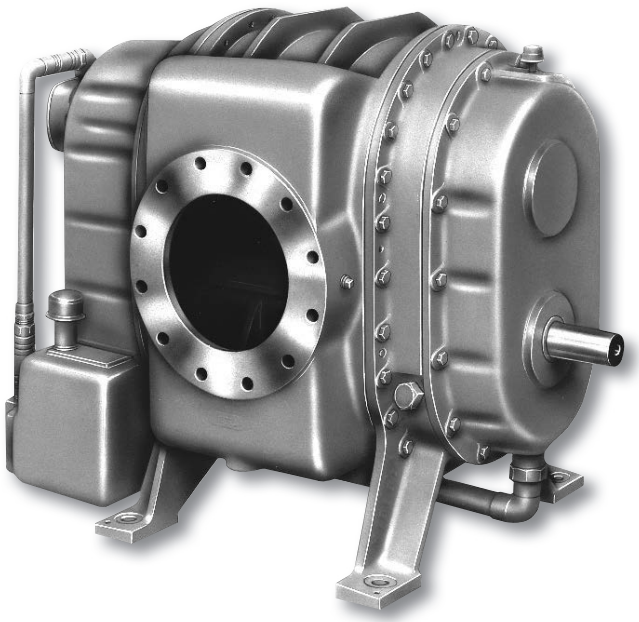
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Howden

Roots™ RAS and RGS Whispair™ Blower - 10”-20” Lubricated

Installation Operation & Maintenance Manual



Revolving Around You™

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Information Summary

Do These Things To Get The Most From Your Roots* Blower from Howden

- Check shipment for damage. If found, file claim with carrier and notify nearest Howden 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 Howden are sold subject to the current General Terms of Sale, GTS-5001 and Warranty Policy WP-5020. Copies are available upon request.
Contact your local Howden Office or Howden Customer Service Hot Line 1-877-363-ROOT(S) (7668) or direct 281-966-4700.

Operating Characteristics

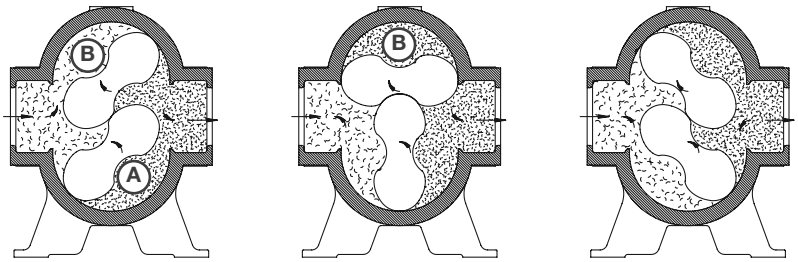
Howden's Roots units covered in this manual range in basic size from 10 inches through 20 inches gear diameter. From a usage or application standpoint there are two general types. Type RAS/RAS Whispair units from Howden are designated as air blowers, and may be used for handling air or some gases where 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 either type of unit. Where statements or data do not apply equally to both, the terms "air blower" and "gas blower" are used for identification. The Roots rotary lobe blower from Howden 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.

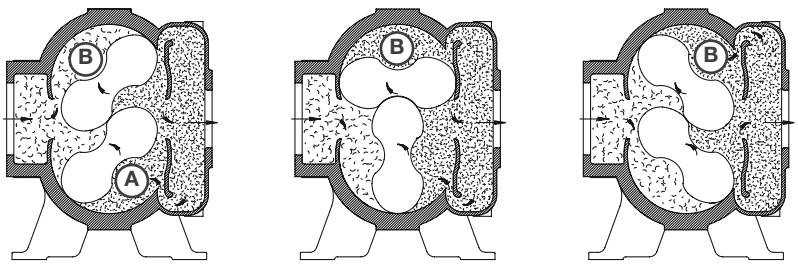
One complete revolution of the driving shaft alternately traps four equal and known volumes of air (two by each impeller) and pushes them through to the discharge. The pumping capacity of a lobe blower operating at constant speed therefore remains relatively independent of reasonable inlet or discharge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

Operation of the proprietary RAS/RGS Whispair design blower from Howden is represented in Figure 2. Air flow again is left to right, with the lower shaft rotation



Position 1 Position 2 Position 3

Figure 1 - Flow Through a Basic Type RAS/RGS Blower



Position 1 Position 2 Position 3

Figure 2 -Flow Through a RAS/RGS Whispair Blower

Operating Characteristics (Cont'd)

counterclockwise. This design differs from the basic type rotary blower in that it provides a chamber on the discharge side of the cylinder.

From this chamber two or more slots open back into the two alternately closed pocket areas of the cylinder, shown as A and B. These slots, at certain impeller positions, allow discharge pressure to bleed into the normally low pressure pockets. They also provide a jet action on the impellers in the direction of rotation. Gradual pressure build-up in the pockets, to a level almost equal to the discharge pressure, reduces backflow rate at the instant of pocket discharge so that pulsing and shock noise are minimized.

Considering Position 1 in Figure 2, known volume (A) is being delivered to the discharge chamber while space (B) is being filled with an equal volume at inlet pressure. In Position 2, this space has been sealed off from the inlet, but some discharge pressure is now entering space (B) through the slot passage, as indicated by the small arrows. Force of this jet gives a rotative assist to the impeller, while also building pressure in sealed space (B). Rotation continues to Position 3, where volume (B) is delivered to the discharge chamber in the same manner as volume (A) in Position 1. Because of the almost complete pressure equalization through the slot, shock is minimized.

With either blower design, 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. Likewise, if a possibility exists that flow to the blower inlet may be cut off during normal operation of a process, then an adequate vacuum relief valve should be installed in the inlet in the line near the blower. A pressure type relief valve in the discharge line near the blower is also strongly recommended for protection against cut-off or blocking in this line.

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, or air may be vented through a manually controlled unloading valve and silencer. 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

Operating Limitations

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

RAS/RGS and RAS/RGS WHISPAIR blowers from Howden are available with two types of internal blower clearances, normal and open. Table 1 lists maximum pressure, temperature, vacuum and speed limits for both types of clearances. Before operating blower at the conditions under open clearances, make sure that your blower is supplied with open clearances, and check with the factory. Table 8 lists the values of normal clearances. Table 9 lists the values of open clearances. Do not exceed any one or combinations of limits listed in Table 1.

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.

Note: Some special purpose blowers may be assembled with non-standard clearances other than those shown in Table 8 or 9. These units may be operated at pressure and or temperature rises higher than those listed in applicable Table 1. Before doing so, however, request specific approval from the nearest Sales Office. Normally, when a blower is operated at the design conditions stamped on its nameplate, the specified limits apply.

Pressure: On pressure service, 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. Also, in any system where the blower inlet is at a positive pressure above atmosphere, the discharge pressure must never exceed 25 PSI (172 kPa) gauge regardless of blower size.

Vacuum: On vacuum service with the discharge going to atmospheric pressure, the inlet suction or vacuum in

Operating Limitations (Cont'd)

Table 1- Maximum Allowable Operating Conditions

		Normal Clearances - RP68						Open Clearances - RP71						Approx. Wgt. (lbs.)
		Pressure Rise		Inlet Vacuum		Temperature Rise		Pressure Rise		Inlet Vacuum		Temperature Rise		
		PSI	kPa	Inches Hg.	kPa	°F	°C	PSI	kPa	Inches Hg.	kPa	°F	°C	
1006	1800	15	103	15	50	205	114	20	138	16	54	280	156	1920
1009		15	103	12	40	205	114	20	138	16	54	280	156	2080
1012		15	103	12	40	205	114	18	124	16	54	280	156	2240
1016		12	83	12	40	148	82	13.3	92	16	54	240	133	2455
1018		11.7	80	12	40	148	82	11.7	92	16	54	240	133	2520
1021		10.4	71	12	40	148	82	10.4	71	16	54	240	133	2610
1024		9.2	63	12	40	148	82	9.2	63	16	54	240	133	3055
1030		7.3	50	12	40	148	82	7.3	50	16	50	240	133	3470
1212*	1500	15	103	16	54	223	124	20	138	16	54	270	150	3130
1216		16.5	113	16	54	223	124	16.5	138	16	54	270	150	3480
1220		12	83	12	40	148	82	13.2	91	16	54	235	131	3720
1222		11.7	80	12	40	148	82	11.7	80	16	54	235	131	3895
1225		10.5	72	12	40	148	82	10.5	72	16	54	235	131	4090
1228		9.2	63	12	40	148	82	9.2	63	16	54	235	131	4250
1236		7.3	50	12	40	148	82	7.3	50	15	50	235	131	4760
1414	1300	20	138	16	54	230	128	20	138	16	54	280	156	4700
1418		16.8	115	16	54	230	128	16.8	115	16	54	280	156	5000
1422		12.0	83	12	40	140	78	13.7	94	16	54	230	128	5330
1425		12.2	84	12	40	140	78	12.2	84	16	54	230	128	5500
1428		11.0	75	12	40	140	78	11.0	75	16	54	230	128	5800
1431		9.8	67	12	40	140	78	9.8	67	16	54	230	128	6060
1435		8.8	60	12	40	140	78	8.8	60	16	54	230	128	6350
1442		7.3	50	12	40	140	78	7.3	50	15	50	230	128	6920
1616*	1130	20	138	16	54	230	128	20	138	16	54	280	156	5700
1620*		17.6	121	16	54	230	128	17.6	121	16	54	280	156	6000
1625*		14.0	96	16	54	230	128	14.0	96	16	54	280	156	6300
1627		11.0	75	12	40	140	78	13.0	89	16	54	230	128	6600
1630		11.0	75	12	40	140	78	11.7	80	16	54	230	128	6850
1633		10.6	73	12	40	140	78	10.6	73	16	54	230	128	7250
1639		9.0	62	12	40	140	78	9.0	62	16	54	230	128	7800
1643*		8.2	56	12	40	140	78	8.2	56	16	54	230	128	8000
1648		7.3	50	12	40	140	78	7.3	50	15	50	230	128	8200
1821*	1000	18.8	129	16	54	230	128	18.8	129	16	54	280	156	7800
1824		16.5	113	16	54	230	128	16.5	113	16	54	280	156	8100
1827		14.6	100	16	54	230	128	14.6	100	16	54	280	156	8400
1830*		12.0	83	12	40	140	78	13.2	91	16	54	230	128	8850
1833		11.7	80	12	40	140	78	11.7	80	16	54	230	128	9300
1841		9.6	66	12	40	140	78	9.6	66	16	54	230	128	9750
1845		8.8	60	12	40	140	78	8.8	60	16	54	230	128	10100
1849*		8.0	55	12	40	140	78	8.0	55	16	54	230	128	10400
1854		7.3	50	12	40	140	78	7.3	50	15	50	230	128	10650
2022	900	19.6	135	16	54	225	125	20	138	16	54	280	156	9800
2026		16.6	114	16	54	225	125	16.6	114	16	54	280	156	10250
2033		12.0	83	12	40	135	75	13.0	89	16	54	225	125	11200
2037		11.0	75	12	40	135	75	11.7	80	16	54	225	125	11800
2040		11.0	75	12	40	135	75	11.0	75	16	54	225	125	12450
2044		10.0	68	12	40	135	75	10.0	68	16	54	225	125	13100
2050		8.8	60	12	40	135	75	8.8	60	16	54	225	125	13800
2055*		7.9	54	12	40	135	75	7.9	54	16	54	225	125	14300
2060		7.3	50	12	40	135	75	7.3	50	15	50	225	125	14750

Operating Limitations (Cont'd)

inches of mercury (kPa) must not be greater than the values listed for the specific frame 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.

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.

Installation

Technical assistance at installation by a Factory Service Engineer is usually not required for the smaller units, 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 1 ton (910 kg) for the smallest to approximately 7 tons (6350 kg). On such units, an eyebolt is provided near each end for lifting. 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 eyebolts, test each one for tightness and fractures by tapping with a hammer. Direction of pull on the bolts during lift should be nearly vertical. Since a considerable cable angle will usually be unavoidable, place a stiff spreader between the eyebolts 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 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 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.

If there is to be an extended period between installation and start up, the following steps should be taken to insure corrosion protection:

1 Coat internals of cylinder, gearbox and drive end bearing covers with Motorstor or equivalent. Repeat once a year or as conditions may require. Motorstor is oil soluble and does not have to be removed before lubricating. If desired, Motorstor may be removed from within the cylinder shortly before start up by spraying a fine mist of petroleum solvent through the blower while it is running at a slow speed with open inlet and discharge, or it can remain in the blower if it is not harmful to the operation of the connected system. Motorstor is a product of Daubert Chemical Co., 2000 Spring Ed., Oak Brook, IL 60521.

2 Paint shaft extension, inlet and discharge flanges, and all other exposed surfaces with Nox-Rust X-145 or equivalent.

3 Seal inlet, discharge, and vent openings. It is not recommended that the unit be set in place, piped to the system, and allowed to remain idle for extended periods. If any part is left open to the atmosphere, the Motorstor vapor will escape and lose its effectiveness.

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

5 Rotate drive shaft three or four revolutions every two weeks.

6 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,

Installation (Cont'd)

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.

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**. If unavoidable, it should be restricted to units of the smaller frame sizes, and spring-type mountings should not be used. Structural members must be rigid, and will probably require reinforcement if part of a building. Noise transmission can be reduced by use of a cork isolating pad. This can be 1 to 2 inch (25-50 mm) thickness, bedding on a full steel plate attached to the structure and carrying rigid concrete slab on which the
equipment is mounted.

ANCHOR BOLTS are to be placed within the foundation forms before concrete is poured. Hook-type bolts installed as shown in Figure 3, with diameter and length as in Table 2, are recommended. The bolts must be located as accurately as possible from dimensions on certified installation drawing. To obtain a bolt location tolerance of 1/8" (3 mm), use of drilled templates firmly secured to the foundation forms is recommended.

The bolt sleeves shown, if kept centered around the bolts and free of concrete, will allow bolts to be sprung enough to correct for small variations in bolt setting and machine drilling. The sleeves are filled in the final grouting operation.

Bolt positions should be adjusted vertically so that the top ends will extend at least 1-1/2 diameters above the soleplate or taper washer, or as shown on the installation drawing.

Jack screws are provided to make leveling the height adjustments easier. Steel plates, approximately 4" x 4" x 1/2" (100 x 100x 13mm), should be placed on the foundation under each jack screw location. Plates and anchor bolts are not furnished as standard accessories.

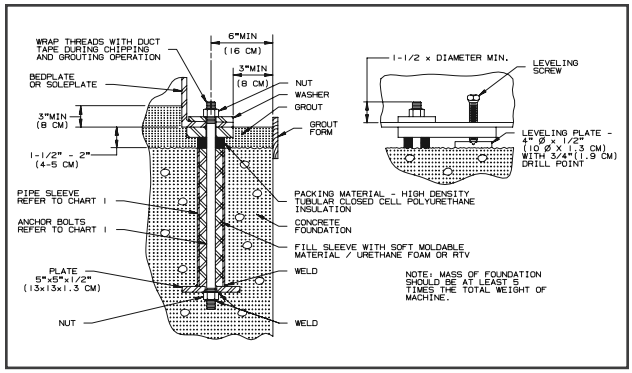


Figure 3 - Typical Anchor Bolt Detail

LEVELING 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.

Installation (Cont'd)

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 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.

Blowers intended for driving by V-belts may be provided with an extended drive shaft and an additional outer bearing to handle the side pull of the drive. They may be recognized by the extended housing for the outer bearing. If necessary, these units may also be used for direct coupling to the driver. Blowers intended specifically for direct coupling have no outer bearing, and may be seriously damaged if used for belt drive. Consult your Sales Office for approval before belting these units.

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

Table 2A – Standard Anchor Bolts in Inches

Unit Frame Size	For Soleplates				For Baseplates			
	Bolts		Sleeves		Bolts		Sleeves	
	Dia.	Lgth.	I.D.	Lgth.	Dia.	Lgth.	I.D.	Lgth.
1000	1	24	2	12	3/4	18	2-1/2	13
1200	1	24	2	12	3/4	18	2-1/2	13
1400	1-1/8	36	2-1/4	18	3/4	18	2-1/2	13
1600	1-1/8	36	2-1/4	18	1	24	3	18
1800	1-1/4	36	2-1/4	18	1	24	3	18
2000	1-1/4	36	2-1/4	18	1	24	3	18

Table 2B – Standard Anchor Bolts in (cm)

Unit Frame Size	For Soleplates				For Baseplates			
	Bolts		Sleeves		Bolts		Sleeves	
	Dia.	Lgth.	I.D.	Lgth.	Dia.	Lgth.	I.D.	Lgth.
1000	2.4	60	5.0	30	2.0	46	6.5	33
1200	2.4	60	5.0	30	2.0	46	6.5	33
1400	3.0	90	6.5	46	2.0	46	6.5	33
1600	3.0	90	6.5	46	2.4	60	8.0	46
1800	3.0	90	6.5	46	2.4	60	8.0	46
2000	3.0	90	6.5	46	2.4	60	8.0	46

Installation (Cont'd)

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 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" (.l3mm) 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. Where driver is a steam turbine the final alignment should be made at operating temperature in order to allow for shaft movement resulting from expansion.

A coupling that has been factory installed as part of a pre-assembled package should receive the same final alignment check as outlined above. It will need to be disassembled by removing cover bolts, drawing back the two cover halves, and removing the internal member. In some cases the latter item may have been packed separately for shipment. After necessary adjustments for alignment are completed, lubricate the coupling with grease as specified by its manufacturer and assemble.

A belt-driven installation should require no realignment

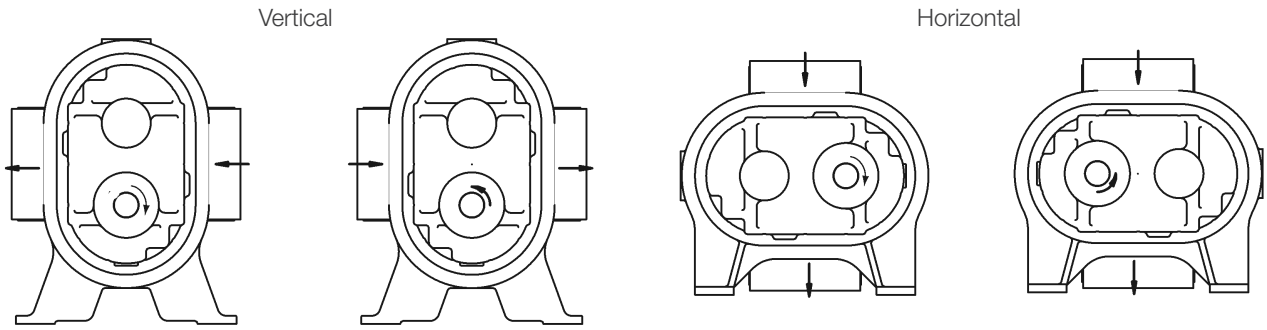


Figure 4 – Rotation and Discharge, Vertical and Horizontal RAS/RAS Blowers

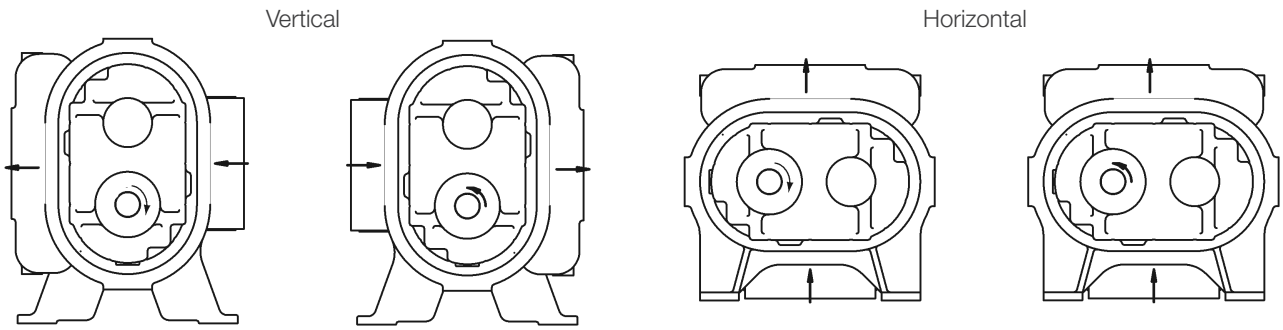


Figure 5 – Rotation and Discharge, Vertical and Horizontal RAS/RAS Whispair™ Blowers

Installation (Cont'd)

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 5 page 8 illustrates the assembly options available by specification on original order, to meet piping and drive requirements.

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 75 feet (23 m) 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 rubber expansion joint near the blower inlet connection is recommended. A similar unit with control elements added to minimize piping vibrations may be required near the discharge. Use of **SNUBBERS** or **SILENCERS** in the inlet or discharge piping will be dependent on such factors as blower speed, operating pressure, length and kind of piping, and consideration of sound level requirements in the general surroundings. Whispair blowers operate at generally lower noise levels than conventional lobe-type units.
For specific silencer recommendations refer to the nearest Sales Office.

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 H2O. 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).

Discharge piping requires a pressure relief valve, and should also include a suitable pressure gauge and unloading valve. The latter permits starting under no-load conditions. The optional back pressure regulator shown in Figure 6 will be required if volume demands vary while blower operates at constant speed. It may blow off to atmosphere if only air is being handled. In a gas installation the regulator will probably need to be located in a by-pass loop back to the blower inlet. However, the volume of gas that may be continuously circulated will be limited by **heat build-up**, which can cause blower damage. Refer such application problems to the nearest Sales Office for recommendations on installation of a by-pass cooler.

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.

An oil cooler is standard equipment on all pressure lubricated gas blowers and some air blowers. Therefore, cooling water supply and return piping may be required. To maintain normal oil temperatures

during operation, the supply water temperature should not exceed
85° F (29° C).

Approximate Screen Pressure Drop, Inches H2O (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

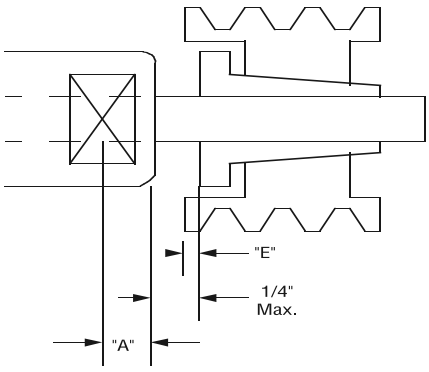
V-Belt Drives

Recommendations:

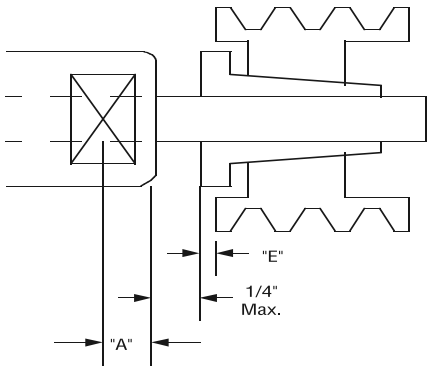
- Attempting to belt drive with a motor in excess of 200 HP will make it difficult to size a drive without exceeding the maximum shaft loads. To belt drive over 200 HP generally requires a jackshaft with pillow block bearings connected to the blower by a coupling.
- Use a minimum of 1.4 service factor on the drive horsepower.
- Vertical units must be driven with the motor on the inlet side. Horizontal units must be driven from the drive shaft side.
- Use molded notch belts, power band type where possible.
- The contact arc of the smaller sheave is not to be less than 170°.
- Blowers must be driven through the Opposite Gear End.

Gear Diameter	Dimension "A" (Inches)		Maximum Allowable Shaft Load
	With Inboard Bearing	W/O Inboard Bearing	
10"	2.32	4	11,000
12"	2.55	4.09	15,000
14"	2.58	4.55	21,000
16"	N/A	4.97	40,500
18"	N/A	5.68	63,000
20"	N/A	6.05	70,000

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



Sheave Type 1



Sheave Type 2

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.

Installation (Cont'd)

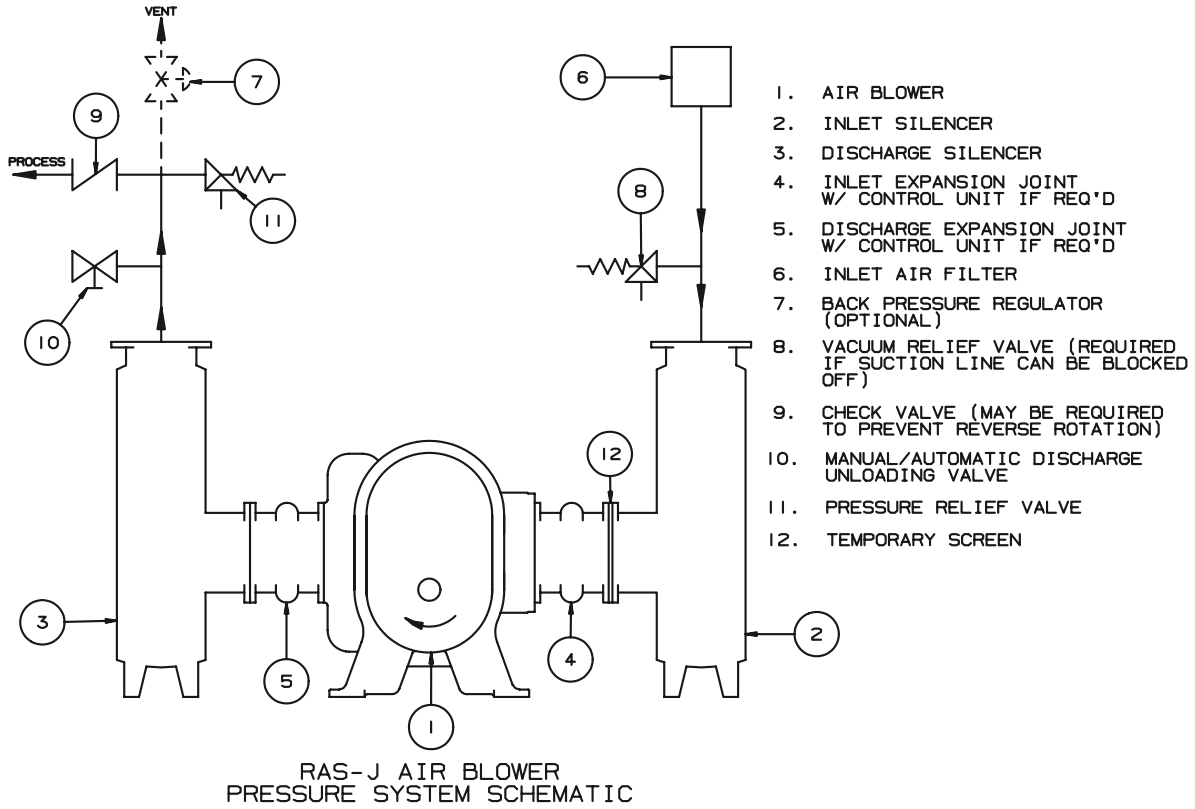


Figure 6 – RAS-J Installation with Accessories

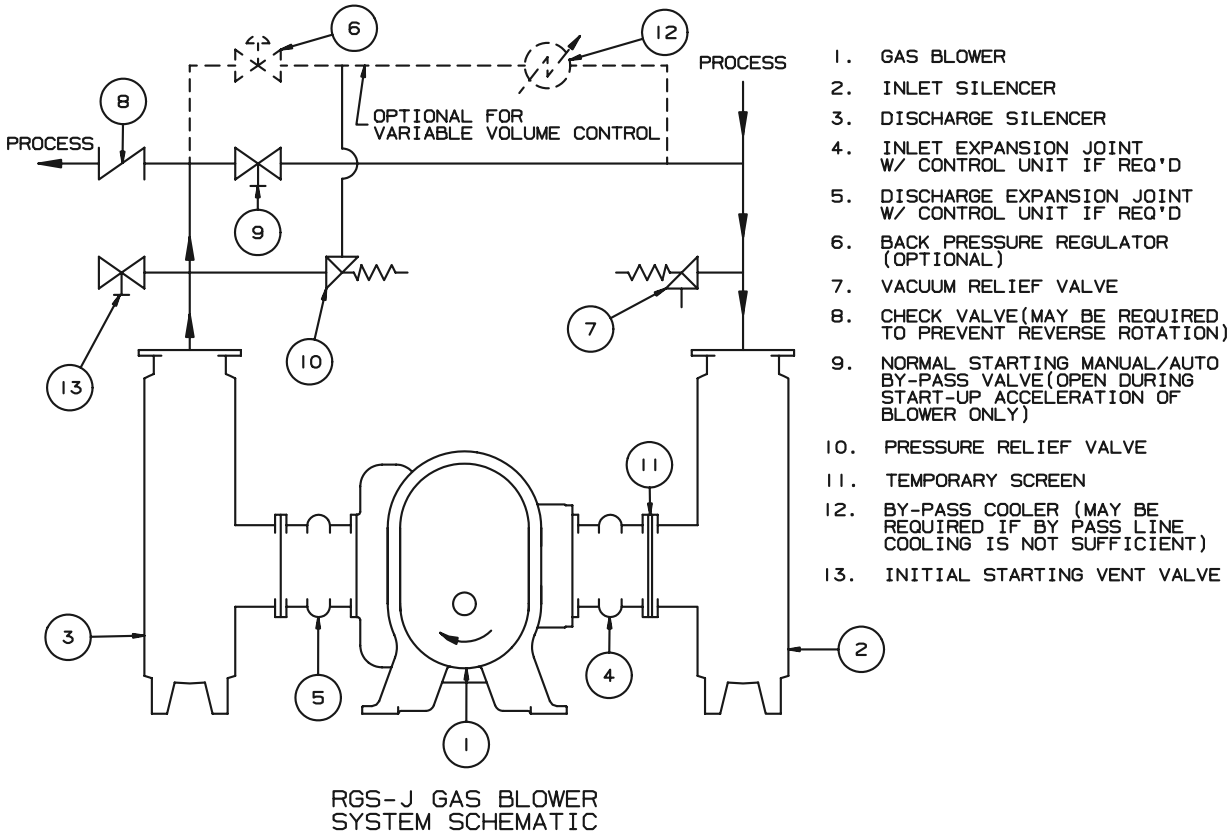


Figure 6a – RGS-J Installation with Accessories

Lubrication

The blowers under discussion are pressure lubricated by a self-contained circulating oil system working from a supply sump located in the bottom of the gear housing. Two lines on a bull's-eye type oil level gauge in the sump wall indicate upper and lower supply limits, and filling is accomplished by removing a breather cap.

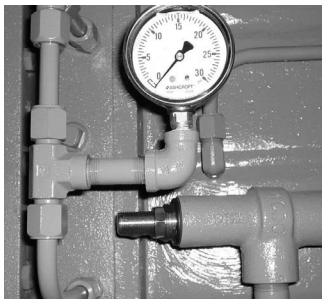
An oil circulating pump mounted on the gearhouse is driven from one of the blower shafts. Its suction line contains a mesh type strainer located within the sump. Oil distribution lines to gears, bearings and seals are external and of steel tubing with compression fittings. Oil is filtered before delivery to bearing and seals, and is also cooled on gas machines and some air blowers. No provision is made in the oil pump or piping for reversed drive rotation.

Working pressure of the lube system is established by the sizing of drilled internal passages, and by the setting of a relief valve that returns excess oil to the sump. A line-mounted gauge is provided to indicate system pressure, which is normally 12 PSIG (83 kPa).

Figure 7 shows all components of a complete pressure lubrication system, including auxiliary pump.

Timing gears receive oil at their meshing point by direct spray from a passage in the side of the gearbox. All main bearings, and face type shaft seals if used, are supplied through inboard passages in the headplates and bearing carriers. 10" through 14" blowers intended specifically for belt drive normally incorporate an outboard drive shaft bearing mounted in an extended bearing carrier. This bearing is lubricated from a shallow reservoir of oil in the carrier, which is fed through the inboard bearing. Oil delivered to the drive end returns to the main sump at the gear end through a drain line under the blower.

Instructions for Adjusting Oil Pressure on Pressure Lube Roots Blower



Tools required: large adjustable wrench, short flat-blade screwdriver.

Note: Blower must be running while adjusting oil pressure.

1. Locate pressure gauge and relief valve on side of blower.
2. Remove relief valve protective cover.
3. Loosen locking nut on relief valve stem.
4. Using a screwdriver, rotate the relief valve stem until the pressure gauge reads correct pressure; normal is 10-12 PSI (8 PSI on HVB). Turning the stem clockwise will raise the pressure. Turning the stem counterclockwise will lower the pressure.
5. Tighten locking nut.
6. Replace relief valve protective cover.

Note: On RGS units with process pressures higher than 10 PSIG at discharge, consult factory for proper oil pressure settings.

On a RAS/RAS Whispair air blower, oil is isolated from the air chamber by a double sealing arrangement.

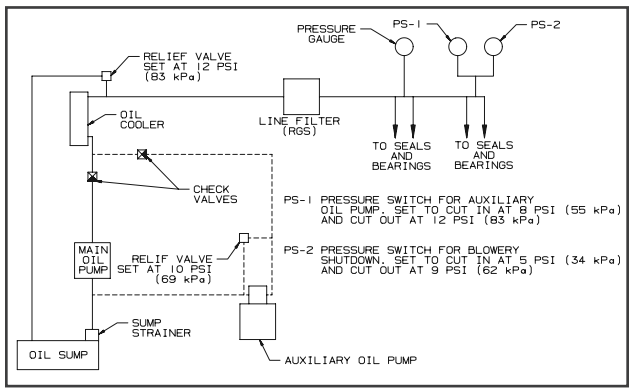


Figure 7 - Lubrication System with Auxiliary Pump

Lip type shaft seals are located directly inboard from the main bearings, followed by labyrinth type seals where shafts pass through the headplates. By venting the chamber between the two sealing points to atmosphere, breathing through the lubrication system is avoided.

On a RGS/RGS Whispair air blower, lip seals are replaced by the rotating mechanical face type shown in Figure 8. While these seals are spring loaded and self-adjusting, their effectiveness as gas seals depends largely on continuous pressure lubrication of the sealing faces. The oil pressure on the shaft side of the seal must be greater than the gas pressure on the opposite side, as noted in Figure 8. If the gas pressure is higher than 8 PSIG (55 kPa), then the normal oiling system pressure of 12 PSIG (83kPa) at the gauge will not provide effective sealing against gas leakage. Refer to factory for correct setting.

The labyrinth type shaft seals in the headplate

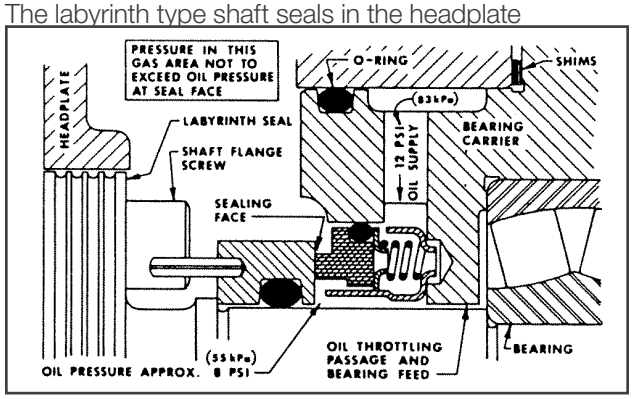


Figure 8 - Face Type Inboard Shaft Seal

Lubrication (Cont'd)

walls allow free passage of gas into the pockets or chambers around the gas seals. To prevent leakage of gas outside the blower, drain holes at the bottom of the chambers are sealed with pipe plugs. Since some oil may work through the seals and collect in the bottom of the chambers, these pipe plugs should be removed during periodic shut-downs in order to drain any accumulated oil. There are two plugs to be removed at each end of the blower.

If mechanical face seals are used under conditions where **the static gas pressure at the blower inlet is above atmospheric**, it will be necessary to prevent seal leakage during normal shut-down periods by maintaining continuous oil pressure at the faces of all seals. This can be accomplished by installing an independently driven oil pump, properly connected into the main oil system as indicated in Figure 7.

Operation of the auxiliary pump is under control of a pres- sure switch in the blower oil distribution piping, normally set to cut in at 8 PSIG (55 kPa) and cut out at 12 PSIG (83 kPa). A pressure relief valve set at 10 PSIG (69kPa) should be installed in a bypass around the pump. The auxiliary pump must run continuously while gas pressure remains in the blower. A second pressure switch is furnished as part of the auxiliary pump package, to protect the blower against low oil pressure during normal operation. Set to operate at 5 PSIG (34kPa) and 9 PSIG (62 kPa), one contact is used to stop the blower motor at the low pressure setting. Another contact may be used to operate an alarm at the same time.

For RGS units with discharge pressure greater than 10 PSIG consult factory for proper setting.

Lubricating oil viscosity should be selected from Table 3 for the existing ambient temperature range. Fill the blower oil sump through the breather pipe 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 Howden is highly recommended.

Table 3 - Recommended Lubricating Oils

Ambient Temperature	ISO Viscosity Range
32° to 120°F (O° 49°C)	200
Below 32°F (18°C)	100
All RGS - Use ISO-VG-100	

Table 4 - Oil Sump Capacities

Frame Series	Approx. Capacity in Gallons (Liters)	
	Vertical	Horizontal
1000	5-1/4 (20)	7-1/2 (28)
1200	7-3/4 (29)	10-3/4 (41)
1400	10-3/4 (41)	14-1/2 (55)
1600	15 (57)	20 (76)
1800	19-1/2 (74)	25-1/4 (96)
2000	23 (87)	30-3/4 (116)

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 Howden can extend life up to eight 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.

On type RGS/RGS Whispair units from Howden also replace the cartridge in each oil line filter at oil change periods in order to protect the mechanical shaft seal faces. These seals may leak a certain amount of oil in normal operation, which will collect in a chamber in each headplate under the lower shaft (under both shafts in a horizontal unit). The oil levels in these chambers should not be allowed to reach the labyrinth shaft seal openings.

Therefore, when an RGS/RGS Whispair blower is shut down, remove the pipe plugs and drain any accumulated oil from these chambers. Experience will indicate the frequency of draining required. Be sure to shut off the gas supply to the blower before removing the drain plugs.

Lip seal oil leakage on RASIRAS Whispair blower from Howden: 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.

On a unit with cooler, the maximum oil temperature to bearings and gears should not be higher than 120° F (49° C). Oil returning to the sump will then normally be at about 160° F (71° C) or less. These conditions can be maintained only if the cooler tube bundle is not allowed to become fouled with deposits from the cooling water, and if the water temperature is less than 85° F (29° C). Rate of water flow required can be expected to be between 3 to 10 GPM.

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.

1. **Be certain** no bolts, rags or dirt have been left in the blower air chamber.
2. **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.
3. **Check** blower leveling, drive alignment, belt tension and tightness of all mounting bolts if installation is not recent.
4. Turn drive shaft over by hand to make sure impellers will rotate without bumping or rubbing at any point.
5. **Check** lubrication system. Oil level in gearhouse sump should be at or near the upper gauge line. **Make sure** filters in bearing lines contain filtering cartridges. If an oil cooler is in the system, be sure water supply and return lines are connected and operating.
6. 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.
7. If unit is an **air blower**: Open the manual unloading valve in the discharge line and make sure that any blocking valve in the inlet piping is open.
8. If unit is a **gas blower**: Vent the discharge line by opening the initial starting blow-off valve, while keeping the normal starting by-pass valve closed. See Figure 6. Inlet piping should be open to atmosphere (not connected to gas supply) during start-up and unit has been tested.
9. Bump blower a few revolutions with driver to check direction of rotation and to see that both units coast freely to a stop.
10. Start blower. Let it accelerate to full speed, then shut off. Listen for any knocking sounds, both with power on and also as it slows down. Observe oil pressure to determine whether oil pump is primed and functioning properly. Pressure should approach 10 to 12 PSI (69 to 83 kPa) after only a few seconds.
11. If no problems have appeared, restart unit and operate for 5 to 10 minutes under no-load conditions as in paragraph 7 or 8. Check the cylinder surfaces all over by feeling to locate any hot spots indicating impeller rubs. Continue to listen for noises and watch for changes in vibration. If all conditions are acceptable, proceed as follows:
12. For an **air blower**: Continue operating, but gradually close the discharge unloading valve. A good pressure gauge or manometer should be connected into the discharge line. Observe the pressure increase as valve is closed, and do not permit it to exceed the rating of the unit as specified under LIMITATIONS.
13. For a **gas blower**: Stop the unit and connect the inlet piping to the gas supply. Close and lock the starting vent valve, or remove it and blank off the opening. Open the normal starting bypass valve and restart the unit. After it reaches full speed, start closing the bypass valve fairly rapidly. Observe the discharge pressure gauge or manometer as the valve is closed, and do not allow the pressure to exceed the rating of the unit as specified under **LIMITATIONS**.(See following **NOTE**).
14. All conditions being satisfactory to this point, continue the run for about one hour under normal operating conditions. It is recommended pressure or vacuum measurements be used on both inlet and discharge to permit determination of pressure rise across the unit. Also use thermometers to determine the temperature rise. Both figures should stay within the specified limits. Continue checking for noises and hot spots, and take periodic reading of oil system pressure. If trouble shows up, refer to the **TROUBLE SHOOTING CHECKLIST** for suggestions.

NOTE - When starting a gas blower under normal operating conditions, open bypass valve only until full speed is reached. Close it rapidly then so that blower temperature will not be increased by the circulating gas. See discussion of discharge piping under **INSTALLATION** relative to use of a regulated continuous **gas bypass with cooler**.

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.

Should operation of an air blower prove that its capacity is a little too high for actual requirements, a small excess may be blown off through the manual unloading or vent valve. **Never rely on the pressure relief valve as an automatic vent.** Such use may cause the discharge pressure to become excessive, and can also result in failure of the valve itself. If blower capacity is low, refer to **TROUBLE SHOOTING**

Troubleshooting Checklist

Trouble		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 4 or 5. Change driver if wrong.
	3	Obstruction in piping	
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		See item 3.
	7	Obstruction in piping	Check inside of casing for worn or eroded surfaces causing excessive
Excessive Power	8	Speed too high	Check speed and compare with Howden's Roots Order Acknowledgement.
	9	Excessive pressure rise	See item 5.
	10	Impellers rubbing	Inspect outside of cylinder for high temperature areas, then check for impeller contact at these points. Look for excessive scale build-up.
Overheating of Bearings of Gears	11	Inadequate lubrication	Check oil pressure, oil sump level and condition of oil.
	12	Excessive lubrication	Check oil pressure, oil sump level and condition of oil.
	13	Excessive pressure rise	See item 5.
	14		Check carefully. Realign if questionable.
	15	Coupling misalignment	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
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 air blowers 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

1. **Daily**
   A. Record the following:
      1) Lube oil pressure (if applicable).
      2) Lube oil temperature (if applicable).
      3) Blower inlet temperature.
      4) Blower inlet pressure.
      5) Blower discharge temperature.
      6) Blower discharge pressure or differential pressure.
      7) Motor amperage.
      8) Motor voltage, if available.
      9) Motor stator temperature, if available.
      10) Motor bearing temperature, if available.
   B. Observe any abnormalities, i.e. burned paint, unusual noises, vibration, strange odors, oil leaks, etc.
   C. 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).
   D. Check oil levels.
   E. Record hour meter readings.

2. **Monthly**
   A. 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.)

3. **Quarterly**
   A. Sample lube oil or change.
   B. Change oil if the following values are exceeded:
      1) Water 100 PPM maximum.
      2) Metals 200 PPM maximum.
      3) Acid 5.0 to 7.5 Mg/KOH/g maximum.
   C. Increase frequency of sampling if any of the above values show about 20 to 25 percent increase over the last sample.
   D. Flush all oil reservoirs before filling with clean oil.

4. **Annually**
   A. Remove an inlet expansion joint, inspect impellers, measure impeller clearances and note wear patterns.
   B. Check coupling alignment, inspect coupling for wear, and repack with fresh grease.
   C. Inspect oil cooler tubes, as applicable.
   D. Check all protective switches for proper setpoints and operation.
   E. Check V-belt drive condition and tension.
5. 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 Howden) 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:

1. Inherent rotary lobe blower characteristics can lead to vibrations:
   a. Impacting bearing loads excite component/ system natural frequencies.
   b. 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

      Blower jet inlet (DVJ): 8% of absolute pressure

   Example: Blower with absolute inlet (14.7 PSIA) and 11 PSIG discharge (25.7 PSIA), would have maximum pressure pulse of .05x14.7= .74 PSI for inlet & .08x25.7= 2.06 PSI for discharge.

   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.
2. Rotary lobe blowers use very close clearances between the impellers and the housing. The impeller contact will setup vibrations as follows:
   a. 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 2X RPM.
   b. 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.
   c. Impeller to head plate contact - the vibration frequency will be erratic and unsteady.
3. Damaged gears will generate vibrations at mesh frequency, number of teeth times RPM.
4. Damaged bearings will generate vibrations at ball pass frequency, fundamental train frequency and ball spin frequency.
5. Rotor unbalance and bent shaft will generate vibrations at 1XRPM.
6. Blower/driver coupling misalignment will generate vibrations at 1XRPM and 2XRPM.
7. Acoustic resonance in the blower inlet/discharge piping will generate vibrations at 4XRPM.
8. Operation of rotary lobe blower at or near system torsionals may cause impeller lobe contact and increases vibrations.
9. External piping if not properly isolated will transmit vibrations into the blower.
10. Foundation design and method of mounting has considerable effect on blower vibrations.

Vibration Criteria:

1. 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.
2. 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

RGS WHISPAIR for Steam Service

Except as noted below, instructions for RGS WHISPAIR blowers from Howden applies.

Limitations

Most blowers for steam service are supplied with involute (RP-71) impellers. The table of maximum operating conditions for these impellers as shown in the IO&M applies except for the speed. The blower may be run at the speeds shown only if the impellers are hardened or the blower is being run on dry steam with no water injection. If the steam is wet, or if water is being injected, the speed is limited to 4200 Ft/Min. Gear Speed.

[RPM=4200/(.262 x Gear Dia.")]

Some blowers for steam service are supplied with Segment Waist (RP-36) impellers. Maximum operating conditions for blowers supplied with this type impeller are the same as those shown for RP-71 impellers except the temperature rises on some sizes as follows:

Table 5 - Segment Waist (RP-36) Maximum Temperature Rise

Frame Size	Temperature Rise		Frame Size	Temperature Rise	
	°F	°C		°F	°C
1009	240	133	1625	230	128
1012	240	133	1627	230	128
1212	235	131	1821	225	125
1216	235	131	1824	225	125
1414	230	128	1827	225	125
1418	230	128	2022	215	19
1616	230	128	2026	215	119
1620	230	128			

The same speed restrictions apply to Segment Waist impellers as to Involute.

Maximum Temperature Rise Correction

In most steam services, the blower inlet temperature is much higher than the ambient temperature. The temperature rise values listed in the tables must be corrected if this is the case. The maximum temperature rise as shown on the tables must be reduced by 2/3 the difference between the actual inlet temperature and the ambient temperature, and the average inlet to discharge temperature must not exceed 250°F. For example:

The maximum temperature rise of a 1009 RGS WHISPAIR is shown as 240°F. With a steam inlet temperature of 212°F and an ambient temperature of 70°F the maximum temperature rise is limited as follows:

Max. Temp. Rise = 240 - 2/3 (212-70) = 145°F

Discharge temperature will then be = 145 + 212 = 357

Average temperature = (212 + 357) / 2 = 284.5°F

This exceeds the 250°F rule, so the temperature rise must be limited to:

Max. Temp. Rise = 2 X (250 - 212) = 76°F

Water Injection

De-mineralized water may be injected, with proper precautions, at the suction of the blower to reduce the temperature rise. The amount of water injected is normally enough to keep the steam at discharge pressure saturated. The actual amount required will depend on the system and the efficiency of evaporation, but the approximate amount can be calculated :

GPM = HP X 42.44 / (1000 X 8.35) Where:

GPM = Gallons Per Minute of Water

HP = Horsepower to the Blower

42.44 = Conversion HP to BTU/Min.

1000 = BTU per Pound of Water

8.35 = Pounds of Water per Gallon

This amount should be doubled to start, and reduced as needed.

Installation

Bellows type stainless steel expansion joints should be used on the inlet and discharge connections of the blower. Both inlet and discharge pipes must be anchored to prevent any piping movement which could cause over extension or compression of the expansion joints.

If water is injected into the inlet of the blower, the inlet and discharge silencers and headplate vent cavities must be continuously drained as condensed water will build up in these areas. The headplates are supplied with two pipe tapped and plugged holes on each headplate. These cavities can be piped to drain by hand at regular intervals as the system characteristics demand, or piped to a trap or barometric seal leg.

(See Figure 9) If the water is allowed to build up in the headplate vent cavity, serious damage to the blower will result.

Note that there may be oil present in the drainage from the headplate vent cavities. This should be disposed of properly.

A typical steam blower piping setup showing recommended gauges and switches is shown in Figure 10.

Startup and Operation

Before the first startup of the blower, follow the instructions in the IO&M with these added measures: (Refer to Figure 10)

1. Vent the discharge line by opening the startup vent valve (9), while keeping the bypass valve (7) closed. The inlet piping should be opened to atmosphere (not connected to the steam supply) during startup and until the blower is tested. Open the cylinder drain valve (14), remove all water and close it.
2. If an auxiliary oil pump is supplied, turn it on and set the auxiliary relief valve at 10 PSIG.

After the initial run of the blower:

1. Stop the blower and connect the inlet piping to the steam supply. Close and lock the starting vent valve (9), or remove it, and blank off the opening. Open the normal starting bypass valve (7).
2. In a vapor re-compression system, the evaporator, compressor (blower), piping and condenser equipment must be purged of air (non-condensables) before startup of the main compressor. In order to assure this fact, the system requires steam to be supplied in the evaporator area so it flows through the compressor and piping to an air/steam vent on the far end of the condenser. An inlet thermometer and a casing temperature switch are recommended to partially assure that the system is purged prior to startup. The casing temperature should be within 10°F of the purge steam saturation temperature.
3. Restart the blower (start the inlet water spray if applicable). After the blower reaches full speed, start closing the bypass valve fairly rapidly.
4. Observe the discharge pressure gauge as the bypass valve is closed, and do not allow the pressure or temperature to exceed the rating of the blower as specified under Limitations.

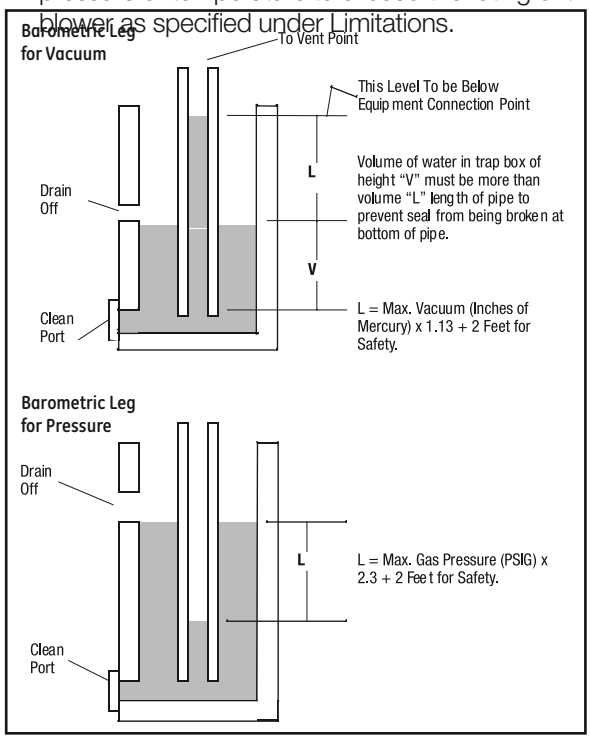
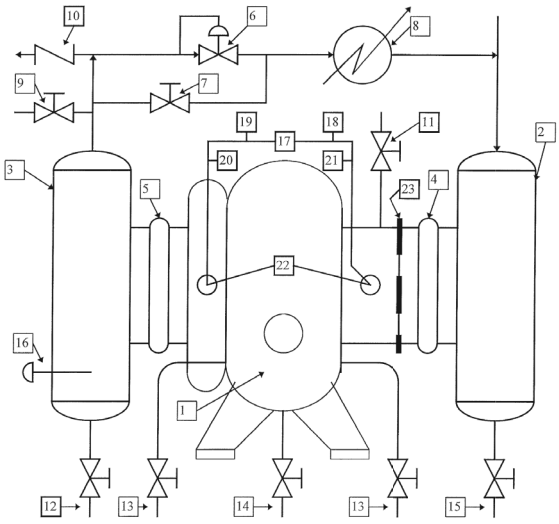


Figure 9 - Barometric Seal Leg



1. RGS-J Blower
2. Inlet Silencer
3. Discharge Silencer
4. Inlet S.S. Expansion Joint
5. Discharge S.S. Expansion Joint
6. Back Pressure Regulator
7. Bypass Valve
8. Bypass Cooler
9. Start Up Vent Valve
10. Check Valve
11. Inlet Water Spray Valve
12. Discharge Silencer Drain
13. Blower Headplate Drain
14. Casing Drain
15. Inlet Silencer Drain
16. High Water Level Switch
17. Differential Pressure Switch
18. Inlet Vacuum Switch
19. Discharge Press. Switch
20. Discharge Press. Gauge
21. Inlet Press./Vac. Gauge
22. Differential Temp. Switch
23. Temporary Screen

Note: Lines 12, 13, and 15, must be continuously drained, connected to a barometric seal or automatic drainage system. Each line will be under different pressure or vacuum levels.

Figure 10 - Steam Blower Installation

RGS 10” - 20” Gear Diameter Blowers for High Vacuum Booster (HVB) Service

NOTE: These instructions are applicable to those type RGS pumps supplied for HVB service. It covers only those points where a booster differs from standard series RGS gas pumps All other information, installation, and service data should be obtained from referenced sections while considering exceptions below.

INSTALLATION

Power required by HVB is generally smaller than required in normal applications. Therefore, the drive shaft arrangement shown for coupling drive is sometimes furnished on V-belt-driven 10 through 14 inch HVB pumps. Reduction in belt load makes extra bearing support for V-belt drive unnecessary.

Vacuum system piping must be vacuum-tight throughout. Leaks will seriously affect and limit performance of HVB and complete vacuum system.

LUBRICATION

Use rust, oxidation and foam inhibited non-detergent oil with low vapor pressure characteristics (0.1 micron of mercury or less at 180°F and 1.8 micron of mercury or less at 250°F). Viscosity range should be 450-600 SUS at 100°F or ISO VG 100 oil. Normal oil pressure is 8 PSIG (55kPa).

OPERATION

Initial starting procedures outlined under OPERATION in Instruction Manual must be followed generally. Steps 11 and 12 in referenced manual are not applicable to HVB and the following should be used:

The final operating checks are made with the HVB connected to vacuum system, which should be set for normal operating conditions. Start the system fore-pump and run it alone until inlet pressure of HVB is about 15 mm Hg absolute (15.0 Torr) (2.0 kPa).

During this pump down, HVB may windmill. Now start HVB manually or with vacuum pressure switch at HVB inlet. NOTE: HVB will OVERHEAT if operated at 15 mm Hg absolute inlet pressure longer than 5 minutes.

Providing a suitable pressure gauge at HVB inlet allows system check for tightness during initial pump-down period. Under normal conditions, systems reach anticipated pressure within 15 to 30 minutes. If it fails to do this, the cause may be continued out-gassing of various surfaces within the system, leaks, or both. Out-gassing sometimes requires 24 hours, but depends on system size. It is advisable to first check for leaks in the piping, joints, seals, etc. This may be done by stopping pumps, isolating system with a vacuum tight valve, and observing pressure rise rate of system.

MAINTENANCE

Periodic inspections include check of liquid level gauge located on side of each headplate. Extended periods of operation allow seal oil to accumulate in chambers behind these gauges. Should gauges show oil, chambers should be drained. Caution: Do not drain main oil supply sumps by mistake.

Segment Waist Clearances

Maximum clearance listed is for reference only. Unit must pass specified slip/flow test for acceptability

Frame Size	Impeller Ends		Impeller Strip to Cylinder			Impeller Lobes		Maximum Tempera-
	Thrust End	Gear End	Inlet	Center	Discharge	Fronts	Backs	
1009	.006-.008	.012-.016	.016-.018	.012-.014	.008-.010	.020-.024	.010-.014	240
1012	.007-.009	.015-.019	.016-.018	.012-.014	.008-.010	.020-.024	.010-.014	240
1015	.009-.011	.020-.024	.016-.018	.012-.014	.008-.010	.020-.024	.010-.014	240
1016	.009-.001	.020-.024	.016-.018	.012-.014	.008-.010	.020-.024	.010-.014	240
1018	.009-.001	.023-.027	.016-.018	.012-.014	.008-.010	.020-.024	.010-.014	240
1021	.010-.012	.025-.029	.016-.018	.012-.014	.008-.010	.020-.024	.010-.014	240
1024	.011-.013	.027-.031	.016-.019	.012-.014	.008-.010	.020-.024	.010-.014	240
1030	.014-.016	.031-.035	.019-.021	.013-.015	.008-.010	.020-.024	.010-.014	240
1212	.007-.009	.020-.024	.017-.019	.013-.015	.009-.011	.021-.025	.011-.015	235
1216	.008-.010	.021-.025	.017-.019	.013-.015	.009-.011	.021-.025	.011-.015	235
1218	.010-.012	.022-.026	.017-.019	.013-.015	.009-.011	.021-.025	.011-.015	235
1220	.010-.012	.024-.028	.017-.019	.013-.015	.009-.011	.021-.025	.011-.015	235
1222	.011-.013	.026-.030	.017-.019	.013-.015	.009-.011	.021-.025	.011-.015	235
1225	.012-.014	.028-.032	.017-.019	.013-.015	.009-.011	.021-.025	.011-.015	235
1228	.013-.015	.031-.035	.019-.021	.014-.016	.009-.011	.021-.025	.011-.015	235
1236	.016-.018	.036-.040	.022-.024	.015-.017	.009-.011	.021-.025	.011-.015	235

RGS 10” - 20” Gear Diameter Blowers for High Vacuum Booster (HVB) Service

Segment Waist Clearances (continued)

Frame Size	Impeller Ends		Impeller Strip to Cylinder			Impeller Lobes		Maximum Tempera-
	Thrust End	Gear End	Inlet	Center	Discharge	Fronts	Backs	
1412	.007-.009	.020-.024	.020-.022	.015-.017	.010-.012	.022-.026	.012-.016	230
1414	.007-.009	.021-.025	.020-.022	.015-.017	.010-.012	.022-.026	.012-.016	230
1416	.008-.010	.022-.026	.020-.022	.015-.017	.010-.012	.022-.026	.012-.016	230
1418	.009-.011	.023-.027	.020-.022	.015-.017	.010-.012	.022-.026	.012-.016	230
1421	.010-.012	.024-.028	.020-.022	.015-.017	.010-.012	.022-.026	.012-.016	230
1422	.010-.012	.025-.029	.020-.022	.015-.017	.010-.012	.022-.026	.012-.016	230
1425	.011-.013	.027-.031	.020-.022	.015-.017	.010-.012	.022-.026	.012-.016	230
1428	.013-.015	.029-.033	.020-.022	.015-.017	.010-.012	.022-.026	.012-.016	230
1431	.014-.016	.032-.036	.020-.022	.015-.017	.010-.012	.022-.026	.012-.016	230
1435	.015-.017	.034-.038	.020-.022	.015-.017	.010-.012	.022-.026	.012-.016	230
1442	.016-.018	.041-.045	.024-.026	.017-.019	.010-.012	.022-.026	.012-.016	230
1616	.008-.010	.025-.029	.021-.023	.016-.018	.011-.013	.024-.028	.014-.018	230
1620	.010-.012	.027-.031	.021-.023	.016-.018	.011-.013	.024-.028	.014-.018	230
1622	.011-.013	.028-.032	.021-.023	.016-.018	.011-.013	.024-.028	.014-.018	230
1627	.012-.014	.029-.033	.021-.023	.016-.018	.011-.013	.024-.028	.014-.018	230
1630	.013-.015	.032-.036	.021-.023	.016-.018	.011-.013	.024-.028	.014-.018	230
1633	.014-.016	.034-.038	.021-.023	.016-.018	.011-.013	.024-.028	.014-.018	230
1639	.017-.019	.038-.042	.024-.026	.017-.019	.011-.013	.024-.028	.014-.018	230
1643	.018-.020	.040-.044	.024-.026	.017-.019	.011-.013	.024-.028	.014-.018	230
1648	.020-.022	.043-.047	.027-.029	.019-.021	.011-.013	.024-.028	.014-.018	230
1821	.010-.012	.029-.033	.024-.026	.018-.020	.012-.014	.025-.029	.015-.019	225
1824	.011-.013	.031-.035	.024-.026	.018-.020	.012-.014	.025-.029	.015-.019	225
1827	.012-.014	.032-.036	.024-.026	.018-.020	.012-.014	.025-.029	.015-.019	225
1830	.013-.015	.033-.037	.024-.026	.018-.020	.012-.014	.025-.029	.015-.019	225
1833	.014-.016	.035-.039	.024-.026	.018-.020	.012-.014	.025-.029	.015-.019	225
1841	.017-.019	.041-.045	.024-.026	.018-.020	.012-.014	.025-.029	.015-.019	225
1845	.019-.021	.044-.048	.026-.028	.019-.021	.012-.014	.025-.029	.015-.019	225
1849	.020-.022	.047-.051	.026-.028	.019-.021	.012-.014	.025-.029	.015-.019	225
1854	.022-.024	.050-.054	.028-.030	.020-.022	.012-.014	.025-.029	.015-.019	225
2022	.010-.012	.029-.033	.026-.028	.020-.022	.014-.016	.027-.031	.017-.021	215
2026	.011-.013	.032-.036	.026-.028	.020-.022	.014-.016	.027-.031	.017-.021	215
2030	.013-.015	.034-.038	.026-.028	.020-.022	.014-.016	.027-.031	.017-.021	215
2033	.014-.016	.035-.039	.026-.028	.020-.022	.014-.016	.027-.031	.017-.021	215
2037	.015-.017	.038-.042	.026-.028	.020-.022	.014-.016	.027-.031	.017-.021	215
2040	.016-.018	.039-.043	.026-.028	.020-.022	.014-.016	.027-.031	.017-.021	215
2044	.018-.020	.043-.047	.026-.028	.020-.022	.014-.016	.027-.031	.017-.021	215
2050	.020-.022	.048-.052	.028-.030	.021-.023	.014-.016	.027-.031	.017-.021	215
2055	.022-.024	.052-.056	.028-.030	.021-.023	.014-.016	.027-.031	.017-.021	215
2060	.023-.025	.056-.060	.030-.032	.022-.025	.014-.016	.027-.031	.017-.021	215

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, and oil line filter cartridges are 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. Numbers shown in brackets ( ) correspond to Item Numbers used in the sectional assembly drawings and in Table 9. Refer to the drawing applying to the type unit being repaired while reading the instructions.

A - Removing Gears With Gear Locking Assemblies

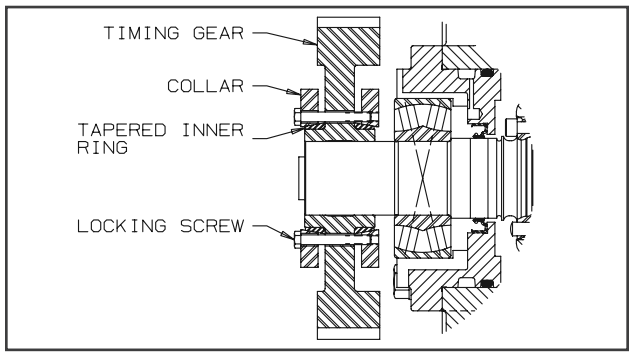


Figure 11 - Gear Locking Assembly

1 Drain oil at plug (67) near bottom of gearbox (3).
2 Remove pipe connecting drive end cover (5) and gearbox (3) by disconnecting unions.
3 Remove oil cooler (47) and/or cover plate (4) from gearbox.
4 Disconnect oil relief valve (11) and the pipe to the side of the gearbox. Remove all external and internal capscrews and bolts, then remove gearbox with oil pump attached.
5 Remove oil pump coupling-half (41) from upper main shaft (12).
6 Match mark gears so that they can be returned to the same shafts in same position.
7 Gradually release gear locking assembly capscrews evenly all round. Initially each screw should be released about a quarter of a turn only to prevent tilting and jamming of collars. **DO NOT REMOVE LOCKING SCREWS COMPLETELY OR THE COLLAR MAY SPRING OFF, CAUSING INJURY.** Just loosen the locking assembly; both collars should be loose on the tapered inner rings. To loosen the back collar, tapping on the locking screws may be necessary.
To loosen the front collar, use of wedges between the collar and the gear web may be required.
8 Using two puller holes in the gear (see Table 6 for size) pull the gears off the shafts.

Table 6 - Puller Hole Sizes

Maintenance/Replacements (Cont'd)

Blower Size	Gear Puller Hole Size	Carrier Puller Hole Size
1000	1/2 - 13	5/8 - 11
1200	3/4 - 10	5/8 - 11
1400, 1600	3/4 - 10	3/4 - 10
1800, 2000	3/4 - 10	1-8

B - Installing Gears With Gear Locking Assemblies

1. Apply Molykote Gn paste on the gear locking device screw threads, under the screw heads, on the tapered rings, on the collar tapers, and on the gear hub outside diameters.
2. Slide each tapered ring collar and the web clearance holes and screw them loosely into the opposite collar.
3. Degrease the gear hub bore and shaft. The gear must be free of lubricant. Mark OD of the taper ring 180 degrees apart. Measure this location with micrometers and record the value.
4. Slide gear and lock ring assemblies on the shafts until flush with the shaft end. If not possible due to slight interference fit, warm up the gear hub bore slightly with torch to expand bore and ease installation. **Do not exceed 200°F.** If the gears are match marked near teeth, be certain to line-up the marks. **Allow gears to cool to ambient temperature before starting torque process.**
5. Use 4 of the locking screws equally spaced and snug them up in order to properly seat the collars on the taper of the inner ring and avoid cocking the collars. **When tightening the locking ring screws, maintain circular tightening pattern. Do not tighten diametrically opposite pattern.** Snug the locking ring screws on both gears to the point that some resistance is given to rotating the shaft inside the gear. **Never use an impact wrench.** Completely tighten one gear locking ring to the specified initial torque in table 7 using a calibrated torque wrench. Tighten each screw one half turn at a time until the initial torque is reached. This will require several "laps" around the circular tightening pattern. Do not assume that the screws have maintained the torque applied on the previous lap until none of the screws move after a full lap.
6. Check to see if the clamping rings are perpendicular to the shaft. A measurement from the clamp ring face to the web of the gear must be taken in four locations using depth micrometer. If and any 2 measurement more than .015", must gradually loosen each screw by 1/4 turn until locking ring is free. **Caution: clamping ring under extreme load so do not loosen each by more than 1/4 turn or remove one completely at this time or the collar may spring off.** Repeat assembly process over.
7. Measure clamping ring expansion at the same previously marked points. If specified minimum expansion in table 7A is achieved, no further

Maintenance/Replacements (Cont'd)

increase screw torque is required. If not, must increase screw torque by 2 Ft-Lbs increments up to maximum specified torque listed in table 7 until reach minimum specified ring expansion list table 7A. If expansion is below minimum, repeat steps 6 & 7.

8. Set the impeller timing as described under step 4 of operation C. Once satisfactory timing is achieved. Use calibrated torque wrench to tighten the locking screws on 2nd gear locking ring per steps 5 thru 7.

Table 7 - Torque Wrench Data

	Gear Cap-screw Size - Metric	Gear Capscrew Torque Values Lb-Ft (kg-M)		Stub Shaft Screws Lb-Ft (kg-M)
		Minimum	Maximum	
1000	N/A	N/A	N/A	45(6)
1200	M8	21(2.9)	25(3.5)	75(10)
1400	M10	45(6.2)	51(7.05)	75(10)
1600	M10	45(6.2)	51(7.05)	105(15)
1800	M12	77(10.7)	85(11.75)	105(15)
2000	M16	200(27.7)	220(30.4)	250(35)

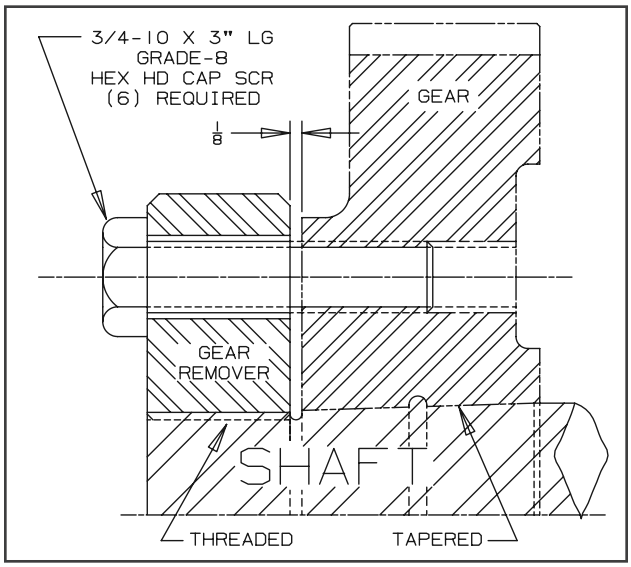


Figure 12 - Taper Gear Remover

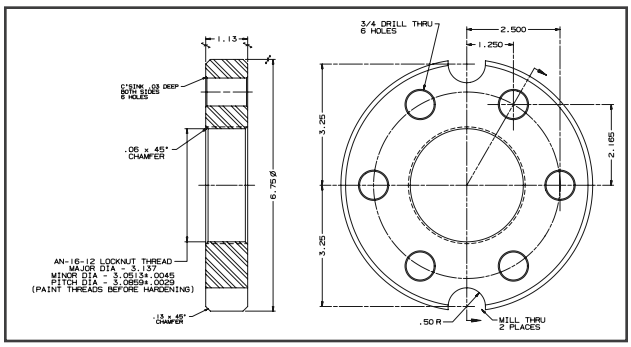


Figure 13 - Gear Remover Material - Steel, Hardness - Rc-

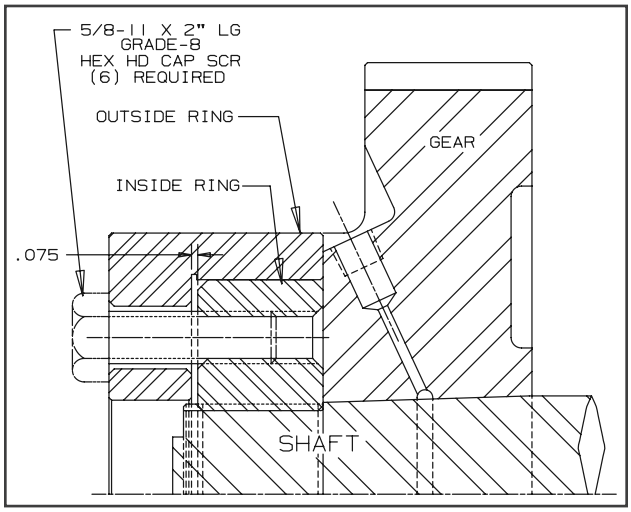


Figure 14 - Taper Gear Installation

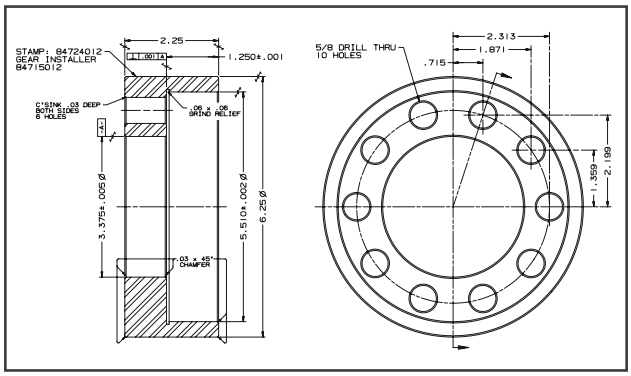


Figure 15 - Outside Ring Material - Steel, Hardness - Rc-25 min

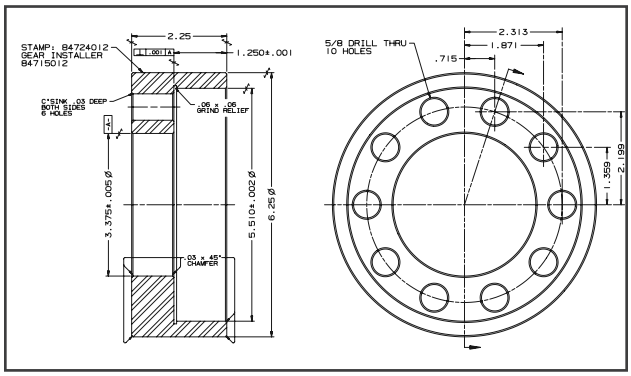


Figure 16 - Inside Ring Material - Steel, Hardness - Rc-25

Frame Series	Locking Ring Collar Expansion	
	Minimum-IN	Maximum-IN

1000	N/A	N/A
1200	0.009	0.013
1400	0.010	0.016
1600	0.014	0.020
1800	0.017	0.024
2000	0.020	0.025

10" Taper Bore Gear Removal Procedure

1. Remove the gear nut and lock washer.
2. Install Gear Remover within 1/8th inch of the gear face. This gap is necessary to unseat gear from the shaft taper.
3. Apply Neverseez on 3/4-10X3" long, grade 8 capscrew threads and under hex heads.
4. Install capscrews through gear remover holes into the gear puller holes.
5. Tighten these capscrews a quarter turn at a time in either clockwise or counter-clockwise sequence, but not diametrically opposite sequence, until the gear is unseated from the taper.
6. If the gear does not come off using above method, use hydraulic assist feature provided in the gear in addition to the above. Hydraulic pump capable of generating about 20,000 PSI pressure is required. Make sure all tubing and fittings are good for 40,000 PSI. The gear connections are 1/4 NPT. Hook up pump to bottom connection. Leave top hole open. Crank the pump till some oil comes through the open hole bleeding all air out. Close the top hole with 1/4 NPT solid steel plug. Crank the pump up till the gear comes off. Do not exceed 20,000 PSI oil pressure. If not sure how to use the hydraulic removal system, contact factory.

10" Taper Bore Gear Installation Procedure

1. Block the impellers inside the blower using wooden blocks/wedges.
2. Degrease gear bore and shaft taper. **THESE SURFACES MUST BE FREE OF OIL.**
3. Screw the inside ring onto the shaft, snug it up against the gear by hand.
4. Slide outside ring onto the inside ring.
5. Apply **Neverseez** on the threads and under the head of the installation capscrews. Install the capscrews finger tight.
6. Install indicator on the gear outside face for measuring the gear axial movement.
7. Tighten each screw quarter turn at a time in either clockwise or counter-clockwise sequence, but not diametrically opposite sequence, till the outer ring is solid against the inside ring. THE GEAR SHOULD MOVE .065 to .075".
8. Loosen up the installation capscrews and remove the gear installation tooling.

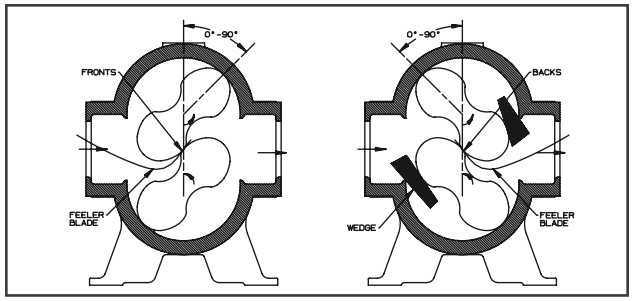


Figure 17 - Impeller Timing Viewed from End RAS/RGS Standard Rotation

Note: There are two fronts and two backs clearances in one complete revolution.

9. Install gear locknut and tighten nut with a spanner wrench.

C - Timing The Impellers

1. Disconnect the piping at both inlet and discharge flanges of the machine, moving the pipe flanges at least far enough away for easy insertion of an arm into the openings.
2. Use a set of feeler gauges with blades about 12" (300 mm) long for measuring clearances between the impeller lobes. These clearances are identified as "front" and "backs", and are measured with the impellers in the positions shown in Figures 17 and 18. The drive shaft rotation indicated is **counter-clockwise**. For opposite rotation, impeller positions will be reversed from that shown in Figures 17 and 18 and the front and back identifications will be interchanged. Fronts may be defined as the lobes that tend to contact during rotation because of pressure load and gear tooth wear; conversely, backs are the surfaces that tend to separate.
3. Determine and record the total lobe clearance by measuring the front and back clearances and adding them. It will normally be satisfactory to take these measurements at the mid-point of the impeller length. Place a wedge between the gear teeth to prevent the impellers from shifting during the measurement, making sure that any gear tooth clearance is always taken up in the same direction. **Note that there are two front and two back clearance positions in one complete revolution and use minimum value of clearance found along length of impeller**

Maintenance/Replacements (Cont'd)

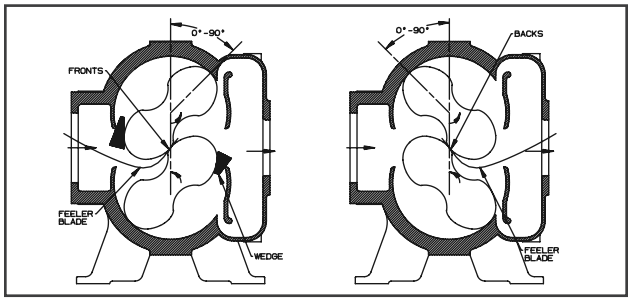


Figure 18 - Same as Figure 14 Except Shows RAS/RGS Whispair Cylinder

for fronts and backs throughout 90° rotation.

4. Loosen the screws on one gear (make sure collars are loose) to permit slight adjustments of position relative to its impeller, and set the impeller "front" clearance so that it is two-thirds of the total clearance found in Step 3. Make sure that any backlash in the gears is taken up in the direction of rotation with the lower gear driving.
5. Tighten all screws as in Step 7. OPERATION B, and recheck front and back clearances.

D - Removing Bearings and/or Seals

1. Dismantle as in Operation A.
2. Remove gear end bearing carriers (6). Bearings and shaft seals will come out with the carriers. Discard the O-rings (20). Impellers will now be supported by the labyrinth seals in headplate holes.
3. Dismount drive and remove drive end cover (5) and/or (58), using care with seal (23).
4. Remove bearing locknuts (24) and lockwashers (25), using a spanner wrench.
5. Remove bearing clamp plates (8).
6. Pull drive end bearing carriers with bearings and seals as on gear end. Shims (17) under the flanges should be kept in order and identified for replacing the same positions.

E - Replacing Lip Seals (RAS/RAS Whispair)

1. Check shafts for surface finish of 10-16 micro-inch (.3 to .4 micrometers) RMS in seal contact area, and for good condition at bearing locations. Carefully remove any burrs or sharp corners, but do not attempt refinishing.

   The seals are "**Directional, Hydrodynamic**", which means for proper sealing they are completely **dependent on the direction of the shaft rotation**. In each seal kit, there are:

(2) Clockwise (CW) "Blue-coated" seals for inboard seal replacement

(2) Counter-Clockwise (CCW) "Red-coated" seals for inboard seal replacement

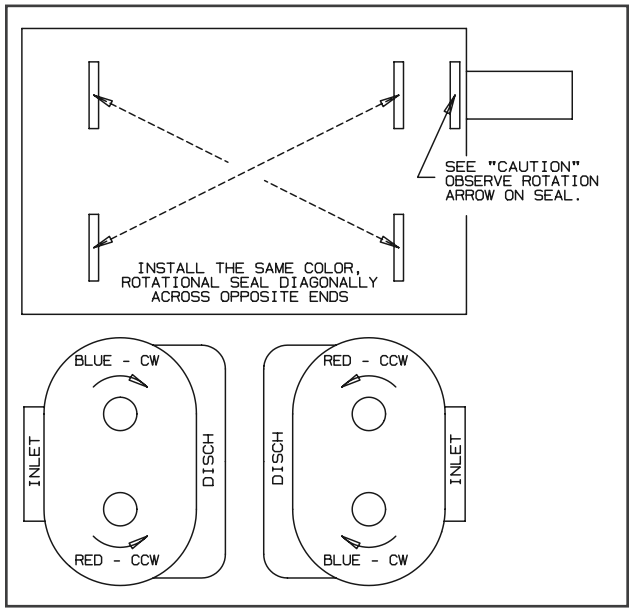
(1) Reversible (CW/CCW) "Green-coated" seal for drive shaft seal replacement

(1) Protective Sleeve Tool (Inboard seals)

(1) Protective Sleeve Tool (Drive shaft seal)

CAUTION: FOR SEALS TO PERFORM PROPERLY

- Use careful handling procedures so as not to damage seals during installation. Must use the installation sleeves provided in kit as shown under Final Assembly. Seal lips are not very flexible and will tear or become damaged if not installed properly.
- Shaft surface must be clean and free of scratches



Seal Installation Guide

with a finish between 10 to 20 RMS.

- Seals must stay on shipping rings until time of installation, or the seal lips will deform over time.

2. Finish the assembly as outlined in "Final Assembly".

F -Replacing Face Seals (RGS/RGS WHISPAIR)

1 Check shafts for 45 (1.1 micrometers) RMS finish, inspect bearing seats, and remove burrs or sharp corners.

2 Remove bearings and seals from carriers. If new seals are to be installed, remove cast iron seat rings and their internal O-rings from shafts. Clean and inspect the carrier bores and replace the external O-rings, but do not reinstall carriers.

Maintenance/Replacements (Cont'd)

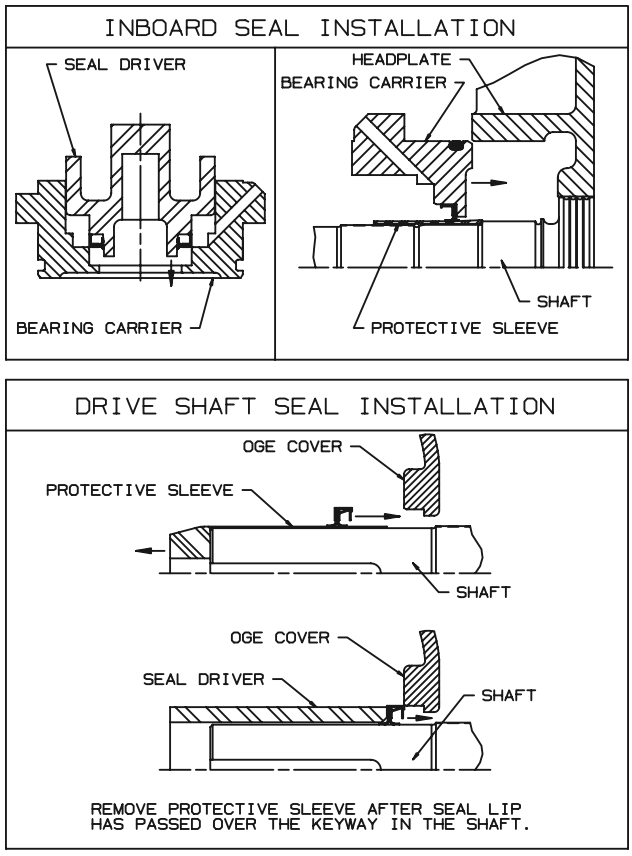
3 Inspect the seal assembly. Be certain that the lapped sealing faces of both iron and carbon rings are absolutely free of scratches and foreign material.

4 Wipe these faces clean with "Sight Saver" silicone treated tissue and apply a thin coating of clean lubricating oil. Also coat the O-rings in these two parts with the same oil. Install the cast iron rings on the shafts, using a tapered thimble to prevent damage to the O-ring on shaft shoulders or threads. Be sure that all rings seat against their shaft shoulders, and that the driving pins are properly positioned between a pair of shaft flange screw heads. Slip the carbon washer and spring assemblies into the back recesses of the bearing carriers. The projections on the retainers must drop into the holes provided in the carriers. Protect the carbon face with clean soft paper. Recheck all seal faces. It is of the utmost importance that these faces have not been marred in any way, and that they have not collected any foreign material during Steps 5 and 6. Install all bearing carriers in their headplates, with the drive end shims in original locations behind the carrier flanges. Finish the assembly as outlined in "Final Assembly".

F - Final Assembly

1. Install all bearings. Making sure they are up tight against their respective shaft shoulders. Work on gear end bearings first and press them info place by using proper installation tools. The impellers will be driven against the opposite headplate. Then remove shims (17) from behind both drive end bearing carrier flanges and press the bearings at this end into place against their shaft shoulders.

   On a belt-drive unit with extended shaft, use proper tool to push inboard bearing (60) into its final position. There is no shaft shoulder behind this bearing, but there is a stop for the sleeve.
2. Install bearing lockwasher (25) and locknuts (24) on each shaft, and tighten nuts with a spanner wrench. Lock the nuts by bending a tab on each washer into a slot in the nut.
3. Install new or original gears and set impellers as described in Operation B.
4. Place bearing clamp plate (8) over main bearing (31) and tighten all screws. In the case of the extended type drive shaft, end cover (58) serves as the clamp plate but cannot be installed until later.
5. Using 1/2" (13mm) feeler gauges, determine for



Inboard Seal Installation and Drive Shaft Seal

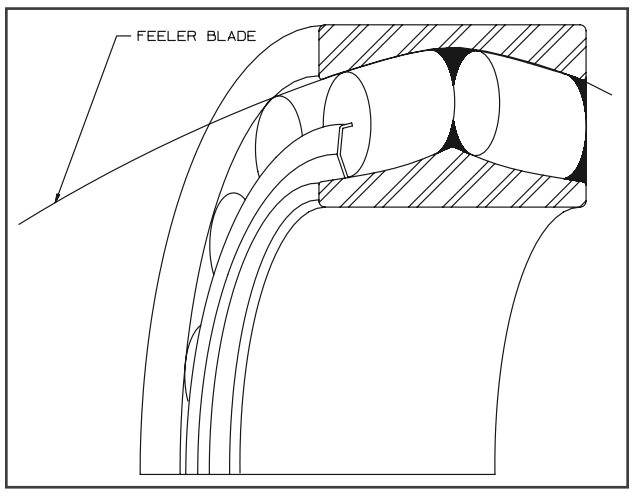


Figure 19

Repair Kit Information For RAS/RGS Lube Blowers

Ref.	Qty.	Part Description
17	1	Shim Set
18	2	Gasket
19	1	Gasket
20	4	0 Ring
23	1	Seal, Drive Shaft
24	2	Locknut, Bearing
25	2	Lockwasher, Bearing - Except
27	4	Seal, Headplate
31	Varies	Bearings
42	1 set	Capscrews
80	2	Bearings

When ordering spare parts contact:

Howden Roots
900 West Mount Street
Connersville, IN 47331-1675
Phone: 765-827-9200
Fax: 765-827-9309

[1]Table 8A – Normal Internal Clearances – (RP-68)-Inches

Frame	Impeller End to Headplate		Impeller Tip to Cylinder			Impeller Lobes	
	Thrust End	Gear End	Inlet	Center	Discharge	Fronts	Backs
1006 *	.006-.008	.011-.015	.014-.016	.010-.012	.006-.008	.020-.024	.010-.014
1009	.006-.008	.013-.017	.014-.016	.010-.012	.006-.008	.020-.024	.010-.014
1012	.008-.010	.015-.019	.014-.016	.010-.012	.006-.008	.020-.024	.010-.014
1016	.008-.010	.015-.019	.012-.014	.008-.010	.004-.014	.020-.024	.010-.014
1018	.008-.010	.015-.019	.012-.014	.008-.010	.004-.014	.020-.024	.010-.014
1021	.008-.010	.018-.022	.012-.014	.008-.010	.004-.014	.020-.024	.010-.014
1024	.009-.011	.019-.023	.012-.014	.008-.010	.004-.014	.020-.024	.010-.014
1030	.010-.012	.021-.025	.013-.015	.009-.011	.005-.015	.020-.024	.010-.014
1212 *	.006-.008	.015-.019	.015-.017	.011-.013	.007-.009	.021-.025	.011-.015
1216	.007-.009	.019-.023	.015-.017	.011-.013	.007-.009	.021-.025	.011-.015
1220	.007-.009	.016-.020	.013-.015	.009-.011	.005-.015	.021-.025	.011-.015
1222	.007-.009	.018-.022	.013-.015	.009-.011	.005-.015	.021-.025	.011-.015
1225	.008-.010	.018-.022	.013-.015	.009-.011	.005-.015	.021-.025	.011-.015
1228	.009-.011	.021-.025	.013-.015	.009-.011	.005-.015	.021-.025	.011-.015
1236	.010-.012	.023-.027	.015-.017	.011-.013	.007-.017	.021-.025	.011-.015
1414	.007-.009	.019-.023	.017-.019	.012-.014	.007-.009	.022-.026	.012-.016
1418	.009-.011	.022-.026	.017-.019	.012-.014	.007-.009	.022-.026	.012-.016
1422	.008-.010	.017-.021	.015-.017	.010-.012	.005-.007	.022-.026	.012-.016
1425	.008-.010	.020-.024	.015-.017	.010-.012	.015-.017	.022-.026	.012-.016
1428	.009-.011	.020-.024	.015-.017	.010-.012	.015-.017	.022-.026	.012-.016
1431	.009-.011	.024-.028	.015-.017	.010-.012	.015-.017	.022-.026	.012-.016
1435	.010-.012	.024-.028	.015-.017	.010-.012	.015-.017	.022-.026	.012-.016
1442	.011-.013	.027-.031	.016-.018	.011-.013	.006-.018	.022-.026	.012-.016
1616 *	.008-.010	.020-.024	.018-.020	.013-.015	.008-.010	.024-.028	.014-.018
1620 *	.010-.012	.023-.027	.018-.020	.013-.015	.008-.010	.024-.028	.014-.018
1625 *	.011-.013	.024-.028	.018-.020	.013-.015	.008-.010	.024-.028	.014-.018
1627	.009-.011	.020-.024	.016-.018	.011-.013	.006-.020	.024-.028	.014-.018
1630	.010-.012	.023-.027	.016-.018	.011-.013	.006-.018	.024-.028	.014-.018
1633	.010-.012	.023-.027	.016-.018	.011-.013	.006-.018	.024-.028	.014-.018
1639	.011-.013	.026-.030	.016-.018	.011-.013	.006-.018	.024-.028	.014-.018
1643	.012-.014	.028-.032	.018-.020	.013-.015	.018-.020	.024-.028	.014-.018
1648	.013-.015	.030-.040	.018-.020	.013-.015	.018-.020	.024-.028	.014-.018
1821 *	.010-.012	.025-.029	.020-.022	.014-.016	.008-.010	.025-.029	.015-.019
1824	.011-.013	.028-.032	.020-.022	.014-.016	.008-.010	.025-.029	.015-.019
1827	.012-.014	.031-.035	.020-.022	.014-.016	.008-.010	.025-.029	.015-.019
1830 *	.011-.013	.024-.028	.018-.020	.012-.014	.006-.008	.025-.029	.015-.019
1833	.011-.013	.024-.028	.018-.020	.012-.014	.006-.008	.025-.029	.015-.019
1841	.013-.015	.030-.034	.018-.020	.012-.014	.006-.008	.025-.029	.015-.019
1845	.013-.015	.030-.034	.018-.020	.012-.014	.006-.008	.025-.029	.015-.019
1849 *	.014-.016	.034-.038	.020-.022	.014-.016	.008-.010	.025-.029	.015-.019
1854	.014-.016	.034-.038	.020-.022	.014-.016	.008-.010	.025-.029	.015-.019
2022	.011-.013	.028-.030	.022-.024	.016-.018	.010-.012	.027-.031	.017-.021
2026	.013-.015	.031-.035	.022-.024	.016-.018	.010-.012	.027-.031	.017-.021
2033	.012-.014	.025-.029	.020-.022	.014-.016	.008-.010	.027-.031	.017-.021
2037	.013-.015	.027-.031	.020-.022	.014-.016	.008-.010	.027-.031	.017-.021
2040	.013-.015	.027-.031	.020-.022	.014-.016	.008-.010	.027-.031	.017-.021
2044	.014-.016	.029-.033	.020-.022	.014-.016	.008-.010	.027-.031	.017-.021
2050	.015-.017	.032-.036	.020-.022	.014-.016	.008-.010	.027-.031	.017-.021
2055 *	.017-.019	.037-.041	.020-.022	.014-.016	.008-.010	.027-.031	.017-.021
2060	.017-.019	.037-.041	.020-.022	.014-.016	.008-.010	.027-.031	.017-.021

*Sizes Not Available in RAS
[1] Minimum clearances are listed for reference only. Actual clearances amy be greater than values listed.

[1]Table 8B – Normal Internal Clearances – (RP-68) - MM

Frame	Impeller End to Headplate		Impeller Tip to Cylinder			Impeller Lobes	
	Thrust End	Gear End	Inlet	Center	Discharge	Fronts	Backs
1006 *	.15-.20	.28-.38	.35-.40	.25-.30	.15-.20	.50-.60	.25-.35
1009	.15-.20	.33-.45	.35-.40	.25-.30	.15-.20	.50-.60	.25-.35
1012	.20-.25	.38-.48	.35-.40	.25-.30	.15-.20	.50-.60	.25-.35
1016	.20-.25	.38-.48	.30-.35	.20-.25	.10-.35	.50-.60	.25-.35
1018	.20-.25	.38-.48	.30-.35	.20-.25	.10-.35	.50-.60	.25-.35
1021	.20-.25	.45-.55	.30-.35	.20-.25	.10-.35	.50-.60	.25-.35
1024	.23-.28	.48-.58	.30-.35	.20-.25	.10-.35	.50-.60	.25-.35
1030	.25-.30	.53-.63	.33-.38	.23-.28	.13-.38	.50-.60	.25-.35
1212 *	.15-.20	.38-.48	.38-.43	.28-.33	.18-.23	.53-.63	.28-.38
1216	.18-.23	.48-.58	.38-.43	.28-.33	.18-.23	.53-.63	.28-.38
1220	.18-.23	.40-.50	.33-.38	.23-.28	.13-.38	.53-.63	.28-.38
1222	.18-.23	.45-.55	.33-.38	.23-.28	.13-.38	.53-.63	.28-.38
1225	.20-.25	.45-.55	.33-.38	.23-.28	.13-.38	.53-.63	.28-.38
1228	.23-.28	.53-.63	.33-.38	.23-.28	.13-.38	.53-.63	.28-.38
1236	.25-.30	.58-.68	.38-.43	.28-.33	.18-.43	.53-.63	.28-.38
1414	.18-.23	.48-.58	.43-.48	.30-.23	.18-.23	.55-.65	.30-.40
1418	.23-.28	.55-.65	.43-.48	.30-.23	.18-.23	.55-.65	.30-.40
1422	.20-.25	.43-.53	.38-.43	.25-.18	.13-.18	.55-.65	.30-.40
1425	.20-.25	.50-.60	.38-.43	.25-.30	.13-.43	.55-.65	.30-.40
1428	.23-.28	.50-.60	.38-.43	.25-.30	.13-.43	.55-.65	.30-.40
1431	.23-.28	.60-.70	.38-.43	.25-.30	.13-.43	.55-.65	.30-.40
1435	.25-.30	.60-.70	.38-.43	.25-.30	.13-.43	.55-.65	.30-.40
1442	.28-.33	.68-.78	.40-.45	.28-.33	.15-.45	.55-.65	.30-.40
1616 *	.20-.25	.50-.60	.45-.50	.33-.38	.20-.25	.60-.70	.35-.45
1620 *	.25-.30	.58-.68	.45-.50	.33-.38	.20-.25	.60-.70	.35-.45
1625 *	.28-.33	.60-.70	.45-.50	.33-.38	.20-.25	.60-.70	.35-.45
1627	.23-.28	.50-.60	.40-.45	.28-.33	.15-.45	.60-.70	.35-.45
1630	.25-.30	.58-.68	.40-.45	.28-.33	.15-.45	.60-.70	.35-.45
1633	.25-.30	.58-.68	.40-.45	.28-.33	.15-.45	.60-.70	.35-.45
1639	.28-.33	.65-.75	.40-.45	.28-.33	.15-.45	.60-.70	.35-.45
1643	.30-.35	.70-.80	.45-.50	.33-.38	.20-.50	.60-.70	.35-.45
1648	.33-.38	.75-.85	.45-.50	.33-.38	.20-.50	.60-.70	.35-.45
1821 *	.25-.30	.63-.73	.50-.55	.35-.40	.20-.25	.63-.73	.38-.48
1824	.28-.33	.70-.80	.50-.55	.35-.40	.20-.25	.63-.73	.38-.48
1827	.30-.35	.78-.88	.50-.55	.35-.40	.20-.25	.63-.73	.38-.48
1830 *	.28-.33	.60-.70	.45-.50	.30-.35	.15-.20	.63-.73	.38-.48
1833	.28-.33	.60-.70	.45-.50	.30-.35	.15-.20	.63-.73	.38-.48
1841	.33-.38	.75-.85	.45-.50	.30-.35	.15-.20	.63-.73	.38-.48
1845	.33-.38	.75-.85	.45-.50	.30-.35	.15-.20	.63-.73	.38-.48
1849 *	.35-.40	.85-.95	.50-.55	.35-.40	.20-.25	.63-.73	.38-.48
1854	.35-.40	.85-.95	.50-.55	.35-.40	.20-.25	.63-.73	.38-.48
2022	.28-.33	.70-.80	.55-.60	.40-.45	.25-.30	.68-.78	.43-.53
2026	.33-.38	.78-.88	.55-.60	.40-.45	.25-.30	.68-.78	.43-.53
2033	.30-.35	.63-.73	.50-.55	.35-.40	.20-.25	.68-.78	.43-.53
2037	.35-.40	.73-.83	.50-.55	.35-.40	.20-.25	.68-.78	.43-.53
2040	.35-.40	.73-.83	.50-.55	.35-.40	.20-.25	.68-.78	.43-.53
2044	.35-.40	.73-.83	.50-.55	.35-.40	.20-.25	.68-.78	.43-.53
2050	.38-.43	.80-.90	.50-.55	.35-.40	.20-.25	.68-.78	.43-.53
2055 *	.43-.48	.93-1.04	.50-.55	.35-.40	.20-.25	.68-.78	.43-.53
2060	.43-.48	.93-1.04	.50-.55	.35-.40	.20-.25	.68-.78	.43-.53

*Sizes Not Available in RAS
[1] Minimum clearances are listed for reference only. Actual clearances amy be greater than values listed.

[1]Table 9A – Open Internal Clearances – (RP-71) - Inches

Frame	Impeller End to Headplate		Impeller Tip to Cylinder			Impeller Lobes	
	Thrust End	Gear End	Inlet	Center	Discharge	Fronts	Backs
1006 *	.006-.008	.014-.018	.014-.016	.010-.012	.006-.008	.020-.024	.010-.014
1009	.007-.009	.016-.020	.014-.016	.010-.012	.006-.008	.020-.024	.010-.014
1012	.009-.011	.020-.024	.014-.016	.010-.012	.006-.008	.020-.024	.010-.014
1016	.010-.012	.020-.024	.014-.016	.010-.012	.006-.016	.020-.024	.010-.014
1018	.010-.012	.023-.027	.014-.016	.010-.012	.006-.016	.020-.024	.010-.014
1021	.011-.013	.024-.028	.014-.016	.010-.012	.006-.016	.020-.024	.010-.014
1024	.012-.014	.026-.030	.016-.018	.011-.013	.006-.018	.020-.024	.010-.014
1030	.013-.015	.032-.036	.019-.021	.012-.014	.006-.021	.020-.024	.010-.014
1212 *	.009-.011	.023-.027	.015-.017	.011-.013	.007-.009	.021-.025	.011-.015
1216	.010-.012	.027-.031	.019-.021	.013-.015	.007-.009	.021-.025	.011-.015
1220	.010-.012	.024-.028	.015-.017	.011-.013	.007-.017	.021-.025	.011-.015
1222	.011-.013	.028-.032	.015-.017	.011-.013	.007-.017	.021-.025	.011-.015
1225	.011-.013	.028-.032	.017-.019	.012-.014	.007-.019	.021-.025	.011-.015
1228	.013-.015	.031-.035	.018-.020	.012-.014	.007-.020	.021-.025	.011-.015
1236	.015-.017	.037-.041	.022-.024	.014-.016	.007-.024	.021-.025	.011-.015
1414	.009-.011	.025-.029	.021-.023	.015-.017	.009-.011	.022-.026	.012-.016
1418	.009-.011	.029-.033	.021-.023	.015-.017	.009-.011	.022-.026	.012-.016
1422	.011-.013	.025-.029	.017-.019	.012-.014	.007-.009	.022-.026	.012-.016
1425	.011-.013	.027-.031	.017-.019	.012-.014	.007-.019	.022-.026	.012-.016
1428	.013-.015	.029-.033	.017-.019	.012-.014	.007-.019	.022-.026	.012-.016
1431	.014-.016	.032-.036	.017-.019	.012-.014	.007-.019	.022-.026	.012-.016
1435	.015-.017	.035-.039	.020-.022	.013-.015	.007-.022	.022-.026	.012-.016
1442	.016-.018	.042-.046	.024-.026	.015-.017	.007-.026	.022-.026	.012-.016
1616 *	.009-.011	.030-.034	.022-.024	.016-.018	.010-.012	.024-.028	.014-.018
1620 *	.011-.013	.034-.038	.022-.024	.016-.018	.010-.012	.024-.028	.014-.018
1625 *	.013-.015	.039-.043	.022-.024	.016-.018	.010-.012	.024-.028	.014-.018
1627	.013-.015	.029-.033	.018-.020	.013-.015	.008-.020	.024-.028	.014-.018
1630	.014-.016	.032-.036	.018-.020	.013-.015	.008-.020	.024-.028	.014-.018
1633	.015-.017	.034-.038	.020-.022	.014-.016	.008-.022	.024-.028	.014-.018
1639	.016-.018	.040-.044	.022-.024	.015-.017	.008-.024	.024-.028	.014-.018
1643	.018-.020	.041-.045	.024-.026	.016-.018	.008-.026	.024-.028	.014-.018
1648	.021-.023	.043-.047	.027-.029	.017-.019	.008-.029	.024-.028	.014-.018
1821 *	.011-.013	.038-.042	.024-.026	.017-.019	.010-.012	.025-.029	.015-.019
1824	.012-.014	.039-.043	.024-.026	.017-.019	.010-.012	.025-.029	.015-.019
1827	.013-.015	.044-.048	.024-.026	.017-.019	.010-.012	.025-.029	.015-.019
1830 *	.013-.015	.034-.038	.020-.022	.014-.016	.008-.010	.025-.029	.015-.019
1833	.015-.017	.036-.040	.020-.022	.014-.016	.008-.010	.025-.029	.015-.019
1841	.017-.019	.042-.046	.023-.025	.015-.017	.008-.010	.025-.029	.015-.019
1845	.018-.020	.045-.049	.025-.027	.015-.017	.008-.010	.025-.029	.015-.019
1849 *	.019-.021	.048-.052	.027-.029	.017-.019	.008-.010	.025-.029	.015-.019
1854	.021-.023	.052-.056	.030-.032	.019-.021	.008-.010	.025-.029	.015-.019
2022	.012-.014	.039-.043	.027-.029	.019-.021	.011-.013	.027-.031	.017-.021
2026	.014-.016	.043-.047	.027-.029	.019-.021	.011-.013	.027-.031	.017-.021
2033	.014-.016	.036-.040	.022-.024	.016-.018	.010-.012	.027-.031	.017-.021
2037	.016-.018	.040-.044	.022-.024	.016-.018	.010-.012	.027-.031	.017-.021
2040	.016-.018	.040-.044	.022-.024	.016-.018	.010-.012	.027-.031	.017-.021
2044	.018-.020	.045-.049	.025-.027	.017-.019	.010-.012	.027-.031	.017-.021
2050	.020-.022	.050-.054	.027-.029	.018-.020	.010-.012	.027-.031	.017-.021
2055 *	.022-.024	.054-.058	.030-.032	.020-.021	.010-.012	.027-.031	.017-.021
2060	.023-.025	.058-.062	.033-.035	.021-.023	.010-.012	.027-.031	.017-.021

[1]Table 9B – Open Internal Clearances – (RP-71) - MM

Frame	Impeller End to Headplate		Impeller Tip to Cylinder			Impeller Lobes	
	Thrust End	Gear End	Inlet	Center	Discharge	Fronts	Backs
1006 *	.15-.20	.36-.45	.36-.41	.25-.30	.15-.20	.51-.61	.25-.35
1009	.18-.23	.40-.50	.36-.41	.25-.30	.15-.20	.51-.61	.25-.35
1012	.23-.28	.51-.61	.36-.41	.25-.30	.15-.20	.51-.61	.25-.35
1016	.25-.30	.51-.61	.36-.41	.25-.30	.15-.41	.51-.61	.25-.35
1018	.25-.30	.58-.68	.36-.41	.25-.30	.15-.41	.51-.61	.25-.35
1021	.28-.33	.60-.70	.36-.41	.25-.30	.15-.41	.51-.61	.25-.35
1024	.30-.35	.66-.76	.41-.46	.28-.33	.15-.46	.51-.61	.25-.35
1030	.33-.38	.80-.90	.48-.53	.30-.35	.15-.53	.51-.61	.25-.35
1212 *	.23-.28	.58-.64	.36-.41	.28-.33	.18-.23	.53-.63	.28-.38
1216	.25-.30	.69-.79	.48-.53	.33-.38	.18-.23	.53-.63	.28-.38
1220	.25-.30	.60-.70	.36-.41	.28-.33	.18-.41	.53-.63	.28-.38
1222	.28-.33	.71-.81	.36-.41	.28-.33	.18-.41	.53-.63	.28-.38
1225	.23-.33	.71-.81	.43-.48	.30-.35	.18-.48	.53-.63	.28-.38
1228	.33-.38	.78-.88	.45-.50	.30-.35	.18-.50	.53-.63	.28-.38
1236	.36-.41	.94 -1.04	.56-.61	.36-.41	.18-.61	.53-.63	.28-.38
1414	.23-.28	.64-.74	.53-.58	.36-.41	.23-.28	.56-.66	.30-.40
1418	.23-.28	.74-.84	.53-.58	.36-.41	.23-.28	.56-.66	.30-.40
1422	.28-.33	.64-.74	.43-.48	.30-.35	.18-.23	.56-.66	.30-.40
1425	.28-.33	.69-.79	.43-.48	.30-.35	.18-.48	.56-.66	.30-.40
1428	.33-.38	.74-.84	.43-.48	.30-.35	.18-.48	.56-.66	.30-.40
1431	.36-.41	.80-.90	.43-.48	.30-.35	.18-.48	.56-.66	.30-.40
1435	.38-.43	.89-.99	.51-.56	.33-.38	.18-.56	.56-.66	.30-.40
1442	.40-.45	1.06-1.16	.60-.65	.38-.43	.18-.65	.56-.66	.30-.40
1616 *	.23-.28	.76-.86	.56-.61	.40-.45	.25-.30	.60-.70	.36-.46
1620 *	.28-.33	.86-.96	.56-.61	.40-.45	.25-.30	.60-.70	.36-.46
1625 *	.33-.38	.99-1.09	.56-.61	.40-.45	.25-.30	.60-.70	.36-.46
1627	.33-.38	.74-.84	.45-.50	.33-.38	.20-.50	.60-.70	.36-.46
1630	.36-.41	.80-.90	.45-.50	.33-.38	.20-.50	.60-.70	.36-.46
1633	.38-.43	.86-.96	.51-.56	.36-.41	.20-.56	.60-.70	.36-.46
1639	.40-.45	1.00-1.10	.56-.61	.38-.53	.20-.61	.60-.70	.36-.46
1643	.45-.50	1.04-1.14	.60-.65	.40-.45	.20-.65	.60-.70	.36-.46
1648	.53-.58	1.09-1.19	.69-.74	.43-.48	.20-.74	.60-.70	.36-.46
1821 *	.28-.33	.96-1.06	.60-.65	.43-.48	.25-.30	.64-.74	.38-.48
1824	.30-.35	.99-1.09	.60-.65	.43-.48	.25-.30	.64-.74	.38-.48
1827	.33-.38	1.10-1.20	.60-.65	.43-.48	.25-.30	.64-.74	.38-.48
1830 *	.33-.38	.86-.96	.51-.56	.36-.41	.20-.25	.64-.74	.38-.48
1833	.38-.43	.90-1.00	.51-.56	.36-.41	.20-.25	.64-.74	.38-.48
1841	.43-.48	1.06-1.16	.58-.63	.38-.43	.20-.25	.64-.74	.38-.48
1845	.45-.50	1.14-1.24	.64-.69	.38-.43	.20-.25	.64-.74	.38-.48
1849 *	.48-.53	1.22-1.32	.69-.74	.43-.48	.20-.25	.64-.74	.38-.48
1854	.53-.58	1.32-1.42	.75-.80	.48-.53	.20-.25	.64-.74	.38-.48
2022	.30-.35	.99-1.09	.69-.74	.48-.53	.28-.33	.69-.79	.43-.53
2026	.36-.41	1.09-1.19	.69-.74	.48-.53	.28-.33	.69-.79	.43-.53
2033	.36-.41	.90-1.00	.56-.61	.40-.45	.25-.30	.69-.79	.43-.53
2037	.41-.46	1.00-1.10	.56-.61	.40-.45	.25-.30	.69-.79	.43-.53
2040	.41-.46	1.00-1.10	.56-.61	.40-.45	.25-.30	.69-.79	.43-.53
2044	.45-.50	1.14-1.24	.64-.69	.43-.48	.25-.30	.69-.79	.43-.53
2050	.51-.56	1.27-1.37	.69-.74	.45-.50	.25-.30	.69-.79	.43-.53
2055 *	.56-.61	1.37-1.47	.75-.80	.51-.56	.25-.30	.69-.79	.43-.53
2060	.58-.63	1.47-1.57	.84-.89	.53-.58	.25-.30	.69-.79	.43-.53

Parts List

Table 10 - Parts Identification List for Figures 21-24

Item Num-	Quan-tity	Identification
1	2	Headplate
2	1	Cylinder
3	1	Gearbox
4	1	Cover Plate - Gearbox
5	1	End Cover - Main
6	4	Bearing Carrier
7	2	Impeller
8	2	Bearing Clamp Plate, Drive End
9	2	Timing Gear
10	2	Gear Locking Assembly
11	1	Relief Valve - Oiling System
12	2	Stub Shaft - Gear End
13	1	Stub Shaft - Driving
14	1	Stub Shaft - Driven
16	1	Key - Drive Sheave or Coupling
17	4	Shims - Bearing Carrier, Drive End
18	2	Gasket - End Cover & Gearbox
19	1	Gasket - Gearbox Cover Plate
20	4	“O” Ring - Brg. Car. (See Data Table)
21	8	Lockwasher - Brg. Clamp Plate & End
22	8	Capscrew - Brg. Clamp Plate & End
23	1	Shaft Seal - Outboard (See Data
24	2	Bearing Locknut
25	2	Bearing Lockwasher
26	16	Lockwasher - Brg. Carrier (See 49)
27	4	Shaft Seal - Inboard (See Data Table)
28	1	Breather Cap - Drive End
29	2	Eyebolt
30	Varies	Capscrew - Headplate & Cylinder
31	4	Bearing - Main (See Data Table)
32	3	Soc. Hd. Screw - Oil Pump Coupling
33	1	Set Screw - Oil Pump Coupling
34	2	Nameplate
35	6	Drive Screw - Name Plate & Rotation
36	12	Dowel Pin - Flange Locating
37	1	Breather Cap - Oil Sump
38	1	Oil Pump (See Data Table)
39	1	Nipple - Oil Sump Breather
40	4	Cap Screw - Oil Pump Mounting
41	1	Coupling - Oil Pump Drive

Item Num-	Quan-tity	Identification
42	Varies	Soc. Hd. Cap Screw - Stub Shaft
43	Varies	Taper Pin - Stub Shaft, Gear End
46	Varies	Capscrew - Gearbox Cover Plate
49	16	Cap Screw - Brg. Carrier (See 26)
51	1	Oil Strainer - Sump (See Data Table)
52	1	Adapter - Oil Strainer
53	4	Cap Screw - Strainer Mounting
54	4	Cap Screw - Oil Gauge Mounting
55	1	Oil Level Gauge
56	1	Rotation Arrow
57	1 or 2	Oil Filter (See Data Table)
58	1	End Cover - Drive Shaft
59	1	“O” Ring - Bearing Carrier, Outboard
60	1	Bearing - Inboard (See Data Table)
61	1	“O” Ring - End Cover (See Data
62	1	Spacer Sleeve - Outboard Bearing
63	1	Bearing Carrier - Drive Shaft,
64	2	Spring Pin - End Cover (10-14”
66	1	Vent - End Cover
67	1	Plug - Oil Drain
68	1	Pipe Plug (12-20” Only)
69	4	Pipe Plug
70	11	Pipe Plug
72	4	Set Screw
74	1	Rotation Arrow
77	2	Spacer Sleeve
79	1	Adapter - Oil Pump, Frames 1000, 1800 & 2000
87	1	Sight Plug, GE
100	4	Dowel Pin (10-14” Only)
101	2	Bearing Locknut (10” Only)
105	1	Shaft, OGE Drive (16-20” Only)
128	1	Cover Plate (16-20” Only)
129	1	Gasket (16-20” Only)
130	4	Screw, Hex Head (16--20” Only)
131	1	Gasket (10, 18 & 20” Only)
140	4	Lockwasher
168	3	Pipe Plug (10” RGS-J Only)
175	4	Pipe Nipple (10” RAS-J Only)
176	1	Bushing (10” Only)

Assembly Drawings

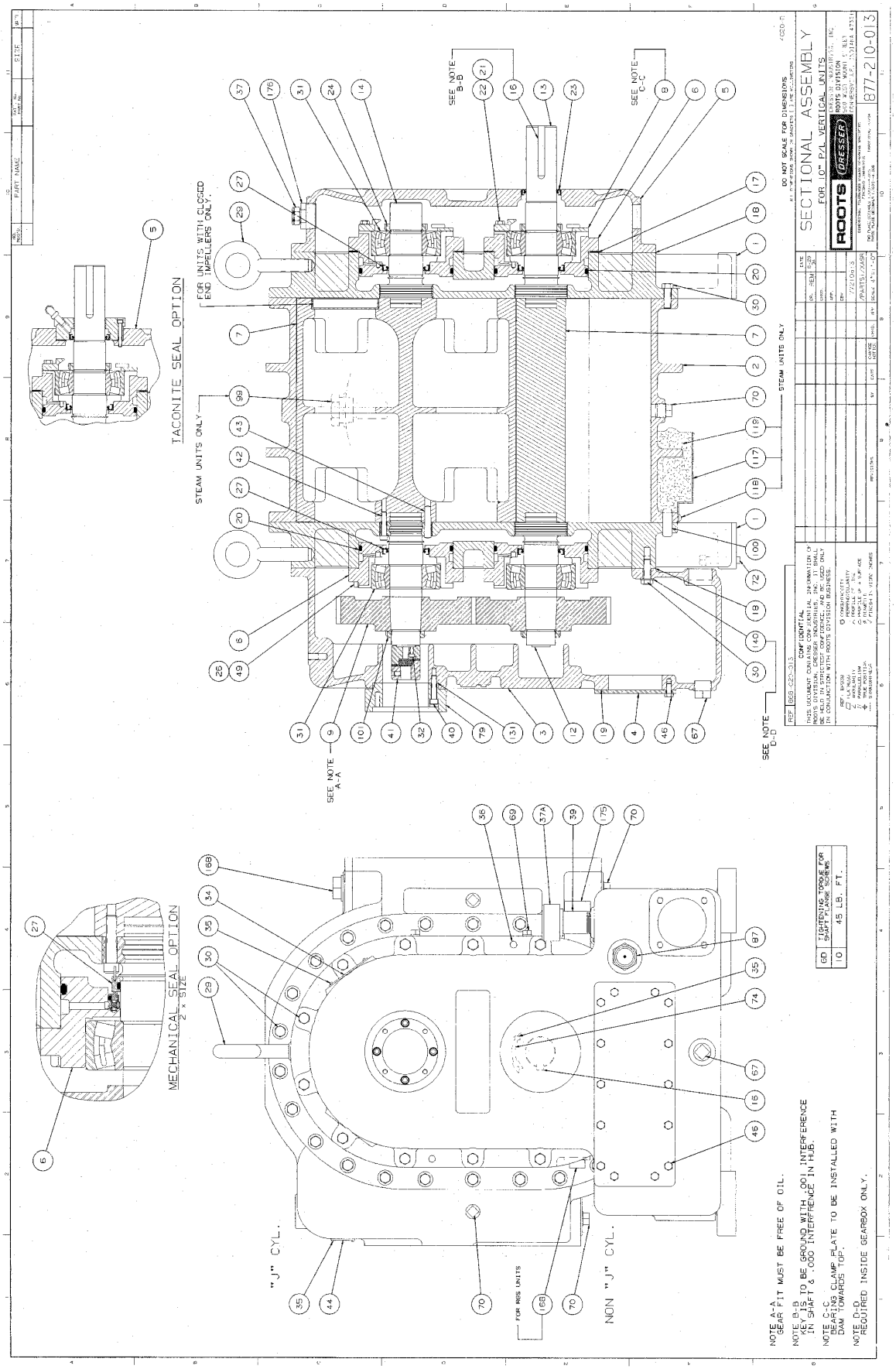


Figure 21 - Assembly of Basic 10" Vertical Blower

Assembly Drawings (Cont'd)

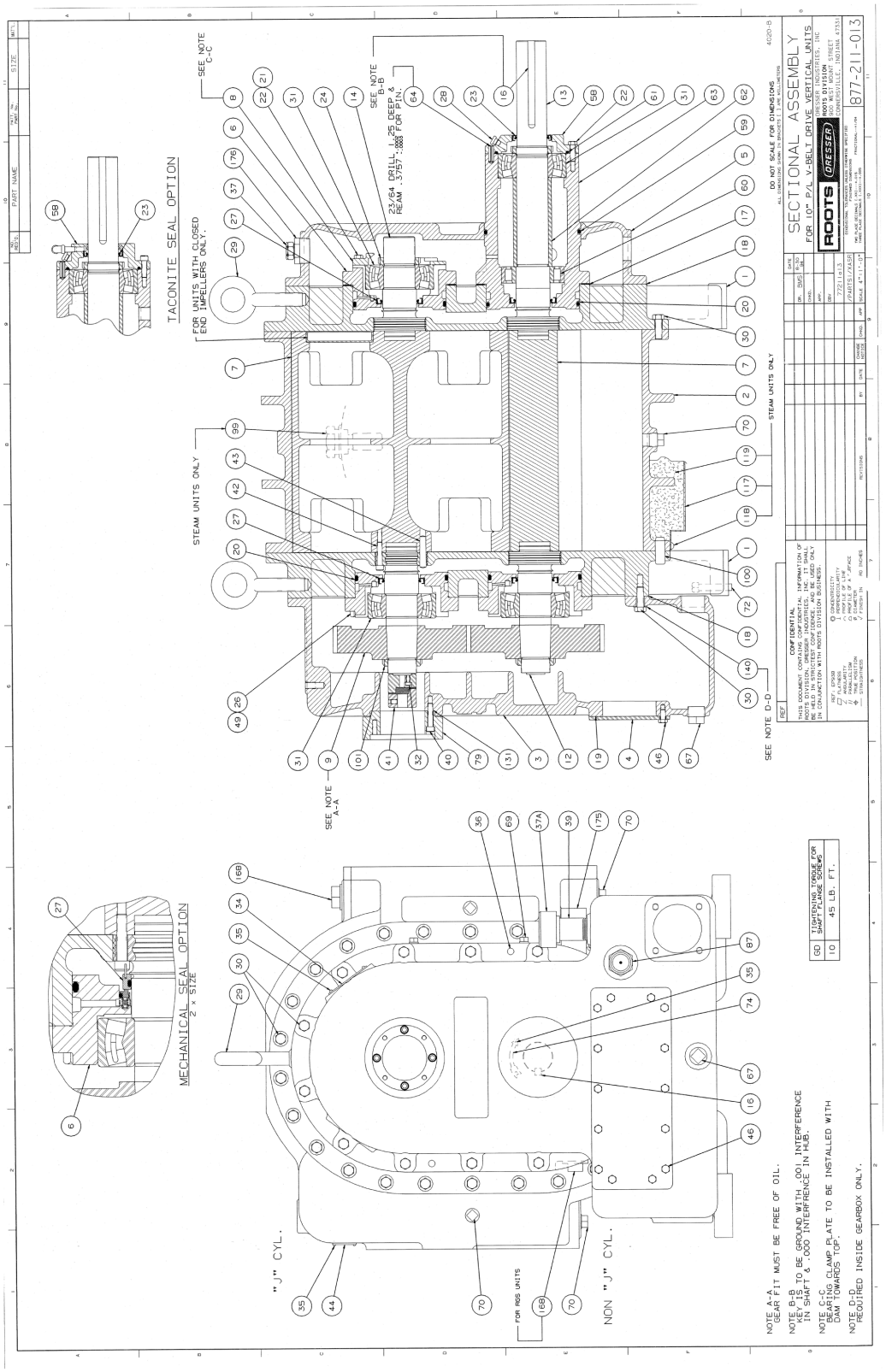


Figure 22 - Assembly of 10" Vertical Blower with V-Belt Drive

Assembly Drawings (Cont'd)

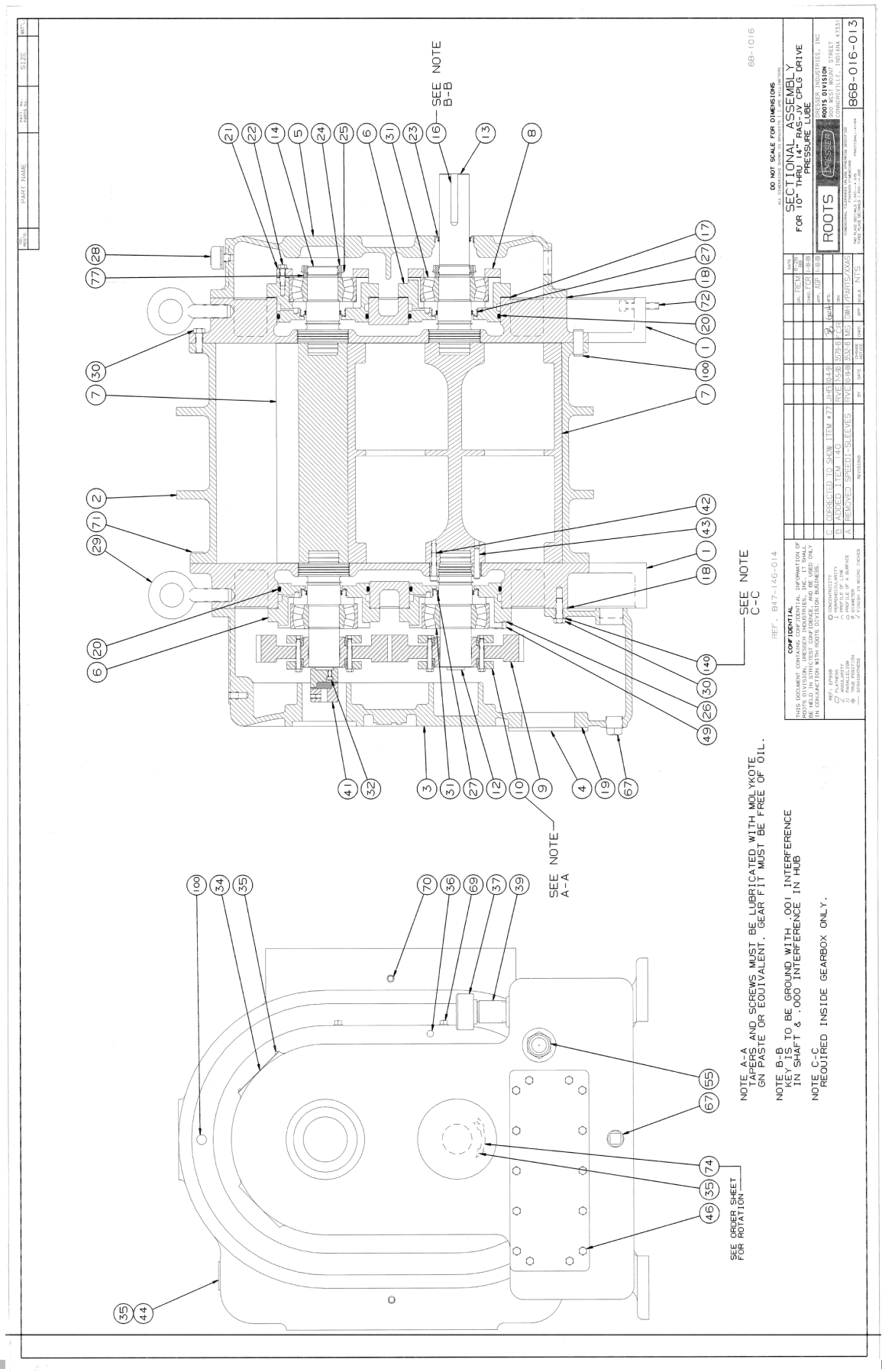


Figure 23 - Assembly of 10" - 14" RAS-JV with CPLG Drive

Assembly Drawings (Cont'd)

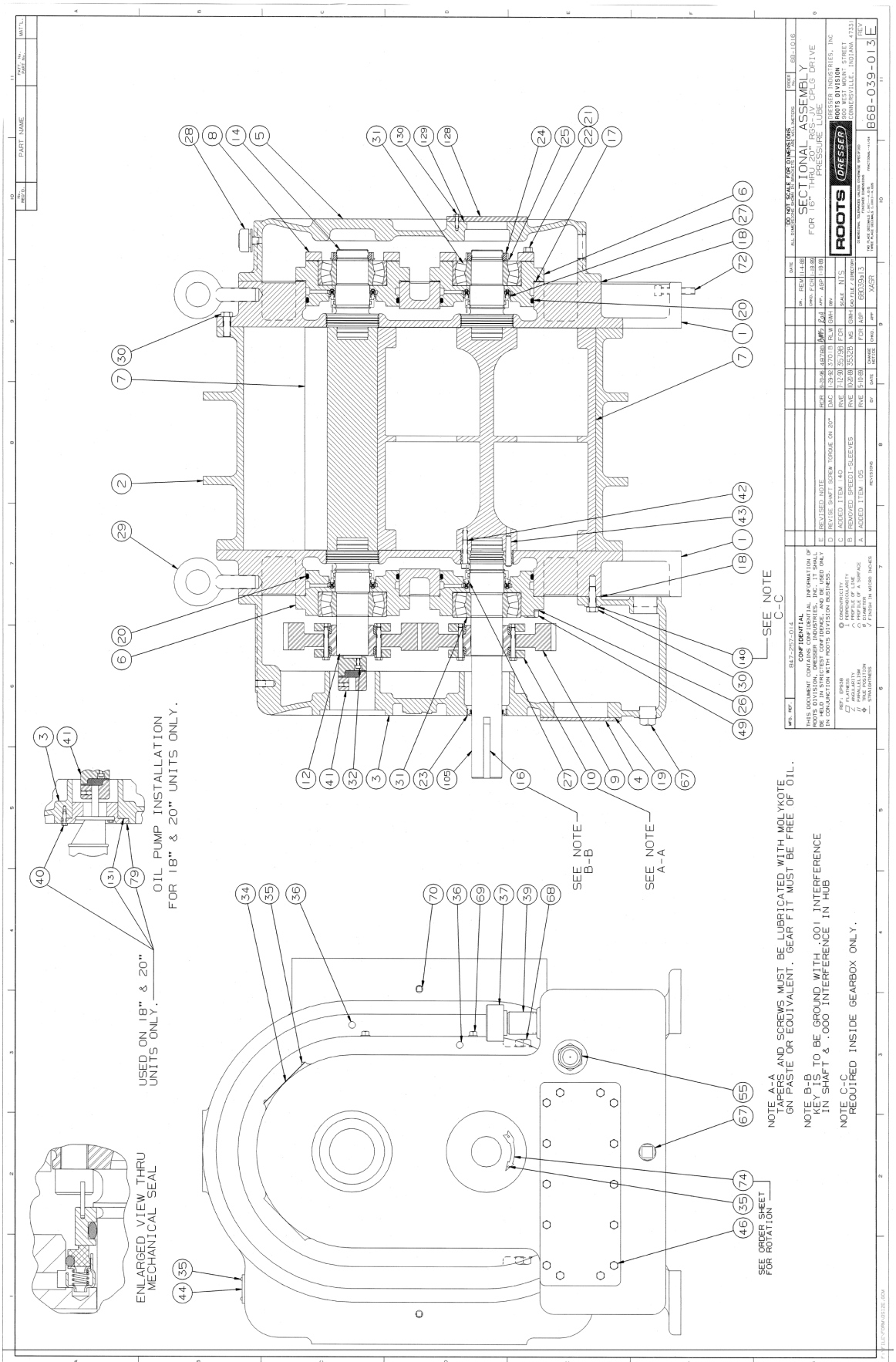


Figure 24 - Assembly of 16" - 20" RGS-JV with CPLG Drive

Assembly Drawings (Cont'd)

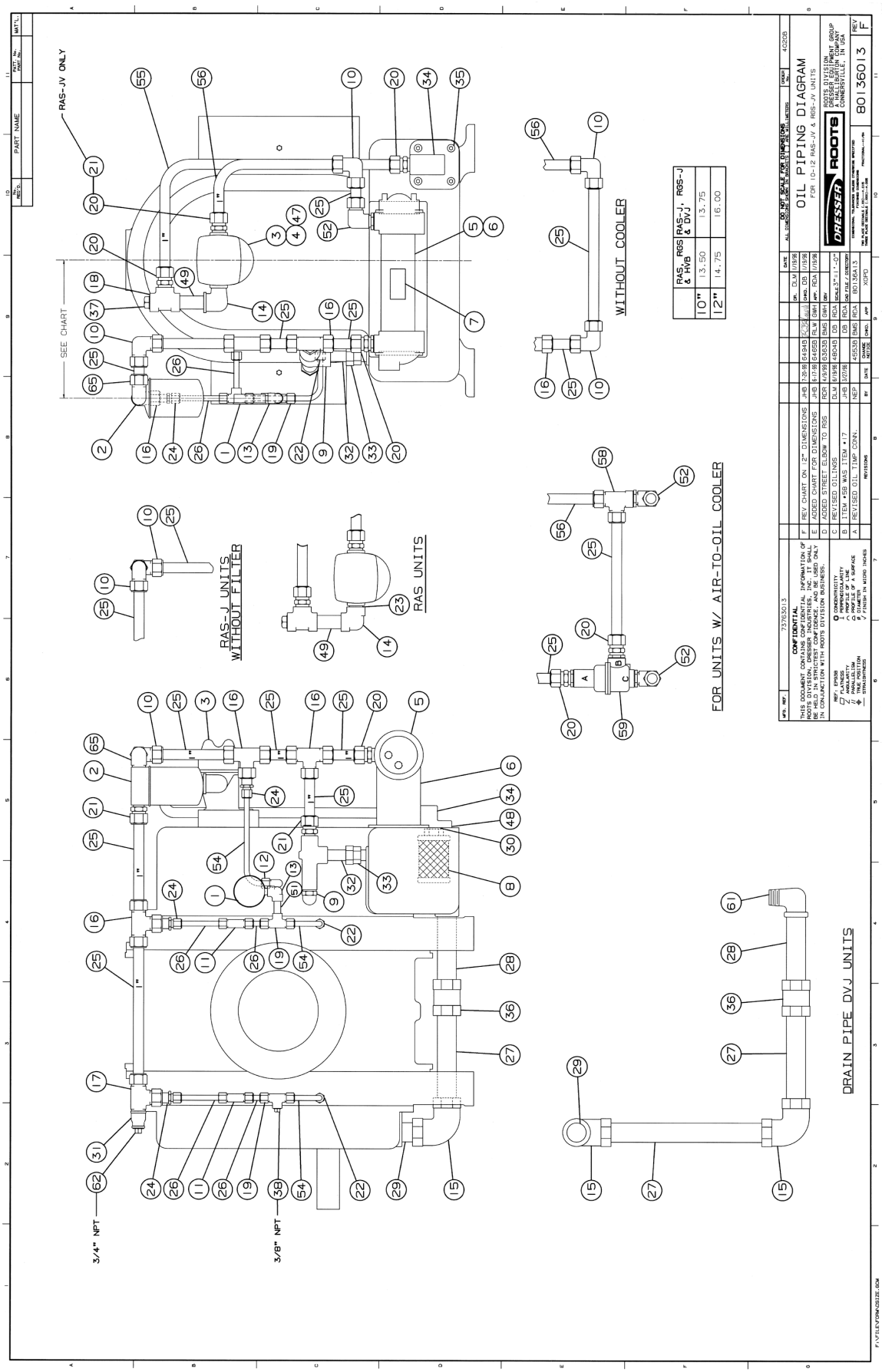
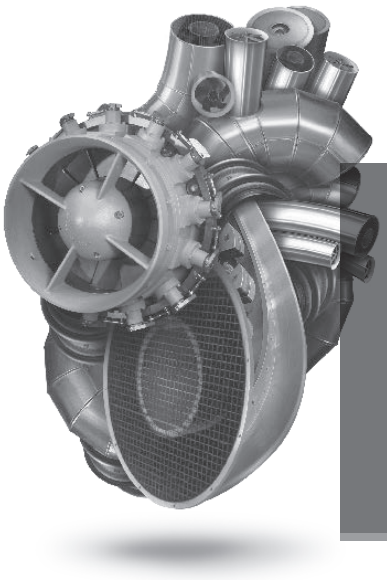


Figure 25 - Oil Piping Diagram

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