ROOTS™

Roots® 2060 HV and 2092 HV

Installation operation and maintenance manual

www.RootsBlower.com

Contents

Information summary

Do these things to get the most from your Roots blower from Roots

Check shipment for damage. If found, file claim with carrier and notify nearest Roots Sales Office.

Unpack shipment carefully, and check contents against Packing List. Notify Sales Office if a shortage appears

Store in a clean, dry location until ready for installation. Lift by methods discussed under **Installation** to avoid straining or distorting the equipment. Keep covers on all openings. Protect against weather and corrosion if outdoor storage is necessary.

Read **limitations** and **Installation** sections in this manual and plan the complete installation.

Provide for adequate safeguards against accidents to persons working on or near the equipment during both installation and operation. See **Safety precautions**.

Install all equipment correctly. Foundation design must be adequate and piping carefully done. Use recommended accessories for operating protection.

Make sure both driving and driven equipment is correctly lubricated before start-up. See **Lubrication**.

Read starting check points under **Operation**. Run equipment briefly to check for obvious faults, and make corrections. Follow with a trial run under normal operating conditions.

In the event of trouble during installation or operation, do not attempt repairs of Roots furnished equipment. Notify nearest Sales Office giving all nameplate information plus an outline of operating conditions and a description of the trouble.

Unauthorized attempts at equipment repair may void manufacturer's warranty. Units out of warranty may be repaired or adjusted by the owner. It is recommended that such work be limited to the operations described in this manual, using Factory Parts. Good inspection and maintenance practices should reduce the need for repairs.

Note: Information in this manual is correct as of the date of publication. The Manufacturer reserves the right to make design or material changes without notice, and without obligation to make similar changes on equipment of prior manufacture.

Roots products from Roots are sold subject to the current General Terms of Sale and Warranty Policy WP-5020. Copies are available upon request.

Operating characteristics

Roots units covered in this manual range in basic size from 10 inches through 20 inches gear diameter. From a usage or application standpoint there are two general types. Type RAS/RAS Whispair units from Roots are designated as air blowers, and may be used for handling air or some gases where leakage to atmosphere is not objectionable. Type RGS/RGS Whispair units are similar in basic design, but include seal modifications necessary for the handling of gases where leakage needs to be reduced to a practical minimum.

For simplicity, the term 'blower' is used generally in this manual to refer to booster. The Roots rotary lobe blower from Roots is a positive displacement type unit whose pumping capacity is determined by size, operating speed and pressure conditions. It employs two double-lobe impellers mounted on parallel shafts and rotating in opposite directions within a cylinder closed at the ends by headplates. As the impellers rotate, air or gas is drawn into one side of the cylinder and forced out the opposite side against the existing pressure. The pressure developed, therefore, depends on the resistance of the discharge system. Effective sealing of the blower inlet area from the discharge area is accomplished by use of very small operating clearances. There is no metal-to-metal contact so internal lubrication is not required. Clearances between the impellers during rotation are maintained by a pair of accurately machined timing gears, mounted on the two shafts extending outside the air chamber blower casing.

Operation of the familiar basic rotary lobe blower is illustrated in **Figure 1**, where air flow is left to right from inlet to discharge with the lower impeller rotating counterclockwise. In Position 1, it is delivering a known volume (A) to the discharge, while space (B) between the upper impeller and cylinder wall is being filled. Clockwise rotation of this impeller then traps equal volume (B) in Position 2, and further rotation delivers it to the discharge in Position 3. At the same time, another similar volume is forming under the lower impeller, and will be discharged when rotation reaches Position 1 again.

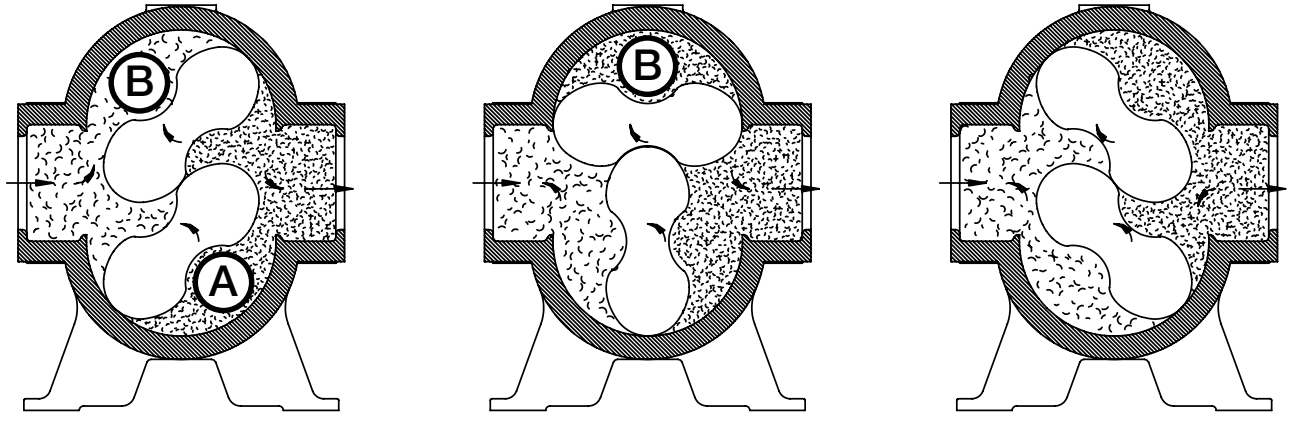
One complete revolution of the driving shaft alternately traps four equal and known volumes of air (two by each impeller) and pushes them through to the discharge. The pumping capacity of a lobe blower operating at constant speed therefore remains relatively independent of reasonable inlet or discharge pressure variations. To change capacity, it is necessary either to change speed of rotation or vent some of the air.

No attempt should ever be made to control capacity by means of a throttle valve in the intake or discharge piping. This increases the power load on the driver, and may seriously damage the blower.

When a belt drive is employed, blower speed can usually be adjusted to obtain desired capacity by changing the diameter of one or both sheaves. In a direct coupled arrangement, a variable speed motor or transmission is required. If discharge air is returned to the blower inlet, it must go through a cooling by-pass arrangement.

Before making any changes in blower capacity or operating conditions, contact the nearest Sales Office for specific information applying to your particular blower. In all cases, operating conditions must be maintained within the approved range of pressures, temperatures and speeds as stated under **Limitations**. Also, the **blower must not be used to handle air containing liquids or solids**. Serious damage to the rotating parts will result.

Figure 1: Flow through a basic type blower



Position 1 Position 2 Position 3

Operating limitations

To establish and maintain continued satisfactory performance, any Roots blower from Roots must be operated within certain approved limiting conditions. The manufacturer's warranty is, of course, contingent on such operation.

Example: the listed maximum allowable temperature rise (increase in air temperature between inlet and discharge) for any particular blower may occur well before maximum speed or maximum pressure rating is reached. Temperature rise then is the limiting condition. In other words, the operating limit is always to be determined by the maximum rating reached first. It can be any one of the three: pressure, temperature or speed.

Be sure to arrange connections or taps for thermometers and pressure or vacuum gauges at or near the inlet and discharge connections of the blower. These, along with a good tachometer, will enable periodic checks of operating conditions to be made easily.

Pressure

The pressure rise in pounds per square inch (kPa) between blower inlet and discharge, must not exceed the figure listed for the specific blower and frame size concerned. Casing design pressure is limited to 25 PSI (172 kPa) gauge. Discharge pressure must never exceed 25 PSI (172 kPa) gauge regardless of blower size.

Temperature

Various blower frame sizes are approved only for installations where the following temperature limitations can be maintained in service.

A. Maximum temperature rise (T.R.) in Fahrenheit degrees (°C) must not exceed listed values when the inlet is at ambient temperatures. Ambient is considered as the general temperature of the space around the blower. This is not outdoor temperature unless the blower is installed outdoors.

B. If inlet temperature is higher than ambient, the listed allowable temperature rise values must be reduced by 2/3 of the difference between the actual measured inlet temperature and the ambient temperature. Also, average temperature of inlet & discharge shall not exceed 250°F (120°C).

Speed Range-Blowers may be operated at speeds up to the maximums listed for the various frame sizes. They may be direct coupled to suitable constant speed drivers if pressure/temperature conditions are also within limits. At lower speeds, excessive temperature rise may be the limiting factor.

Table 1 – HV booster operating limitations

Unit	Max speed	Max pressure rise		Max temperature rise		Approx weight	
	RPM	PSI	mm Hg	F°	C°	Lbs	Kg
2060 HV	1000	2.5	129	215	119.5	13200	5990
2092 HV	1000	1.5	77.5	215	119.5	15800	7170

Installation

Technical assistance at installation by a Factory Service Engineer is usually not required for the this unit, frame series 1000 through 1400. Workers with general experience in installing heavy machinery should be able to complete a satisfactory installation. Information in this manual is supplemented by the more detailed discussions of foundations and piping in Compressed Air and Gas Handbook published by the Compressed Air and Gas Institute, New York City. However, a Service Engineer may be employed for assistance or for final checking of an installation.

Handling of the equipment should be accomplished by methods conforming to safe practice for the weight involved. Weight of a bare unit, without base plate, driver or accessories will range from about 7 ton (6000 kg) to 8 ton (7200 kg). On such units, 4 cast lifting eyes in cylinder is provided. A unit mounted on a base plate should be lifted only by the four lifting lugs provided in the baseplate. Weight in this case will be greater than the above figures.

Before lifting with four casting lifting eyes, test each one for tightness and fractures by tapping with a hammer. Direction of pull on the bolts during lift should be nearly vertical.

> **Warning:** Cable length should be a minimum of 2 meters to assure angle between cables does not exceed 60°.

Since a considerable cable angle will usually be unavoidable, place a stiff spreader between the four casting lifting eyes to take the side strain, and adjust cable lengths so that the unit is approximately level during the lift. A harness featuring four lifting hooks is required to lift base-mounted units. After inserting the hooks in the lifting lugs, block the chains out on the sides to avoid placing the unit under strain. At the same time, adjust lengths to produce a level lift.

Location

Location of the installation is generally not a critical matter. A clean, dry and protected indoor location is to be preferred. However, an outdoor location will give satisfactory service if correct lubrication for expected temperatures is provided. Effect of such a location on driver and other equipment must also be considered.

Protection

Protection of internal machined surfaces against normal atmospheric corrosion has been provided at the factory, using a vaporizing inhibitor. Maximum period of protection is one year under average conditions, if flange covers and closing seals are not removed. Protection against chemical or salt water atmosphere is not provided. Leave covers and tape seals over all openings as long as possible during installation to avoid loss of protection.

Units are not to be subjected to excessive vibration during storage. If stored outdoors, provide coverage such as a tarpaulin or lean-to.

Rotate drive shaft three or four revolutions every two weeks.

Prior to start up, remove flange covers on both inlet and discharge and inspect internals to insure absence of rust. Check all internal clearances. Also, at this time, remove gearbox and bearing covers and inspect gear teeth and bearings for rust.

When ready to connect piping, remove main flange covers and inspect blower interior for presence of foreign particles or dirt adhering to machined surfaces. Clean out such material by washing carefully with a petroleum solvent, then rotate impellers manually to make sure they turn freely. Also use the same solvent to remove the anti-rust coating from flange faces and any other surfaces.

> **Note:** Interior cleaning is not required if no dirt is found.

> **Note:** Make sure solvent does leave oil residue that could outgas later when under deep vacuum.

Foundation

Foundation design depends on local soil conditions and several other factors and can only be discussed generally here. Additional information will be found in the publication referred to at the beginning of this section. For satisfactory operation of supported equipment, a concrete foundation must be rigid, must have minimum deflections, and must be free from resonant frequencies in the operating speed range of the equipment.

Length and width dimensions of the foundation should provide at least 6 inches (150 mm) from any edge to the nearest machine anchor bolt, as located from the certified manufacturer's general arrangement drawing. Depth dimension should be determined by design, but a minimum practical depth is considered to be twice the distance between shaft centers (or gear diameter) of the unit. This would put at least 24 inches (610 mm) of concrete under a frame series 1200 unit, such as a 1225. The concrete block should be permitted to cure for a minimum of 28 days before the blower is grouted in place. Any block distortions during curing then will have little or no affect on equipment and alignment. To simplify machine leveling and provide good grouting bond, the top of the foundation should be struck off as level as possible but left with a rough surface.

Spring-type vibration isolating mountings are not recommended for use directly between the operating equipment and the foundation. Where such mountings are required, they should be designed to carry a reinforced concrete slab on which the equipment is mounted. This slab must have good rigidity against bending and twisting, and the suspension system will require careful adjustment to produce a reasonably level condition during operation. All piping will require flexible sections and supports to reduce connection strains on the unit to a minimum. Direct use of structural framing members for mounting is not recommended. Chemical anchors of 1" (25mm) diameter minimum are to be used.

Leveling

Levelling is very important and should be performed with care, using a good machinist's level having a ground glass bubble vial. A setting as level as possible in all directions is the desired result.

When blower and driver have been factory mounted on a common baseplate, the assembly is to be treated as a unit for leveling purposes. Use the jack screws to establish grouting space under the base flanges, and to level the base. Adjust these screws until the indicated variation from level does not exceed ,001" per foot (.08 mm per m) in either length or width. Any variations should all be in the same direction, to minimize twist. The maximum allowable twist is considered to be .001" per horizontal foot (.08 mm per horizontal m) measured between any two sections of the base.

Units mounted on soleplates are to be leveled in a similar manner. The plates should be large enough to provide extensions for leveling in both length and width on the finished upper surfaces. Fasten the plates solidly to the blower feet, which are machined flat and parallel to each other, then install and level the blower carefully, using jack screws, shims or wedges for adjusting.

Alignment

Alignment of the drive shafts when the blower unit and its driver are direct coupled requires careful attention. This precaution will not only help insure satisfactory coupling operation, but will minimize chances for damage to either driving or driven unit from vibration or thrust forces. In package units with driver and blower mounted on a common baseplate, the two shafts will have been put in approximate alignment at the factory. However, baseplate deflections can occur during shipping and installation. A close coupling alignment should be obtained during leveling, so that only small final adjustments will need to be made after grouting. In a soleplate type installation, the separately mounted driver must be positioned, leveled and aligned as part of the installation procedure. Whether it is on soleplates or on its own base, shims of 1/16" to 1/8" (2-3 mm) thickness placed directly under the driver feet before setting will permit more accurate final alignment. Spacing between the two shaft ends as required by the coupling must also be established. If a motor is being used that has end-play in the shaft, be sure its rotor is located on magnetic center before setting this spacing.

When blower is driven through V-belts, the driver must be mounted on an adjustable base to permit tightening or removing the belts. In this case the driver shaft height is of no concern, but it must be parallel to the blower shaft and level. To position the driver properly, both sheaves need to be mounted on their shafts, and the shaft center distance must be known

The blower sheave, usually the larger one in diameter, must be of the narrow hub type. Install it so that its inner hub face is not more than 1/4" (13 mm) away from the bearing housing end cover. The driver sheave should also be mounted as close to its bearing as possible. Now position the driver so that faces of the two sheaves are accurately in line, with the adjustable base so located as to make 2/3 of its total movement available in the direction away from the blower. This positioning provides minimum belt wear and slip, and allows sufficient adjustment for installation and tightening of belts. Do not install belts until grouting has set and anchor bolts are tightened.

Grouting

Grouting follows completion of leveling and preliminary alignment. Assuming the foundation has been properly cured, its top surface should first be roughened by chipping to remove glazed areas, and oil or grease should be removed with a strong hot detergent or caustic solution. Grouting serves not only to compensate for surface irregularities in the foundation and machine base but also to provide restraint against shifting. Anchor bolts are used for hold-down only. Therefore, the grout must be adequate thickness under the soleplate or base flange, must flow into anchor bolt sleeves and all interior cavities, and must have minimum shrinkage during the setting period. By virtue of the open frame design, it is recommended that the bedplate be filled with concrete to a level equal to the top of the main channels. Special grouting materials designed to counteract shrinkage are commercially available.

The manufacturer's instructions should be followed in using these materials. Care must be exercised when employing non-shrink additives with cement, as too much can be worse than none. Any gas forming or air-entraining additives should be avoided completely, since they tend to reduce grout strength.

Wait at least 24 hours before tightening anchor bolts or connecting any piping. When jack screws have been used for leveling, make sure the bottom of the leveling screw is treated according to grout manufacturer's instructions so that leveling screw can be backed off. Such points of concentrated loading are likely to wear during machine operation, resulting in loose anchor bolts. Final bolt tightening should be only enough to hold the machine firmly against the foundation and prevent vibration.

After all anchor bolts are secured, recheck the blower for twist and level. Make corrections to meet the requirements specified under **Leveling** by shimming under the blower feet. Then rotate the drive shaft by hand to make sure both impellers turn freely at all positions.

When the blower is direct coupled to its driver, final alignment of the two shafts should be accomplished next by adjusting the shims under the driver feet.

This needs to be done with the greatest possible care. Even though a flexible coupling can accept some degree of misalignment, it should not be forced to compensate for careless workmanship. The flexing or sliding member in a coupling will transmit undesirable forces between the two shafts in proportion to the degree of misalignment, thus promoting vibration and unnecessary wear problems.

Misalignment

Misalignment can be of two basic types, offset and angular, but usually it will be a combination of both. For satisfactory coupling operation it is recommended that the following limits be used: maximum deviation in offset alignment not greater than .005" (.13mm) total indicator reading on the coupling hubs; maximum deviation from parallel of the inside coupling faces not greater than .001" (.03 mm) when checked at six points.

A belt-driven installation should require no realignment if all items were correctly positioned and leveled before grouting. Belts may be installed now by adjusting driver position toward the blower sufficiently to permit belts to be laid in their sheave groves easily. Do not pry or roll them into place. Before doing this, inspect all grooves for burrs, rough spots or oil that might shorten belt life. If equipment is not to be operated immediately, leave the belts slack.

Proper tensioning of the drive for operation should be done in accordance with manufacturer's recommendations, keeping in mind that excessive tension can seriously overload shaft bearings and also lead to premature drive failure. Undertensioning can produce slippage, with consequent loss of blower capacity in addition to belt damage.

Make sure at this point that driver rotation is correct to produce the blower shaft rotation indicated by an arrow near the shaft. The Whispair blowers are not reversible, hence drive shaft rotation and discharge flange location are predetermined in manufacturing assembly. **Figure 2** on page 6 illustrates the assembly options available by specification on original order, to meet piping and drive requirements.

Piping

Piping must be clean, and not smaller in size than the blower connections. A good rule-of-thumb is that the air or gas line velocity should not exceed 100 feet (33 meters) per second.. Where possible, use long radius elbows to insure smooth flow. Design the piping layout so that no strains are placed on the blower, either from weight or expansion forces. This means providing adequate supports, anchors, and expansion joints or loops.

Installation of a spool-type expansion joint near the blower inlet connection is recommended. A similar unit added to minimize piping vibrations may be required near the discharge. Use of **Snubbers** or **Silencers** in the inlet or discharge piping is typically not necessary for high vacuum service due to very low pulsations occurring.

Inlet piping should be completely free of valves or restrictions, but when a shut-off valve cannot be avoided, **make sure** a full size vacuum relief valve is installed near the blower inlet connection. This will protect against an overload caused by accidental valve closing. Even in a gas installation this relief valve protection is essential. Further protection can be provided by installation of a dependable pressure sensitive device with alarm or shutdown action.

During initial operation, install a temporary corrosion-resistant screen at the compressor inlet connection. Screen should be made of 16 mesh (.020" diameter) wire backed with 2 mesh wire cloth. Backing cloth-wire diameter shall be a minimum of 0.063" diameter for 12" pipe, 0.080" diameter for 16" pipe, 0.105" diameter for 20" pipe, and 0.120" diameter for 24" pipe. For 30" and 36" pipe use 1 mesh backing cloth with a minimum of .180" wire diameter for 36" pipe. The table below gives approximate screen pressure drop. A manometer connected to read pressure drop across the screen will indicate when it needs cleaning. Do not allow pressure drop to exceed 55 inches H_2O. Clean and replace the screen until debris no longer appears. Do not leave the screen installed permanently, as the wire will eventually deteriorate and pieces may go into the blower causing serious damage. (Typically, screens are installed for 1-2 days of operation).

In some installations, particularly where two or more blowers discharge into a common header, it is **recommended** that a direct acting or free swinging check valve be provided in each discharge line. These valves, properly installed, protect against damage resulting from reverse rotation caused by back flow through an idle blower.

In making pipe connections to the blower, use special care in lining up the mating flanges. They must contact squarely and accurately, without imposing strain on the blower casing. Any attempt to draw flanges together by force will probably distort the blower and cause internal contacts. Also, the blower should not carry more than the weight of one pipe fitting at each connection. After bolting up the flanges, rotate the drive shaft by hand to check for rubbing contacts caused by strains or dirt.

Vacuum system piping must be vacuum tight throughout. Leaks will seriously effect and limit performance of booster and complete vacuum system.

Table 2 – Approximate Screen Pressure Drop, Inches H_2O (16 Mesh, .020" Wire Dia.)

Flow	Pipe diameter (Inches)					
	12"	16"	20"	24"	30"	36"
2,500	3.0	1.1	0.3	0.3		
5,000	12.7	3.9	1.7	0.8		
10,000		15.5	6.4	3	1.3	
15,000			14.4	7.2	2.8	1.4
20,000				12.7	5.1	2.4
30,000					11.4	5.5
45,000						12.3

V-belt Drive Recommendations:

- Use minimum of 1.4 service factor on the drive horsepower.
- Motor must be located on booster drive shaft side thus no cross belt loading.
- Use molded notched belts, power band type where possible.
- The contact arc of smaller sheave not to be less than 170°.
- "A" dimension = 7.92"
- Maximum shaft load = 40,000 IN-LBS.

Figure 2: Blower orientation

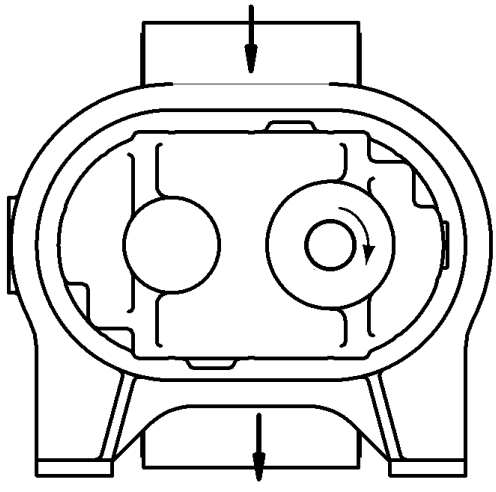
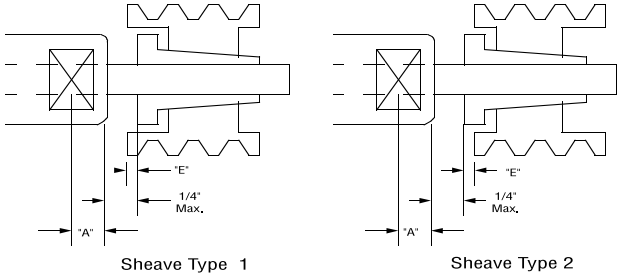


Figure 3: Overhung load calculation



Belt Pull (Lbs.) = (275,000 X Motor HP) / (Blower RPM X Sheave Diameter)

Shaft Load (Lb.-In.) = Belt Pull X (A + ?" (+ or – E see below *) + Sheave width / 2)

* Subtract "E" if sheave type 1 is used, Add "E" if sheave type 2 is used.

Lubrication

Oil must be low vapor pressure of 0.1 micron Hg or less at 180°F and 1.8 micron Hg or less at 250°F. Lubricating oil viscosity should be selected from **Table 3** for the existing ambient temperature range. Fill the blower oil sump through the top plug on both covers to the upper gauge line before starting operation, and recheck the level soon after the first startup. If it falls below the lower gauge line, add sufficient oil to bring it back to the upper line. During the first week of normal blower operation the oil level should be checked daily. Thereafter a weekly check probably will be sufficient. Do not permit the level to drop below the lower gauge line, nor go above the upper line. Use only non-detergent premium grade lubricant with foam, oxidation, and rust inhibitors. The use of Roots synthetic oil from Roots is highly recommended.

Table 3 – Recommended lubricating oils

Ambient* Temperature °F (°C)	ISO Viscosity No.
32° to 120°F (O° 49°C)	220
Below 32°F (18°C)	100

Table 4 – Oil sump capacities

Frame series	Approx. Oil capacity, Gallons (Liters)	
	Drive end	Gear end
2000	1.25 (4.7)	3.0 (11.4)

Oil should be changed after the first 100 hours of operation. After the initial oil change, an oil change frequency of 2,000 hours would be considered normal. More frequent oil changes may be necessary if the blower is in a very dusty or contaminated environment. The use of Roots synthetic oil from Roots can extend life up to three times that of mineral oil. Testing of oil should be used to determine change intervals. It may be advisable to check oil condition each time the weekly level check is made, until a regular change period can be determined. At each oil change, remove and thoroughly clean the strainer screen in the oil sump.

Some oil seal leakage will occur at the drive shaft seal and the headplate seals since an oil film under the lip is required for proper operation. Periodically, the leaked oil should be wiped off from the blower as well as base plate surfaces, since even a small amount of leaked oil spreads over a large area making the leakage look worse than actual.

Any inboard seal leakage will collect in a chamber inside each head plate.

Operation

Before starting the blower under power for the first time, recheck the installation thoroughly to reduce the likelihood of troubles.

Use the following procedure check list as a guide, but also consider any other special conditions in the installation.

Be certain no bolts, rags or dirt have been left in the blower air chamber.

Be certain that inlet piping is free of debris. Use of the temporary protective screen at the blower inlet as described under **Installation** is strongly recommended during early operation. If an outdoor intake without filter is used, be sure the opening is clean and protected by a strong screen.

Check blower leveling, drive alignment, belt tension and tightness of all mounting bolts if installation is not recent.

Turn drive shaft over by hand to make sure impellers will rotate without bumping or rubbing at any point.

Check lubrication system. Oil level in both covers should be at or near the upper gauge line.

If driver is an electric motor, make sure it is also properly lubricated. Check that power is available, and that all electrical overload devices are installed and in operating condition.

Start system forepump and run it alone until inlet pressure of booster is about 15mm Hg absolute. **Note:** During pump down, booster may windmill.

Bump blower a few revolutions with driver to check direction of rotation and to see that both units coast freely to a stop.

Start booster manually or with vacuum pressure switch at booster inlet.

> **Note:** Booster will overheat if operated at 15mm Hg absolute inlet pressure for longer than 5 minutes. Providing a suitable pressure transmitter at booster inlet allows system check for tightness during initial pump down period. Under normal conditions, system reaches anticipated pressure within 15-30 minutes. If it fails to do this, the cause continued outgassing of various surfaces within the system, leaks or both. Outgassing sometimes requires 24 hours, but depends on the system size. It is advisable to first check for leaks in piping, joints, seals, etc. This may be done by stopping pumps, isolating system vacuum tight valve and observing pressure rise rate of system.

The unit should now be ready for continuous duty under full load. During the first several days, make periodic checks to be sure that all conditions remain reasonably steady and within limits. These checks may be especially important if the unit is part of a process system where conditions may vary. At the first opportunity, stop the blower and clean or remove the protective inlet screen. At the same time, verify leveling, coupling alignment or belt tension, and anchor bolt tightness.

Troubleshooting checklist

Trouble	Item	Possible cause	Remedy
No flow	1	Speed too low	Check by tachometer and compare with speed on Howden's Roots Order Acknowledgment
	2	Wrong rotation	Compare actual rotation with **Figure 2**. Change driver if wrong.
	3	Obstruction in piping	Check piping, screen, valves, silencer, to assure open flow path.
Low capacity	4	Speed too low	See item 1. If belt drive, check for slippage and readjust tension.
	5	Excessive pressure rise	Check inlet vacuum and discharge pressure, and compare these figures with specified operating conditions on order.
	6	Obstruction in piping	See item 3.
	7	Excessive slip	Check inside of casing for worn or eroded surfaces causing excessive clearances.
Excessive power	8	Speed too high	Check speed and compare with Howden's Roots Order Acknowledgement.
	9	Excessive pressure rise	See item 5.
	10	Impeller rubbing	Inspect outside of cylinder for high temperature areas, then check for impeller contact at these points. Look for excessive scale build-up. Correct blower mounting, drive alignment.
Overheating of bearings or gears	11	Inadequate lubrication	Check oil sump level and condition of oil.
	12	Excessive lubrication	Check oil sump level and condition of oil.
	13	Excessive pressure rise	See item 5.
	14	Coupling misalignment	Check carefully. Realign if questionable.
	15	Excessive belt tension	Readjust for correct tension.
Vibration	16	Misalignment	See item 14.
	17	Impellers rubbing	See item 10.
	18	Worn bearings/gears	Check gear backlash and condition of bearings, and replace as indicated.
	19	Unbalanced or rubbing impellers	Scale or process material may build up on casing and impellers, or inside impellers. Remove build-up to restore original clearances and impeller balance.
	20	Driver or blower loose	Tighten mounting bolts securely.
	21	Piping resonances	Determine whether standing wave pressure pulsations are present in the piping. Refer to Sales Office.
Oil in process	22		See discussion of sealing under **Lubrication**.

Safety precautions

For equipment covered specifically or indirectly in this instruction book, it is important that all personnel observe safety precautions to minimize the chances of injury.

Among many considerations, the following should particularly be noted:

Blower casing and associated piping or accessories may become hot enough to cause major skin burns on contact.

Internal and external rotating parts of the blower and driving equipment can produce serious physical injuries. Do not reach into any openings in the blower while it is operating, or while subject to accidental starting. Cover external moving parts with adequate guards.

Disconnect power before doing any work, and avoid by-passing or rendering inoperative any safety or protective devices.

If blower is operated with piping disconnected, place a strong coarse screen over the inlet and avoid standing in the inlet or discharge air stream.

Stay clear of the blast from pressure relief valves and the suction area of vacuum relief valves.

Avoid extended exposure in close proximity to machinery with high intensity noise levels.

Use proper care and good procedures in handling, lifting, installing, operating and maintaining the equipment.

Casing pressure must not exceed 25 PSI (172 kPa) gauge. Do not pressurize vented cavities from an external source, nor restrict the vents.

Do not use booster on explosive or hazardous gases.

Other potential hazards to safety may also be associated with operation of this equipment. All personnel working in or passing through the area should be warned by signs and trained to exercise adequate general safety precautions.

Preventive maintenance

Daily

Record the following:
– Lube oil pressure (if applicable).
– Lube oil temperature (if applicable).
– Blower inlet temperature.
– Blower inlet pressure.
– Blower discharge temperature.
– Blower discharge pressure or differential pressure.
– Motor amperage.
– Motor voltage, if available.
– Motor stator temperature, if available.
– Motor bearing temperature, if available.

Observe any abnormalities, i.e. burned paint, unusual noises, vibration, strange odors, oil leaks, etc.

Review log sheets to determine if there are any changes from previous readings (it is very important to look for any changes or tends which might indicate pending problems).

Check oil levels.

Record hour meter readings.

Monthly

Record bearing housing vibration levels at each Use velocity (in./sec.) measurements and note any changes from previous readings. Take a complete vibration signature (amplitude versus frequency) if any trends are noted. (It may be helpful to keep a chart on monthly readings.)

Quarterly

Sample lube oil or change.

Change oil if the following values are exceeded:
– Water 100 PPM maximum.
– Metals 200 PPM maximum.
– Acid 5.0 to 7.5 Mg/KOH/g maximum.

Increase frequency of sampling if any of the above values show about 20 to 25 percent increase over the last sample.

Flush all oil reservoirs before filling with clean oil.

Annually

Remove an inlet expansion joint, inspect impellers, measure impeller clearances and note wear patterns.

Check coupling alignment, inspect coupling for wear, and repack with fresh grease.

Inspect oil cooler tubes, as applicable.

Check all protective switches for proper setpoints and operation.

Check V-belt drive condition and tension.

A Preventative Maintenance Schedule should be established for driver(s) and all accessories in accordance with the applicable manufacturer's recommendation.

Rotary Lobe Blower vibrations

The general vibration severity charts derived from Rathbone vibration severity charts provide guidelines for machines basically having mass unbalance (turbomachinery, electric motors, etc.) The German specification VDI 2056 – Criteria for Assessing Mechanical Vibrations of Machines – provides vibration guide lines for machines with rotating masses (turbomachinery) and machines having mass effects which cannot be balanced (reciprocating machines), but does not specifically address rotary lobe blowers (also known as Roots blowers from Roots) with inherent fluctuating dynamic bearing loads and torques.

API Standard 619, Rotary Type Positive Displacement Compressors for General Refinery Services, limits the vibration level to 0.1 in/sec peak, which is quite ambitious.

Based on experience, practical acceptable vibration levels lie somewhere between API 619 requirement and VDI 2056 allowance for group D reciprocating machines.

Elements generating vibrations in Rotary Lobe Blower

Inherent rotary lobe blower characteristics can lead to vibrations:
- Impacting bearing loads excite component/system natural frequencies.
- Pressure pulsations set off vibrations at four times the running speed (RPM).
- Pulse maximum limits (PSI peak to peak) of rotary blowers are as follows:
  - Blower inlet: 5% of absolute pressure
  - Blower discharge: 8% of absolute pressure
- During blower commissioning, measurement of system pressure pulsation levels and blower vibrations are recommended to validate the system design. Pressure measurement shall be a dynamic pressure probe located approximately 1 pipe diameter from blower flange. Also pressure probe should be minimum of 2 pipe diameters away from significant transition such as pipe elbow or process valve.

Rotary lobe blowers use very close clearances between the impellers and the housing. The impeller contact will setup vibrations as follows:
- Impeller to impeller frontal lobe contact – if contact is between only one set of lobes, the vibration frequency will be 1XRPM; if both sets of lobes contact, the vibration frequency will be 2XRPM.
- Impeller to cylinder contact – the vibration frequency will depend on the number of impeller tips contacting the cylinder, which could range from one to four times the RPM.
- Impeller to head plate contact – the vibration frequency will be erratic and unsteady.

Damaged gears will generate vibrations at mesh frequency, number of teeth times RPM.

Damaged bearings will generate vibrations at ball pass frequency, fundamental train frequency and ball spin frequency.

Rotor unbalance and bent shaft will generate vibrations at 1XRPM.

Blower/driver coupling misalignment will generate vibrations at 1XRPM and 2XRPM.

Acoustic resonance in the blower inlet/discharge piping will generate vibrations at 4XRPM.

Operation of rotary lobe blower at or near system torsionals may cause impeller lobe contact and increases vibrations.

External piping if not properly isolated will transmit vibrations into the blower.

Foundation design and method of mounting has considerable effect on blower vibrations.

Vibration criteria

Units of measurement: Rotary lobe blower vibrations are measured in inches/sec. Measurements of spike energy are not recommended for judging blower condition because the rotary lobe blower has inherent impacting bearing loads.

Measurement location: Vibrations should be measured at the bearing locations on the housing.

The following table provides an appropriate assessment guideline for rotary lobe blowers rigidly mounted on the stiff foundations.

Unfiltered vibrations (in/sec peak)	Assessment
<0.45	Very good
>0.45 to 0.62	Good
>0.62 thru 1.0	Satisfactory
>1.0	Review required

If the blower is operating at 'review required' levels then the installation must be fully evaluated to determine the source or cause of vibration and the cause shall be corrected.

In general, blower vibration levels should be monitored on a regular basis and the vibration trend observed for progressive or sudden change in level. If such a change occurs, the cause should be determined through spectral analysis.

The blower vibrations will be transmitted into the motor, speed reducer etc. and more so if they are mounted on the common blower baseplate. Allowable vibration levels into these accessories should be obtained from the vendors.

HV Booster clearances in inches

Unit	Impeller ends		Impeller strip to cylinder			Impeller lobes		Temp rise
	Trust End	Gear End	Inlet	Center	Discharge	Fronts	Backs	°F
2060	.023-.025	.056-.060	.030-.032	.022-.025	.014-.024	.027-.031	.017-.021	215
2092	.025-.027	.081-.085	.033-.035	.025-.028	.017-.027	.028-.032	.018-.022	215

HV Booster clearances in mm

Unit	Impeller ends		Impeller strip to cylinder			Impeller lobes		Temp rise
	Trust End	Gear End	Inlet	Center	Discharge	Fronts	Backs	°C
2060	.58-.64	1.42-1.52	.76-.81	.56-.64	.36-.61	.69-.79	.43-.53	119.5
2092	.64-.69	2.06-2.16	.84-.89	.64-.71	.43-.69	.71-.81	.46-.56	119.5

Maintenance/replacements

A good program of inspection and maintenance servicing, if followed consistently, is the most reliable means of preventing costly repairs to a blower. A simple record of procedures and dates will help maintain this work on a regular schedule. Basic requirements are lubrication and cleaning, along with periodic checking for increased vibration and hot spots on the cylinder. Inlet and discharge pressures and temperatures should be observed frequently, to minimize the chances for trouble resulting from blower ratings being exceeded. **Above all, the unit must be operated within its specifications.**

In a blower properly installed and operated, there is no moving contact between the two impellers, or between the impellers and cylinder or headplates. Wear is then confined to the timing gears, the bearings which support and locate the shafts, and shaft seals, and the oil pump. All are lubricated, and wear should be normal if they are always supplied with clean, high grade lubricating oil. Shaft seals, whether lip type or rotating mechanical type, are subject to deterioration as well as wear. They may require replacement at varying periods. O-rings should be replaced at each disassembly as routine replacement items.

If trouble should occur during operation, and its cause cannot be readily determined, consult the **Trouble Shooting List**. Remedies suggested there can usually be performed by qualified mechanics, using procedures detailed in this manual. Major repairs not covered here are considered beyond the scope of maintenance, and should be referred to the nearest Sales Office. **Warranty failures** should not be repaired at all, unless specific approval has been obtained through a Sales Office before starting the work. Unauthorized disassembly within the warranty period may void the warranty.

Where repairs involve parts replacement, it is recommended that Factory Parts be used to insure fit and suitability. Delay in making such repairs can be reduced by having spare parts on hand.

When ordering parts, please furnish all information from the blower nameplate.

Repairs or adjustments to blowers should be performed by personnel with a good background of general mechanical experience and the ability to follow the detailed instructions in this manual. Some special tools are required. Some operations involve extra care and a degree of precision work. This is especially true in timing impellers, and in handling bearings. Experience indicates that a high percentage of bearing failure is caused by dirt contamination before or during assembly. Therefore, clean the work area before starting disassembly, and protect new or reusable parts during progress of the work.

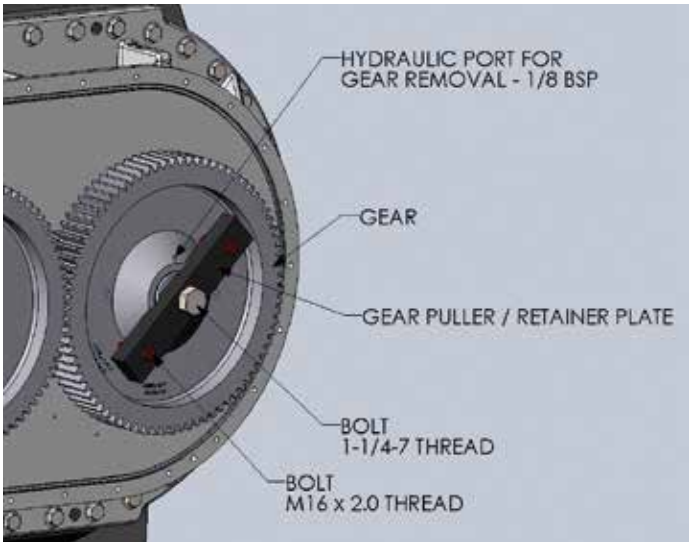
The following detailed work procedures cover repairs and adjustments that can normally be handled successfully at the installation site.

Any repairs to be completed on booster must be conducted by a qualified technician and trained by Roots.

Removal of gears

Use retainer plate as shown below and leave 1/8" gap between plate and shaft end to allow gear to be fully unset from taper. Inject oil at the 1/8" BSP port on the face of the gear via manual operated hydraulic pump and gear will expand and release from shaft taper.

If necessary tighten retainer plate bolts until tight to end of shaft thus adding force to gear face to allow easier removal from shaft taper. Must though, have gap between gear face and end of shaft to work.



Install of gears

Make sure shaft & gear taper is free from scratches, nicks or any oil. Clean all taper surfaces with solvent to remove all grease and oil prior to installing gear.

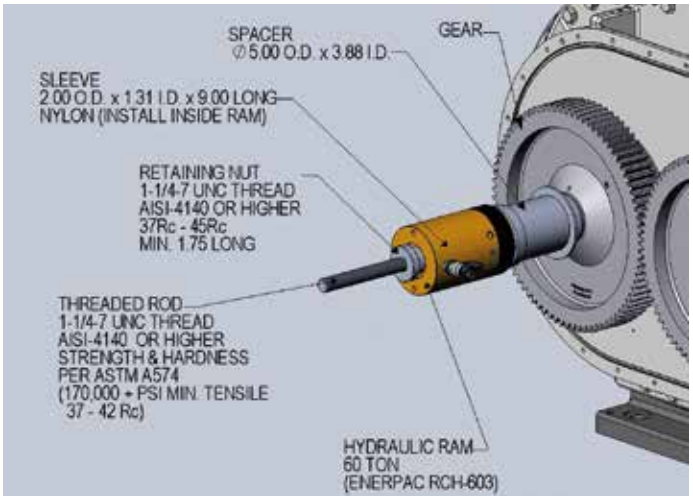
Use threaded rod, nut, hydraulic ram and sleeve as shown below to fully install gear. Pay special attention to the proper strength of threaded rod that is required as well as size of hydraulic ram. Nearly full capability of ram will be used.

Proper push up distance for each gear is .160-170 inches (4.06-4.3 mm). Use indicator on face of gear to determine actual push up distance has occurred.

For 2nd gear install, block impellers inside the blower with wooden blocks/wedges.

Set impeller lobe clearances using feeler blades. Once set, install 2nd gear using same procedure as first gear.

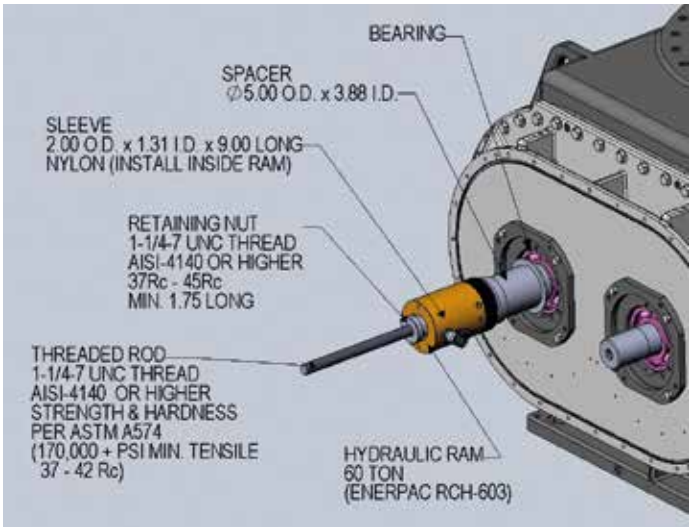
If necessary, timing of impellers can be adjusted slightly (few thousands of an inch) by injecting small pressure of oil into 1/8"BSP port on face of gear, which allows gear to expand at taper to shaft, so able to tap face of gear and allow slight rotation of gear relative to shaft.



Install of bearings

Make sure shafts and bearing surfaces are free from scratches & nicks. Apply light oil to shaft fit.

After bearing carrier installed, add light coat oil to shaft diameter and press each bearing on shaft as shown below. Same tooling used for gear install can be used for bearing. Press bearing on until bearing seats against seal sleeve shoulder.



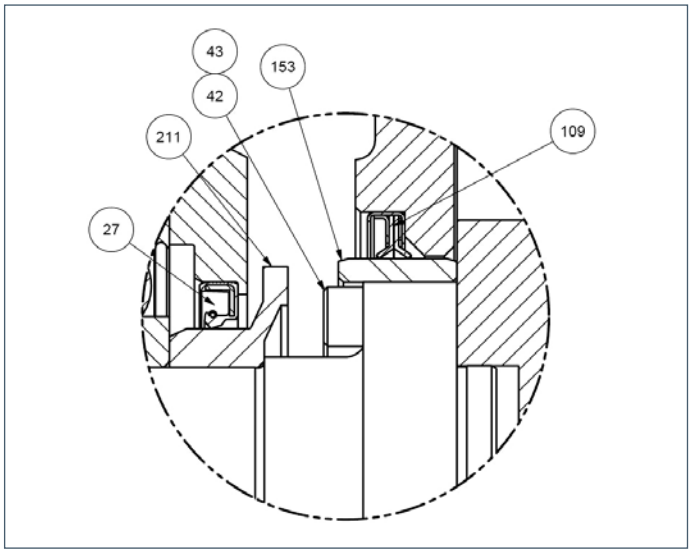
Inboard seal install:

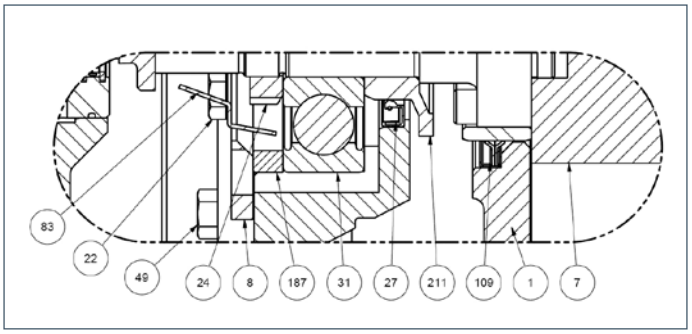
See parts List and detail layouts shown below.

To install each seal sleeve, heat sleeve to 250–300°F using induction heater and slide on to shaft in proper position. Prior to install add light coat of Loctite 640 to shaft OD. NOTE: Sleeves are very hard and wear from seals is not typically expected, so if visually see no groove or damage, replacement of any or all sleeves is not necessary. If sleeve removal is required, torch heat sleeve OD and use of gear puller tool as necessary to slide off of shaft fit.

For purge seal install, seal driver with dimension of 7.00"ID x 7.625"OD x minimum 15.5"LG, is required to be fabricated to allow seal to be pressed into head plate bore until firmly against back shoulder.

For oil seal install, seal driver with dimension of 5.866"OD x minimum 2.5"LG, is required to be fabricated to allow seal to be pressed into bearing carrier bore firmly against back shoulder.





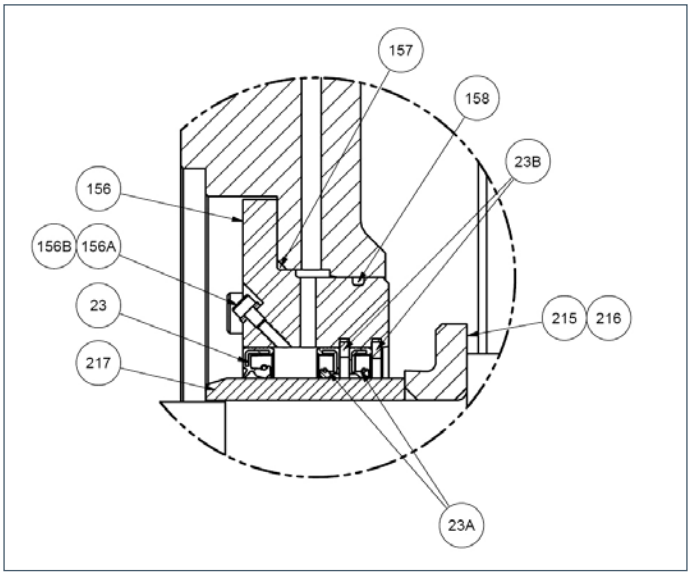
Driveshaft seal install:

See parts List and detail layout show below.

First slide sleeve extractor and O-ring (item #215&216) into place. To install seal sleeve, heat sleeve to 250°F using induction heater and slide on to shaft till shoulders against sleeve extractor. Prior to install add light coat of Loctite 640 to shaft OD.

For oil seal install, first install snap ring (item #23B) into inner most groove. Then a seal driver with dimension of 3.720"OD x minimum 1.0"LG, is required to be fabricated to allow two seals (item #23A) to be pressed into seal housing bore until firmly against back shoulder of each side of snap ring. Second snap ring is installed into most outer groove. Finally seal (item #23) can be pressed into front of housing till flush on front. A seal driver with dimension of 4.25"OD x minimum 1.0"LG, is required to be fabricated to allow install squarely to front face.

After seal housing assembly is installed into cover, add oil to oil bottle on top of cover. Release set screw (item #156A) enough to allow trapped air to be released and until oil starts escaping screw and then retighten screw. Refill oil bottle accordingly.



HV Booster parts list

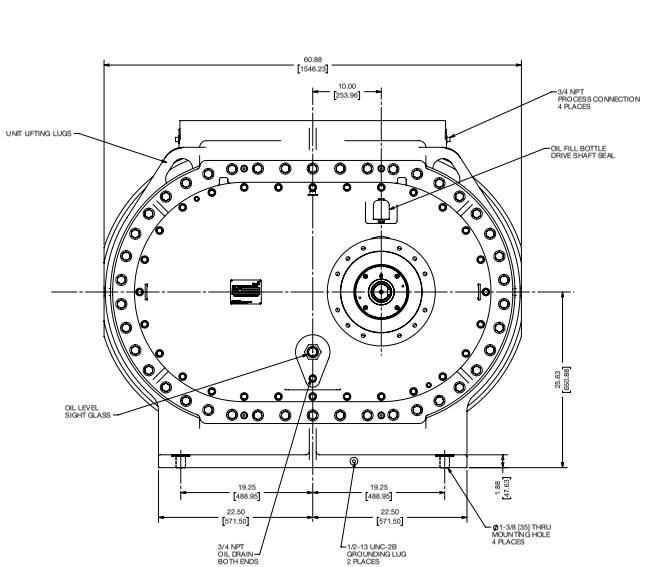
Item Number	Part Name	Quantity
1	Headplate	2
2	Cylinder	1
3	Gearbox	1
5	Cover	1
6	Bearing carrier	4
7	Impeller	2
8	Bearing clamp plate	4
9	Gear	2
12	Shaft g.E. Driven	2
13	Shaft o.G.E. Drive	1
14	Shaft o.G.E. Driven	1
16	Key, square 18mm x 11mm	1
17	Shim set	1
18	O-ring	2
18A	O-ring	2
20	O-ring	4
22	Cap screw m16 x 40	12
23	Seal	1
23A	Seal	2
23B	Retaining ring – internal	2
24	Lock nut an-19	2
27	Seal	4
30	Screw hex 1/2-13 x 1.50	56
30A	Screw hex 3/4-10 x 2.00	84
31	Bearing	4
32	Spring pin 1/4 x 1.00	1
34	Nameplate ‘serial no.’	1
35	Drive screw #4 x 0.19	6
36	Dowel pin 1/2 x 2	2

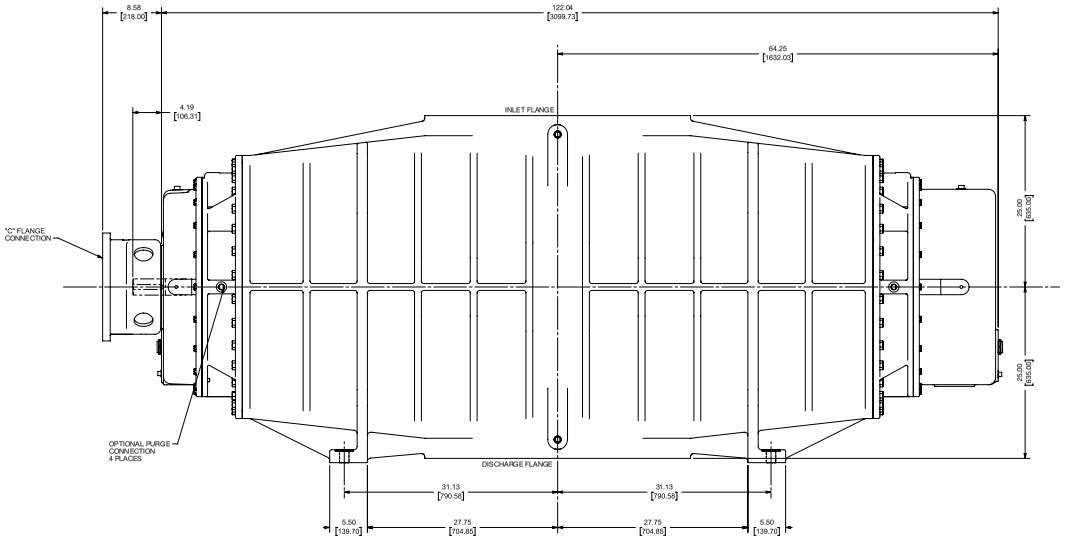
Item Number	Part Name	Quantity
42	Screw soch 1/2-13 x 2.00	68
43	Taper pin #8 x 3.50	12
49	Screw hex 5/8-11 x 1.75	16
55	Sight gauge - oil level	2
70	3/4 Pipe plug	4
70A	1 Pipe plug	2
74	Rotation arrow - curved	1
83	Shield - oil control	4
84	Oil pan	2
85	Screw hex 1/4-20 x 0.50	12
100	Dowel pin (pull-out)	8
109	Seal	4
132	Oil bottle	1
141	Oil slinger	1
141A	Washer heavy duty 1-1/4	1
141B	Screw hex 1-1/4-7 x 2.75	1
153	Sleeve – shaft seal	4
156	Seal housing	1
156A	Screw socket m4 x 6	1
156B	Gasket	1
157	O-ring	1
158	O-ring	1
163	Screw socket m8 x 20	4
187	Spacer – bearing	2
211	Oil slinger	4
215	Extractor sleeve	1
216	O-ring	1
217	Sleeve - seal	1

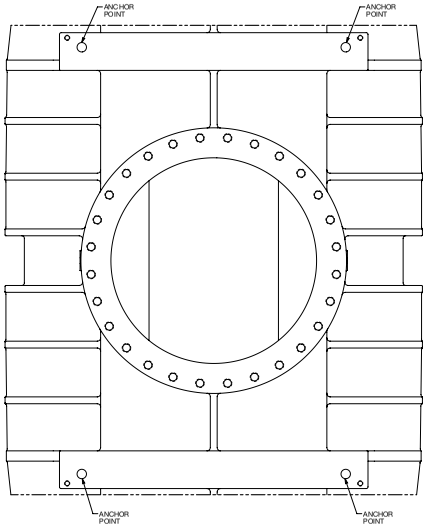
HV Booster repair kit

Item Number	Part Name	Quantity
17	Shim set	1
18	O-ring	2
18A	O-ring	2
20	O-ring	4
23	Seal	1

Assembly of RC-206726A13







LOADING DATA			
	STATIC	DYNAMIC	UNBALANCE
ANCHOR POINT	3950 LBS [1792 Kg] VERTICALLY DOWN	177±45 LBS [80±20 Kg] VERTICALLY UP	500 LBS [227 Kg] RADIAL (AROUND SHAFT)

FLANGE	AA	AB	AC	AD	AE
INLET	Ø30.00 [762]	Ø36.00 [914]	Ø38.75 [984]	28	1-1/4 - 7 UNC-2B 1.88 DEEP STRADDLING C/L
DISCHARGE	Ø30.00 [762]	Ø36.00 [914]	Ø38.75 [984]	28	1-1/4 - 7 UNC-2B 1.88 DEEP STRADDLING C/L

AA - FLANGE OPENING
AB - FLANGE BOLT CIRCLE
AC - FLANGE O.D.
AD - NO. OF HOLES
AE - SIZE OF HOLES

NOTE:

APPROXIMATE UNIT WEIGHT 15,800 LBS [7167 Kg]

REVISIONS						
		BY	DATE M/D/Y	CHANGE NOTICE	CHKD	APP
A	RELEASED	JJ	12/07/2017			RDA
B	ADDED LOADING INFO	JJ	03/26/2018	17660B		RDA
C	ADDED TAP INFO	JJ	04/26/2018	17684B		RDA

MFG. REF. :
SPEC SECTION:
ENGINEER CO.:
CERTIFIED
PURCHASE ORDER:
PROJECT:
LOCATION:
EQUIPMENT No. :
CERTIFIED BY:
DATE (M/D/Y):
CAD FORMAT SOLIDWORKS
CAD FILE / DIRECTORY RC-206726A13 / XGDR

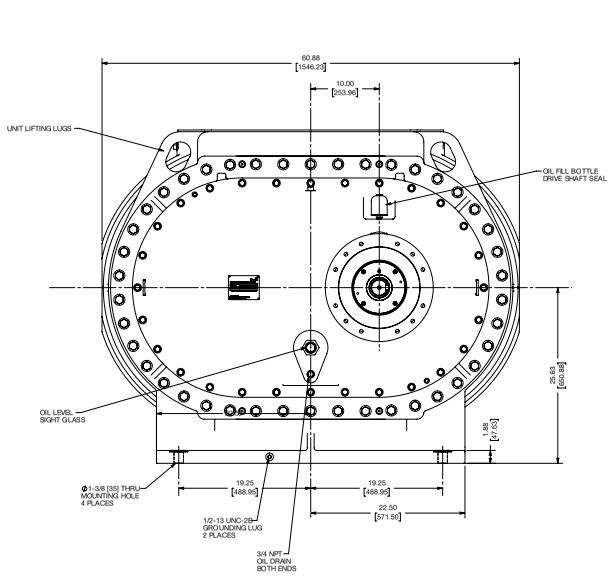
MAT'L.:
DR. JJ 10/20/2017
CHKD.
APP. RDA 12/07/2017
DEV.
SCALE 1-1/2"=1'-0"
DATE M/D/Y

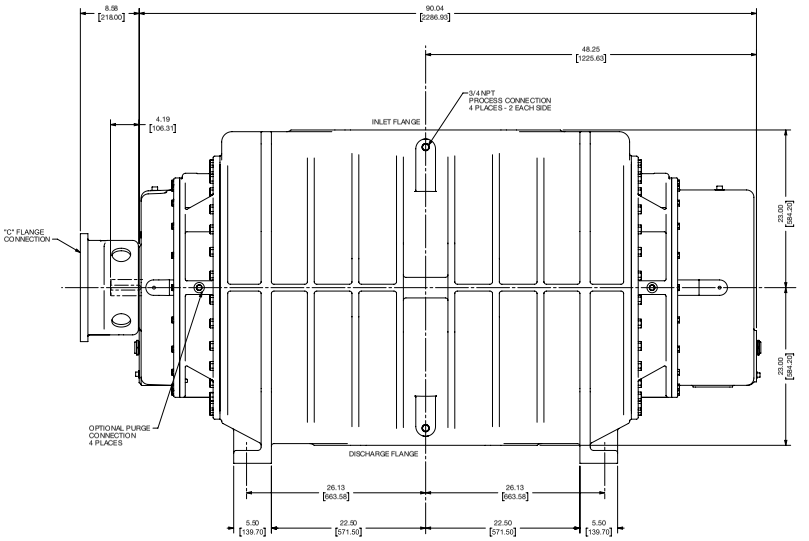
PATT. No. :
GEOMETRIC TOLERANCE PER STD035
DRWG No.
DO NOT SCALE FOR DIMENSIONS
THIRD ANGLE PROJECTION

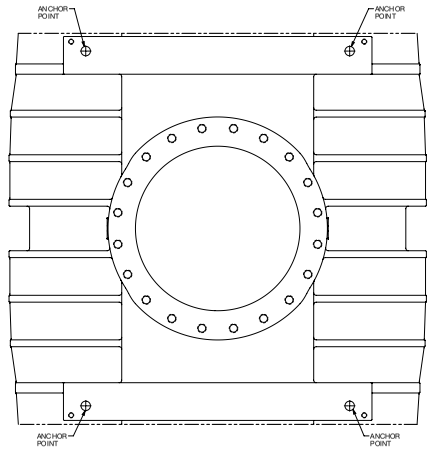
OUTLINE BARE UNIT
2092 HVB

Connersville, IN USA
P: 765-827-9200 F: 765-827-9266
RC-206726013
REV. C
SHEET 1 OF 1

Assembly of RC-206729A13







LOADING DATA			
	STATIC	DYNAMIC	UNBALANCE
ANCHOR POINT	3300 LBS [1497 Kg] VERTICALLY DOWN	177 ±45 LBS [80 ±20 Kg] VERTICALLY UP	500 LBS [227 Kg] RADIAL (AROUND SHAFT)

FLANGE	AA	AB	AC	AD	AE
INLET	Ø30.00 [762]	Ø36.00 [914]	Ø38.75 [984]	28	1-1/4 - 7 UNC-2B 1.88 DEEP STRADDLING C/L
DISCHARGE	Ø24.00 [610]	Ø29.50 [749]	Ø32.00 [813]	20	1-1/4 - 7 UNC-2B 1.88 DEEP STRADDLING C/L

AA - FLANGE OPENING
AB - FLANGE BOLT CIRCLE
AC - FLANGE O.D.
AD - NO. OF HOLES
AE - SIZE OF HOLES

NOTE:
APPROXIMATE UNIT WEIGHT 13,200 LBS [5988Kg]

REVISIONS						
		BY	DATE M/D/Y	CHANGE NUMBER	CHKD	APP
A	RELEASED	JJ	01/29/2016		RDA	
B	CORRECTED INLET/DISCHARGE DIMS	JJ	02/26/2016	17631B	RDA	
C	ADDED LOADING INFO, ADDED PROC. CONN.	JJ	03/29/2016	17660B	RDA	
D	ADDED TAP INFO	JJ	04/29/2016	17684B	RDA	

CERTIFIED
PURCHASE ORDER:
PROJECT:
LOCATION:
EQUIPMENT No. :
CERTIFIED BY:
DATE (M/D/Y):

CAD FORMAT: SOLIDWORKS
CAD FILE / DIRECTORY: RC-206729A13 / XGDR

MAT'L.:
DR. JJ 10/20/2017
CHKD.:
APP. RDA 01/29/2018
DEV.:
SCALE 1-1/2"=1'-0"
DATE M/D/Y

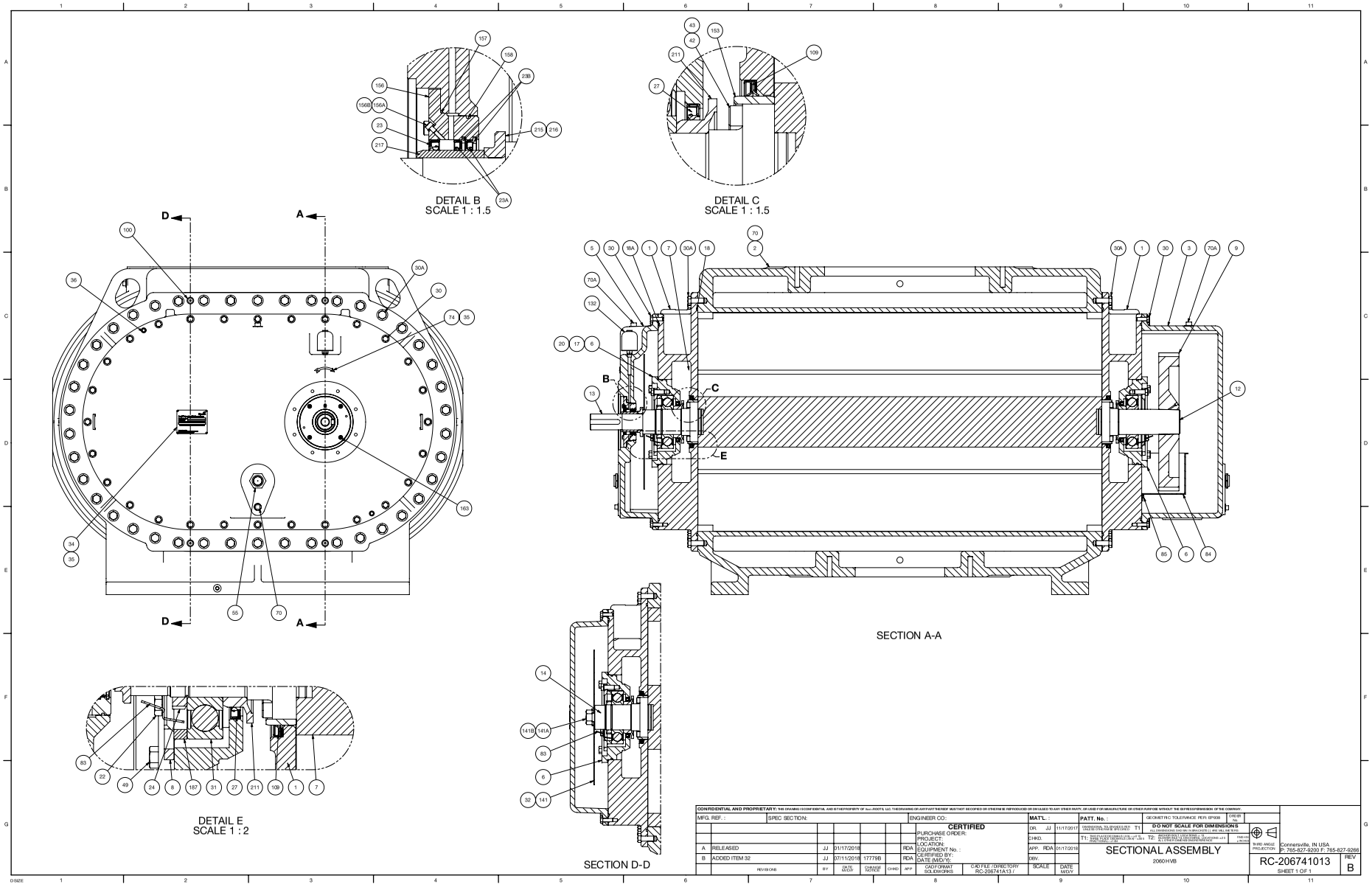
PATT. No.:
GEOMETRIC TOLERANCE PER: ISO8015
DO NOT SCALE FOR DIMENSIONS
THIRD ANGLE PROJECTION

OUTLINE BARE UNIT
2060 HV

RC-206729013
REV. D
SHEET 1 OF 1

Connersville, IN USA
P: 765-827-9200 F: 765-827-9266

Assembly of RC-206741A13



Notes

900 W. Mount St. Connersville

Indiana, 47331, USA

Please recycle after use.

www.RootsBlower.com

ILRB-3009-0124