pressure on the line, the Lubricator will continuously leak lubricant through the Starter and out the exhaust.

Either one of two lubrication systems is recommended. For typical Starter installations where the cranking cycle is less than 10 seconds, we recommend an Ingersoll-Rand No. HDL2 Lubricator. Use either diesel fuel or 20W non-detergent motor oil for lubricant. If the cranking cycle is more than 10 seconds, we recommend the Ingersoll-Rand No. NL-24-8 Lubricator installed in the main air supply line. Use a good quality 20W non-detergent oil and adjust the Lubricator to flow 1 to 3 drops per second.

DISASSEMBLY

General Instructions

1. Do not disassemble the Starter any further than necessary to replace or repair damaged parts.
2. Whenever grasping a part in a vise, always use leather-covered or copper-covered vise jaws to protect the surface of the part and help prevent distortion. This is particularly true of threaded members and housings.
3. Do not remove any part which is a press fit in or on a subassembly unless the removal of that part is necessary for repairs or replacement.
4. Always have a complete set of seals and O-rings on hand before starting any overhaul of Series 3BMG Starters. Never reuse old seals or gaskets.
5. Always mark adjacent parts so that these members can be located in the same relative position when the Starter is reassembled.

6. Never wash the Starter Drive in solvent.
7. Do not press any needle bearing from a part unless you have a new needle bearing on hand for installation. Needle bearings are always damaged during the removal process.

Disassembly of the Motor Housing

1. If replacing the motor assembly, remove the Plugs (2) and allow any oil to drain.
2. Unscrew the Motor Housing Cover Cap Screws (28).
3. Separate the Motor Housing Cover (1) from the Motor Housing (8).
4. Remove the Rear End Plate (6) and the Cylinder Dowel (10).
5. If required, remove the Rotor Bearing (3) from the Motor Housing Cover.
6. Remove the Rotor (4) and Vanes (9) from the Cylinder (7).
7. Work the Cylinder from the Motor Housing. Remove the Front End Plate (11), Front Motor Gasket (12), Rotor Bearing (3), and the Seal (13) from the Motor Housing.

Disassembly of the Drive Housing

1. Separate the Drive Housing (19) from the Motor Housing (8) by removing the Drive Housing Cap Screws (26).
2. Remove the Starter Drive (16) from the Drive Housing.
3. Pull the Drive Shaft (17) from the Starter Drive. Do not lose the Drive Shaft Key (15) and the Drive Shaft Thrust Washer (18).
4. If required, unscrew the Mounting Flange Cap Screw (25), remove the Mounting Flange (21), Mounting Flange Snap Ring (22), and the Mounting Flange Clamp Ring (23).

ASSEMBLY

General Instructions

1. Always press on the **inner** ring of a ball-type bearing when installing the bearing on a shaft.
2. Always press on the **outer** ring of a ball-type bearing when pressing the bearing into a bearing recess.
3. Whenever grasping a starter or part in a vise, always use leather-covered or copper-covered vise jaws. Take extra care with threaded parts and housings.
4. Always clean every part and wipe every part with a thin film of oil before installation.
5. Check every bearing for roughness. If an open bearing must be cleaned, wash it thoroughly in a suitable cleaning solution and dry with a clean cloth. **Sealed or shielded bearing should never be cleaned.** Work grease thoroughly into every open bearing before installation.

MAINTENANCE SECTION

6. Apply a film of O-ring lubricant to all O-rings before final assembly.
7. Unless otherwise noted, always press on the stamped end of a needle bearing when installing the needle bearing in a recess. Use a bearing inserting tool similar to the one shown in Dwg. TPD786.

Needle Bearing Inserting Tool

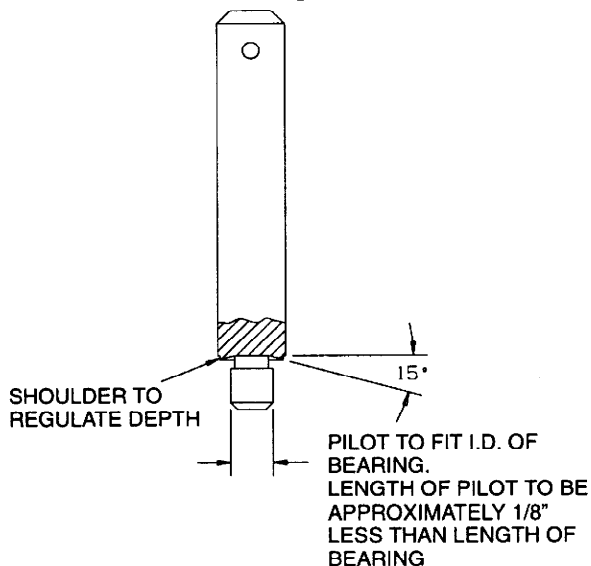


Figure 3

(Dwg. TPD786)

Assembly of the Drive Housing

1. With the Drive Shaft Key (15) in the keyway in the Drive Shaft (17), insert the Drive Shaft into the Starter Drive (16).
2. Place the Drive Shaft Thrust Washer (18) on the geared end of the Drive Shaft.
3. Using a needle bearing inserting tool, press the Drive Housing Bearing (20), unstamped end first, into the Drive housing (19) until the trailing face of the Bearing is flush with the bearing recess. Refer to Figure 3.

4. Carefully insert the Drive Shaft/Starter Drive into the Drive Housing. Make sure that the end of the Drive Shaft goes through the Drive Housing Bearing.
5. If required, replace the Drive Shaft Collar (14) into the Motor Housing (8).
6. Secure the Drive Housing to the Motor Housing with the Drive Housing Cap Screws (26). Tighten to 9 ft-lb (12.2 Nm) torque.
7. If required, place the Mounting Flange Clamp Ring (23), the Mounting Flange Snap Ring (22), and the Mounting Flange (21) onto the Drive Housing. Secure the Clamp Ring to the Mounting Flange with the Mounting Flange Cap Screws (25). Tighten to 18 ft-lb (24.4 Nm) torque.

Assembly of the Motor Housing

1. Place the Seal (13) and the Rotor Bearing (3) into the Motor Housing (8).
2. Reinstall the Front Motor Gasket (12) and the Front End Plate (11) into the Housing.
3. Aligning the Cylinder Dowel holes in the Cylinder (7) and the Front End Plate, work the Cylinder into the Housing.
4. Place the Cylinder Dowel (10) through the Cylinder and the Front End Plate.
5. Place the Rotor (4) into the Motor Housing.
6. Reinstall lightly lubricated Vanes (9) into the slots in the Rotor.
7. If required, replace the Rotor Bearing (3) into the Motor Housing Cover (1).
8. Reinstall the Rear End Plate (6). Make sure that the Cylinder Dowel goes through the dowel hole in the End Plate.
9. Secure the Motor Housing Cover to the Motor Housing with the Motor Housing Cover Cap Screws (28). Tighten to 9 ft-lb (12.2 Nm) torque.

MAINTENANCE SECTION

TROUBLESHOOTING GUIDE

Trouble	Probable Cause	Solution
Motor will not run	No air or gas supply	Check for blockage or damage to supply lines or tank.
	Damaged Motor Assembly	Inspect Motor Assembly and power train and repair or replace if necessary.
	Foreign material in Motor and/or piping	Remove Motor Assembly and/or piping and remove blockage.
	Blocked exhaust system	Remove housing exhaust cover and check for blockage.
	Defective Control Valve or Relay Valve	Replace Control Valve or Relay Valve.
Loss of Power	Low air or gas pressure to Starter	Check air or gas supply.
	Restricted air or gas supply line	Check for blockage or damage to air or gas lines.
	Relay Valve malfunctioning	Clean or replace lines or Relay Valve. Lube Relay Valve.
	Exhaust flow restricted	Check for blocked or damaged piping. Clean or replace piping. Check for dirt or foreign material and clean or remove. Check for ice build-up. Melt ice and reduce moisture build-up to Starter.
	Damaged Motor Assembly	Replace Motor Assembly.

NOTICE

SAVE THESE INSTRUCTIONS. DO NOT DESTROY.

When the life of the starter has expired, it is recommended that the starter be disassembled, degreased and parts be separated by material so that they can be recycled.

SERVICE & OPERATING MANUAL



Model G1F Metallic Design Level 1

Certified to CSA Requirement 2.01 U.S. for natural gas operated diaphragm pumps.

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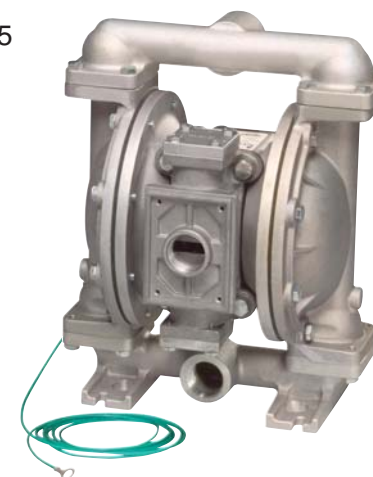
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II 2GD b T5



U.S. Patent #
5,996,627; 6,241,487
Other U.S. Patents
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**WARREN
RUPP®**

Quality System
ISO9001 Certified

Environmental
Management System
ISO14001 Certified

IDEX
IDEX CORPORATION



II 2GD b T5



U.S. Patent #
5,996,627; 6,241,487
Other U.S. Patents
Applied for



SANDPIPER®
A WARREN RUPP PUMP BRAND

G1F Metallic
Certified to CSA
Requirement 2.01 U.S.
for natural gas operated
diaphragm pumps.

ENGINEERING, PERFORMANCE
& CONSTRUCTION DATA

INTAKE/DISCHARGE PIPE SIZE 1" NPT(internal) 1" BSPT Tapered (internal)	CAPACITY 0 to 45 gallons per minute (0 to 170 liters per minute)	GAS VALVE No-lube, no-stall design	SOLIDS-HANDLING Up to .25 in. (6mm)	HEADS UP TO 125 psi or 289 ft. of water (8.6 Kg/cm ² or 86 meters)	DISPLACEMENT/STROKE .11 Gallon / .42 liter
⚠ CAUTION! Operating temperature limitations are as follows: Materials					
Buna N General purpose, oil-resistant. Shows good solvent, oil, water and hydraulic fluid resistance. Should not be used with highly polar solvents like acetone and MEK, ozone, chlorinated hydrocarbons and nitro hydrocarbons. Virgin PTFE Chemically inert, virtually impervious. Very few chemicals are known to react chemically with PTFE: molten alkali metals, turbulent liquid or gaseous fluorine and a few fluoro-chemicals such as chlorine trifluoride or oxygen difluoride which readily liberate free fluorine at elevated temperatures.				Operating Temperatures	
				Maximum	Minimum
				190°F 88°C	-10°F -23°C
				220°F 104°C	-35°F -37°C

For specific applications, always consult "Chemical Resistance Chart" Technical Bulletin

These G1F SANDPIPER® models are designed to be powered only by natural gas.

Explanation of Pump Nomenclature

G1F Metallic · Design Level 1· Ball Valve

MODEL	Pump Brand	Pump Size	Check Valve Type	Design Level	Wetted Material	Diaphragm/ Check Valve Materials	Check Valve Seat	Non-Wetted Material Options	Porting Options	Pump Style	Pump Options	Kit Options	Shipping Weight lbs. (kg)
G1FB1ABTXNSX00.	G	1F	B	1	A	B	T	X	N	S	X	00.	28 (13)
G1FB1ATTXNSX00.	G	1F	B	1	A	T	T	X	N	S	X	00.	28 (13)
G1FB1SBTXNSX00.	G	1F	B	1	S	B	T	X	N	S	X	00.	43 (20)
G1FB1STTXNSX00.	G	1F	B	1	S	T	T	X	N	S	X	00.	43 (20)
G1FB1ABTXBSX00.	G	1F	B	1	A	B	T	X	B	S	X	00.	28 (13)
G1FB1ATTXBSX00.	G	1F	B	1	A	T	T	X	B	S	X	00.	28 (13)
G1FB1SBTXBSX00.	G	1F	B	1	S	B	T	X	B	S	X	00.	43 (20)
G1FB1STTXBSX00.	G	1F	B	1	S	T	T	X	B	S	X	00.	43 (20)

Pump Brand

G= Sweet Gas Operated

Pump Size

1F=1"

Check Valve Type

B= Ball

Design Level

1= Design Level

Wetted Material

S= Stainless Steel

A= Aluminum

Diaphragm Check Ball Materials

B= Buna/Buna

T=PTFE -Buna/PTFE

Check Valve Seat

T= Virgin PTFE

A= Aluminum

S= Stainless Steel

Non-Wetted Material Options

X= Unpainted Aluminum

Porting Options

N=NPT Threads

B= BSPT (Tapered) Threads

Pump Style

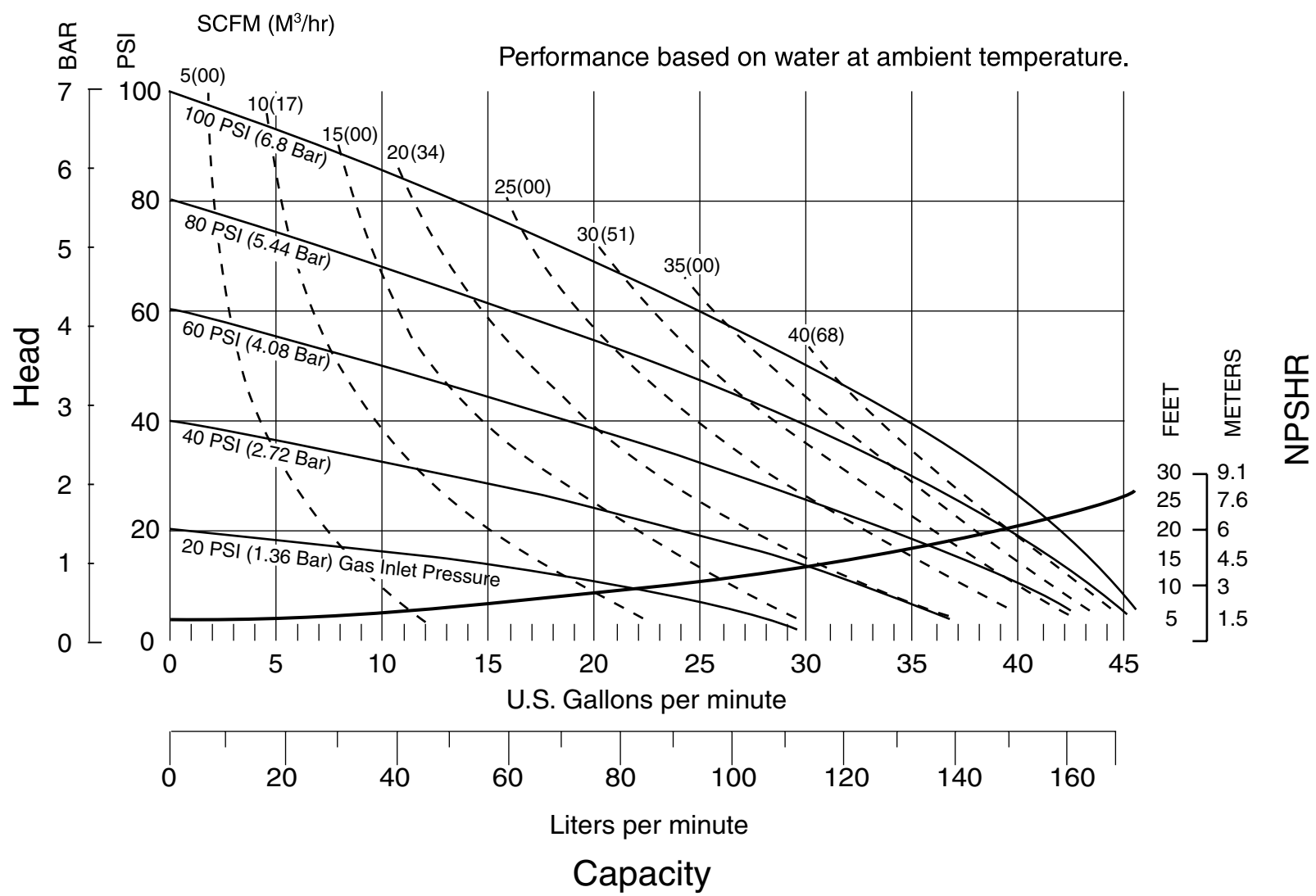
S= Standard

Pump Options

X= No Muffler

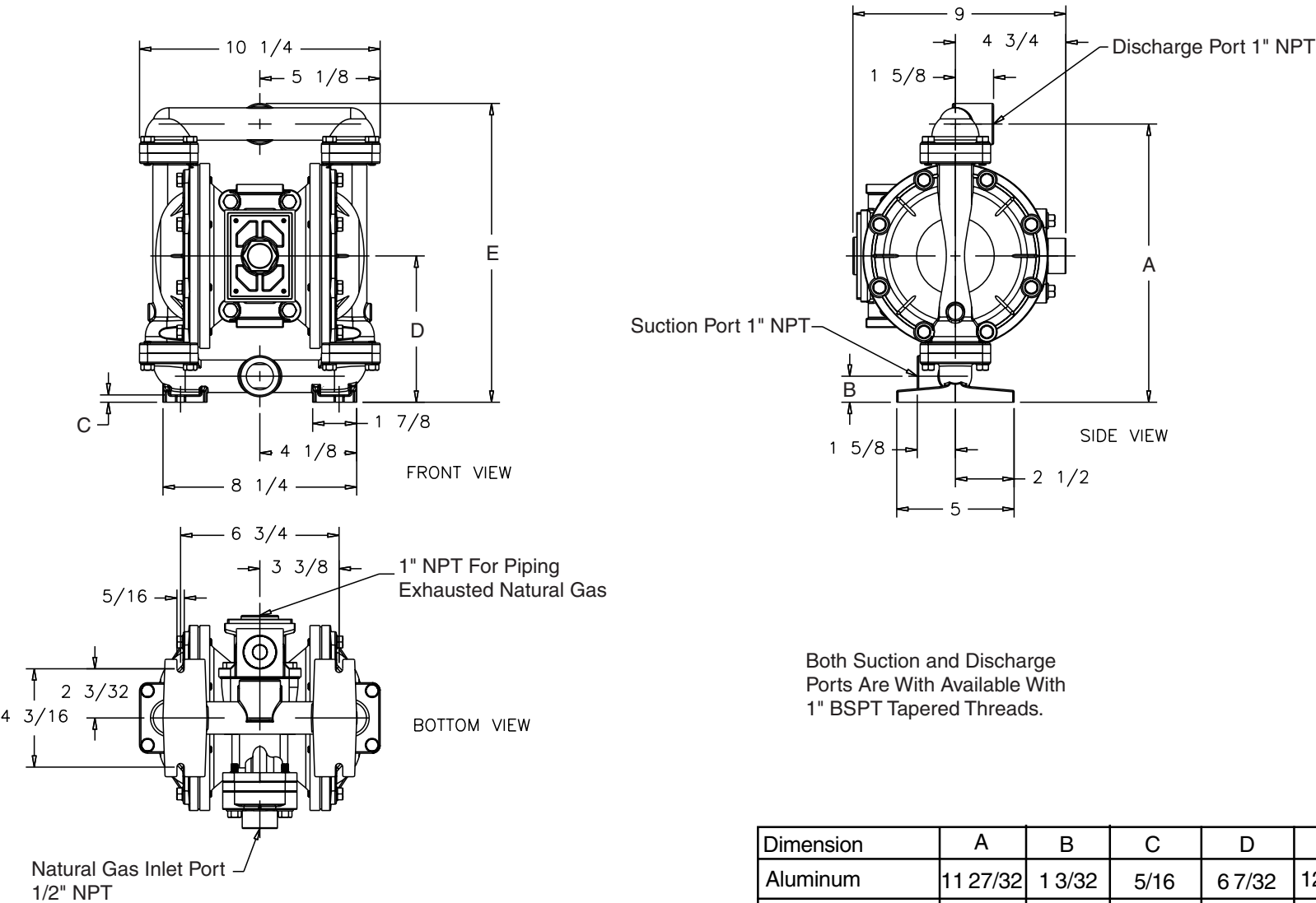
These pump models are designed to pump the following fluids:
Crude Oil, Salt Water, Drilling Mud, Condensate, Lubrication Oils,
Glycol, Caustic liquids, and Acids.

Performance Curve, G1F Model Metallic Design Level 1



Dimensions: G1F Model Metallic

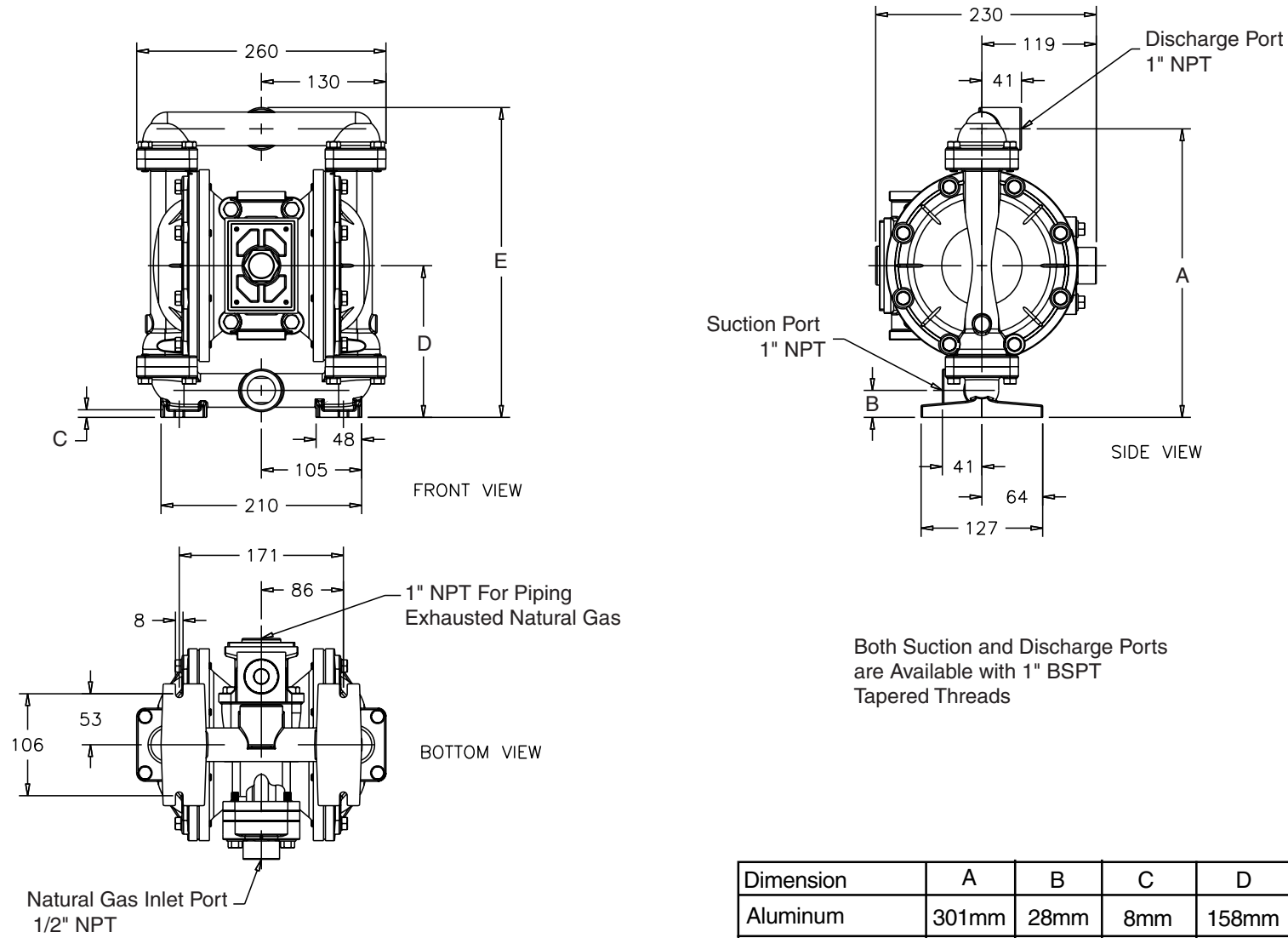
Dimensions in Inches
Dimensional Tolerance: $\pm 1/8$ "



Dimension	A	B	C	D	E
Aluminum	$11 \frac{27}{32}$	$1 \frac{3}{32}$	$5/16$	$6 \frac{7}{32}$	$12 \frac{23}{32}$
Stainless Steel	$11 \frac{31}{32}$	$1 \frac{7}{32}$	$7/16$	$6 \frac{11}{32}$	$12 \frac{27}{32}$

Metric Dimensions: G1F Model Metallic

Dimensions in Millimeters
Dimensional Tolerance:± 3mm



Dimension	A	B	C	D	E
Aluminum	301mm	28mm	8mm	158mm	323mm
Stainless Steel	304mm	31mm	11mm	161mm	326mm

PRINCIPLE OF PUMP OPERATION

This ball type check valve pump is powered by sweet natural gas and is a 1:1 ratio design. The inner side of one diaphragm chamber is alternately pressurized while simultaneously exhausting the other inner chamber. This causes the diaphragms, which are connected by a common rod secured by plates to the centers of the diaphragms, to move in a reciprocating action. (As one diaphragm performs the discharge stroke the other diaphragm is pulled to perform the suction stroke in the opposite chamber.) Gas pressure is applied over the entire inner surface of the diaphragm while liquid is discharged from the opposite side of the diaphragm. The diaphragm operates in a balanced condition during the discharge stroke which allows the pump to be operated at discharge heads over 200 feet (61 meters) of water.

For maximum diaphragm life, keep the pump as close to the liquid being pumped as possible. Positive suction head in excess of 10 feet of liquid (3.048 meters) may require a back pressure regulating device to maximize diaphragm life.

Alternate pressurizing and exhausting of the diaphragm chamber is performed by an externally mounted, pilot operated, four way spool type gas distribution valve. When the spool shifts to one end of the valve body, inlet pressure is applied to one diaphragm chamber and the other diaphragm chamber exhausts. When the spool shifts to the opposite end of the valve

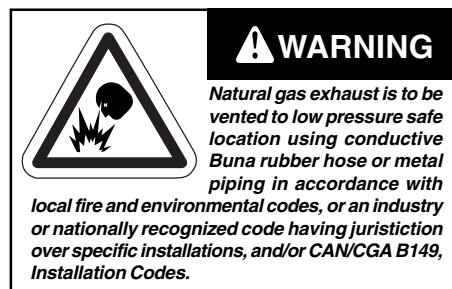
body, the pressure to the chambers is reversed. The gas distribution valve spool is moved by a internal pilot valve which alternately pressurizes one end of the valve while exhausting the other end. The pilot valve is shifted at each end of the diaphragm stroke when a actuator plunger is contacted by the diaphragm plate. This actuator plunger then pushes the end of the pilot valve spool into position to activate the gas distribution valve.

The chambers are connected with manifolds with a suction and discharge check valve for each chamber, maintaining flow in one direction through the pump.

INSTALLATION AND START-UP

Locate the pump as close to the product being pumped as possible. Keep the suction line length and number of fittings to a minimum. Do not reduce the suction line diameter.

For installations of rigid piping, short sections of flexible conductive hose should be installed between the pump and the piping. The flexible conductive hose reduces vibration and strain to the pumping system. A surge suppressor is recommended to further reduce pulsation in flow.



NATURAL GAS SUPPLY

Natural gas inlet pressure must be regulated to 100 (7 bar) psi with a pressure regulator. Connect the pump gas inlet to an gas supply of sufficient capacity and pressure required for desired performance. When the gas supply line is solid piping, use a short length of flexible conductive hose not less than 3/4" (19mm) in diameter between the pump and the piping to reduce strain to the piping. The weight of the gas supply line, regulators and filters must be supported by some means other than the gas inlet cap. Failure to provide support for the piping may result in damage to the pump. A pressure regulating valve should be installed to insure gas supply pressure does not exceed recommended limits.

VALVE LUBRICATION

The natural gas distribution valve and the pilot valve are designed to operate WITHOUT lubrication. This is the preferred mode of operation. There may be instances of personal preference or poor quality gas supplies when lubrication of the supply is required. The pump system will operate with properly lubricated supply. Proper lubrication requires the use of an gas line lubricator (available from Warren Rupp) set to deliver one drop of SAE 10 non-detergent oil for every 20 SCFM (9.4 liters/sec.) of gas the pump consumes at the point of operation. Consult the pump's published Performance Curve to determine this.

GAS INLET AND PRIMING

To start the pump, open the gas valve approximately 1/2" to 3/4" turn. After the pump primes, the valve can be opened to increase gas flow as desired. If opening the valve increases cycling rate, but does not increase the rate of flow, cavitation has occurred. The valve should be closed slightly to obtain the most efficient gas flow to pump flow ratio.

BETWEEN USES

When the pump is used for materials that tend to settle out or solidify when not in motion, the pump should be flushed after each use to prevent damage. (Product remaining in the pump between uses could dry out or settle out. This could cause problems with the diaphragms and check valves at restart.) In freezing temperatures the pump must be completely drained between uses in all cases.

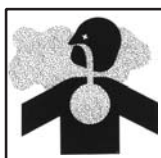


INSTALLATION GUIDE

Top Discharge Ball Valve Pump



Available from Warren Rupp



CAUTION

The natural gas exhaust must be piped to an area for safe disposition of the product being pumped, in the event of a diaphragm failure. (See page 21)

1

020.063.000. Filter

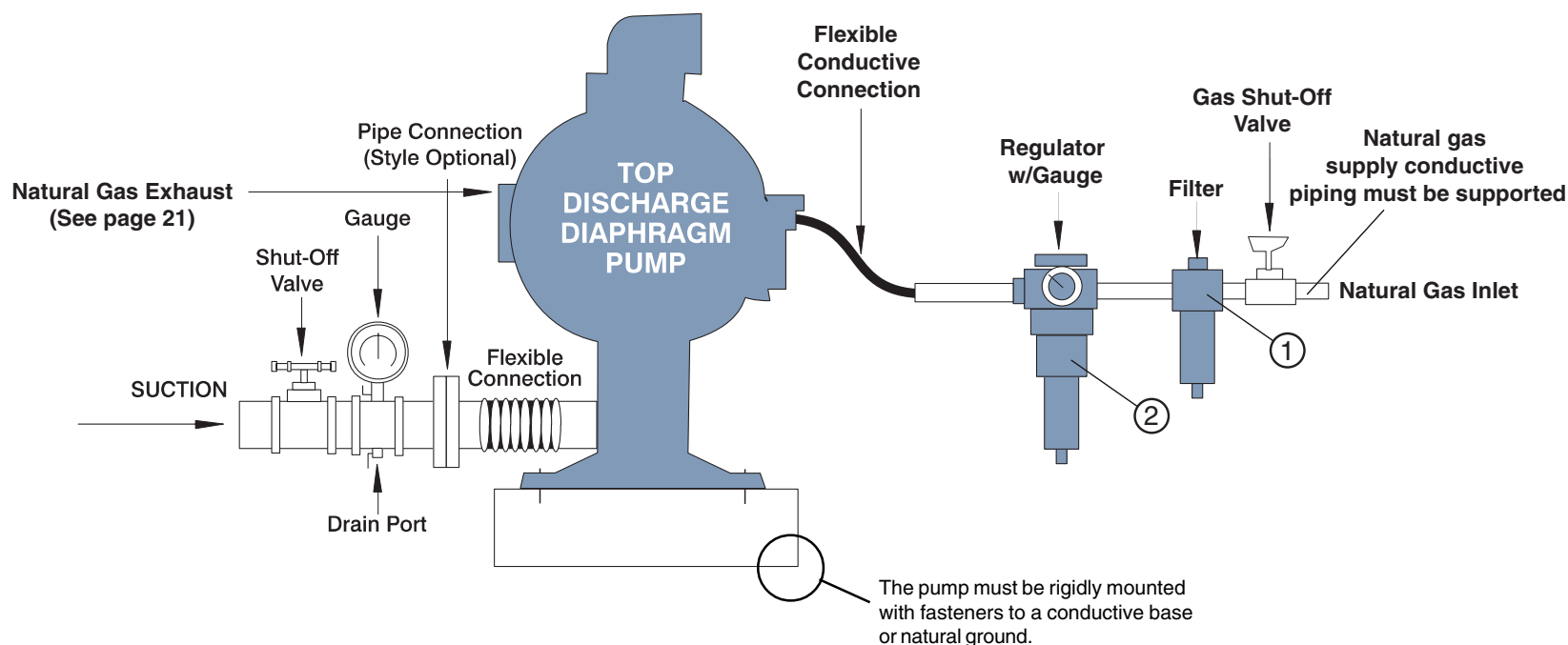
VENTING WARNING: This filter is equipped with a stainless steel manual drain. The port is 1/8" NPT. When draining moisture from the filter, first shut off the natural gas supply.

2

020.058.000. REGULATOR WITH GAGE

PRESSURE WARNING: This regulator is to be installed at point of use with the pump. The maximum gas supply is 400psi. Full line pressure needs to be regulated below 400psi prior to the regulator installation position.

VENTING WARNING: This regulator is equipped with a 1/8" NPT vent port. In the event of a diaphragm rupture, natural gas can be exhausted into the surrounding environment. Connect a conductive hose or pipe to the vent port to send the escaping natural gas to a safe area for gas reclamation. Make sure to ground the regulator, hose, and/or pipe.



TROUBLESHOOTING

Possible Symptoms:

- Pump will not cycle.
- Pump cycles, but produces no flow.
- Pump cycles, but flow rate is unsatisfactory.
- Pump cycle seems unbalanced.
- Pump cycle seems to produce excessive vibration.

What to Check: Excessive suction lift in system.

Corrective Action: For lifts exceeding 20 feet (6 meters), filling the pumping chambers with liquid will prime the pump in most cases.

What to Check: Excessive flooded suction in system.

Corrective Action: For flooded conditions exceeding 10 feet (3 meters) of liquid, install a back pressure device.

What to Check: System head exceeds natural gas supply pressure.

Corrective Action: Increase the inlet gas pressure to the pump. Most diaphragm pumps are designed for 1:1 pressure ratio at zero flow.

What to Check: Natural gas supply pressure or volume exceeds system head.

Corrective Action: Decrease inlet gas pressure and volume to the pump as calculated on the published PERFORMANCE CURVE. Pump is cavitating the fluid by fast cycling.

What to Check: Undersized suction line.

Corrective Action: Meet or exceed pump connection recommendations shown on the DIMENSIONAL DRAWING.

What to Check: Restricted or undersized gas line.

Corrective Action: Install a larger gas line and connection. Refer to gas inlet recommendations shown in your pump's SERVICE MANUAL.

What to Check: Check the externally serviceable gas distribution system of the pump.

Corrective Action: Disassemble and inspect the natural gas distribution valve, pilot valve and pilot valve actuators. Refer to the parts drawing and valve section of the SERVICE MANUAL. Check for clogged discharge or closed valve before reassembly.

What to Check: Pumped fluid in gas exhaust line.

Corrective Action: Disassemble pump chambers. Inspect for diaphragm rupture or loose diaphragm plate assembly. Refer to the Diaphragm Replacement section of your pump SERVICE MANUAL.

What to Check: Fluid suction side air leakage or air in product.

Corrective Action: Visually inspect all suction side gaskets and pipe connections.

What to Check: Obstructed check valve.

Corrective Action: Disassemble the wet end of the pump and manually dislodge obstruction in the check valve pocket. Refer to the Check Valve section of the pump SERVICE MANUAL for disassembly instructions.

What to Check: Worn or misaligned check valve or check valve seat.

Corrective Action: Inspect check valves and seats for wear and proper seating. Replace if necessary. Refer to Check Valve section of the pump SERVICE MANUAL for disassembly instructions.

What to Check: Blocked suction line.

Corrective Action: Remove or flush obstruction. Check and clear all suction screens and strainers.

What to Check: Blocked discharge line.

Corrective Action: Check for obstruction or closed discharge line valves.

What to Check: Blocked pumping chamber.

Corrective Action: Disassemble and inspect the wetted chambers of the pump. Remove or flush any obstructions. Refer to the pump SERVICE MANUAL for disassembly instructions.

What to Check: Entrained air or vapor lock in one or both fluid pumping chambers.

Corrective Action: Purge chambers through tapped chamber vent plugs. PURGING THE CHAMBERS OF AIR CAN BE DANGEROUS! Contact the Warren Rupp Technical Services Group before performing this procedure. Any model with top-ported discharge will reduce or eliminate problems with entrained air.

If your pump continues to perform below your expectations, contact your local Warren Rupp Distributor or factory Technical Services Group for a service evaluation.

WARRANTY

Refer to the enclosed Warren Rupp Warranty Certificate.

RECYCLING

Many components of Natural Gas Operated SANDPIPER® Metallic pumps are made of recyclable materials (see chart on page 10 for material specifications). We encourage pump users to recycle worn out parts and pumps whenever possible, after any hazardous pumped fluids are thoroughly flushed.



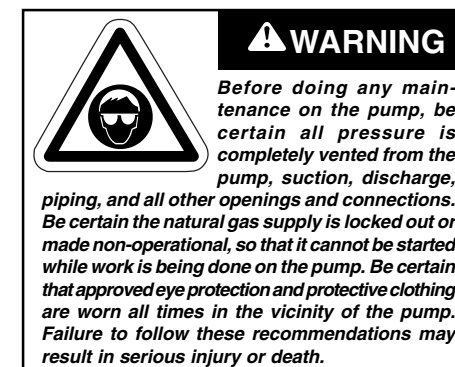
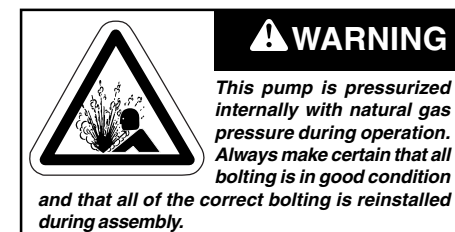
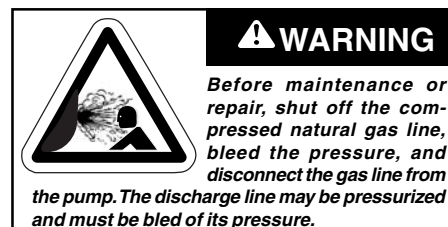
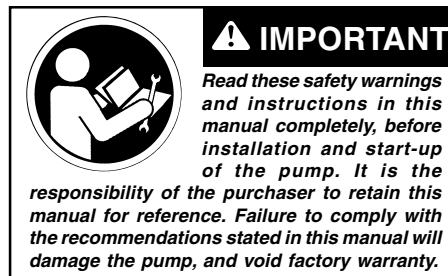
Pump complies with EN809 Pumping Directive, Directive 98/37/EC Safety of Machinery, and Directive 94/9/EC Equipment for use in Potentially Explosive Environments. For reference to the directive certificates visit: www.warrenrupp.com. The technical file is stored at KEMA, notified body 0344, under document #203040000.



II 2GD b T5



IMPORTANT SAFETY INFORMATION



NATURAL GAS DISTRIBUTION VALVE SERVICING

To service the natural gas valve first shut off the compressed air, bleed pressure from the pump, and disconnect the gas supply line from the pump.

Step #1: See COMPOSITE REPAIR PARTS DRAWING.

Using a 9/16" wrench or socket, remove the four hex capscrews (items 12). Remove the air valve assembly from the pump.

Remove and inspect gasket (item 16) for cracks or damage. Replace gasket if needed.

Step #2: Disassembly of the natural gas valve.

Using a 7/16" wrench or socket, remove the eight hex capscrews (items 1-F) that fasten the end caps to the valve body. Next remove the two end caps (items 1-E). Inspect the two o-rings (items 1-D) on each end cap for damage or wear. Replace the o-rings as needed.

Remove the bumpers (items 1-C). Inspect the bumpers for damage or wear. Replace the bumpers as needed.

Remove the spool (part of item 1-B) from the sleeve. Be careful not to scratch or damage the outer diameter of the spool. Wipe spool with a soft cloth and

inspect for scratches or wear.

Inspect the inner diameter of the sleeve (part of item 1-B) for dirt, scratches, or other contaminants. Remove the sleeve if needed and replace with a new sleeve and spool set (item 1-A).

Step #3: Reassembly of the natural gas valve.

Install one bumper (item 1-C) and one end cap (item 1-E), with two o-rings (items 1-D), and fasten with four hex capscrews (items 1-F) to the valve body (item 1-A).

Remove the new sleeve and spool set (item 1-B) from the plastic bag. Carefully remove the spool from the sleeve. Install the six o-rings (item 1-D) into the six grooves on the sleeve. Apply a light coating of grease to the o-rings before installing the sleeve into the valve body (item 1-A), align the slots in the sleeve with the slots in the valve body. Insert the spool into the sleeve. Be careful not to scratch or damage the spool during installation. Install the remaining bumper and end cap (with o-rings), and fasten with the remaining hex capscrews.

Fasten the natural gas valve assembly (item 1) and gasket to the pump. Connect the compressed gas line to the pump. The pump is now ready for operation.



! IMPORTANT

Read these instructions completely, before installation and start-up. It is the responsibility of the purchaser to retain this manual for reference. Failure to comply with the recommendations stated in this manual will damage the pump, and void factory warranty.

Pilot Valve Servicing, Assembly Drawing & Parts List

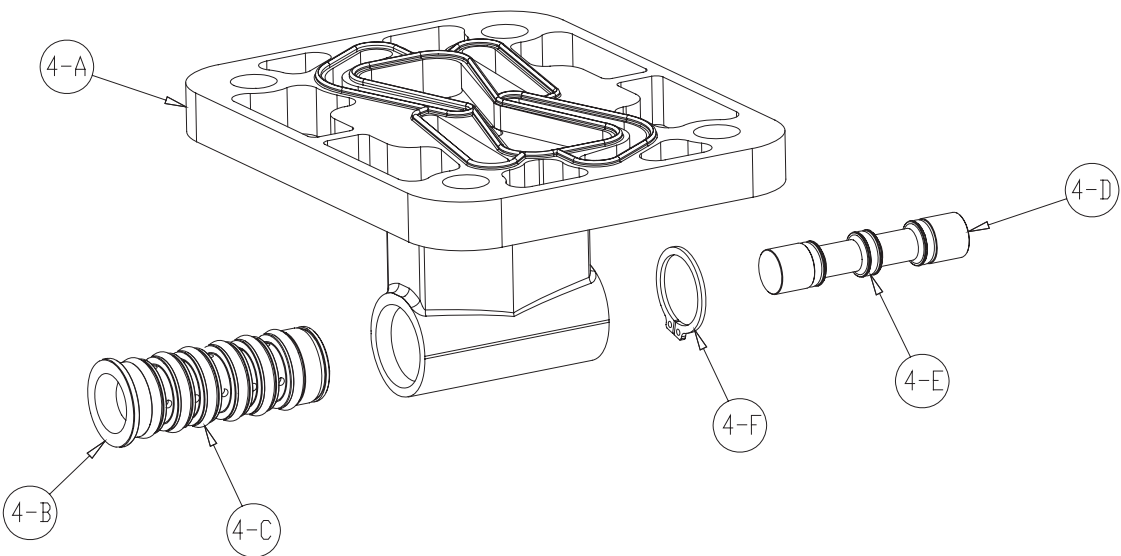
PILOT VALVE ASSEMBLY PARTS LIST

ITEM	PART NUMBER	DESCRIPTION	QTY
4	095-110-000	Pilot Valve Assembly	1
4-A	095-095-157	Valve Body	1
4-B	755-051-000	Sleeve (With O-rings)	1
4-C	560-033-379	O-ring (Sleeve)	6
4-D	775-055-000	Spool (With O-rings)	1
4-E	560-023-379	O-ring (Spool)	3
4-F	675-037-080	Retaining Ring	1

FOR PUMPS WITH CAST IRON CENTER SECTION

ITEM	PART NUMBER	DESCRIPTION	QTY
4	095-110-558	Pilot Valve Assembly	1
4-A	095-095-558	Valve Body	1

(includes all other items used on 095-110-000)



PILOT VALVE SERVICING

To service the pilot valve first shut off the compressed air supply, bleed the pressure from the pump, and disconnect the air supply line from the pump.

STEP #1: See pump assembly drawing.

Using a 1/2" wrench or socket, remove the four capscrews (item 11). Remove the air inlet cap (item 8) and air inlet gasket (item 18). The pilot valve assembly (item 4) can now be removed for inspection and service.

STEP #2: Disassembly of the pilot valve.

Remove the pilot valve spool (item 4-D). Wipe clean and inspect spool and o-rings for dirt, cuts or wear. Replace the o-rings and spool if necessary.

Remove the retaining ring (item 4-F) from the end of the sleeve (item 4-B) and remove the sleeve from the valve body (item 4-A). Wipe clean and inspect sleeve and o-rings for dirt, cuts or wear. Replace the o-rings and sleeve if necessary.

STEP #3: Re-assembly of the pilot valve.

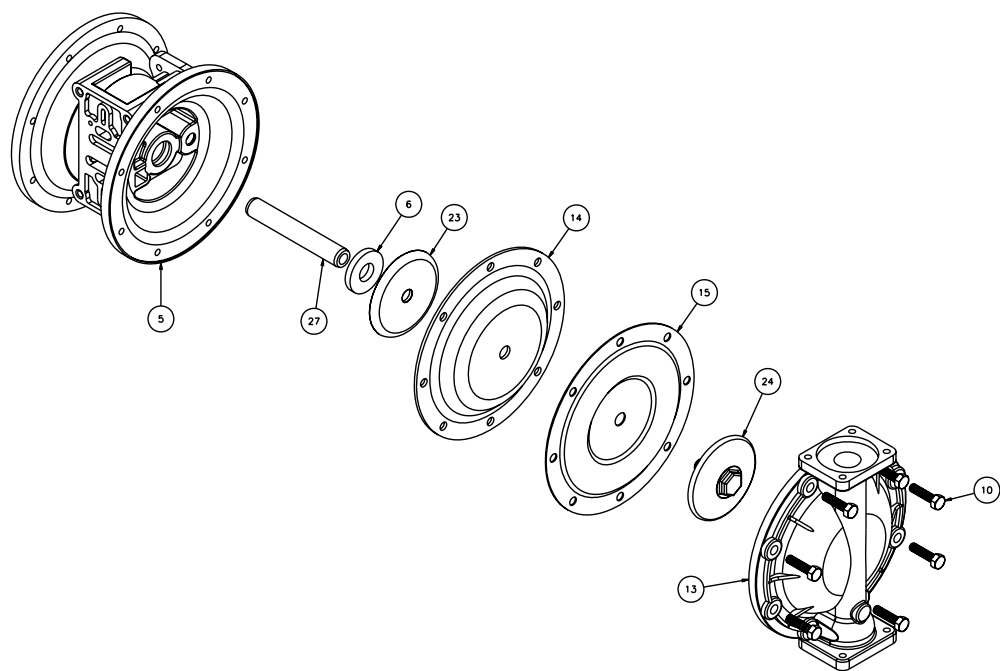
Generously lubricate outside diameter of the sleeve and o-rings. Then carefully insert sleeve into valve body. Take CAUTION when inserting sleeve, not to shear any o-rings. Install retaining ring to sleeve. Generously lubricate outside diameter of spool and o-rings. Then carefully insert spool into sleeve. Take CAUTION when inserting spool, not to shear any o-rings. Use BP-LS-EP-2 multipurpose grease, or equivalent.

STEP #4: Re-install the pilot valve assembly into the intermediate.

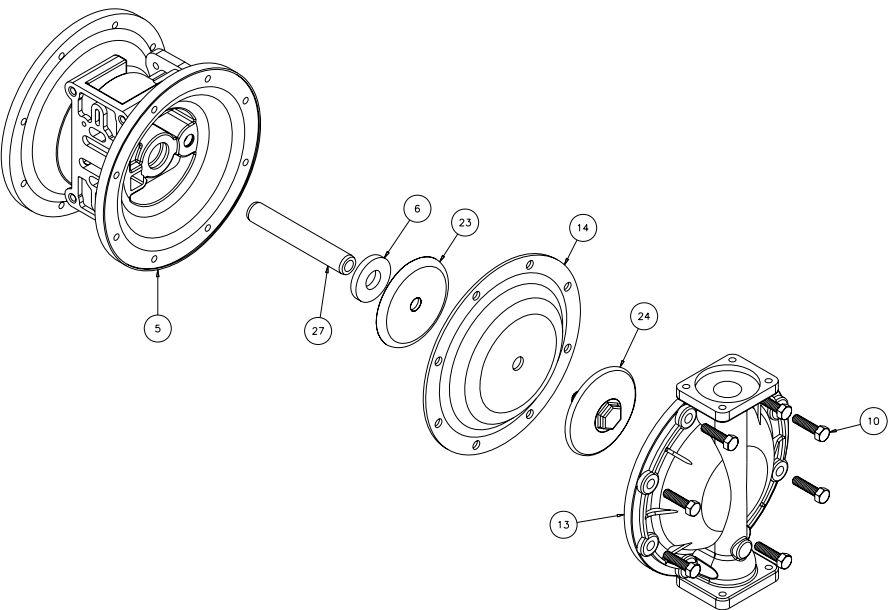
Be careful to align the ends of the pilot valve stem between the plunger pins when inserting the pilot valve into the cavity of the intermediate.

Re-install the gasket, air inlet cap and capscrews. Connect the air supply to the pump. The pump is now ready for operation.

Diaphragm Service Drawing, with Overlay



Diaphragm Service Drawing, Non-Overlay



DIAPHRAGM SERVICING

To service the diaphragms first shut off the suction, then shut off the discharge lines to the pump. Shut off the natural gas supply, bleed the pressure from the pump and disconnect the natural gas supply line from the pump. Drain any remaining liquid from the pump.

Step #1: See the pump assembly drawing and the diaphragm servicing illustration.

Using a 1/2" wrench or socket, remove the 16 capscrews (item 9) that fasten the manifolds (items 19 & 20) to the outer chambers (item 13).

Step #2: Removing outer chambers.

Using a 1/2" wrench or socket, remove the 16 capscrews (item 10), that fasten the outer chambers (item 13), diaphragms (item 14) and intermediate (item 5) together.

Step #3: Removing the diaphragms and diaphragm plates.

Use a 7/8" wrench or six point socket to remove the outer diaphragm plate assemblies (item 24), diaphragms (item 14) and inner diaphragm plates (item 23) from the diaphragm rod (item 27) by turning counterclockwise. Inspect the diaphragm for cuts, punctures, abrasive wear or chemical attack. Replace the diaphragms if necessary. **DO NOT USE A WRENCH ON THE DIAPHRAGM ROD. FLAWS ON THE SURFACE MAY DAMAGE BEARINGS AND SEALS.**

Step #4: Assembling the diaphragm and diaphragm plates to the diaphragm rod.

Push the threaded stud of one outer diaphragm plate assembly through the center of one diaphragm and through one inner diaphragm plate. Install the diaphragm with the natural bulge facing away from the diaphragm rod and make sure the radius on the inner diaphragm plate is towards the diaphragm, as indicated on the diaphragm servicing illustration. Thread the assembly onto the diaphragm rod, leaving loose.

Step #5: Installing the diaphragm and rod assembly to the pump.

Make sure the bumper (item 6) is installed over the diaphragm rod. Insert rod into pump.

On the opposite side of the pump, pull the diaphragm rod out as far as possible. Make sure the second bumper is installed over the diaphragm rod.

Push the threaded stud of the other outer diaphragm plate assembly through the center of the other diaphragm and through the other inner diaphragm plate. Make sure the radius on the inner diaphragm plate is towards the diaphragm. Thread the assembly onto the diaphragm rod. Use a 7/8" wrench or socket to hold one outer diaphragm plate. Then, use a torque wrench to tighten the other outer diaphragm plate to the diaphragm rod to 500 in. lbs. (56.5 Newton meters).

Align one diaphragm with the intermediate and install the outer chamber to the pump using the 8

capscrews. Tighten the opposite diaphragm plate until the holes in the diaphragm align with the holes in the intermediate. Then, install the other outer chamber using the 8 capscrews.

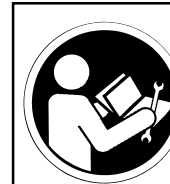
Step #6: Reinstall the manifolds to the pump using the 16 capscrews.

The pump is now ready to be reinstalled, connected and returned to operation.

OVERLAY DIAPHRAGM SERVICING

The overlay diaphragm (item 15) is designed to fit over the exterior of the standard diaphragm (item 14).

Follow the same procedures described for the standard diaphragm for removal and installation, except tighten the outer diaphragm plate assembly, diaphragms and inner diaphragm plate to the diaphragm rod to 500 in. lbs. (56.5 Newton meters).



! IMPORTANT

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ACTUATOR PLUNGER SERVICING

To service the actuator plunger first shut off the compressed natural gas supply, bleed the pressure from the pump, and disconnect the natural gas supply line from the pump.

Step #1: See PUMP ASSEMBLY DRAWING.

Using a 1/2" wrench or socket, remove the four capscrews (items 11). Remove the gas inlet cap (item 8) and gas inlet gasket (item 18). The pilot valve assembly (item 4) can now be removed.

Step #2: Inspect the actuator plungers.

See ILLUSTRATION AT RIGHT.

The actuator plungers (items 25) can be reached through the pilot valve cavity in the intermediate assembly (item 5).

Remove the plungers (item 25) from the bushings (item 7) in each end of the cavity. Inspect the installed o-ring (items 21) for cuts and/or wear. Replace the o-rings if necessary. Apply a light coating of grease to each o-ring and re-install the plungers in to the bushings. Push the plungers in as far as they will go.

To remove the bushings (item 7), first remove the retaining rings (item 26) by using a flat screwdriver.

NOTE: It is recommended that new retaining rings be installed.

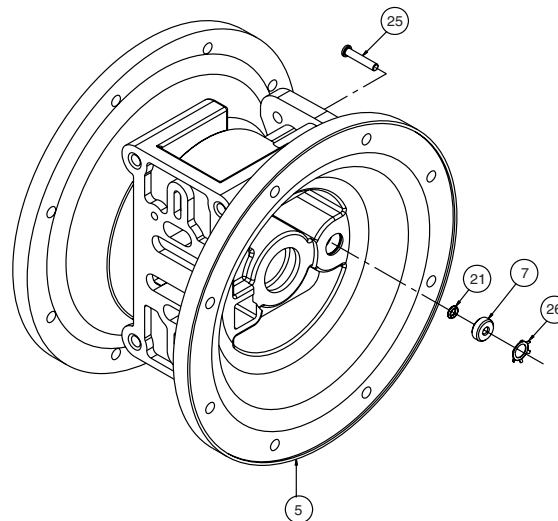
Step #3: Re-install the pilot valve assembly into the intermediate assembly.


Be careful to align the ends of the stem between the plungers when inserting the stem of the pilot valve into the cavity of the intermediate.

Re-install the gasket (item 18), natural gas inlet cap (item 8) and capscrews (item 11).

Connect the natural gas supply to the pump. The pump is now ready for operation.

ACTUATOR PLUNGER SERVICING





! IMPORTANT
Read these instructions completely, before installation and start-up. It is the responsibility of the purchaser to retain this manual for reference. Failure to comply with the recommendations stated in this manual will damage the pump, and void factory warranty.

CHECK VALVE SERVICING

Before servicing the check valve components, first shut off the suction line and then the discharge line to the pump. Next, shut off the compressed natural gas supply, bleed natural gas pressure from the pump, and disconnect the natural gas supply line from the pump. Drain any remaining fluid from the pump. The pump can now be removed for service.

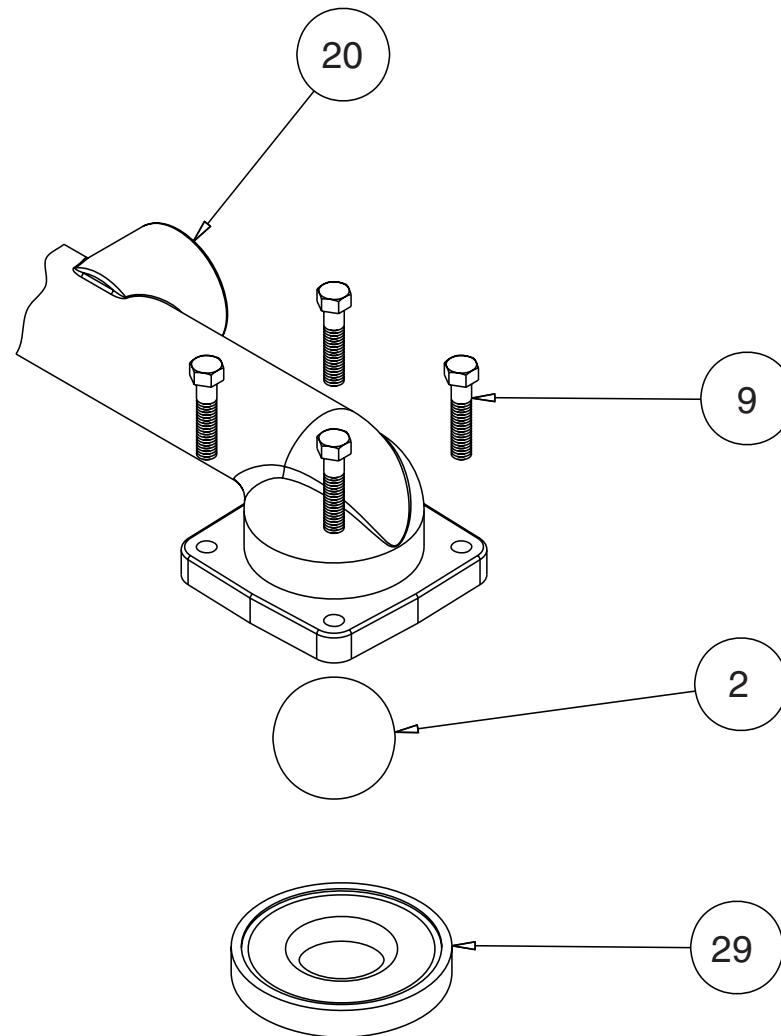
To access the check valve components, remove the manifolds (item 19 not shown). Use a 9/16" wrench or socket to remove the fasteners. Once the manifold is removed, the check valve components can be seen.

Inspect the check balls (items 2) for wear, abrasion, or cuts on the spherical surface. The check valve seats (item 29) should be inspected for cuts, abrasive wear, or embedded material on the surfaces of both the external and internal chambers. The spherical surface of the check balls must seat flush to the surface of the check valve seats for the pump to operate to peak efficiency. Replace any worn or damaged parts as necessary.

Re-assemble the check valve components. The seat should fit into the counter bore of the outer chamber.

The pump can now be reassembled, reconnected and returned to operation.

Check Valve Drawing



PUMPING HAZARDOUS LIQUIDS

When a diaphragm fails, the pumped liquid or fumes enter the natural gas end of the pump. Fumes are exhausted into the surrounding environment. When pumping hazardous or toxic materials, the exhaust gas must be piped to an appropriate area for safe disposal. See illustration #1 at right.

This pump can be submerged if the pump materials of construction are compatible with the liquid being pumped. The natural gas exhaust must be piped above the liquid level. See illustration #2 at right. Piping used for the gas exhaust must not be smaller than 1" (2.54 cm) diameter. Reducing the pipe size will restrict natural gas flow and reduce pump performance. When the pumped product source is at a higher level than the pump (flooded suction condition), pipe the exhaust gas higher than the product source to prevent siphoning spills. See illustration #3 at right.

PIPING THE NATURAL GAS EXHAUST

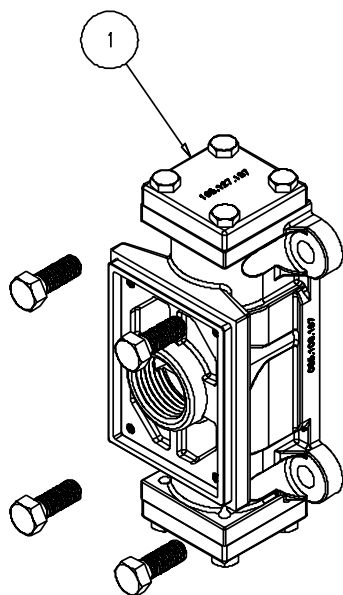
The following steps are necessary to pipe the exhaust gas away from the pump.


The gas distribution valve assembly (item 1) has 1" NPT threads for piped exhaust.

in damage to the natural gas distribution valve body.

Any piping or hose connected to the pump's natural gas exhaust port must be conductive and physically supported. Failure to support these connections could also result in damage to the valve body.

If a high pressure gas spike is possible through the exhaust line, a pressure regulator is required in the exhaust piping.

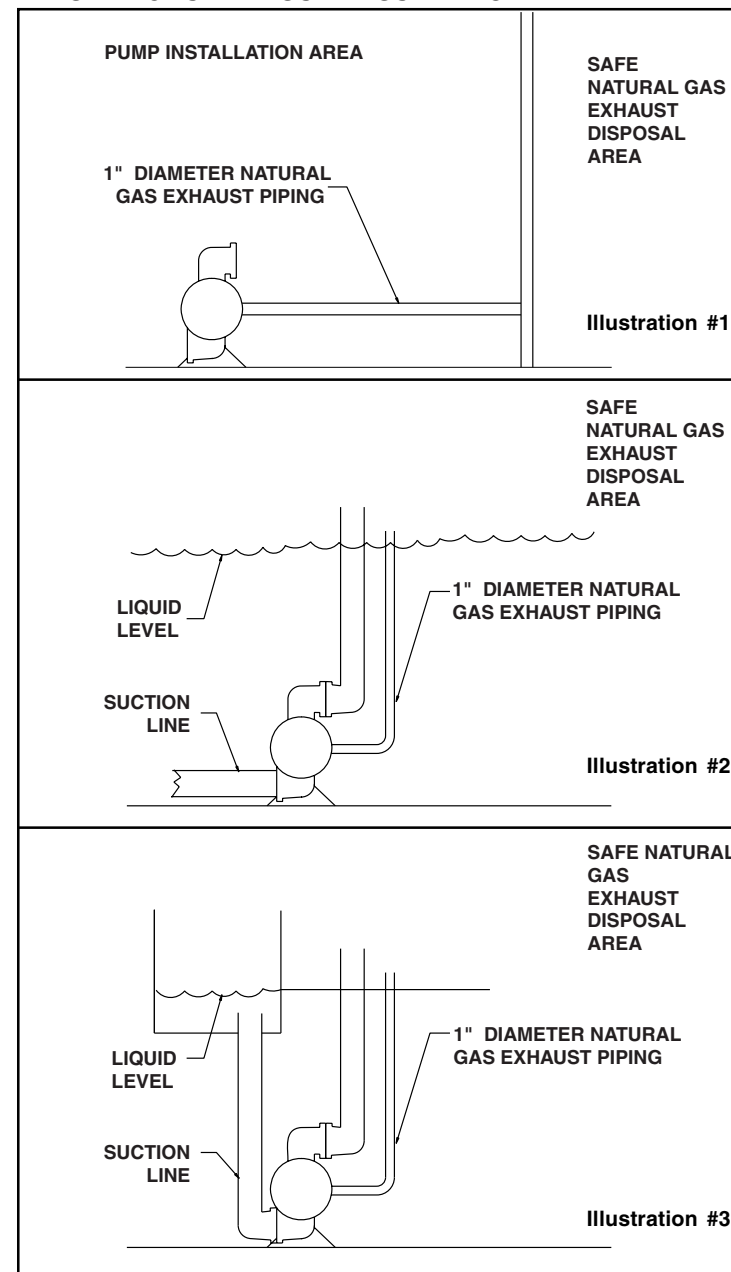




WARNING

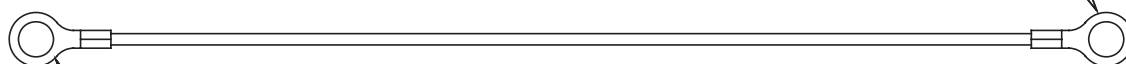
Natural gas exhaust is to be vented to low pressure safe location using conductive Buna rubber hose or metal piping in accordance with local fire and environmental codes, or an industry or nationally recognized code having jurisdiction over specific installations, and/or CAN/CGA B149, Installation Codes.

NATURAL GAS EXHAUST ILLUSTRATION



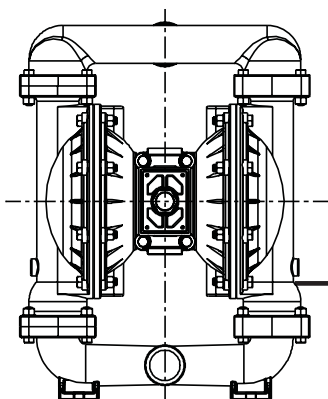
Grounding The Pump

One eyelet is installed to a true earth ground. (Requires a maximum 5/16 or 8mm maximum diameter blot)

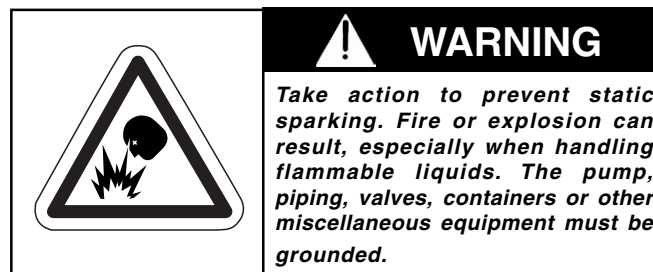


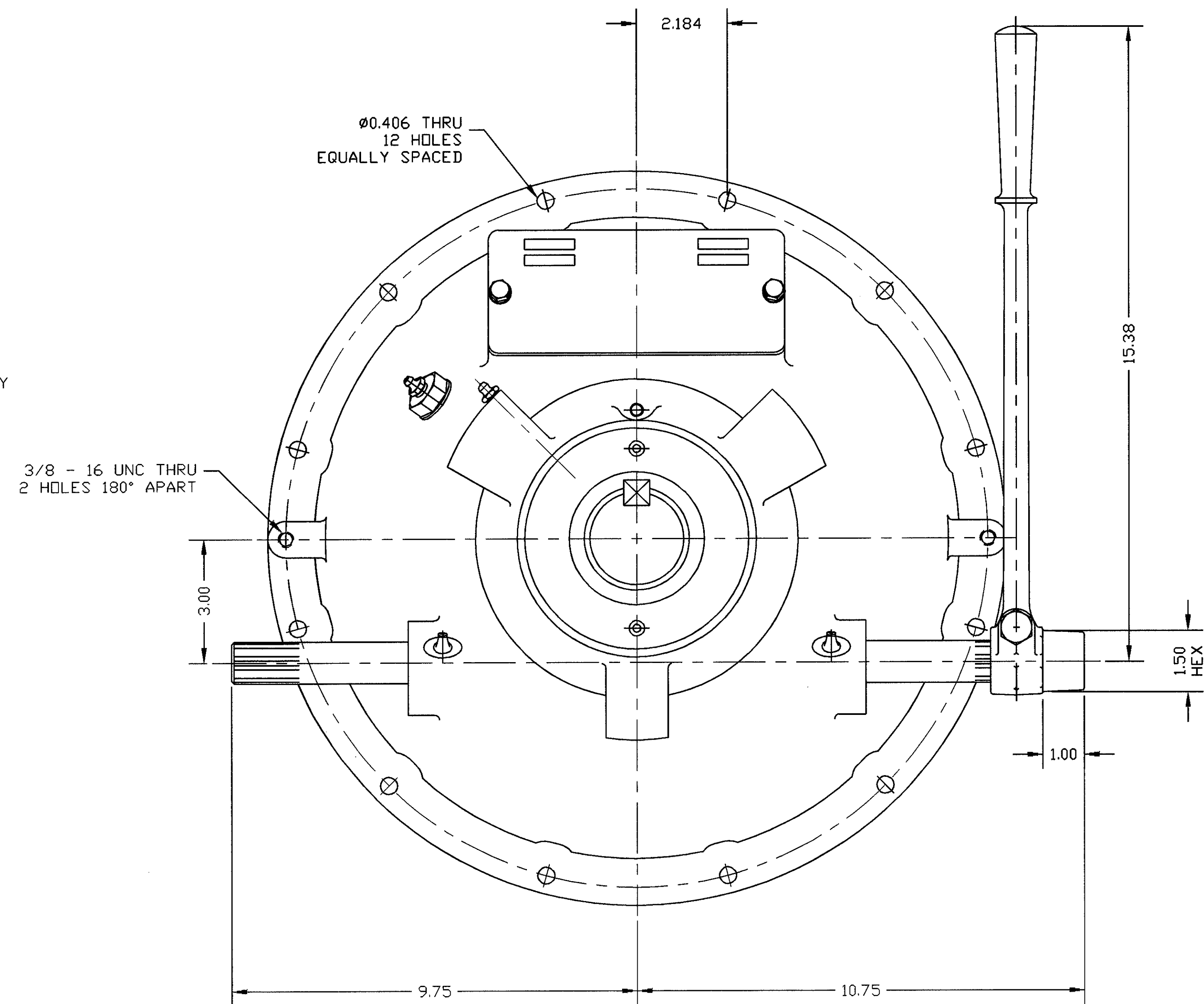
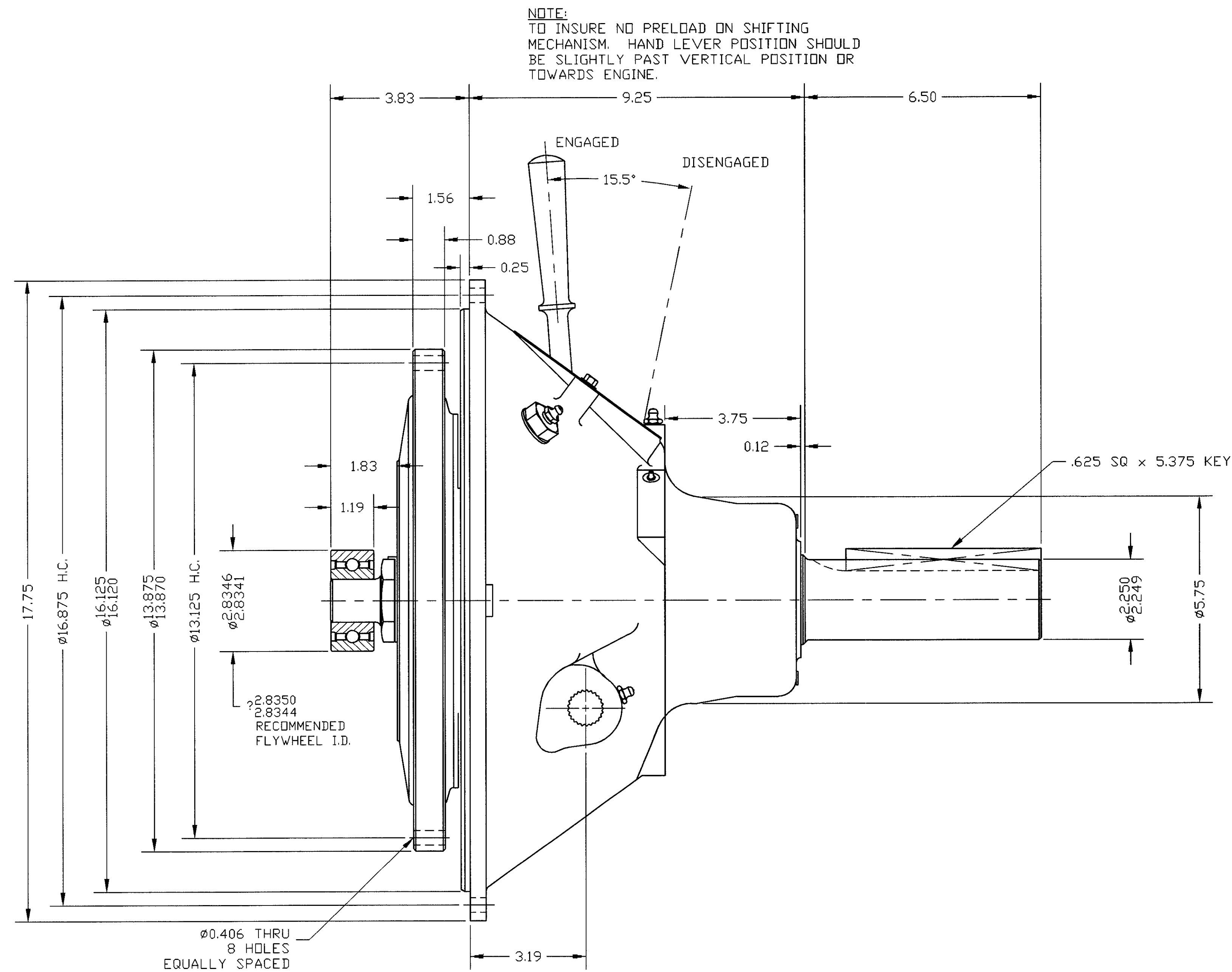
One eyelet is fastened to the pump hardware.

This 8 foot long (244 centimeters) Ground Strap (Item 30) is shipped with the eyelet end fastened to the pump hardware.



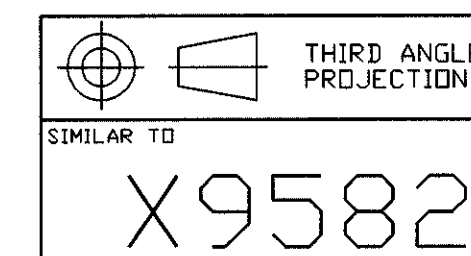
To reduce the risk of static electrical sparking, this pump must be grounded. Check the local electrical code for detailed grounding instruction and the type of equipment required, or in the absence of local codes, an industry or nationally recognized code having jurisdiction over specific installations, and/or CAN/CGA B149, installation codes.



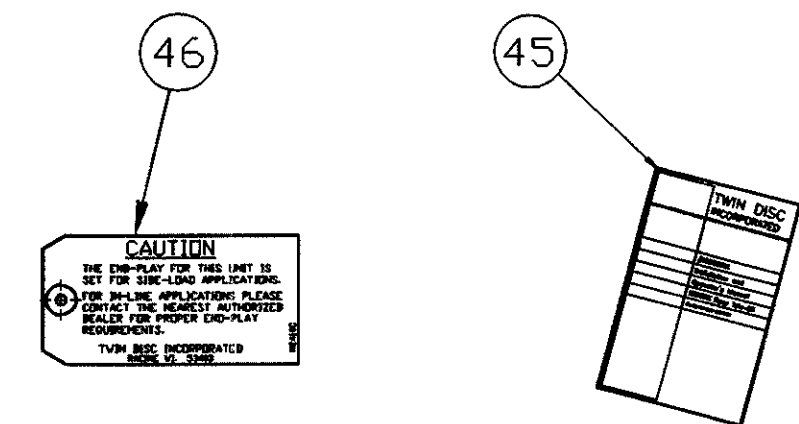
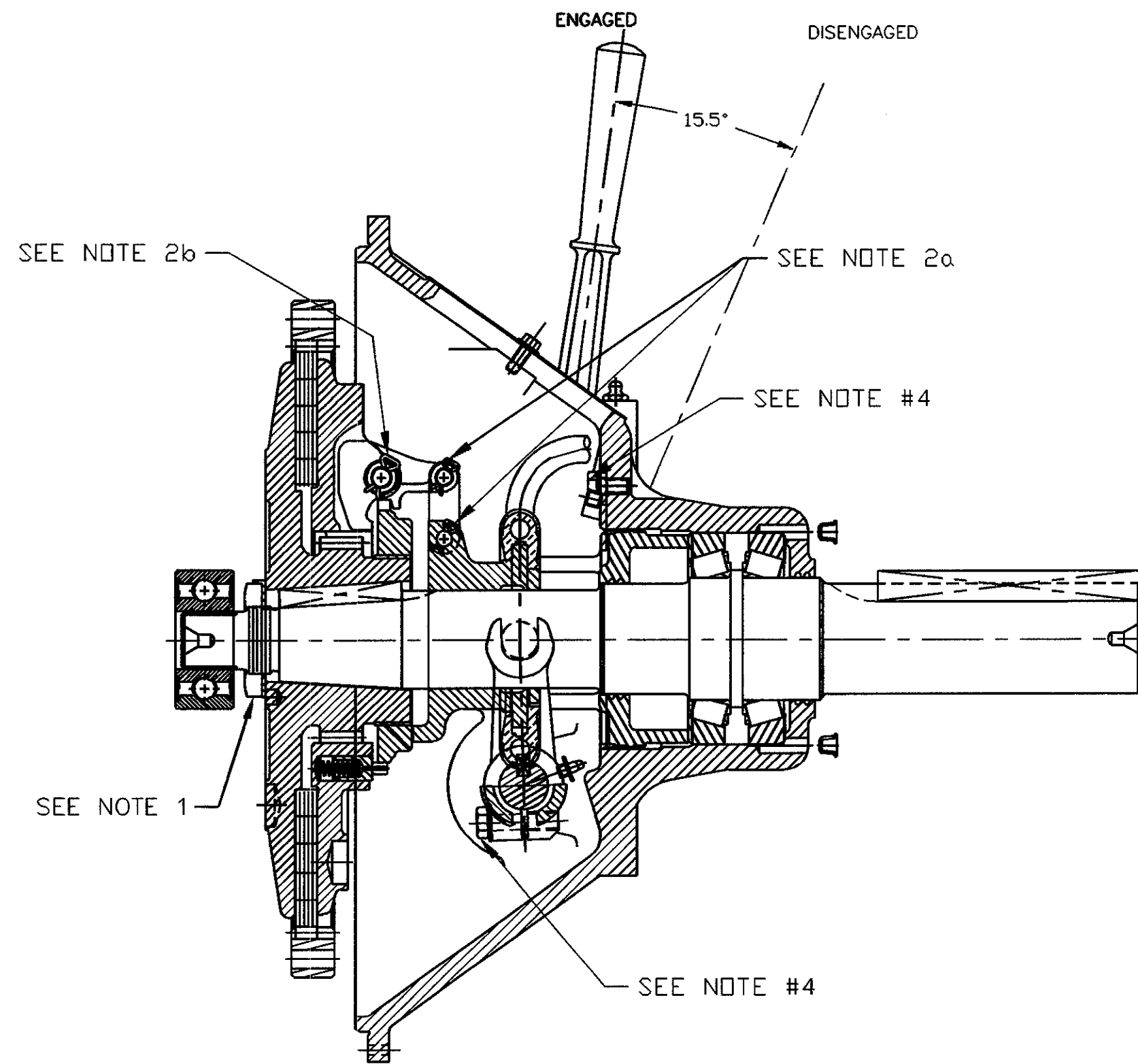
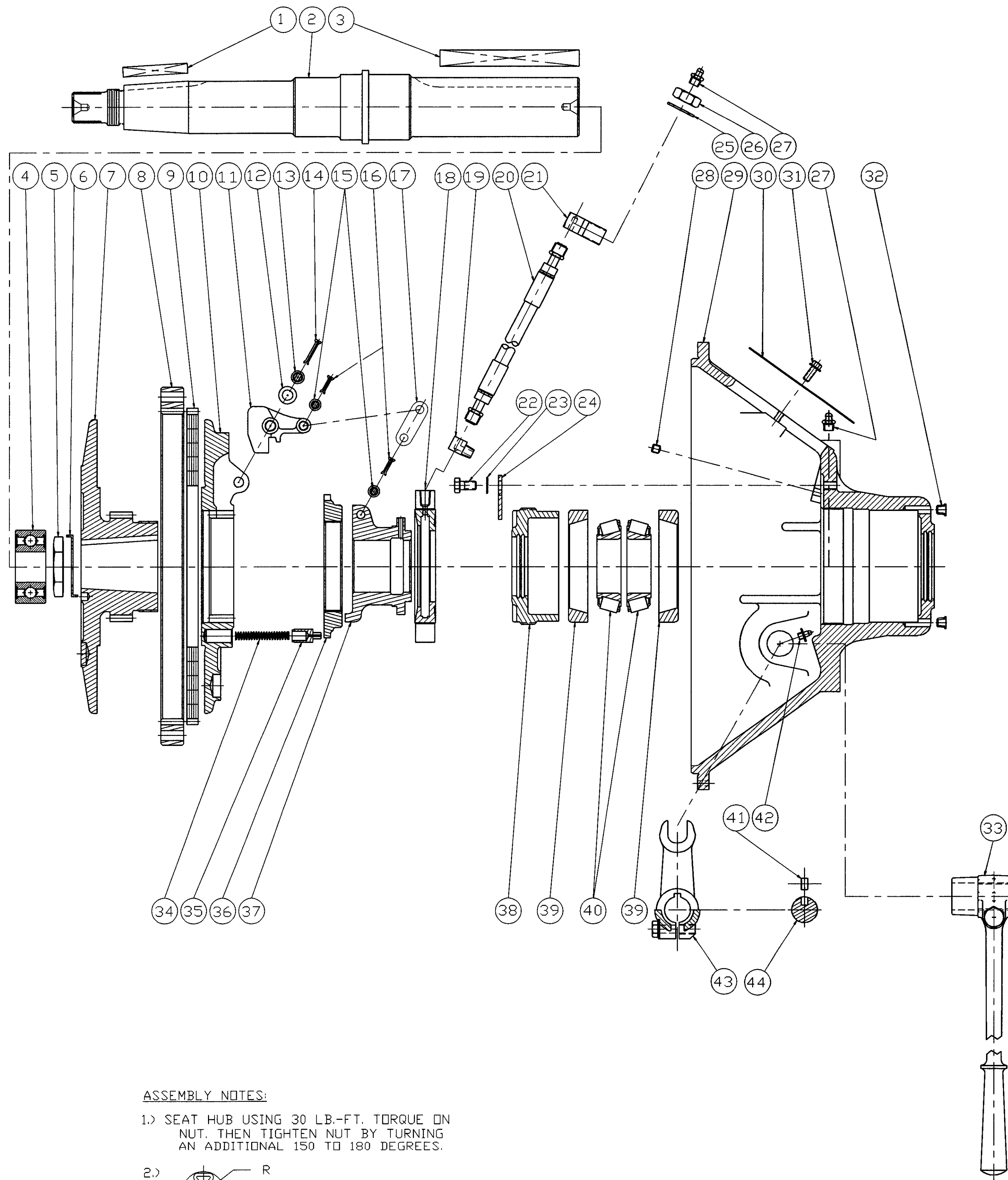


GENERAL NOTES:

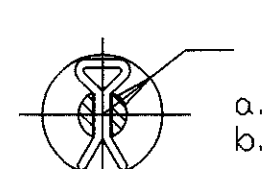
- a.) REFER TO BILL OF MATERIAL LIST WHEN ORDERING PARTS.
- b.) REFER TO CARE & OPERATION MANUAL FOR ADDITIONAL INFO.



NOTICE: THIS PRINT CONTAINS PROPRIETARY INFORMATION AND IS NOT TO BE USED IN ANY MANNER DETRIMENTAL TO THE INTERESTS OF TWIN DISC, INCORPORATED RACINE, WI 53403 - USA THIS NOTICE IS NOT INTENDED TO NULLIFY OR LIMIT RIGHTS GRANTED TO THE U.S. GOVERNMENT OR OTHERS BY CONTRACT.	MATERIAL	WEIGHT LBS.	VR ¹ LBS. IN ³	UNLESS OTHERWISE SPECIFIED MACHINED DIMENSIONS XX ±0.030 XXX ±0.010 XXXX ±0.005 ALL ANGULAR TOLERANCES ±1° GEOMETRIC TOLERANCING PER ANSI Y14.5M 1982	DATE 07-30-02 SCALE 1:50=1	TWIN DISC INCORPORATED RACINE, WI 53403 - USA SP111P303 SHEET 2 OF 2 REV A
	HEAT TREAT	FIRST USE ASSY.	MODEL	DRN. DUH CHK. JTS APPD. JTS		
	SURFACE TREATMENT	NAME SP111HP3	POWER TAKE-OFF			



ASSEMBLY NOTES:

- 1.) SEAT HUB USING 30 LB.-FT. TORQUE ON NUT. THEN TIGHTEN NUT BY TURNING AN ADDITIONAL 150 TO 180 DEGREES.
- 2.) 
a. R=.38 MAX. FOR COTTER PINS
b. R=.47 MAX. FOR COTTER PINS
- 3.) REFER TO BDM FOR INSTRUCTION PLATE STAMPING INFORMATION
- 4.) REFER TO TWIN DISC STANDARD S574 FOR TORQUE VALUES.
- 5.) REFER TO TWIN DISC STANDARD S564 FOR LUBRICATION PROCEDURES.
- 6.) ITEM #46 IS ATTACHED ABOVE THE INSTRUCTION PLATE (#30) USING SCREW (#31).

ITEM	PART NO.	-303	NAME	REMARKS
1	M2032BE	1	KEY	
2	A5188AZ	1	SHAFT, CLUTCH	
3	M2033BJ	1	KEY	
4	M224A	1	BEARING, PILOT	
5	1092	1	NUT	
6	A1588	1	WASHER	
7	ZA6505A	1	HUB AND BACKPLATE	
8	6625D	1	RING, DRIVING	
9	A5579E	1	PLATE, FRICTION	
10	A6506B	1	PLATE, PRESSURE	
11	B1304	3	LEVER	
12	M2115C	6	WASHER	
13	B1538A	3	PIN, CLEVIS	
14	B1535C	3	PIN, COTTER	
15	B1537D	6	PIN, CLEVIS	
16	B1535B	6	PIN, COTTER	
17	2617	6	LINK	
18	X117	1	COLLAR ASSY.	
19	M1283	1	FITTING	
20	M1292A	1	HOSE	
21	M1284	1	FITTING	
22	M2001E	1	SCREW, HEX. HD.	
23	M2046L	1	WASHER	
24	1216	1	RETAINER, CLIP	
25	M2046AF	1	WASHER	
26	M2027AN	1	NUT	
27	M268	2	FITTING	
28	M2041AB	1	SET SCREW	
29	8252	1	HOUSING	
30	2815AQ	1	PLATE, INSTRUCTION	
31	02006092	2	SCREW	
32	M2067L	2	PROTECTOR	
33	X3799E	1	LEVER, HAND	
34	A2701BD	1	SPRING, COMPRESSION	
35	B2340	1	PIN	
36	A4238	1	RING, ADJUSTING	
37	A4237	1	SLEEVE, SLIDING	
38	B2147	1	RETAINER, BEARING	
39	MA590	2	BEARING, CUP	
40	MA585	2	BEARING, CONE	
41	M2022Z	2	KEY, WOODRUFF	
42	M503	2	FITTING	
43	X125A	1	YOKE	
44	1144E	1	SHAFT, OPERATING	
45	1015591	1	MANUAL	
46	M2410C	1	TAG, ENDPLAY	

PACKAGING NOTES:

- 1.) THESE ITEMS ARE SHIPPED LOOSE FROM PTD.

3 4 8 33 45

THIRD ANGLE PROJECTION
X9582

REV	SHEET	ZONE	CH. NO.	DATE	REV	SHEET	ZONE	CH. NO.	DATE
A									

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MATERIAL	WEIGHT LBS.	VR ² LBS. IN ²	UNLESS OTHERWISE SPECIFIED MACHINED DIMENSIONS X.XX ±0.030 X.XXX ±0.010 X.XXX ±0.005 ALL ANGULAR TOLERANCES ±1° GEOMETRIC TOLERANCING PER ANSI Y14.5M 1982	DATE 07-30-02 SCALE 3/8" = 1"	TWIN DISC INCORPORATED RACINE, WI 53403 - USA
HEAT TREAT	FIRST USE ASSY. SP111P303 MODEL SP111HP3	NAME SP111HP3 POWER TAKE-OFF	CHK. JTS	DRN. DJH	SP111P303
SURFACE TREATMENT			APPD. JTS		SHEET 1 OF 2 REV A



FAQ

(VRG330 / A54 Engine)

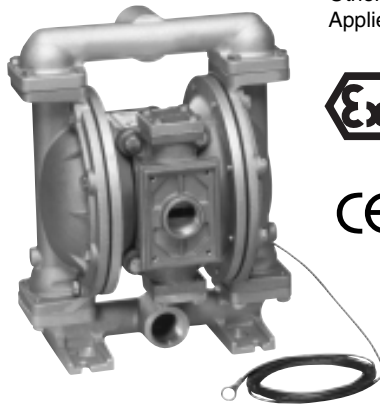
Engine weight (approximate).....	1100
Engine length (engine only).....	41.5"
Engine Width (engine only).....	23.5"
Engine Height (engine only).....	36.5"
Bore.....	3.875
Stroke.....	4.665
Compression ratio.....	8:1
Firing order.....	1-5-3-6-2-4
Ignition timing.....	24 Deg. (N/G) 18 Deg. (LPG)
Cylinder compression (@ cranking speed (normal oper.temp.).....	170 - 200 psi
Valve clearance	In. 30 Ex. 30
Oil capacity including filter - (qts.).....	9 - Reg. pan 17 - H/C pan
Coolant capacity with oil cooler & less radiator - (qts.).....	9.25
Peak RPM continuous duty.....	1800 rpm
Peak H.P. @ 1800rpm (1500 Ft. altitude).....	68 bhp
Peak Torque - ft. lbs. Natural gas @ 1800 rpm.....	220
Normal jacket water temperature.....	185 - 200
Normal oil sump temperature - SAE 30.....	160 - 210
Normal oil psi.....	35-50 lbs
Exhaust flange size (NPT).....	2 1/2"
Exhaust flow rate.....	400 acfm @ 68 bhp
Normal Exhaust temperature.....	1250 - 1300
Exhaust back psi (maximum) - inches of H ₂ O.....	20
Intake vacuum unloaded @ idle (approximate) - inches of H ₂ O.....	16-18
Fuel psi.to carburetor -- (CA100 carb.).....	3-6 ounces
Fuel consumption-continuous duty @ 1800 rpm (1000btu gas).....	8,000.000.00 btu p/d 8.0 mcf per day
Normal oil consumption - (24 hr.).....	0.50 to 1 qt.
Spark plug (resistor type).....	RN5C
Flywheel housing size	SAE #3
Clutch shaft size - (O.D.).....	2 1/4"
Arrow Engine Clutch part number.....	SP-111-HP-3
CD-1 Ignition system power source.....	12 Volt. (Required)

**WARREN
RUPP®**

**Quality System
ISO9001 Certified**

**Environmental
Management System
ISO14001 Certified**

IDEX
IDEX CORPORATION



U.S. Patent #
5,996,627; 6,241,487
Other U.S. Patents
Applied for



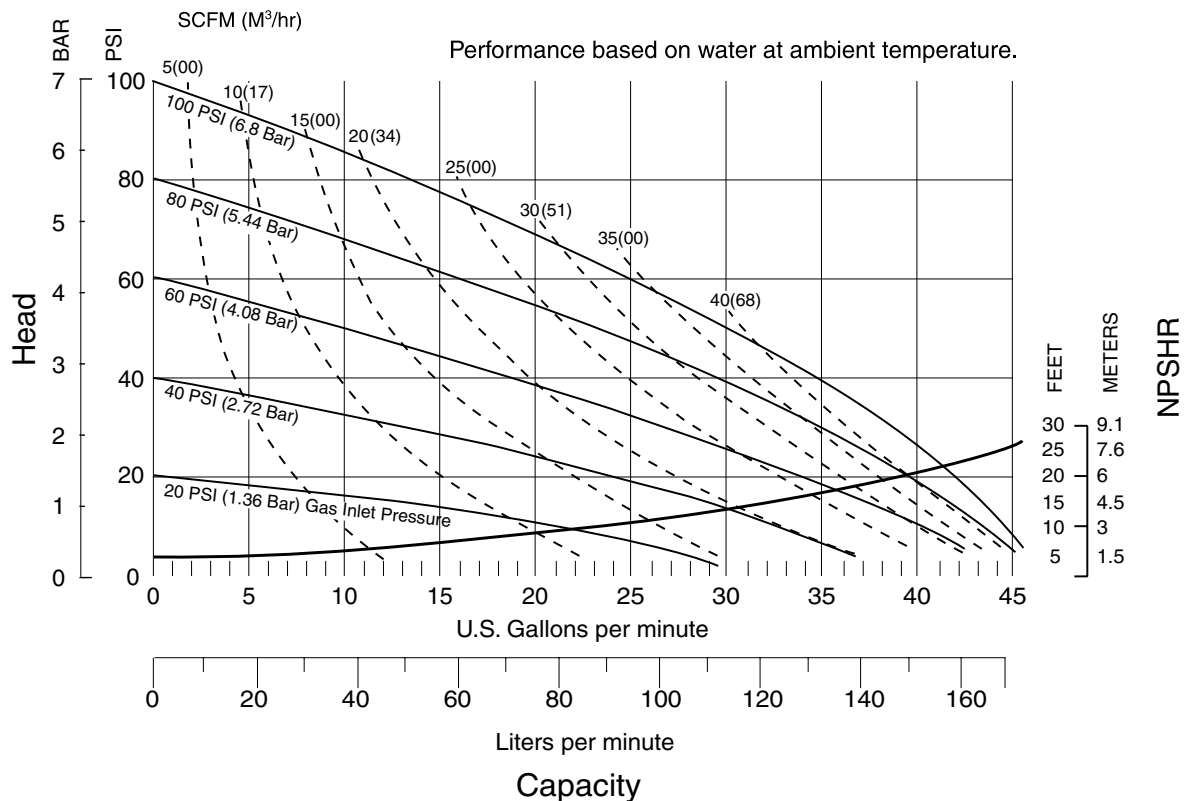
SANDPIPER®
A WARREN RUPP PUMP BRAND

G1F Metallic Design Level 1 Ball Valve

**Natural Gas-Powered
Double-Diaphragm Pump**

ENGINEERING, PERFORMANCE
& CONSTRUCTION DATA

INTAKE/DISCHARGE PIPE SIZE	CAPACITY	AIR VALVE	SOLIDS-HANDLING	HEADS UP TO	DISPLACEMENT/STROKE
1" NPT (internal) 1" BSPT Tapered (internal)	0 to 45 gallons per minute (0 to 170 liters per minute)	No-lube, no-stall design	Up to .25 in. (6mm)	125 psi or 289 ft. of water (8.6 Kg/cm ² or 86 meters)	.11 Gallon / .42 liter



These SANDPIPER® models are designed to be powered only by natural gas.

Explanation of Pump Nomenclature

G1F Metallic · Design Level 1· Ball Valve

MODEL	Pump Brand	Pump Size	Check Valve Type	Design Level	Wetted Material	Diaphragm/ Check Valve Materials	Check Valve Seat	Non-Wetted Material Options	Porting Options	Pump Style	Pump Options	Shipping Kit Options	Weight lbs. (kg)
G1FB1ABTXNSX00.	G	1F	B	1	A	B	T	X	N	S	X	00.	28 (13)
G1FB1ATTXNSX00.	G	1F	B	1	A	T	T	X	N	S	X	00.	28 (13)
G1FB1SBTXNSX00.	G	1F	B	1	S	B	T	X	N	S	X	00.	43 (20)
G1FB1STTXNSX00.	G	1F	B	1	S	T	T	X	N	S	X	00.	43 (20)
G1FB1ABTXBSX00.	G	1F	B	1	A	B	T	X	B	S	X	00.	28 (13)
G1FB1ATTXBSX00.	G	1F	B	1	A	T	T	X	B	S	X	00.	28 (13)
G1FB1SBTXBSX00.	G	1F	B	1	S	B	T	X	B	S	X	00.	43 (20)
G1FB1STTXBSX00.	G	1F	B	1	S	T	T	X	B	S	X	00.	43 (20)

Pump Brand

G=Gas Operated

Pump Size

1F=1"

Check Valve Type

B=Ball

Design Level

1=Design Level

Wetted Material

S=Stainless Steel

A=Aluminum

Diaphragm Check Ball Materials

B=Buna/Buna

T=Virgin PTFE

Check Valve Seat

T=Virgin PTFE

Non-Wetted Material

X=Unpainted Aluminum

Porting Options

N=NPT Threads

B= BSPT (Tapered) Threads

Pump Style

S= Standard

Pump Options

X= No Muffler

These pump models are designed to pump the following fluids: Crude Oil, Salt Water, Drilling Mud, Condensate, Lubrication Oils, Glycol, Caustic liquids, and Acids.



CAUTION! Operating temperature limitations are as follows:

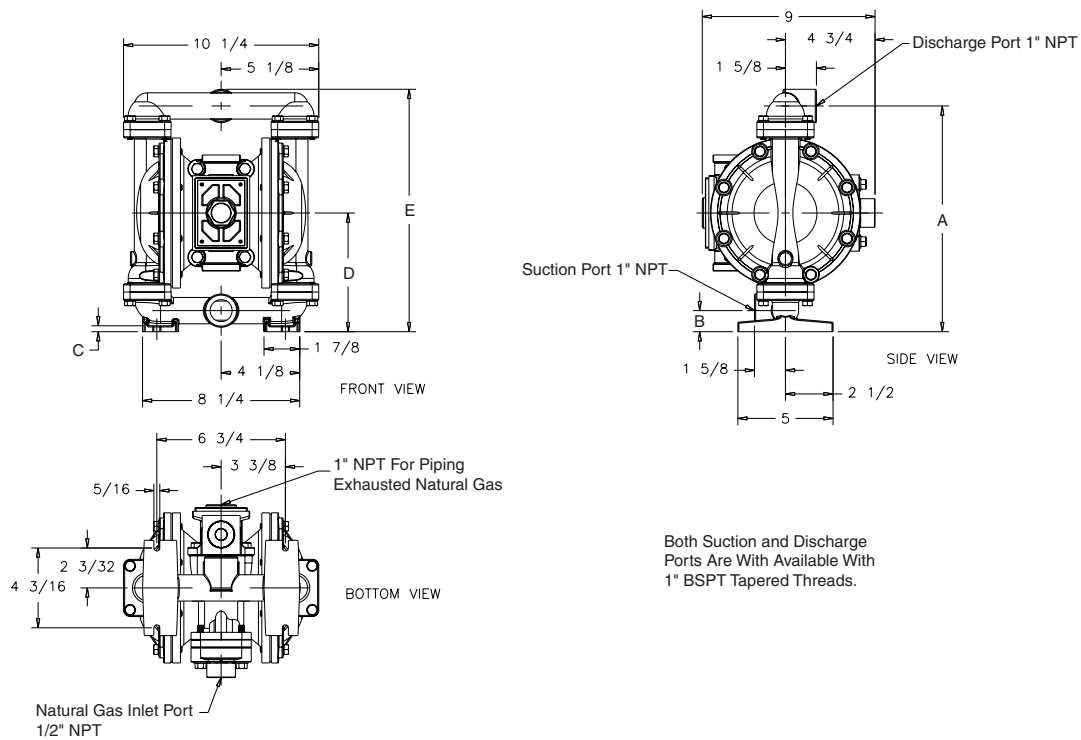
Materials	Operating Temperatures	
	Maximum	Minimum
Buna N General purpose, oil-resistant. Shows good solvent, oil, water and hydraulic fluid resistance. Should not be used with highly polar solvents like acetone and MEK, ozone, chlorinated hydrocarbons and nitro hydrocarbons.	190°F 88°C	-10°F -23°C
Virgin PTFE Chemically inert, virtually impervious. Very few chemicals are known to react chemically with PTFE: molten alkali metals, turbulent liquid or gaseous fluorine and a few fluoro-chemicals such as chlorine trifluoride or oxygen difluoride which readily liberate free fluorine at elevated temperatures.	220°F 104°C	-35°F -37°C

For specific applications, always consult "Chemical Resistance Chart" Technical Bulletin

Dimensions: G1F Metallic

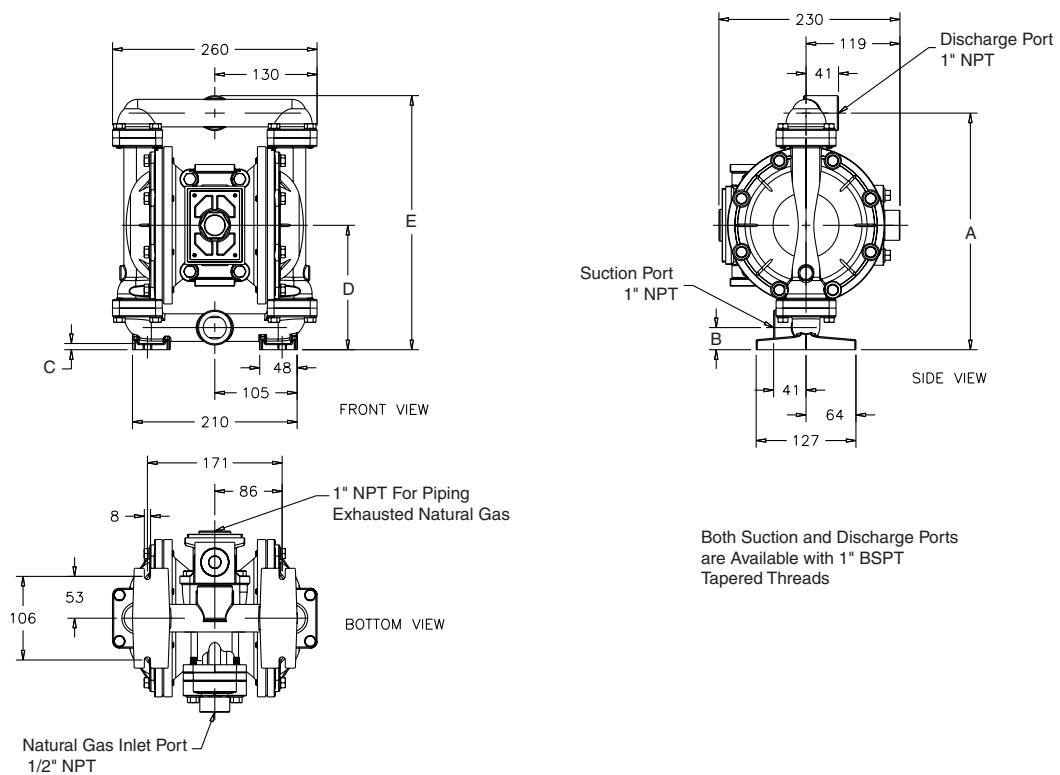
Dimensions in Inches

Dimensional Tolerance: $\pm 1/8$ "



Dimensions in Millimeters

Dimensional Tolerance: ± 3 mm





VR&A

SERIES ENGINES

VR 220 330

© December 2006



AEO_VRnA_06d

FEATURES

The Arrow VR & A Series Engines are versatile in thier applications, providing continuous power for....

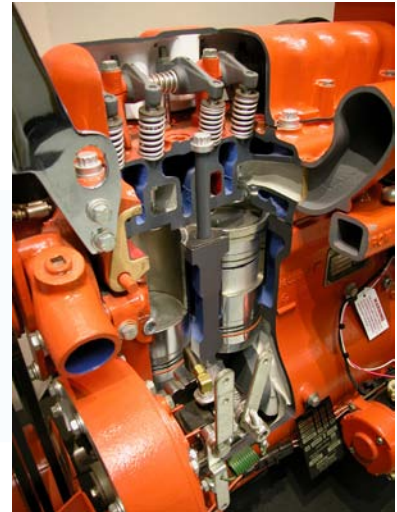
- ▲ Welders
- ▲ Pumps of all types
- ▲ Electrical generators
- ▲ Powering pump jacks
- ▲ Gas compressors
- ▲ Mobile equipment power
- ▲ Agriculture water irrigation
- ▲ Portable air compressors
- ▲ Farm tractors and much more!

Spark Ignited Features

- ▲ Over 40 years history of operating on Natural and well head gas
- ▲ Gasoline carburetion or demand regulator for gaseous fuel
- ▲ Capable of operating on most spark ignited fuels
- ▲ Most popular ignition systems available
- ▲ Aftercooling featured on VR330TA

Other Outstanding Features

- ▲ Lifting eyes - front and rear
- ▲ Forged Steel connecting rods
- ▲ Vertical in-line adjustable fan bracket
- ▲ Heavy-duty, deep skirted crankcases
- ▲ Exhaust manifold with top or rear outlets
- ▲ Replaceable precision main and rod bearings
- ▲ Full pressure lube oil system with full flow oil filter
- ▲ Flywheel - SAE No 3 w/ring gear and SAE No 3 housing
- ▲ Overhead valve cylinder heads with replaceable guides and seats
- ▲ 5 Main bearings on VR220; and 7 main bearings on VR330 models
- ▲ 10% regulated speed by mechanical governor - other governor options available
- ▲ 4 groove crankshaft pulley; 2 groove fan; 1 groove water pump; 4th groove auxiliary
- ▲ Forged steel, dynamically balanced and counterweighted crankshafts with hardened journals



ENGINE SPECS

POWER RATINGS

I=INTERMITTENT

C=CONTINUOUS

ENGINE UNIT	MODEL	PEAK INTERMITTENT TORQUE @ RPM FT.LB. N*M		BRAKE HORSEPOWER AT SPEEDS INDICATED (S.A.E.)											
				900		1000		1200		1400		1600		1800	
	Spark Ignited														
ENGINE UNIT	VR220/A36, Natural Gas	148 @ 1600	201 @ 1600	19	17	24	22	31	28	39	35	45	41	50	45
	VR220/A36, HD-5 Propane	191 @ 1400	259 @ 1400	29	26	33	30	43	39	51	46	56	51	61	55
	VR220/A36, Gasoline	179 @ 1600	239 @ 1600	25	21	30	25	39	34	48	41	54	49	61	55
	VR330/A54, Natural Gas	220 @ 1600	298 @ 1600	29	26	36	33	47	42	58	52	67	60	75	68
	VR330/A54, HD-5 Propane	285 @ 1400	386 @ 1400	43	39	50	45	64	58	76	69	85	76	92	83
	VR330/A54, Gasoline	268 @ 1400	360 @ 1400	35	30	44	37	60	50	75	65	85	75	95	85
	VR330CF/A54CF, Natural Gas	233 @ 1600	317 @ 1600			38	35	50	45	61	55	71	64	80	72
	VR330TA/A54TA, Natural Gas	334 @ 1400	454 @ 1400			50	47	68	63	89	82	97	92	106	100

Actual Horsepower may vary depending upon engine configuration.

Altitude

NA engines

Continuous duty Deduct 3% for each 1000' (305m) above 1500' (457m.)

Intermittent duty Deduct 3% for each 1000' (305m) above 500' (152m.)

VR330TA/A54TA

Continuous duty Deduct 3% per 1000' (305m) above 3000' (914m.)

Intermittent duty Deduct 3% for each 1000' (305m) above 1500' (457m.)

Temperature

Continuous duty Deduct 1% for every 10°F. (6°C.) above 100°F. (38°C.)

Intermittent duty Deduct 1% per 10°F. (5.5°C.) above 85°F. (29°C.)

Intermittent Rating (I)

The highest load and speed that can be applied under specific conditions of varying load and/or speed.

Continuous Rating (C)

The load and speed that can be applied without interruption except for normal maintenance.

All ratings corrected to 500' (152m) altitude, 29.38" (746 mm) Hg. and temperature of 85°F. (29°C.).

Natural gas ratings are based on use of 900 BTU (33.5 J/cm³) LHV gas. HD-5 propane ratings are based on use of 2335 BTU.



Continued.....



Model VR220/A36 4 cycle, 4 cylinder, in-line

Bore and Stroke - 3.875" x 4.665" (98 x 118 mm)

Displacement - 220 cubic inch (3.6 liters)

Lube Oil System - capacity-7.0 qts. (6.6 liters), including filter

Jacket Water System - capacity-7.0 qts. (6.6 liters), engine only

Dry Weight - (engine only) approximately 835 lbs (378 Kg)

Dry Weight - (complete GenSet) aprox. 1485 lbs (675 Kg)

Rotation - Counterclockwise when facing flywheel

Model VR330/A54

4 cycle, 6 cylinder, in-line

Bore and Stroke - 3.875" x 4.665" (98 x 118 mm)

Displacement - 330 cubic inch (5.4 liters)

Lube Oil System - capacity-8.5 qts. (8.0 liters), including filter

Jacket Water System - capacity-8.25 qts. (7.8 liters), engine only

Dry Weight - (engine only) approximately 1000 lbs (453 Kg)

Dry Weight - (complete GenSet) aprox. 1800 lbs (815 Kg)

Rotation - Counterclockwise when facing flywheel

Model VR330CF/A54CF - Crossflow

4 cycle, 6 cylinder, in-line

Bore and Stroke - 3.875" x 4.665" (98 x 118 mm)

Displacement - 330 cubic inch (5.4 liters)

Lube Oil System - capacity-8.5 qts. (8.0 liters), including filter

Jacket Water System - capacity-8.25 qts. (7.8 liters), engine only

Dry Weight - (engine only) approximately 1000 lbs (453 Kg)

Dry Weight - (complete GenSet) aprox. 1800 lbs (815 Kg)

Rotation - Counterclockwise when facing flywheel

Model VR330TA/A54TA - Turbocharged

4 cycle, 6 cylinder, in-line

Bore and Stroke - 3.875" x 4.665" (98 x 118 mm)

Displacement - 330 cubic inch (5.4 liters)

Lube Oil System - capacity-9 qts. (8.5 liters), including filter

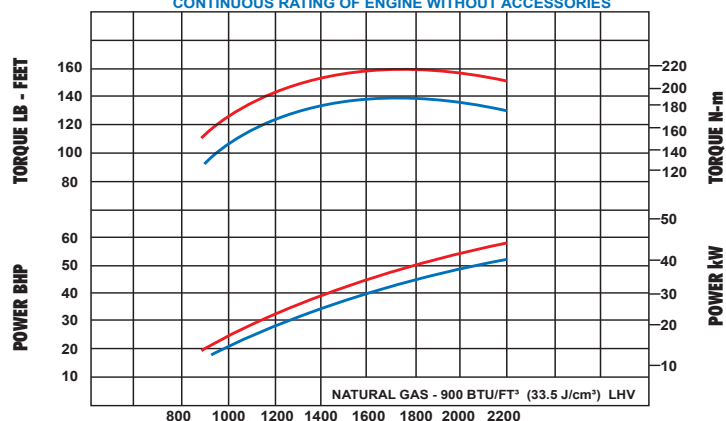
Jacket Water System - capacity-9.25 qts. (8.8 liters), engine only

Dry Weight - (engine only) approximately 1200 lbs (544 Kg)

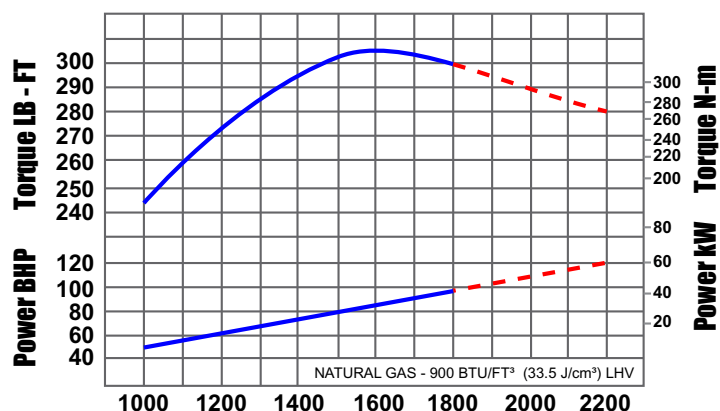
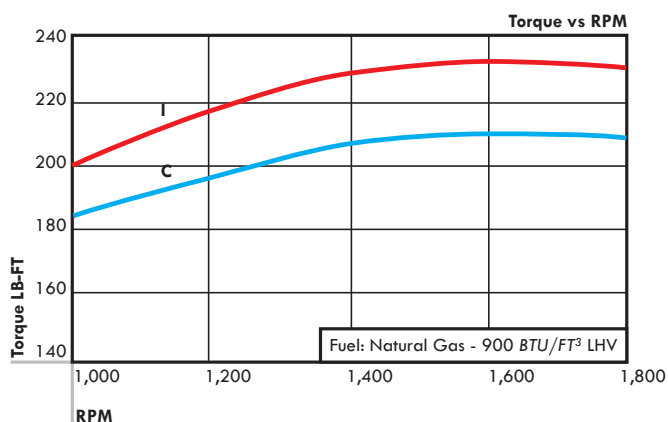
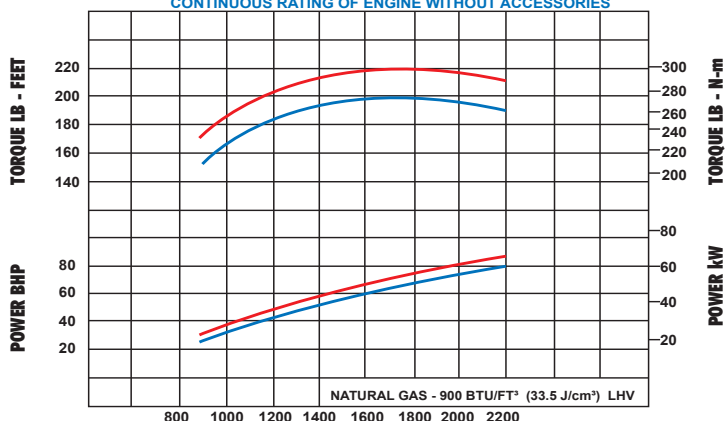
Dry Weight - (complete GenSet) aprox. 2000 lbs (907 Kg)

Rotation - Counterclockwise when facing flywheel

INTERMITTENT RATING OF ENGINE WITHOUT ACCESSORIES
CONTINUOUS RATING OF ENGINE WITHOUT ACCESSORIES



INTERMITTENT RATING OF ENGINE WITHOUT ACCESSORIES
CONTINUOUS RATING OF ENGINE WITHOUT ACCESSORIES



GENSETS

NATURAL GAS GENERATOR SETS

VR220/A36 VR330/A54 VR330TA/A54TA
20 - 65 Kilowatts

GENSET POWER RATINGS

Model	Prime Power Ratings		Standby Power Ratings	
	1800 RPM kW Rating	1500 RPM kW Rating	1800 RPM kW Rating	1500 RPM kW Rating
VR220/A36	28	23	30	25
VR330/A54	43	36	48	39
VR330TA/A54TA	60	50	65	54



RATING DEDUCTIONS FOR ALTITUDE AND TEMPERATURE

Model	Deduction	Continuous Rating for Standby Power	Prime Power Ratings
VR220/A36 VR330/A54	Altitude Deduct 3% for each 1000' (305m) above...	500' (152m) 85°F (29°C)	1500' (457m) 100°F (38°C)
VR330TA/A54TA	Temperature - Deduct 1% for each 10°F (5.5°C) above...	1500' (457m) 85°F (29°C)	3000' (305m) 100°F (38°C)

Above ratings are based on 3 phase generation 480/240V for 60 Hz and 415/208 for 50 Hz. For any changes in ratings please consult factory

Air Cleaners

Dry type

Arrow-Nator Base

Engine, generator, and radiator or heat exchanger, air to air aftercooler on VR330TA/A54TA, are mounted and aligned on a channel steel base suitable for lifting.

Battery Charging Alternator

12 volt D.C., 55 amp., negative ground, integral voltage regulator, mounting and drive.

Bearings

Engine, replaceable, precision type main and rod bearings.

Continued.....



Connecting Rods

Forged steel.

Cooling System

Standard front mount radiator with suction fan. For other options and VR330TA/A54TA details consult factory.

Control Panel

Generator mounted. NEMA 1 for general indoor use. 3.5" (89 mm) Panel type 2% accuracy, voltmeter, ammeter, frequency meter, hourmeter and combination voltmeter/ammeter switch. **Engine Instruments** - 2" (51 mm) water temperature and oil pressure gauges.

Crankcase

Single piece, heavy duty, deep-skirted crankcase.

Crankshaft

Forged steel, dynamically balanced and counterweighted with hardened journals. VR220/A36: Five (5) main bearings. VR330/A54: Seven (7) main bearings.

Cylinder Head

Open combustion chamber. Overhead valves with replaceable valve guides. One piece construction. Special alloy valves and inserts on VR330TA/A54TA.

Cylinders

Centrifugally cast, replaceable wet liners. VR220/A36 - 4 cylinders. VR330/A54 - 6 cylinders.

Exhaust Manifold

Vertical exhaust (2 1/2" NPT).

Fuel System

Natural gas carburetor. Regulators available.

Generator

Direct connected, fan cooled, A.C. revolving field type, single bearing generator, with brushless exciter and damper windings. Twelve lead broad range voltage, reconnectable, 60HZ/50HZ. Insulation material Nema class H to F temperature rise within Nema (105° C) for prime power duty, within Nema (130° C) for continuous standby duty. All generators are rated at .8 power factor; are mounted on the engine flywheel housing and have multiple steel disc flexible coupling drive.

Governor

Electric 3% regulation standard.

Ignition

Solid state magneto is standard.

Oil Pan

Rear sump. Capacity VR220/A36 7.0 qts., VRG330/A54 8.5 qts. (7.6 liter including filter without cooler (330 only). Right hand dipstick.

Pistons

Aluminum alloy with full floating pin.

Starting Equipment

Electric starting motor, 12 volt DC solenoid engagement.

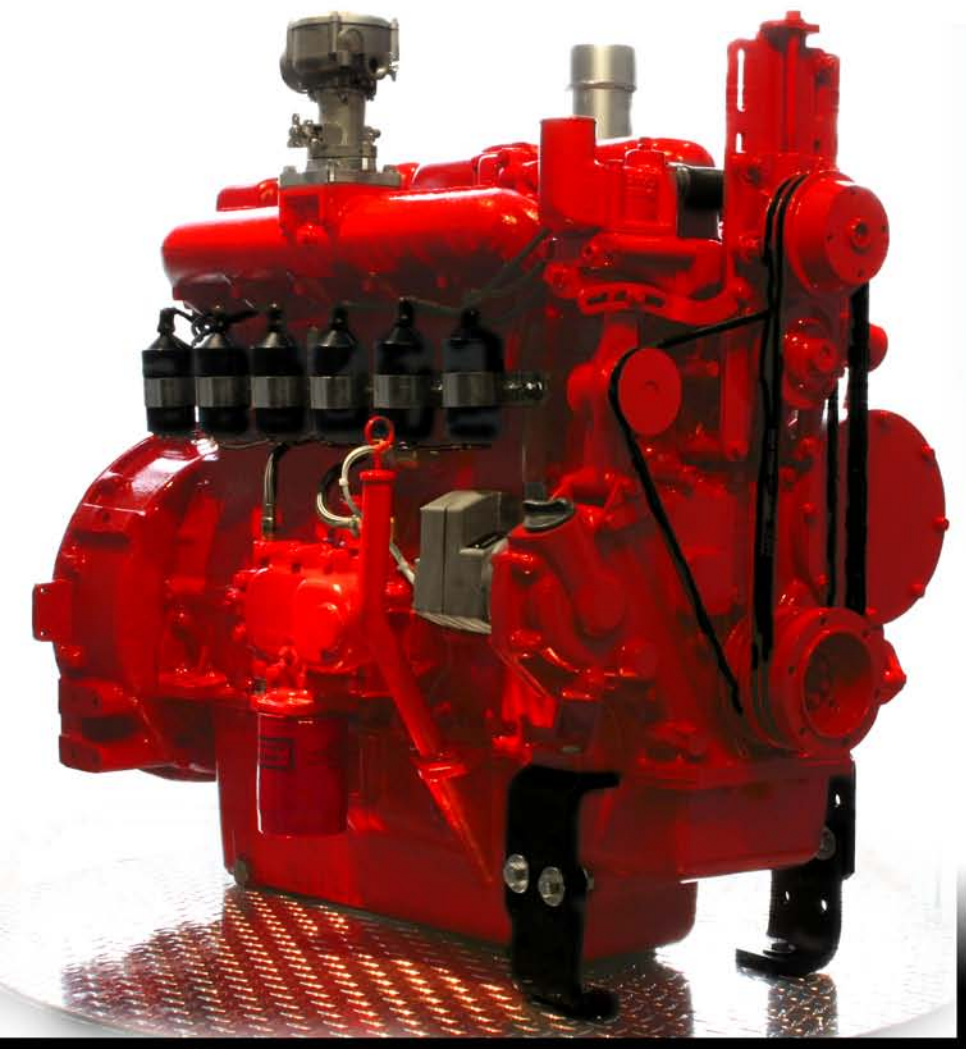
Voltage Regulator

Solid state automatic providing 1% regulation from no load to full load. Includes stability adjustment and under speed protection, EMI filtered to commercial standard, encapsulated for moisture protection.

Water Circulation System

Belt driven water pump, 175° F. (79°C.) start-to-open thermostat. Positive bypass shut-off.





VR330CF/A54CF CROSSFLOW ENGINE

The newly developed VRG330CF/A54CF (cross flow head) engine incorporates a completely redesigned cylinder head with intake and exhaust manifolds on opposite sides of the cylinder head.

The engine incorporates a redesigned camshaft, pistons and complete head and manifold assembly which will increase airflow within the engine.

PERFORMANCE & FUNCTIONAL ADVANTAGES

Approximately 6-8% increase in HP
and fuel efficiency

Lower exhaust temperatures

Lower intake manifold temperatures

Less possibility of detonation on hotter fuels or in
higher ambients due to cooler fuel/air mixture

Longer overall head and manifold life

FEATURES

Increased air inlet and exhaust flow due to
distinct porting design

Separation of the inlet and exhaust manifolds

Valves and seats for inlet and exhaust are high
temperature long life alloy



ARROW ENGINE COMPANY

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Fax: 918.388.3204

www.arrowengine.com

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ARROW REPLACEMENT PARTS

OEM

C-Series

Continental Engine Models

*C-46 *C-106
*C-66 *C-255
 *C-96

VR-Series

Waukesha Engine Models

VR-155 VR-283
*VR-220 VR-310
VR-232 *VR-330
 VR-265

A-Series

*A54 *A36

*K6 Slow Speed Engine

Lufkin Engines

L-333 *L-1770
*L-795 *L-2165

Witte Engines

National Oilwell Models

98 E20
B12 F32
E15 F42

Arrow Chemical Pumps

10 Series (beam operated)
12 & 13 Series (pneumatic)
430 Series (electric)
500 Series (pneumatic)
510 Series (pneumatic)

* Engine models currently manufactured by
Arrow Engine Company & owned as OEM

Caterpillar® Engines

G379 G3304
G398 G3306
G399

Ford® Engines

300 Industrial Engine
Governor

Waukesha® Engines

F2895 P9390
F3521 145G/F817
F5108 140G/F554
L5790 WAK/1197
L7042

Gemini® Engines

G26 G40
Compressor Parts

Fairbanks® Engines

ZC-118 ZC-503
ZC-208 ZC-739
ZC-346

Ajax® Engines

5 x 6½
EA-22, 6½ x 8 CMA
EA-30, 7¼ x 8 CMA
E-30, 7½ x 10 CMA
E-42, 8½ x 10 CMA
DP-60, 9½ x 10 CMA
DP-70/80/160, 11 x 14 CMA
DP-115/230, 13¼ x 16

Piston & Rod Assemblies

180
360
600
800



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From: Gary Mills [Gary@abcomp.ca]
Sent: Monday, January 15, 2007 5:17 PM
To: gkibria@vaportechinc.com
Subject: VRG330U

VRG330
VRG330TA
Specifications Summary

Model, spark ignited	Peak intermittent torque @ RPM		Brake horsepower at speeds indicated (S.A.E.)							
	Ft.Lb.	N-M	900	1000	1200	1400	1600	1800	2000	2200
VRG330 Natural gas	220 @ 1600	298 @ 1600	29 26	36 33	47 42	58 52	67 60	75 68	82 74	89 80
VRG330, HD5 Propane	285 @ 1400	386 @ 1400	43 39	50 45	64 58	76 69	85 76	92 83	99 89	106 96
VRG330, Gasoline	268 @ 1400	360 @ 1400	35 30	44 37	60 50	75 65	85 75	95 85	105 95	110 100
VRG330TA, Natural gas	302 @ 1600	405 @ 1600	-	50 47	68 63	89 82	97 92	106 100	110*	118*