



**CAMCORP**  
A MEMBER OF THE SCHEUCH GROUP

# INSTALLATION, OPERATION, & MAINTENANCE MANUAL

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PRESSURE BLOWER PACKAGE



DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP

# TABLE OF CONTENTS

## SECTION 1: SAFETY

■ Safety Recommendations .....3-5

## SECTION 2: PRINCIPLE OF OPERATION

■ Principle of Operation.....6

## SECTION 3: INSTALLATION

■ Installation.....7-8

## SECTION 4: Maintenance

■ Maintenance .....9

## SECTION 5: Roots™, Universal RAI, URAI-DSL, URAI-G and Metric Series

■ Safety Precautions and Operating Limitations.....11-12

■ Installation.....13-18

■ Technical Supplement .....19

■ Lubrication.....20-21

■ Operation.....22-23

■ Troubleshooting.....24-25

■ Inspection & Maintenance .....26

■ Figures .....27-31

■ Tables.....32-34

## SECTION 6: Roots™ RAM™ and RAM-J Series

■ Safety Precautions and Operating Limitations.....36-37

■ Installation.....38-43

■ Lubrication.....44-45

■ Operation.....46-47

■ Troubleshooting.....48-49

■ Inspection & Maintenance .....50-51

■ Figures .....52-53

■ Tables.....54

## SECTION 7:Component Information

■ Ordering Spare Parts.....55

■ Component Breakout Drawing .....56

■ Air Intake Filters and Filter Silencers.....57

■ Weighted Relief Valves.....58

■ Switches and Motors.....59



# SECTION 1

## SAFETY

### RECOMMENDATIONS

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#### Safety Disclaimer

- It is your responsibility to work safely around this equipment. Pay attention to safety decals such as warnings, cautions, and electric hazards.
- Always work safely when installing metal products and use extreme caution on the roof at all times.
- Wear gloves and safety glasses to reduce the risk of injury, and use hearing protection when operating power tools.
- Safety harnesses or other special equipment may be required; be sure to consult OSHA guidelines for compliance with all safety requirements.
- Only a qualified electrician must work on electrical motors and the motor must be disconnected from supply lines.
- Be sure to check the equipment regularly. Loose connections, damaged cables or wiring points that have not been closed correctly are a danger for the operating staff or the environment. The device has to be stopped and disconnected immediately from all supply lines and the damage must be repaired or replaced.

#### Receiving and Unpacking

Prior to unloading, compare the received goods to your packing slips for quantity and descriptions. Review the items received for any damage. This should include any punctured packaging, scratches, dents or other signs of distress. Record any discrepancies or damage on the packing slip prior to signing of the packing slip. Also, report any discrepancies or damage within 24 hours to the shipping company.

#### Installation and Operation

##### Extended or Outside Storage Guidelines

If you are NOT installing the equipment immediately (within 30 days), use the following as a general guideline to prepare and

maintain the equipment during storage.

1. Coat internal surfaces of airbox and impellers with a petroleum based product (mineral oil). Fill the gear box and drive side sump completely with oil. (For Roots blowers, Roots recommends using their own brand of oil.)

#### IMPORTANT

**Oil must be drained and refilled with the proper lubrication and level before operation.**

2. Coat internal surfaces of air box and rotors with a petroleum based product.
3. Cover inlet and discharge with plastic (for long-term storage over 1 month)
4. Rotate the shaft 3-4 revolutions every 2 weeks.
5. Repeat steps 1 and 2 once per year or as conditions require.

#### Blower Package Mounting Guidelines

Use the following as a general guideline to mount your blower package.

- Anchor Bolts – Expansion style bolts are not permitted. Shall be hook style or heavy duty epoxy style, such as the Hilti #HVA System, Red Head Concrete Anchoring Specialists, or the Chem-Stud® Anchor System. See the manufacturer's technical manual for specific information on these anchoring systems.
- Mounting Pads – A general guideline you can use is that the depth of inertia pad shall be twice the blower gear diameter and the pad's mass must be two times the mass of the blower, motor and drive. (Use 150 lbs/CF for concrete.) Housekeeping pads poured on top of finished floors are not acceptable.
- Leveling and Tensioning – Sometimes it is specified or desirable to use a second nut under the equipment base for purposes of leveling the base. **UNDER NO CIRCUMSTANCES SHOULD THIS BE DONE.** The result of doing so is complete lack of tension put on the anchor bolt. More equipment failures during this first



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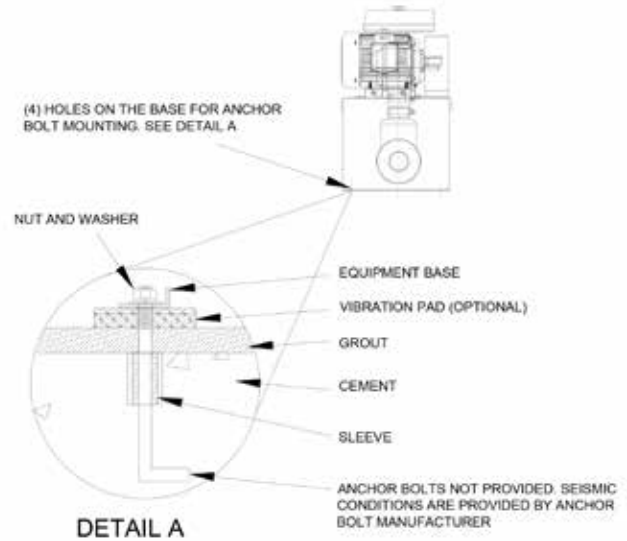
# SECTION 1

## SAFETY

### RECOMMENDATIONS

year of operation are due to improper anchor bolt tension or selection than any other single thing.

- Grout – It is important to fill the area between the base and the pad (1" min. [25.4mm] fill) with grout and not concrete. Grout expands as it dries thus forming a tight fit whereas concrete shrinks and leaves a loose fit.
- Substructure - the inertia pad guidelines described herein are dependent upon having proper compacted soil substructure which will allow the inertia pad to remain flat, rigid, and free of resonant frequencies within the equipment operating range.



BLOWER GEAR SIZE	BOLT SIZE			FOR HOOK STYLE BOLT		
	DIAMETER	LENGTH		GRADE	SLEEVES	
		EMBEDDED	TOTAL		I.D.	LENGTH
2	1/2	6	9	5	2	4
3	1/2	6	9	5	2	4
4	1/2		9	5	2	4
4-1/2	1/2	8	11	5	2	6
5	1/2	8	11	5	2	6
6	1/2	10	13	5	2	7
7	5/8	12	15	5	3	10
8	5/8	14	17	5	3	10
10	3/4	18	21	8	3	15
12	3/4	18	21	8	3	15
14	3/4	18	21	8	3	15
16	1	24	27	8	3	18
18	1	24	27	8	3	18
20	1	24	27	8	3	18



DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP

# SECTION 1 SAFETY RECOMMENDATIONS

## Serial Number Plate

Important information contained on these is needed by CAMCORP when calling for parts or service.



## QR Code - Ordering Spare Parts

CAMCORP makes ordering replacement parts easier and faster with QR code stickers. All you need is a mobile device and you've got instant access to your equipment's common spare parts and part numbers in one location.



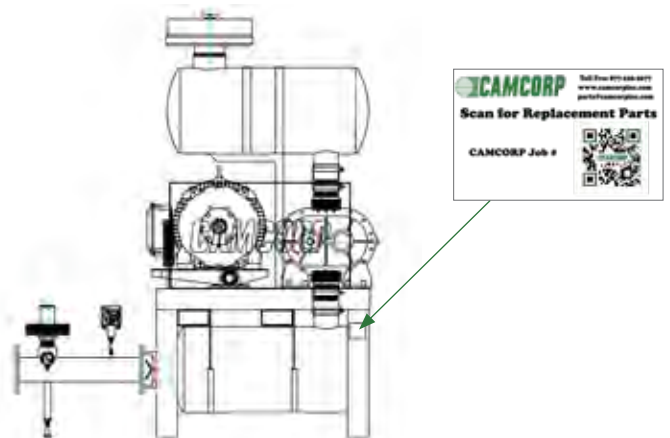
Here's how it works:

1. Locate the QR sticker on your dust collection or pneumatic conveying equipment.
2. Open your QR code reader app on your mobile device. You can download an app by searching "QR code reader" in the Google Play (Android) or App Store (Apple).
3. Hold your phone over the QR code and your spare parts list will appear complete with part numbers and CAMCORP Parts contact information.

Don't have a QR sticker on your equipment? Contact the CAMCORP Parts Department to request your sticker today.

## QR Code - Download Equipment Manual

Access to an electronic copy of this manual can be found by scanning the QR code sticker on your CAMCORP equipment. Simply follow the same instructions as Ordering Spare Parts.





## SECTION 2 PRINCIPLE OF OPERATION

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CAMCORP blower packages are set up to provide air to a pressure conveying system required for a negative pressure system. Typically the positive displacement blower used on such a package is not capable of supplying air to a pressure higher than 15 psig. Depending on the specific blower, it may have a maximum pressure capability of somewhat less than that. Because of limitations involved, the blower, motor and line size of the system must be designed specifically to meet the requirements of the system.

Because of the tight clearances used in the design and manufacture of the PD blowers, they require filtered intake air. Proper maintenance of the intake filter will help insure a long service life for your blower.

We recommend you give consideration to building certain precautions into your system. Due to unforeseen circumstances your system may at some point experience an upset condition. By allowing for this when setting up your system, you may minimize the affect of such an occurrence. Three major areas should be considered: the positive displacement blower, the motor and the integrity of the system controls.

Provided, as standard equipment on all of our blower packages is a mechanical relief valve, which is factory set at or below the pressure limit of the specific blower. This protects the blower from overheating because flow is decreasing if a line plugs or valve closes at the wrong time. This type of blower is not designed to run at zero airflow.

A properly sized and installed motor starter provides protection for your motor. Hire a qualified electrician to design and install the electrical service to your system.

The integrity of the controls for your system can usually best be maintained during an upset condition by proper use of a pressure switch. A pressure switch set two to three PSI/Hg. above the expected operating pressure of your system will allow a high pressure signal to initiate a preventative action. Check with CAMCORP for expected operating pressure. This may involve stopping the infeed or material to the system to allow it a certain time to clear itself or it may be as simple as triggering an alarm to alert an operation to the condition.

Caution must be taken to be sure that any steps initiated by such an upset condition does not create a problem or even a hazard elsewhere in your process. For example, your upstream equipment may need to be shut down in a very specific sequence. In any case, you need to analyze the affect on your complete process before establishing the actions initiated by an upset condition.



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## SECTION 3 INSTALLATION

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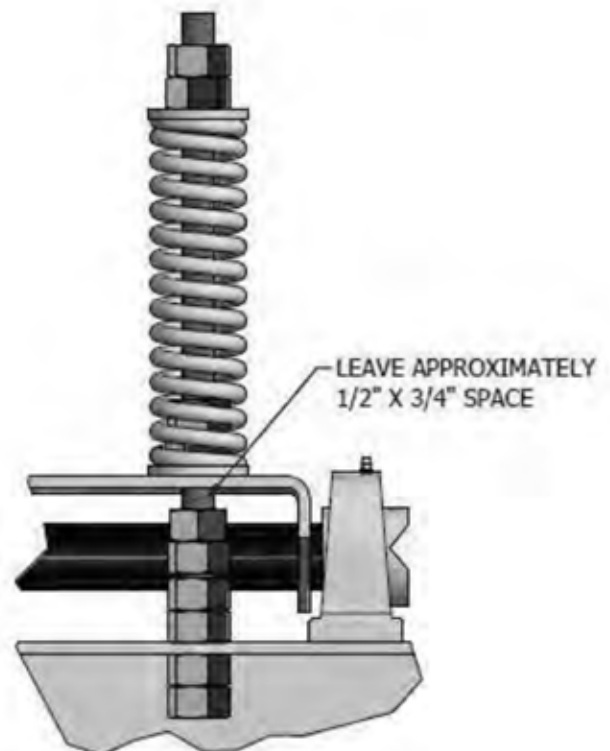
1. Use a fork lift truck or crane to transport the Blower Package to the installation location. Make sure that parts supplied loose on another pallet or in a box remain with the equipment during the transport so that they are available on site for installation.
2. Anchor both items to the mounting pad.
3. Have a licensed electrician wire the motor. Refer to the manufacturer's manual (included) for instructions or call your sales representative if you need assistance.
4. Verify all mounting bolts are tight.

### IMPORTANT

Blowers are shipped dry. Consult the manufacturer's manual (included) for lubrication information. **DO NOT RUN THE BLOWER WITHOUT OIL.**

5. Fill the blower with oil. Make sure to consult the manufacturer's manual (included) for lubrication information. Roots recommends using their own brand of oil.
6. Turn the blower shaft by hand. Verify it does not bind or make any unusual noise.
7. Verify the blower breather/filter plug is installed.
8. If necessary, install the relief valve per the manufacturer's manual (included). Verify the relief valve is unrestricted.
9. If necessary, zero out the pressure or vacuum gauge.
10. If necessary, set the pressure or vacuum switch per the manufacturer's manual (included).
11. Have a licensed electrician wire the motor for the appropriate rotation. Some blowers are unidirectional. Consult the manufacturer's manual (included) for instructions or call your sales representative if you need assistance.
12. Bump the motor and verify the rotation is correct.
13. Run the motor for 15-20 minutes with no load. Verify correct operation of all components. Shut off the motor. Allow the blower to cool to room temperature and check the oil level. If necessary, add oil.

14. Connect the load. Start the motor and observe operation for the first hour. Watch and listen for unusual noises, vibration, oil leaks, air leaks, etc.
15. After the first 8 hours, shut off the motor and check your belt tension. If you need to purchase a belt tension gauge, call your sales representative. Make sure you replace the belt guard before starting the motor.





**DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP**

## SECTION 3 INSTALLATION

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The Spring Loaded Motor Mount utilizes a spring system to control belt tension. It has been sized and set at the factory specifically for your system. Your blower package will operate at peak efficiency limiting belt slippage and excessive belt tension.

16. To tighten your belt tension, turn the adjustment screw on the spring clockwise to move the motor away from the blower. To loosen your belt tension, turn the adjustment screw counter-clockwise to move the motor closer to the blower.
17. After the first 24 hours, shut off the motor and check your belt tension.
18. After the first 72 hours, shut off the motor and check your belt tension. Also, verify the intake filter/silencer is free of product.





**DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP**

## SECTION 4 MAINTENANCE

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1. Watch your oil levels in the blower. If possible, check your oil every day. Refer to the blower manufacturer's manual for the recommended lubrication schedule.

The Spring Loaded Motor Mount utilizes a spring system to control belt tension. It has been sized and set at the factory specifically for your system. Your blower package will operate at peak efficiency limiting belt slippage and excessive belt tension.

2. To tighten your belt tension, turn the adjustment screw on the spring clockwise to move the motor away from the blower. To loosen your belt tension, turn the adjustment screw counter-clockwise to move the motor closer to the blower.
3. Inspect the belts and check the belt tension every 3-6 months or more frequently depending on your operating conditions. If you need to purchase a belt tension gauge, call your sales representative.

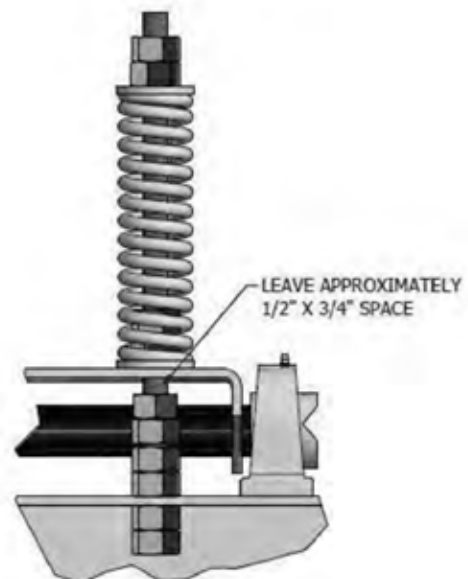
Experience with specific equipment is the best guide to how often to inspect belt drives. Drives operating at high speeds, heavy loads, frequent stop/start conditions and at temperature extremes or operating on critical equipment require frequent inspection.

Mark or note a point on the belt, or on one of the belts in a multiple V-belt drive. Wearing gloves, work around the belt(s), checking for cracks, frayed spots, cuts, or unusual wear patterns.

4. Check the sheave alignment every 720 hours. If using a straight edge (or string), line the straight edge along the outside face of both sheaves. If the drive is properly

aligned, the straight edge or string will contact each sheave evenly. The straight edge or string (pulled tight) should touch the two outer edges of each sheave or pulley for a total of four points of contact. Misalignment of sheaves and shafts will show up as a gap between the outside face of the sheave and the straight edge. Check for tilting or shaft misalignment by using a bubble level. For proper alignment, the bubble should be in the same position as measured on each shaft.

5. Make sure you replace the belt guard before restarting the motor.
6. Inspect the intake filter/silencer every 40 hours or more depending on your operating conditions. The element should be clean and free of product. If you need replacement filter elements, contact your sales representative.





**DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP**

## SECTION 5

# ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

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Do these things to get the most from your Roots\* Blower

- Check shipment for damage. If found, file claim with carrier and notify Howden Roots.
- Unpack shipment carefully, and check contents against Packing List. Notify Howden Roots 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 OPERATING 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 installation errors and make corrections. Follow with a trial run under normal operating conditions.
- In event of trouble during installation or operation, do not attempt repairs of Howden Roots furnished equipment. Notify Howden Roots, giving all nameplate information plus an outline of operating conditions and a description of the trouble. Unauthorized attempts at equipment repair may void Howden Roots warranty.
- Units out of warranty may be repaired or adjusted by the owner. Good inspection and maintenance practices should reduce the need for repairs.

NOTE: Information in this manual is correct as of the date of publication. Howden Roots 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 are sold subject to the current General Terms of Sale, ES104 and Warranty Policy WP-5020. Copies are available upon request.



# SECTION 5

## ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

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### Safety Precautions & Operating Limitations

#### Safety Precautions

It is important that all personnel observe safety precautions to minimize the chances of injury. Among many considerations, the following should be particularly 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 opening in the blower while it is operating, or while subject to accidental starting. Protect external moving parts with adequate guards.
- Disconnect power before doing any work, and avoid bypassing 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 discharge air stream.

CAUTION: Never cover the blower inlet with your hand or other part of body.

- Stay clear of the blast from pressure relief valves and the suction area of vacuum relief valves.
- Use proper care and good procedures in handling, lifting, installing, operating and maintaining the equipment.
- Casing pressure must not exceed 25 PSI (1725 mbar) gauge. Do not pressurize vented cavities from an external source, nor restrict the vents without first consulting Roots.
- 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 trained to exercise adequate general safety precautions.

#### Operating Limitations

A Roots blower or exhauster must be operated within certain approved limiting conditions to enable continued satisfactory performance. Warranty is contingent on such operation.

Maximum limits for pressure, temperature and speed are specified in Table 1 for various models & sizes of blowers and exhausters. These limits apply to all units of normal construction, when operated under standard atmospheric conditions. Be sure to arrange connections or taps for instruments, thermometers and pressure or vacuum gauges at or near the inlet and discharge connections of the unit. These, along with a tachometer, will enable periodic checks of operating conditions.

**PRESSURE** – The pressure rise, between inlet and discharge, must not exceed the figure listed for the specific unit frame size concerned. Also, in any system where the unit inlet is at a positive pressure above atmosphere a maximum case rating of 25 PSI gauge (1725 mbar) should not be exceeded without first consulting Roots. Never should the maximum allowable differential pressure be exceeded.

**TEMPERATURE** – Blower & exhauster frame sizes are approved only for installations where the following temperature limitations can be maintained in service:

- Measured temperature rise must not exceed listed values when the inlet is at ambient temperature. Ambient is considered as the general temperature of the space around the unit. This is not outdoor temperature unless the unit is installed outdoors.
- 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



**DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP**

# SECTION 5

## ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

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### Safety Precautions & Operating Limitations

and the ambient temperature.

- The average of the inlet and discharge temperature must not exceed 250°F. (121°C).
- The ambient temperature of the space the blower/motor is installed in should not be higher than 120°F (48.8°C).

**SPEED** – These blowers & exhausters may be operated at speeds up to the maximum 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 low speeds, excessive temperature rise may be a limiting factor

**Special Note:** The listed maximum allowable temperature rise for any particular blower & exhauster may occur well before its maximum pressure or vacuum rating is reached. This may occur at high altitude, low vacuum or at very low speed. The units' operating limit is always determined by the maximum rating reached first. It can be any one of the three: Pressure, Temperature or Speed.



# SECTION 5

## ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

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### Installation

Roots blowers & exhausters are treated after factory assembly to protect against normal atmospheric corrosion. The maximum period of internal protection is considered to be one year under average conditions, if shipping plugs and seals are not removed. Protection against chemical or salt water atmosphere is not provided. Avoid opening the unit until ready to start installation, as corrosion protection will be quickly lost due to evaporation.

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

Coat internals of cylinder, gearbox and drive end bearing reservoir with Nox-Rust VCI-10 or equivalent. Repeat once a year or as conditions may require. Nox-Rust VCI-10 is petroleum soluble and does not have to be removed before lubricating.

- Paint shaft extension, inlet and discharge flanges, and all other exposed surfaces with Nox-Rust X-110 or equivalent.
- 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 Nox-Rust VCI-10 vapor will escape and lose its effectiveness.
- Protect units from excessive vibration during storage.
- Rotate shaft three or four revolutions every two weeks.
- Prior to start up, remove flange covers on both inlet and discharge and inspect internals to insure absence of rust. Check all internal clearances. Also, at this time, remove gearbox and drive end bearing cover and inspect gear teeth and bearings for rust.

Because of the completely enclosed unit design, location of the installation is generally not a critical matter. A clean,

dry and protected indoor location is preferred. However, an outdoor location will normally give satisfactory service. Important requirements are that the correct grade of lubricating oil be provided for expected operating temperatures, and that the unit be located so that routine checking and servicing can be performed conveniently. Proper care in locating driver and accessory equipment must also be considered.

Supervision of the installation by a Howden Roots Service Engineer is not usually required for these units. Workmen with experience in installing light to medium weight machinery should be able to produce satisfactory results. Handling of the equipment needs to be accomplished with care, and in compliance with safe practices. Unit mounting must be solid, without strain or twist, and air piping must be clean, accurately aligned and properly connected.

**Bare-shaft Units:** Two methods are used to handle a unit without base. One is to use lifting lugs bolted into the top of the unit headplates. Test them first for tightness and fractures by tapping with a hammer. In lifting, keep the direction of cable pull on these bolts as nearly vertical as possible. If lifting lugs are not available, lifting slings may be passed under the cylinder adjacent to the headplates. Either method prevents strain on the extended drive shaft.

**Packaged Units:** When the unit is furnished mounted on a baseplate, with or without a driver, use of lifting slings passing under the base flanges is required. Arrange these slings so that no strains are placed on the unit casing or mounting feet, or on any mounted accessory equipment. DO NOT use the lifting lugs in the top of the unit headplates. Before starting the installation, remove plugs, covers or seals from unit inlet



**DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP**

# SECTION 5

## ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

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### Installation continued

and discharge connections and inspect the interior completely for foreign material. If cleaning is required, finish by washing the cylinder, headplates and impeller thoroughly with an appropriate solvent. Turn the drive shaft by hand to make sure that the impellers turn freely at all points. Anti-rust compound on the connection flanges and drive shaft extension may also be removed at this time with the same solvent. Cover the flanges until ready to connect piping.

#### Mounting

Care will pay dividends when arranging the unit mounting. This is especially true when the unit is a "bare-shaft" unit furnished without a baseplate. The convenient procedure may be to mount such a unit directly on a floor or small concrete pad, but this generally produces the least satisfactory results. It definitely causes the most problems in levelling and alignment and may result in a "Soft Foot" condition. Correct soft foot before operation to avoid unnecessary loading on the casing and bearings. Direct use of building structural framing members is not recommended.

For blowers without a base, it is recommended that a well anchored and carefully levelled steel or cast iron mounting plate be provided. The plate should be at least 1 inch (25 mm) thick, with its top surface machined flat, and large enough to provide levelling areas at one side and one end after the unit is mounted. It should have properly sized studs or tapped holes located to match the unit foot drilling. Proper use of a high quality machinist's level is necessary for adequate installation.

With the mounting plate in place and levelled, set the unit on it without bolting and check for rocking. If it is not solid, determine the total thickness of shims required under one foot to stop rocking. Place half of this under each of the diagonally-opposite

short feet, and tighten the mounting studs or screws. Rotate the drive shaft to make sure the impellers turn freely. If the unit is to be direct coupled to a driving motor, consider the height of the motor shaft and the necessity for it to be aligned very accurately with the unit shaft. Best unit arrangement is directly bolted to the mounting plate while the driver is on shims of at least 1/8 inch (3mm) thickness. This allows adjustment of motor position in final shaft alignment by varying the shim thickness.

#### Aligning

When unit and driver are factory mounted on a common baseplate, the assembly will have been properly aligned and is to be treated as a unit for levelling purposes. Satisfactory installation can be obtained by setting the baseplate on a concrete slab that is rigid and free of vibration, and levelling the top of the base carefully in two directions so that it is free of twist. The slab must be provided with suitable anchor bolts. The use of grouting under and partly inside the levelled and shimmed base is recommended.

It is possible for a base-mounted assembly to become twisted during shipment, thus disturbing the original alignment. For this reason, make the following checks after the base has been levelled and bolted down. Disconnect the drive and rotate the unit shaft by hand. It should turn freely at all points. Loosen the unit foot holddown screws and determine whether all feet are evenly in contact with the base. If not, insert shims as required and again check for free impeller rotation. Finally, if unit is direct coupled to the driver, check shaft and coupling alignment carefully and make any necessary corrections.

In planning the installation, and before setting the unit, consider how piping arrangements are dictated by the unit design and



**DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP**

# SECTION 5

## ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

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### Installation continued

assembly. Drive shaft rotation must be established accordingly and is indicated by an arrow near the shaft.

Typical arrangement on vertical units has the drive shaft at the top with counterclockwise rotation and discharge to the left. Horizontal units are typically arranged with the drive shaft at the left with counterclockwise rotation and discharge down. See Figure 4 for other various unit arrangements and possible conversions.

When a unit is DIRECT COUPLED to its driver, the driver RPM must be selected or governed so as not to exceed the maximum speed rating of the unit. Refer to Table 1 for allowable speeds of various unit sizes.

A flexible type coupling should always be used to connect the driver and unit shafts.

When direct coupling a motor or engine to a blower you must insure there is sufficient gap between the coupling halves and the element to prevent thrust loading the blower bearings. When a motor, engine or blower is operated the shafts may expand axially. If the coupling is installed in such a manner that there is not enough room for expansion the blower shaft can be forced back into the blower and cause the impeller to contact the gear end headplate resulting in damage to the blower. The two shafts must be in as near perfect alignment in all directions as possible, and the gap must be established with the motor armature on its electrical center if end-play exists. Coupling manufacturer's recommendations for maximum misalignment, although acceptable for the coupling, are normally too large to achieve smooth operation and maximum life of the blower.

The following requirements of a good installation are recommended. When selecting a coupling to be fitted to the blower shaft Howden Roots recommends a taper lock style coupling to insure proper contact with the blower shaft. If the coupling must have a straight bore the coupling halves must be fitted to the two shafts with a line to line thru .001" interference fit. Coupling halves must be warmed up per coupling manufacturer's recommendations. Maximum deviation in offset alignment of the shafts should not exceed .005" (.13mm) total indicator reading, taken on the two coupling hubs. Maximum deviation from parallel of the inside coupling faces should not exceed .001" (.03 mm) when checked at six points around the coupling.

When a unit is BELT DRIVEN, the proper selection of sheave diameters will result in the required unit speed. When selecting a sheave to be fitted to the blower shaft Howden Roots recommends a taper lock style sheave to ensure proper contact with the blower shaft. This flexibility can lead to operating temperature problems caused by unit speed being too low. Make sure the drive speed selected is within the allowable range for the specific unit size, as specified under Table 1.

Belt drive arrangements usually employ two or more Vbelts running in grooved sheaves. Installation of the driver is less critical than for direct coupling, but its shaft must be level and parallel with the unit shaft. The driver should be mounted on the inlet side of a vertical unit (horizontal piping) and on the side nearest to the shaft on a horizontal unit. Acceptable Blower Drive Arrangement Options. The driver must also be mounted on an adjustable base to permit installing, adjusting and removing the V-belts. To position the driver correctly, both sheaves need to be mounted on their shafts and the nominal shaft center distance known for the belt lengths to be used.



**DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP**

# SECTION 5

## ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

---

### Installation continued

**CAUTION:** Drive couplings and sheaves (pulleys) should have an interference fit to the shaft of the blower (set screw types of attachment generally do not provide reliable service.) It is recommended that the drive coupling or sheave used have a taperlock style bushing which is properly sized to provide the correct interference fit required. Drive couplings, that require heating to fit on the blower shaft, should be installed per coupling manufacturer recommendations. A drive coupling or sheave should not be forced on to the shaft of the blower as this could affect internal clearances resulting in damage to the blower.

Engine drive applications often require special consideration to drive coupling selection to avoid harmful torsional vibrations. These vibrations may lead to blower damage if not dampened adequately. It is often necessary to install a fly-wheel and/or a torsionally soft elastic element coupling based on the engine manufacturer recommendations.

The driver sheave should also be mounted as close to its bearing as possible, and again should fit the shaft correctly. Position the driver on its adjustable base so that 2/3 of the total movement is available in the direction away from the unit, and mount the assembly so that the face of the sheave is accurately in line with the unit sheave. This position minimizes belt wear, and allows sufficient adjustment for both installing and tightening the belts. After belts are installed, adjust their tension in accordance with the manufacturer's instructions. However, only enough tension should be applied to prevent slippage when the unit is operating under load. Excessive tightening can lead to early bearing concerns or shaft breakage.

Before operating the drive under power to check initial belt tension, first remove covers from the unit connections. Make

sure the interior is still clean, and then rotate the shaft by hand. Place a coarse screen over the inlet connection to prevent anything being drawn into the unit while it is operating, and avoid standing in line with the discharge opening. Put oil in the sumps per instructions under LUBRICATION.

#### Piping

Before connecting piping, remove any remaining antirust compound from unit connections. Clean pipe should be no smaller than unit connections. In addition, make sure it is free of scale, cuttings, weld beads, or foreign material of any kind. To further guard against damage to the unit, especially when an inlet filter is not used, install a substantial screen of 16 mesh backed with hardware cloth at or near the inlet connections. Make provisions to clean this screen of collected debris after a few hours of operation. It should be removed when its usefulness has ended, as the wire will eventually deteriorate and small pieces going into the unit may cause serious damage.

Pipe flanges or male threads must meet the unit connections accurately and squarely. DO NOT attempt to correct misalignment by springing or cramping the pipe. In most cases this will distort the unit casing and cause impeller rubbing. In severe cases it can prevent operation or result in a broken drive shaft. For similar reasons, piping should be supported near the unit to eliminate dead weight strains. Also, if pipe expansion is likely to occur from temperature change, installation of flexible connectors or expansion joints is advisable.

Figure 3 represents an installation with all accessory items that might be required under various operating conditions. Inlet piping should be completely free of valves or other restrictions. When a shut-off valve cannot be avoided, make sure a full size vacuum relief is installed nearest the unit inlet. This will





**DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP**

# SECTION 5

## ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

---

### Installation continued

protect against unit overload caused by accidental closing of the shutoff valve.

DO NOT operate the unit at this time unless it has been lubricated per instructions.

Need for an inlet silencer will depend on unit speed and pressure, as well as sound-level requirements in the general surroundings. An inlet filter is recommended, especially in dusty or sandy locations. A discharge silencer is also normally suggested, even though WHISPAIR\* units operate at generally lower noise levels than conventional rotary blowers. Specific recommendations on silencing can be obtained from your local Howden Roots distributor. Discharge piping requires a pressure relief valve, and should include a manual unloading valve to permit starting the unit under no-load conditions. Reliable pressure/vacuum gauges and good thermometers at both inlet and discharge are recommended to allow making the important checks on unit operating conditions. The back-pressure regulator shown in Figure 3 is useful mainly when volume demands vary while the unit operates at constant output. If demand is constant, but somewhat lower than the unit output, excess may be blown off through the manual unloading valve.

In multiple unit installations where two or more units operate with a common header, use of check valves is mandatory. These should be of a direct acting or free swinging type, with one valve located in each line between the unit and header. Properly installed, they will protect against damage from reverse rotation caused by air and material back-flow through an idle unit.

After piping is completed, and before applying power, rotate the drive shaft by hand again. If it does not move with uniform freedom, look for uneven mounting, piping strain, excessive belt tension or coupling misalignment.



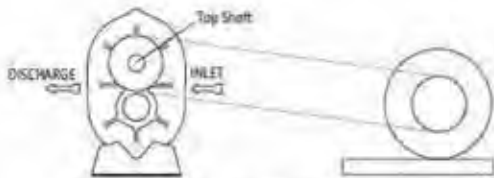
DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP

# SECTION 5 ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

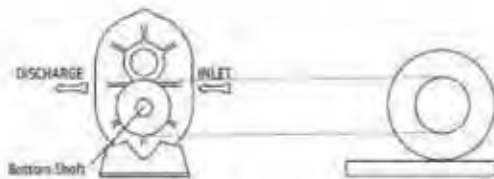
Installation continued

Fig. 1 - Acceptable Blower Drive Arrangement Options

Acceptable



Motor On Inlet Side of Blower (Top Shaft)



Motor On Inlet Side of Blower (Bottom Shaft)

Above are suggested locations for available accessories.

Unacceptable



Motor On Discharge Side of Blower (Top Shaft)



Motor On Discharge Side of Blower (Bottom Shaft)



# SECTION 5

## ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

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### Technical Supplement

#### Technical Supplement for URAI-G Gas Blowers

Technical Supplement for 32, 33, 36, 42, 45, 47, 53, 56, 59, 65, 68, 615 Universal RAI-G blowers

Precaution: URAI-G blowers: Care must be used when opening the head plate seal vent chamber plugs (43) as some gas will escape—if it is a pressure system, or the atmospheric air will leak into the blower if the system is under vacuum. There is a possibility of some gas leakage through the mechanical seals. This leakage on the gear end will escape through the gear box vent, and on the drive end, through the grease release fittings. If the gas leakage is undesirable, each seal chamber must be purged with an inert gas through one purge gas hole (43) per seal. There are two plugged purge gas holes (1/8 NPT) provided per seal. The purge gas pressure must be maintained one PSI above the discharge gas pressure. Also, there exists a possibility of gear end oil and drive end grease leakage into the gas stream.

Roots Universal RAI-G rotary positive gas blowers are a design extension of the basic Roots Universal RAI blower model. URAIG blower uses (4) mechanical seals in place of the standard inboard lip seals to minimize gas leakage into the atmosphere.

These units are intended for gases which are compatible with cast iron case material, steel shafts, 300/400 series stainless steel and carbon seal components, viton orings and the oil/ grease lubricants. If there are any questions regarding application or operation of this gas blower, please contact factory.

A simple but very effective lubrication system is employed on the drive shaft end bearings. Hydraulic pressure relief fittings are provided to vent any excess grease, preventing pressure

build-up on the seals. A restriction plug and metering orifice prevent loss of lubricant from initial surges in lubricant pressure but permit venting excess lubricant under steadily rising pressures.

Using a pressure gun, slowly force new lubricant into each drive end bearing housing until traces of clean grease comes out of the relief fitting. The use of an electric or pneumatic grease gun could force the grease in too rapidly and thus invert the seals and should not be used.

Gear end bearings, gears and oil seals are lubricated by the action of the timing gears which dip into the main oil sumps causing oil to splash directly on gears and into bearings and seals. A drain port is provided below each bearing to prevent an excessive amount of oil in the bearings. Seals located inboard of the bearings in each headplate effectively retain oil within the sumps. Any small weepage that may occur should the seals wear passes into a cavity in each vented headplate and is drained downward.

Proper lubrication is usually the most important single consideration in obtaining maximum service life and satisfactory operation from the unit. Unless operating conditions are severe, a weekly check of oil level and necessary addition of lubricant should be sufficient.

During the first week of operation, check the oil levels in the oil sumps about once a day, and watch for leaks. Replenish as necessary. Thereafter, an occasional check should be sufficient.

More frequent oil service may be necessary if the blower is operated in a very dusty location.



# SECTION 5

## ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

### Lubrication

#### Lubrication

Due to sludge build-up and seal leakage problems, Howden Roots recommendation is **DO NOT USE Mobil SHC synthetic oils** in Roots blowers.

Proper lubrication is usually the most important single consideration in obtaining maximum service life and satisfactory operation from the unit.

URAI Air and Gas gear end bearing lubrication/oil with splash lubrication on the gear end only (Drive end grease lubricated).

The specified and recommended oil is Roots Synthetic Oil of correct viscosity per Table 2, page 33.

- To fill the gearbox, remove the breather plug (25) and the oil overflow plug (21) - see page 32. Fill the reservoir up to the overflow hole. **DO NOT OVERFILL**. Place the breather and the overflow plug back into their respective holes.
- The lubrication should be changed after initial 100 hours of operation.
- Proper service intervals of the oil thereafter are based on the discharge air temperature of the blower. Please refer to the information below to "How to properly determine the oil service intervals" shown on this page.
- Unless operating conditions are quite severe, a weekly check of the oil level and necessary addition of lubricant should be sufficient. During the first week of operation, check the oil levels in the oil sumps about once a day, and watch for leaks. Replenish as necessary.
- If you choose to use another oil other than the specified and recommended ROOTS Synthetic, use a good grade of industrial type non-detergent, rust inhibiting, antifoaming oil and of correct viscosity per Table 2, page 33.

- Howden Roots does NOT recommend the use of automotive type lubricants, as they are not formulated with the properties mentioned above.

Roots URAI-DSL blowers with splash lubrication/oil on each end. No grease.

- The specified and recommended oil is Roots Synthetic Oil of correct viscosity per Table 2, page 33.
- The lubrication should be changed after initial 100 hours of operation.
- The proper oil level should be half way or middle of the sight gauge when the blower is not operating. **DO NOT OVERFILL OIL SUMP/S** as damage to the blower may occur.
- The oil level should not fall below the middle of the site gauge when the blower is idle.
- The lubrication/oil level may rise or fall in the gauge during operation to an extent depending somewhat on oil temperature and blower speed. Proper service intervals of the oil thereafter are based on the discharge air temperature of the blower. Please refer to the information below to "How to properly determine the oil service intervals" shown on this page.
- Unless operating conditions are quite severe, a weekly check of the oil level and necessary addition of lubricant should be sufficient. During the first week of operation, check the oil levels in the oil sumps about once a day, and watch for leaks. Replenish as necessary.
- If you choose to use another oil other than the specified and recommended Roots Synthetic Oil, use a good grade of industrial type non-detergent, rust inhibiting, antifoaming oil and of correct viscosity per Table 2, page 33.
- Roots does NOT recommend the use of automotive type lubricants, as they are not formulated with the properties mentioned above.



# SECTION 5 ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

## Lubrication

### How to properly determine the oil service intervals.

Normal life expectancy of the specified and recommended Roots Synthetic Oil is approximately 6000 hours with an oil temperature of 180°F (82°C) or less. As the oil temperature increases by increments of 15°F (8°C), the oil life is reduced by half for each 15°F (8°C) increase. Example: Oil temperatures of 195°F (90.5°C) will produce a life expectancy reduced by half or 3000 hours oil service life.

Normal life expectancy of petroleum based oils is about 2000 hours with an oil temperature of about 180°F (82°C). As the oil temperature increases by increments of 15°F (8°C), the life is reduced by half for each 15°F (8°C) increase. Example: Oil temperatures of 195°F (90.5°C) will produce life expectancy reduced by half or 1000 hours oil service life.

NOTE: To estimate oil temperature, multiply the discharge temperature of the blower by 0.80. Example: if the discharge air temperature of the blower is 200° F, it is estimated that the oil temperature is 160° F.

For Units with grease lubricated drive end bearings.

### URAI AIR (Non GAS) blower grease specifications.

- When servicing drive end bearings of a AIR (Non Gas) blower, use the specified and recommended Shell Darina SD 2 NLGI #2 product code 5067628.
- For grease lubricated drive end blowers see page 34, table 4, regarding specified greasing intervals.
- Lithium based greases are not compatible with the specified and recommended Shell Darina SD 2 grease used when assembling the blower. Lithium based grease is not approved for any ROOTS blowers.

- Table 4 page 34 has been prepared as a general greasing schedule guide based on average operating conditions. More frequent intervals may be necessary depending on the grease operating temperature and unusual circumstances. URAI-G blower grease specifications.
- When servicing drive end bearings of a URAI-G blower, use the specified NLGI #2 premium grade aluminium complex† grease, GE P/N T20019001. Lithium based greases are not compatible with the specified and recommended Roots Synthetic Grease used when assembling a GAS blower. Lithium based grease is not approved for any Roots blowers.
- The lubricants selected must be compatible with the gas.

†Roots Synthetic Oil is superior in performance to petroleum based products. It has high oxidation stability, excellent corrosion protection, extremely high film strength and low coefficient of friction. Typical oil change intervals are increased 2-3 times over petroleum based lubricants. Also, Roots Synthetic Oil is 100% compatible with petroleum based oils. Simply drain the oil in the blower and refill the reservoirs with Roots Synthetic Oil to maintain optimum performance of your Roots



**DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP**

# SECTION 5

## ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

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### Operation

#### Operation

Before operating a blower under power for the first time, recheck the unit and the installation thoroughly to reduce the likelihood of avoidable troubles. Use the following procedure check list as a guide, but consider any other special conditions in the installation.

- Be certain that no bolts, tools, rags, or debris have been left in the blower air chamber or piping.
- If an outdoor intake without filter is used, be sure the opening is located so it cannot pick up dirt and is protected by a strong screen or grille. Use of the temporary protective screen as described under INSTALLATION is strongly recommended.
- Recheck blower levelling, drive alignment and tightness of all mounting bolts if installation is not recent. If belt drive is used, adjust belt tension correctly.
- Turn drive shaft by hand to make sure impellers still rotate without bumping or rubbing at any point.
- Ensure oil levels in the main oil sumps are correct.
- Check lubrication of driver. If it is an electric motor, be sure that power is available and that electrical overload devices are installed and workable.
- Open the manual unloading valve in the discharge air line. If a valve is in the inlet piping, be sure it is open.
- Bump blower a few revolutions with driver to check that direction of rotation agrees with arrow near blower shaft, and that both coast freely to a stop.

After the preceding points are cleared, blower is ready for trial operation under "no-load" conditions. The following procedure is suggested to cover this initial operation test period.

- Start blower, let it accelerate to full speed, then shut off. Listen for knocking sounds, both with power on and as speed slows down.

- After blower comes to a complete stop, repeat above, but let blower run 2 or 3 minutes. Check for noises, such as knocking sounds.
- After blower comes to a complete stop, operate blower for about 10 minutes unloaded. Check oil levels. Observe cylinder and headplate surfaces for development of hot spots such as burned paint, indicating impeller rubs. Be aware of any noticeable increase in vibration.

Assuming that all trials have been satisfactory, or that necessary corrections have been made, the blower should now have a final check run of at least one hour under normal operating conditions. After blower is restarted, gradually close the discharge unloading valve to apply working pressure.

At this point it is recommended that a pressure gauge or manometer be connected into the discharge line if not already provided, and that thermometers be in both inlet and discharge lines. Readings from these instruments will show whether pressure or temperature ratings of the blower are being exceeded.

During the final run, check operating conditions frequently and observe the oil levels at reasonable intervals. If excessive noise or local heating develops, shut down immediately and determine the cause. If either pressure rise or temperature rise across the blower exceeds the limit specified in this manual, shut down and investigate conditions in the piping system. Refer to the TROUBLESHOOTING CHECKLIST for suggestions on various problems that may appear.

The blower should now be ready for continuous duty operation at full load. During the first few days make periodic checks to determine whether all conditions remain steady, or at least



# SECTION 5 ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

## Operation

acceptable. This may be particularly important if the blower is supplying air to a process system where conditions can vary. At the first opportunity, stop the blower and clean the temporary inlet protective screen. If no appreciable amount of debris has collected, the screen may be removed. See comments under INSTALLATION. At this same time, verify levelling, coupling alignment or belt tension, and mounting bolt tightness.

Should operating experience prove that blower capacity is a little too high for the actual air requirements, a small excess may be blown off continuously 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 unsafe operation of the valve itself. If blower capacity appears to be too low, refer to the TROUBLESHOOTING CHECKLIST.

### Vibration Assessment Criteria

With measurements taken at the bearing locations on the housings, see chart below for an appropriate assessment guide for rotary lobe blowers rigidly mounted on stiff foundations.

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.

As shown on the chart, the level of all pass vibration will determine the need to measure discrete frequency vibration levels and the action required.

ALL PASS VIBRATIONS (IN/SEC)	DISCRETE FREQUENCY VIBRATION (IN/SEC.)	ACTION
0.45 or less	N/R	Acceptable
Greater than 0.45 but 1.0 or less	0.45 or less @ any frequency	Acceptable
	Greater than 0.45 @ any frequency	Investigate
Greater than 1.0	Less than 1.0	Investigate
	Greater than 1.0	Investigate



DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP

# SECTION 5 ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

## Troubleshooting

TROUBLE	ITEM	POSSIBLE CAUSE	REMEDY
No flow	1	Speed too low	Check by tachometer and compare with published performance.
	2	Wrong rotation	Compare actual rotation with Figure 1, change driver if wrong.
	3	Obstruction in piping	Check piping, valves, silencer to ensure open flow path.
Low Capacity	4	Speed too low	See item 1, if belt drive check for slippage and re-adjust tension.
	5	Excessive pressure rise	Check inlet vacuum and discharge pressure and compare with published performance.
	6	Obstruction in piping	See item 3.
Excessive Power	7	Excessive slip	Check inside of casing for worn or eroded surfaces causing excessive clearances.
	8	Speed too high	Check speed and compare with published performance.
	9	Excessive pressure rise	See item 5.
	10	Impeller rubbing	Inspect outside of cylinder for high temperature areas, then check for impeller contact at these points. Correct blower mounting, drive alignment.
Damage to bearings or gears	11	Scale, sludge, rust or product build-up	Clean blower appropriately.
	12	Inadequate lubrication	Check oil sump levels in gear and drive end headplates.
	13	Excessive lubrication	Check oil levels. If correct, drain and refill with clean oil of recommended grade.
	14	Excessive pressure rise	See item 5.
	15	Coupling misalignment	Check carefully. Re-align if questionable.
Vibration	16	Excessive belt tension	Re-adjust for correct tension.
	17	Misalignment	See item 15.
	18	Impellers rubbing	See item 10.
	19	Worn bearings/gears	Check gear backlash and conditions of bearings and replace as indicated.
	20	Unbalanced or rubbing impeller	Scale or process material may build up on casing and impellers, or inside impellers. Remove build-up to restore original clearances and impeller balance.
	21	Driver or blower loose	Tighten mounting bolts securely.
	22	Piping resonances	Determine whether standing wave pressure pulsations are present in the piping.
23	Scale/sludge build-ups	Clean out interior of impeller lobes to restore dynamic balance.	





DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP

# SECTION 5 ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

## Troubleshooting continued

TROUBLE	ITEM	POSSIBLE CAUSE	REMEDY
Driver stops, or will not start	24	Casing strain	Re-work piping alignment to remove excess strain.
	25	Impeller struck	Check for excessive hot spot on headplate or cylinder. See item 10. Look for defective shaft bearing and/or gear teeth.
	26	Scale, sludge, rust or product build-up	Clean blower appropriately.
Excessive breather Blow-by or excessive oil leakage to vent area Excessive oil leakage in vent area	27	Broken seal	Replace seals.
	28	Defective O-ring	Replace seals and O-ring.
	29	Defective/plugged breather	Replace breather and monitor oil leakage.
	30	Oil level too high	Check sump levels in gear and drive headplates.
	31	Oil type or viscosity incorrect	Check oil to ensure it meets recommendations. Drain then fill with clean oil of recommended grade.
	32	Blower running hot	Check blower operating conditions to ensure they are within the operating limitations defined in this manual.



# SECTION 5

## ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

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### Inspection and Maintenance

#### Inspection & Maintenance: Roots Universal RAI series blowers

A good program of consistent inspection and maintenance is the most reliable method of minimizing repairs to a blower. A simple record of services and dates will help keep this work on a regular schedule. Basic service needs are:

- Lubrication
- Checking for hot spots
- Checking for increases or changes in vibration and noise
- Recording of operating pressures and temperatures

Above all, a blower must be operated within its specified rating limits, to obtain satisfactory service life. A newly installed blower should be checked often during the first month of full-time operation. Attention thereafter may be less frequent assuming satisfactory performance. Lubrication is normally the most important consideration and weekly checks of lubricant levels in the gearbox and bearing reservoirs should be customary. Complete oil change schedules are discussed under LUBRICATION.

Driver lubrication practices should be in accordance with the manufacturer's instructions. If direct connected to the blower through a lubricated type coupling, the coupling should be checked and greased each time blower oil is changed. This will help reduce wear and prevent unnecessary vibration. In a belted drive system, check belt tension periodically and inspect for frayed or cracked belts.

In a new, and properly installed, unit there is no contact between the two impellers, or between the impellers and cylinder or headplates. Wear is confined to the bearings (which support and locate the shafts) the oil seals, and the timing gears. All are lubricated and wear should be minimal if clean oil of the correct

grade is always used. Seals are subject to deterioration as well as wear, and may require replacement at varying periods.

Shaft bearings are designed for optimum life under average conditions with proper lubrication and are critical to the service life of the blower. Gradual bearing wear may allow a shaft position to change slightly, until rubbing develops between impeller and casing. This will cause spot heating, which can be detected by observing these surfaces. Sudden bearing failure is usually more serious. Since the shaft and impeller are no longer supported and properly located, extensive general damage to the blower casing and gears is likely to occur.

Oil seals should be considered expendable items, to be replaced whenever drainage from the headplate vent cavity becomes excessive or when the blower is disassembled for any reason. Some oil seal leakage may occur since an oil film under the lip is required for proper operation. Periodically leaked oil should be wiped off from surfaces. Minor seal leakage should not be considered as indicating seal replacement.

Timing gear wear, when correct lubrication is maintained, should be negligible. Gear teeth are cut to provide the correct amount of backlash, and gears correctly mounted on the shafts will accommodate a normal amount of tooth wear without permitting contact between lobes of the two impellers. However, too high an oil level will cause churning and excessive heating. This is indicated by unusually high temperature at the bottom of the gear housing. Consequent heating of the gears will result in loss of tooth-clearance, backlash and rapid wear of the gear teeth usually will develop.

Continuation of this tooth wear will eventually produce impeller contacts (knocking), and from this point serious damage will be



# SECTION 5 ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

## Figures

unavoidable if blower operation is continued. A similar situation can be produced suddenly by gear tooth fracture, which is usually brought on by sustained overloading or momentary shock loads.

Problems may also develop from causes other than internal parts failure. Operating clearances within a blower are only a few thousandths of an inch. This makes it possible for impeller interference or casing rubs to result from shifts in the blower mounting or from changes in piping support. If this type of trouble is experienced, and the blower is found to be clean, try removing mounting strains. Loosen blower mounting bolts and reset the levelling and drive alignment. Then tighten mounting again, and make sure that all piping meets blower connections accurately and squarely. Foreign materials in the blower will also cause trouble, which can only be cured by disconnecting the piping and thoroughly cleaning the blower interior.

A wide range of causes and solutions for operating troubles are covered in the TROUBLE SHOOTING CHECKLIST. The remedies suggested should be performed by qualified mechanics with a good background. Major repairs generally are to be considered beyond the scope of maintenance, and should be referred to an authorized Howden Roots distributor.

Warranty failures should not be repaired at all, unless specific approval has been obtained through Howden Roots before starting work. Unauthorized disassembly within the warranty period may void the warranty.

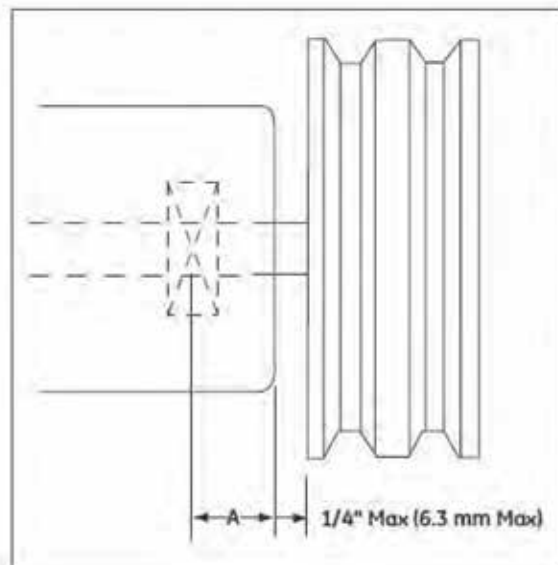


Figure 2 - Allowable Overhung Loads for V-belt Drives Roots Universal RAI/URAI-J Units.

$$\text{Belt Pull lbs} = \frac{252100 \cdot \text{Motor HP}}{\text{Blower RPM} \cdot \text{Sheave Diameter in Inches}}$$

$$\text{Shaft Load (lb.in)} = \text{Belt Pull} \cdot (A + \frac{1}{4}) + \frac{\text{Sheave Width (")}}{2}$$

(Based on SF = 1.4 for v-belt drives. If higher SF belt is used, belt load should be increased proportionally and may exceed limits of the blower.)

FRAME	DIM "A"	MAX. ALLOW. SHAFT LOAD (LB.IN.)	MIN. SHEAVE DIAMETER
22, 24	0.61	150	4.00
32, 33, 36	0.80	400	5.00
42, 45, 47	1.02	730	5.00
53, 56, 59	1.13	1325	6.00
65, 68, 615	1.36	2250	8.00
76, 711, 718	1.16	3000	9.50



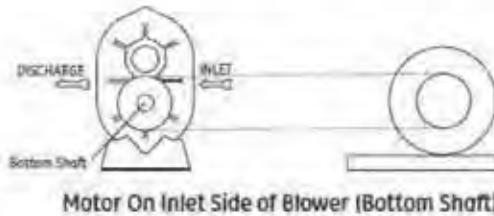
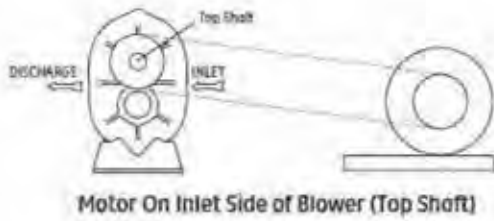
DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP

# SECTION 5 ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

## Figures

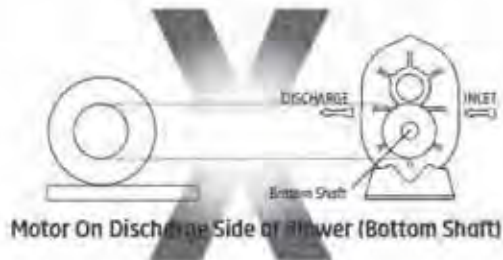
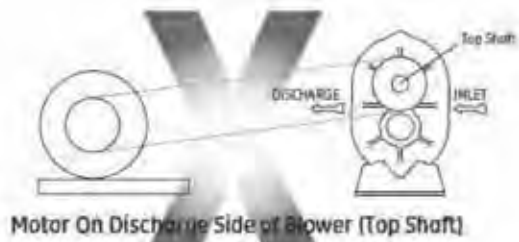
### Acceptable Blower Drive Arrangement Options

Acceptable



Above are suggested locations for available accessories.

Unacceptable



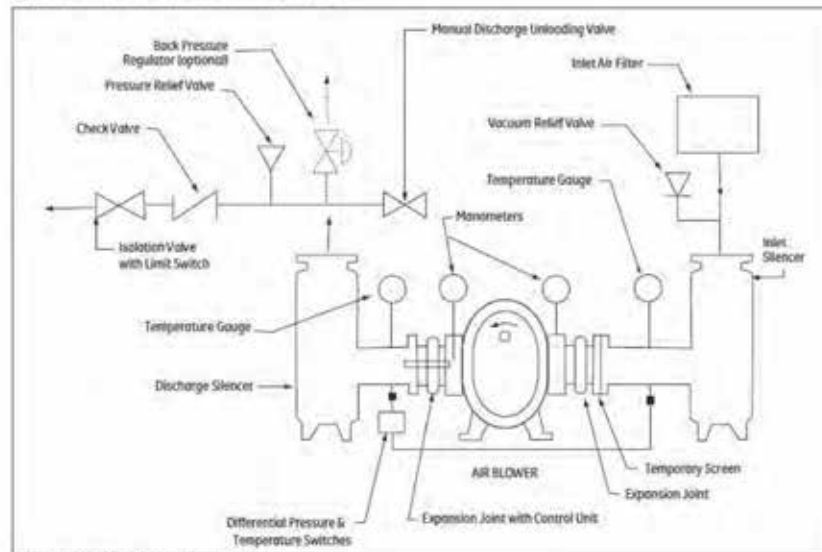


DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP

# SECTION 5 ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

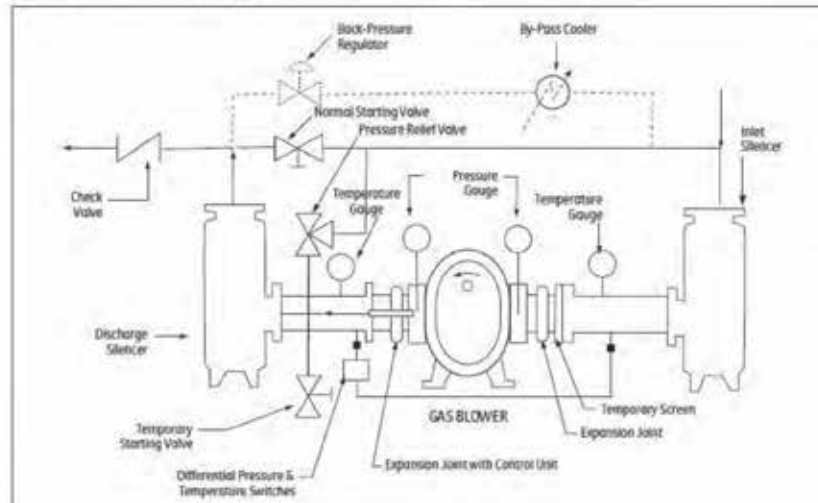
## Figures

Figure 3a - Air Blower Installations with Accessories



Above are suggested locations for optional accessories.

Figure 3b - Gas Blower Installations with Accessories





DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP

# SECTION 5 ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

## Figures

Figure 4 - Blower Orientation Conversion

MODEL	REVERSIBLE ROTATION	WHISPAIR® DESIGN
Roots Universal RAI	Yes	No
Roots URAI-JWHISPAIR	No	Yes
Roots URAI-G	Yes	No

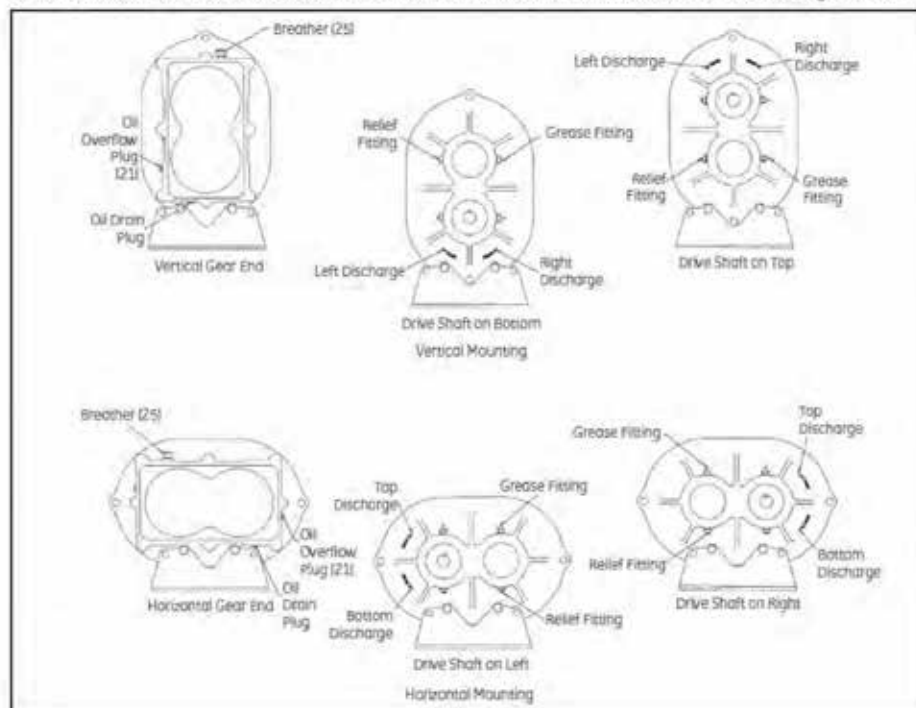
Special Note: WHISPAIR models are designed to operate with only one shaft rotation direction to take full advantage of the WHISPAIR feature. Therefore, a WHISPAIR blower may be operated in the following combinations:

- CCW Rotation: Bottom Shaft; Right side discharge or a Left Shaft, Bottom discharge
- CCW Rotation: Top Shaft; Left side discharge or a Right Shaft; Top discharge

OR

- CW Rotation: Bottom Shaft; Left side discharge or a Right Shaft Bottom discharge
- CW Rotation: Top Shaft; Right side discharge or a Left Shaft Top discharge

Blower Orientation and Lubrication Points: Grease Lubricated Drive End Roots Universal RAI series & URAI-G gas blowers





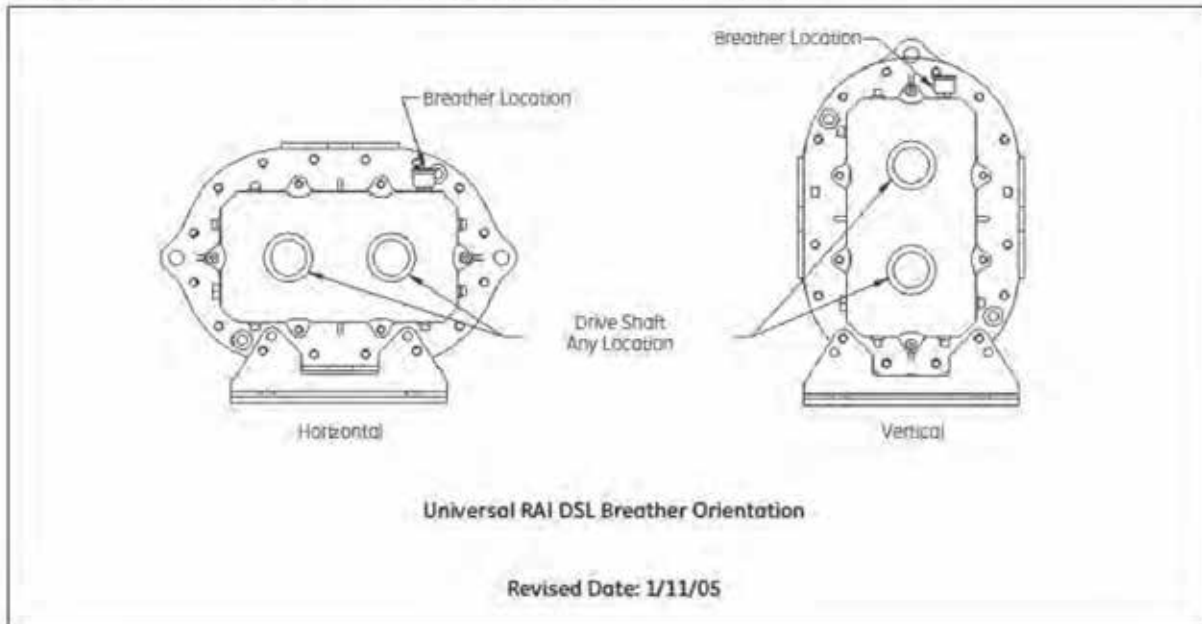
DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP

# SECTION 5 ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

## Figures

Drive End Breather Orientation for Roots Universal RAI Series - DSL with Oil Lube

Drive End Breather Orientation for Roots Universal RAI Series - DSL with Oil Lube





DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP

# SECTION 5 ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

## Table

Table 1 - Universal RAI series, Universal RAI-DSL & URAI-G gas blower, maximum allowable operating conditions

FRAME SIZE	GEAR DIA. (INCH)	SPEED RPM	TEMPERATURE RISE		DELTA PRESSURE		INLET VACUUM	
			F°	C°	PSI	mbar	INHG	mbar
22	2.5	5275	225	125	12	827	15	500
24	2.5	5275	210	117	7	483	15	500
32	3.5	3600	240	133	15	1034	16	539
33	3.5	3600	225	125	12	827	15	500
36	3.5	3600	225	125	7	483	15	500
42	4.0	3600	240	133	15	1034	16	539
45	4.0	3600	225	125	10	827	16	539
47	4.0	3600	225	125	7	483	15	500
53	5.0	2850	225	125	15	1034	16	539
56	5.0	2850	225	125	13	690	16	539
59	5.0	2850	225	125	7	483	15	500
65	6.0	2350	250	130	15	1034	16	539
68	6.0	2350	240	133	14	896	16	539
615	6.0	2350	130	72	7	483	14	472
76	7.0	2050	250	139	15	1034	16	539
711	7.0	2050	225	125	10	690	16	539
718	7.0	2050	130	72	6	414	12	405





DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP

# SECTION 5 ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

## Table

Table 2 - Recommended Oil Grades

AMBIENT* TEMPERATURE °F (°C)	ISO VISCOSITY NO.
Above 90 (32)	320
32-90 (0-32)	220
0-32 (-18-0)	150
Below 0 (-18)	100

\*Ambient temperature is defined as the temperature of the space in which the blower and drive are located.

### Roots URAI Gas Blower Oil and Grease Specifications

The specified oil should be Roots Synthetic Oil P/N 813-106-XX of the proper viscosity.

Table 3 - Approximate Oil Sump Capacities

These capacities are provided to assist in stocking the correct amount of oil. Exact sump capacities may differ slightly. See "Lubrication" section for proper filling instructions.

### Roots Universal RAI, URAI-J, URAI-G

MODEL NO./DRIVE SHAFT LOCATION	GEAR END APPROX. OIL SUMP CAPACITIES	
	FL. OZ	LITERS
22, 24 (left or right)	6.1	0.18
22, 24 (top or bottom)	3.4	0.1
32, 33, 36 (left or right)	10.5	0.31
32, 33, 36 (top or bottom)	8.5	0.25
42, 45, 47 (left or right)	14.5	0.43
42, 45, 47 (top or bottom)	12.7	0.37
53, 56, 59 (left or right)	27.6	0.82
53, 56, 59 (top or bottom)	16	0.47
65, 68, 615 (left or right)	52.1	1.54
65, 68, 615 (top or bottom)	28.3	0.84
76, 711, 718 (left or right)	59.5	1.76
76, 711, 718 (top or bottom)	32.3	0.96

### Roots Universal RAI series - DSL Splash Lubricated Drive End

Note that the gear and sump capacity is provided on the adjacent table.

MODEL NO./DRIVE SHAFT LOCATION	GEAR END APPROX. OIL SUMP CAPACITIES	
	FL. OZ	LITERS
32, 33, 36 (left or right)	6.5	0.19
32, 33, 36 (top or bottom)	4	0.12
42, 45, 47 (left or right)	10.8	0.32
42, 45, 47 (top or bottom)	5.5	0.16
53, 56, 59 (left or right)	14.8	0.44
53, 56, 59 (top or bottom)	7.5	0.22
65, 68, 615 (left or right)	31	0.91
65, 68, 615 (top or bottom)	16	0.47



DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP

# SECTION 5 ROOTS\* UNIVERSAL RAI\*, URAI-DSL, URAI-G\* & METRIC SERIES

## Table

Table 4 - Roots Universal RAI series with Grease Lubricated Drive End. Specified Bearing Greasing Intervals.

SPEED IN RPM	OPERATING HOURS PER DAY		
	8	16	24
	GREASING INTERVAL IN WEEKS		
750-1000	7	4	2
1000-1500	5	2	1
1500-2000	4	2	1
2000-2500	3	1	1
2500-3000	2	1	1
3000 and up	1	1	1

The specified grease for servicing drive end bearings of a gas blower, use a NLGI #2 premium grade aluminum complex grease GE P/N T20019001 with 3000F (1490C) service temperature and moisture resistance and good mechanical stability.

When servicing drive end bearings of non-gas blower, use a NLGI #2 premium grade microgel grease with 2500F (1210C) service temperature and moisture resistance and good mechanical stability. GE specifies Shell Darina SD2 NLGI #2. Product code 5067628.

Note: Lithium based greases are not compatible with the Roots Synthetic Grease used when assembling gas blower or the non-soap base grease used when assembling a standard Roots URAI blower. Lithium based grease is not approved for any Roots blowers.



**DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP**

## SECTION 6

# ROOTS™ RAM™ AND RAM-J SERIES

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### Do these things to get the most from your Roots Blower

- Check shipment for damage. If found, file claim with carrier and notify Howden.
- Unpack shipment carefully, and check contents against Packing List. Notify Howden 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 OPERATING 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.
- In event of trouble during installation or operation, do not attempt repairs of Howden furnished equipment. Notify Howden, giving all nameplate information plus an outline of operating conditions and a description of the trouble. Unauthorized attempts at equipment repair may void Howden warranty.
- Units out of warranty may be repaired or adjusted by the owner. Good inspection and maintenance practices should reduce the need for repairs.

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



# SECTION 6

## ROOTS™ RAM™ AND RAM-J SERIES

### Safety Precautions & Operating Limitations

#### Safety Precautions

It is important that all personnel observe safety precautions to minimize the chances of injury. Among many considerations, the following should be particularly 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 opening in the blower while it is operating, or while subject to accidental starting. Protect external moving parts with adequate guards.
- Disconnect power before doing any work, and avoid bypassing 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 discharge air stream.

CAUTION: Never cover the blower inlet with your hand or other part of body.

- Stay clear of inlet and discharge openings.
- Stay clear of the blast from pressure relief valves and the suction area of vacuum relief valves.
- Use proper care and good procedures in handling, lifting, installing, operating and maintaining the equipment.
- Casing pressure must not exceed 25 psi (1725 mbar) gauge. Do not pressurize vented cavities from an external source, nor restrict the vents without first consulting Howden.
- 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 trained to exercise adequate general safety precautions.

#### Operating Limitations

A Roots blower or exhauster must be operated within certain approved limiting conditions to enable continued satisfactory performance. Warranty is contingent on such operation.

Maximum limits for pressure, temperature and speed are specified in Table 1, page 54 for various models & sizes of blowers & exhausters. These limits apply to all units of normal construction, when operated under standard atmospheric conditions. Be sure to arrange connections or taps for instruments such as thermometers and pressure or vacuum gauges at or near the inlet and discharge connections of the unit. These, along with a tachometer, will enable periodic checks of operating conditions.

Pressure – The pressure rise, between inlet and discharge, must not exceed the figure listed for the specific unit frame size concerned. Also, in any system where the unit inlet is at a positive pressure above atmosphere a maximum case rating of 25 PSI gauge (1725 mbar) should not be exceeded without first consulting Roots. Never should the maximum allowable differential pressure be exceeded.

Temperature – Blower & exhauster frame sizes are approved only for installations where the following temperature limitations can be maintained in service:

- Measured temperature rise must not exceed listed values when the inlet is at ambient temperature. Ambient is considered as the general temperature of the space around the unit. This is not outdoor temperature unless the unit is installed outdoors.
- 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



**DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP**

# SECTION 6

## ROOTS™ RAM™ AND RAM-J SERIES

---

### Safety Precautions & Operating Limitations

temperature and the ambient temperature.

- The average of the inlet and discharge temperature must not exceed 250°F. (121°C).
- The ambient temperature of the space the blower/motor is installed in should not be higher than 120°F (48.8°C).

Speed – These blowers & exhausters may be operated at speeds up to the maximum 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 low speeds, excessive temperature rise may be a limiting factor.

Special Note: The listed maximum allowable temperature rise for any particular blower & exhauster may occur well before its maximum pressure or vacuum rating is reached. This may occur at high altitude, low vacuum or at very low speed. The units' operating limit is always determined by the maximum rating reached first. It can be any one of the three: Pressure, Temperature or Speed.



# SECTION 6

## ROOTS™ RAM™ AND RAM-J SERIES

### Installation

Howden blowers & exhausters are treated after factory assembly to protect against normal atmospheric corrosion. The maximum period of internal protection is considered to be one year under average conditions, if shipping plugs & seals are not removed. Protection against chemical or salt water atmosphere is not provided. Avoid opening the unit until ready to start installation, as corrosion protection will be quickly lost due to evaporation.

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

- Coat internals of cylinder, gearbox and drive end bearing reservoir with Nox-Rust VCI-10 or equivalent. Repeat once a year or as conditions may require. Nox-Rust VCI-10 is petroleum soluble and does not have to be removed before lubricating. It may be obtained from Daubert Chemical Co., 2000 Spring Rd., Oak Brook, Ill. 60521.
- Paint shaft extension, inlet and discharge flanges, and all other exposed surfaces with Nox-Rust X-110 or equivalent.
- 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 Nox-Rust VCI-10 vapor will escape and lose its effectiveness.
- Protect units from excessive vibration during storage.
- Rotate shaft three or four revolutions every two weeks.
- Prior to start up, remove flange covers on both inlet and discharge and inspect internals to ensure absence of rust. Check all internal clearances.

Because of the completely enclosed unit design, location of the installation is generally not a critical matter. A clean, dry

and protected indoor location is preferred. However, an outdoor location will normally give satisfactory service. Important requirements are that the correct grade of lubricating oil be provided for expected operating temperatures, and that the unit be located so that routine checking and servicing can be performed conveniently. Proper care in locating driver and accessory equipment must also be considered.

Supervision of the installation by a Howden Service Engineer is not usually required for these units. Workmen with experience in installing light to medium weight machinery should be able to produce satisfactory results. Handling of the equipment needs to be accomplished with care, and in compliance with safe practices. Unit mounting must be solid, without strain or twist, and air piping must be clean, accurately aligned and properly connected.

**Bare-shaft Units:** Two methods are used to handle a unit without base. One is to use lifting lugs bolted into the top of the unit headplates. Test them first for tightness and fractures by tapping with a hammer. In lifting, keep the direction of cable pull on these bolts as nearly vertical as possible. If lifting lugs are not available, lifting slings may be passed under the cylinder adjacent to the headplates. Either method prevents strain on the extended drive shaft.

**Packaged Units:** When the unit is furnished mounted on a baseplate, with or without a driver, use of lifting slings passing under the base flanges is required. Arrange these slings so that no strains are placed on the unit casing or mounting feet, or on any mounted accessory equipment. **DO NOT** use the lifting lugs in the top of the unit headplates.

Before starting the installation, remove plugs, covers or seals



**DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP**

# SECTION 6

## ROOTS™ RAM™ AND RAM-J SERIES

---

### Installation

from unit inlet and discharge connections and inspect the interior completely for foreign material. If cleaning is required, finish by washing the cylinder, headplates and impeller thoroughly with a petroleum solvent. Turn the drive shaft by hand to make sure that the impellers turn freely at all points. Anti-rust compound on the connection flanges and drive shaft extension may also be removed at this time with the same solvent. Cover the flanges until ready to connect piping.

#### Mounting

Care will pay dividends when arranging the unit mounting. This is especially true when the unit is a "bare-shaft" unit furnished without a baseplate. The convenient procedure may be to mount such a unit directly on a floor or small concrete pad, but this generally produces the least satisfactory results. It definitely causes the most problems in leveling and alignment and may result in a "Soft Foot" condition. Correct soft foot before operation to avoid unnecessary loading on the casing and bearings. Direct use of building structural framing members is not recommended.

For blowers without a base, it is recommended that a well anchored and carefully leveled steel or cast iron mounting plate be provided. The plate should be at least 1 inch (25 mm) thick, with its top surface machined flat, and large enough to provide leveling areas at one side and one end after the unit is mounted. It should have properly sized studs or tapped holes located to match the unit foot drilling. Proper use of a high quality machinist's level is necessary for adequate installation.

With the mounting plate in place and leveled, set the unit on it without bolting and check for rocking. If it is not solid, determine the total thickness of shims required under one foot to stop rocking. Place half of this under each of the diagonally opposite

short feet, and tighten the mounting studs or screws. Rotate the drive shaft to make sure the impellers turn freely. If the unit is to be direct coupled to a driving motor, consider the height of the motor shaft and the necessity for it to be aligned very accurately with the unit shaft. Best unit arrangement is directly bolted to the mounting plate while the driver is on shims of at least 1/8 inch (3mm) thickness. This allows adjustment of motor position in final shaft alignment by varying the shim thickness.

#### Aligning

When unit and driver are factory mounted on a common baseplate, the assembly will have been properly aligned and is to be treated as a unit for leveling purposes. Satisfactory installation can be obtained by setting the baseplate on a concrete slab that is rigid and free of vibration, and leveling the top of the base carefully in two directions so that it is free of twist. The slab must be provided with suitable anchor bolts. The use of grouting under and partly inside the leveled and shimmed base is recommended.

It is possible for a base-mounted assembly to become twisted during shipment, thus disturbing the original alignment. For this reason, make the following checks after the base has been leveled and bolted down. Disconnect the drive and rotate the unit shaft by hand. It should turn freely at all points. Loosen the unit foot hold-down screws and determine whether all feet are evenly in contact with the base. If not, insert shims as required and again check for free impeller rotation. Finally, if unit is direct coupled to the driver, check shaft and coupling alignment carefully and make any necessary corrections.

In planning the installation, and before setting the unit, consider how piping arrangements are dictated by the unit design and



# SECTION 6

## ROOTS™ RAM™ AND RAM-J SERIES

---

### Installation

assembly. Drive shaft rotation must be established accordingly and is indicated by an arrow near the shaft.

Typical arrangement on vertical units has the drive shaft at the top with counterclockwise rotation and discharge to the left. Horizontal units are typically arranged with the drive shaft at the left with counterclockwise rotation and discharge down. See Figure 4 for other various unit arrangements and possible conversions.

When a unit is DIRECT COUPLED to its driver, the driver RPM must be selected or governed so as not to exceed the maximum speed rating of the unit. Refer to Table 1, page 54 for allowable speeds of various unit sizes. A flexible type coupling should always be used to connect the driver and unit shafts.

When direct coupling a motor or engine to a blower you must ensure there is sufficient gap between the coupling halves and the element to prevent thrust loading the blower bearings. When a motor, engine or blower is operated the shafts may expand axially. If the coupling is installed in such a manner that there is not enough room for expansion the blower shaft can be forced back into the blower and cause the impeller to contact the gear end headplate resulting in damage to the blower. The two shafts must be in as near perfect alignment in all directions as possible, and the gap must be established with the motor armature on its electrical center if end-play exists. Coupling manufacturer's recommendations for maximum misalignment, although acceptable for the coupling, are normally too large to achieve smooth operation and maximum life of the blower.

The following requirements of a good installation are recommended. When selecting a coupling to be fitted to the blower shaft Roots recommends a taper lock style coupling to

ensure proper contact with the blower shaft. Coupling halves must be fitted to the two shafts with a line to line thru .001" interference fit. Coupling halves must be warmed up per coupling manufacturer's recommendations. Maximum deviation in offset alignment of the shafts should not exceed .005" (.13 mm) total indicator reading, taken on the two coupling hubs. Maximum deviation from parallel of the inside coupling faces should not exceed .001" (.03 mm) when checked at six points around the coupling.

When a unit is BELT DRIVEN, the proper selection of sheave diameters will result in the required unit speed. When selecting a sheave to be fitted to the blower shaft Roots recommends a taper lock style sheave to ensure proper contact with the blower shaft. This flexibility can lead to operating temperature problems caused by unit speed being too low. Make sure the drive speed selected is within the allowable range for the specific unit size, as specified under Table 1, page 54.

Belt drive arrangements should employ two or more V-belts running in grooved sheaves. Installation of the driver is less critical than for direct coupling, but its shaft must be level and parallel with the unit shaft. The driver should be mounted on the inlet side of a vertical unit (horizontal piping) and on the side nearest to the shaft on a horizontal unit. The driver must also be mounted on an adjustable base to permit installing, adjusting and removing the V-belts. To position the driver correctly, both sheaves need to be mounted on their shafts and the nominal shaft center distance known for the belt lengths to be used.

**CAUTION:** Drive couplings and sheaves (pulleys) should have an interference fit to the shaft of the blower (set screw types of attachment generally do not provide reliable service.) It is recommended that the drive coupling or sheave used have a

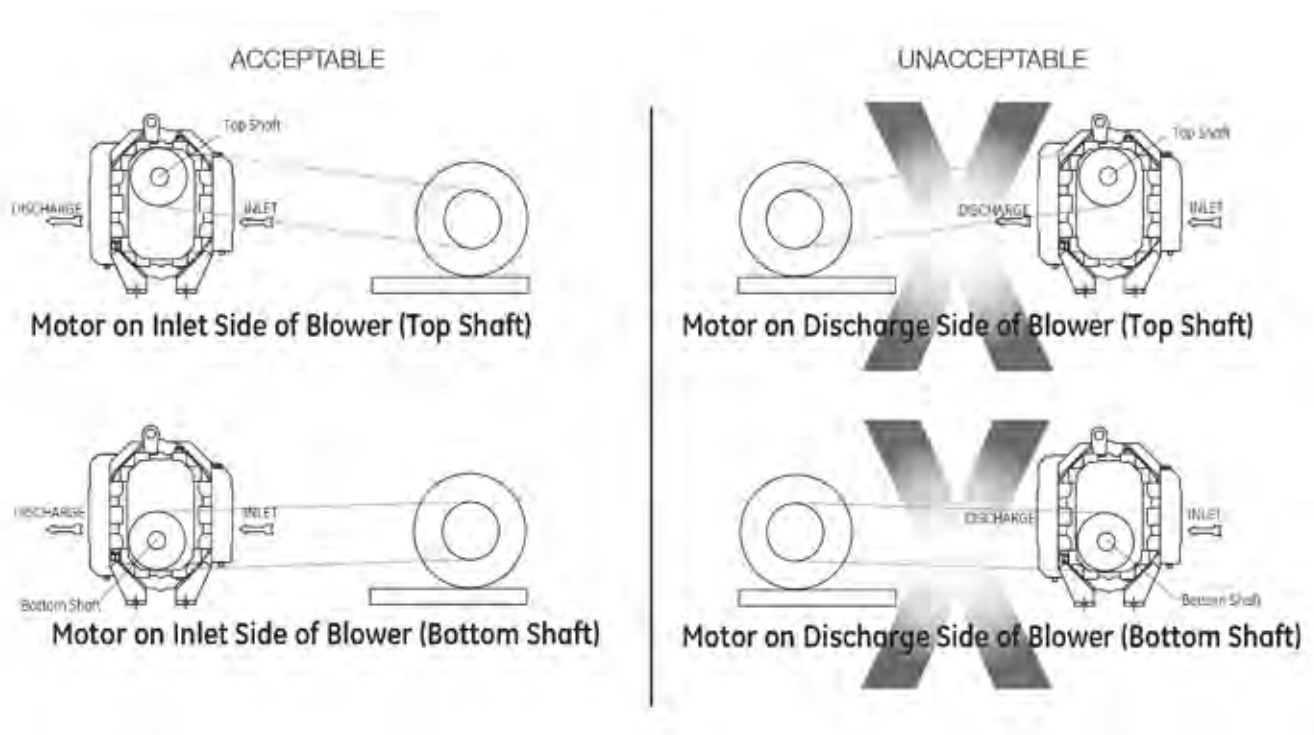




DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP

# SECTION 6 ROOTS™ RAM™ AND RAM-J SERIES

## Installation



taper lock style bushing which is properly sized to provide the correct interference fit required. Drive couplings, that require heating to fit on the blower shaft, should be installed per coupling manufacturer recommendations. A drive coupling or sheave should not be forced on to the shaft of the blower as this could affect internal clearances resulting in damage to the blower.

Engine drive applications often require special consideration to drive coupling selection to avoid harmful torsional vibrations. These vibrations may lead to blower damage if not dampened adequately. It is often necessary to install a fly-wheel and/or a torsionally soft elastic element coupling based on the Engine manufacturer recommendations.

The driver sheave should also be mounted as close to its bearing as possible, and again should fit the shaft correctly. Position the driver on its adjustable base so that 2/3 of the total movement is available in the direction away from the unit, and mount the assembly so that the face of the sheave is accurately in line with the unit sheave. This position minimizes belt wear, and allows sufficient adjustment for both installing and tightening the belts. After belts are installed, adjust their tension in accordance with the manufacturer's instructions. However, only enough tension should be applied to prevent slippage when the unit is operating under load. Excessive tightening can lead to early bearing concerns or shaft breakage. Before operating the drive under power to check initial belt tension, first remove covers from the unit connections. Make



# SECTION 6

## ROOTS™ RAM™ AND RAM-J SERIES

---

### Installation

sure the interior is still clean, then rotate the shaft by hand. Place a coarse screen over the inlet connection to prevent anything being drawn into the unit while it is operating, and avoid standing in line with the discharge opening. Put oil in the sumps per instructions under LUBRICATION.

#### Piping

Before connecting piping, remove any remaining anti-rust compound from Unit connections. Clean pipe should be no smaller than unit connections. In addition, make sure it is free of scale, cuttings, weld beads, or foreign material of any kind. To further guard against damage to the unit, especially when an inlet filter is not used, install a substantial screen of 16 mesh backed with hardware cloth at or near the inlet connections. Make provisions to clean this screen of collected debris after a few hours of operation. It should be removed when its usefulness has ended, as the wire will eventually deteriorate and small pieces going into the unit may cause serious damage.

Pipe flanges or male threads must meet the unit connections accurately and squarely. DO NOT attempt to correct misalignment by springing or cramping the pipe. In most cases this will distort the unit casing and cause impeller rubbing. In severe cases it can prevent operation or result in a broken drive shaft. For similar reasons, piping should be supported near the unit to eliminate dead weight strains. Also, if pipe expansion is likely to occur from temperature change, installation of flexible connectors or expansion joints is advisable.

Figure 3, page 57 represents an installation with all accessory items that might be required under various operating conditions. Inlet piping should be completely free of valves or other restrictions. When a shut-off valve can not be avoided, make sure a full size vacuum relief is installed nearest the unit

inlet. This will help protect against unit overload caused by accidental closing of the shut-off valve.

Need for an inlet silencer will depend on unit speed and pressure, as well as sound-level requirements in the general surroundings. An inlet filter is recommended, especially in dusty or sandy locations. A discharge silencer is also normally suggested, even though WHISPAIR™ units operate at generally lower noise levels than conventional rotary blowers. Specific recommendations on silencing can be obtained from your local Roots distributor.

Discharge piping requires a pressure relief valve, and should include a manual unloading valve to permit starting the unit under no-load conditions. Reliable pressure/vacuum gauges and good thermometers at both inlet and discharge are recommended to allow making the important checks on unit operating conditions. The back-pressure regulator shown in Figure 3, page 57 is useful mainly when volume demands vary while the unit operates at constant output. If demand is constant, but somewhat lower than the unit output, excess may be blown off through the manual unloading valve.

In multiple unit installations where two or more units operate with a common header, use of check valves is mandatory. These should be of a direct acting or free swinging type, with one valve located in each line between the unit and header. Properly installed, they will protect against damage from reverse rotation caused by air and material backflow through an idle unit.

After piping is completed, and before applying power, rotate the drive shaft by hand again. If it does not move with uniform freedom, look for uneven mounting, piping strain, excessive belt



**DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP**

# SECTION 6

## ROOTS™ RAM™ AND RAM-J SERIES

---

### Installation

tension or coupling misalignment.

DO NOT operate the unit at this time unless it has been lubricated per instructions.



# SECTION 6

## ROOTS™ RAM™ AND RAM-J SERIES

### Lubrication

Due to sludge build-up and seal leakage problems, Roots recommendation is DO NOT USE Mobil SHC synthetic oils in Roots blowers.

#### LUBRICATION: For Units with Splash Lubrication on Both Ends.

- The specified and recommended oil is Roots Synthetic oil of correct viscosity per Table 2, page 54.
- The proper oil level should be half way or middle of the sight gauge when the blower is not operating. DO NOT OVERFILL OIL SUMP/S as damage to the blower may occur.
- Oil level may rise or fall in the gauge during operation to an extent depending somewhat on oil temperature and blower speed.
- It is recommended that the oil be changed after initial 100 hours of operation.
- Proper service intervals of the oil thereafter are based on the discharge air temperature of the blower. Please refer to the information below to properly determine the oil service intervals.
- If you choose to use another oil other than the specified and recommended Roots Synthetic, use a good grade of industrial type non-detergent, rust inhibiting, anti-foaming oil and of correct viscosity per Table 2, page 54.
- Roots does NOT recommend the use of automotive type lubricants, as they are not formulated with the properties mentioned above.

Normal life expectancy of the specified and recommended Roots Synthetic oil is approximately 6000 hours with an oil temperature of 180°F (82°C) or less. As the oil temperature increases by increments of 15°F (8°C), the oil life is reduced by half for each 15°F (8°C) increase. Example: Oil temperatures of 195°F (90.5°C) will produce a life expectancy reduced by half or

3000 hours oil service life.

Normal life expectancy of petroleum based oils is about 2000 hours with an oil temperature of about 180°F (82°C). As the oil temperature increases by increments of 15°F (8°C), the life is reduced by half for each 15°F (8°C) increase. Example: Oil temperatures of 195°F (90.5°C) will produce life expectancy reduced by half or 1000 hours oil service life.

NOTE: To estimate oil temperature, multiply the discharge temperature of the blower by 0.80. Example: if the discharge air temperature of the blower is 200° F, it is estimated that the oil temperature is 160° F.

Bearings and oil seals are lubricated by the action of the timing gears or oil slingers which dip into the main oil sumps causing oil to splash directly on gears and into bearings and seals. A drain port is provided below each bearing to prevent an excessive amount of oil in the bearings. Seals located inboard of the bearings in each headplate effectively retain oil within the sumps. Any small leakage that may occur should the seals wear passes into a cavity in each vented headplate and is drained downward. Oil sumps on each end of the blower are filled by removing top vent plugs, Item (21), and filling until oil reaches the middle of the oil level sight gauge, Item (37).

Initial filling of the sumps should be accomplished with the blower not operating, in order to obtain the correct oil level. Approximate oil quantities required for blowers of the various models and configurations are listed in Table 3, page 54.

The oil level should not fall below the middle of the site gauge when the blower is idle. Proper lubrication is usually the most important single consideration in obtaining maximum service



**DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP**

# SECTION 6

## ROOTS™ RAM™ AND RAM-J SERIES

---

### Lubrication

life and satisfactory operation from the unit. Unless operating conditions are severe, a weekly check of oil level and necessary addition of lubricant should be sufficient. During the first week of operation, check the oil levels in the oil sumps about once a day, and watch for leaks. Replenish as necessary. Thereafter, an occasional check should be sufficient.

More frequent oil service may be necessary if the blower is operated in a very dusty location. Roots Synthetic oil is superior in performance to petroleum based products. It has high oxidation stability, excellent corrosion protection, extremely high film strength and low coefficient of friction. Typical oil change intervals are increased 2-3 times over petroleum based lubricants. Also, Roots Synthetic oil is 100% compatible with petroleum based oils. Simply drain the oil in the blower and refill the reservoirs with Roots Synthetic oil to maintain optimum performance of your Roots blower.



# SECTION 6

## ROOTS™ RAM™ AND RAM-J SERIES

### Operation

Before operating a blower under power for the first time, recheck the unit and the installation thoroughly to reduce the likelihood of avoidable troubles. Use the following procedure check list as a guide, but consider any other special conditions in the installation.

- Be certain that no bolts, tools, rags, or debris have been left in the blower air chamber or piping.
- If an outdoor intake without filter is used, be sure the opening is located so it cannot pick up dirt and is protected by a strong screen or grille. Use of the temporary protective screen as described under INSTALLATION is strongly recommended.
- Recheck blower leveling, drive alignment and tightness of all mounting bolts if installation is not recent. If belt drive is used, adjust belt tension correctly.
- Turn drive shaft by hand to make sure impellers still rotate without bumping or rubbing at any point.
- Ensure oil levels in the main oil sumps are correct.
- Check lubrication of driver. If it is an electric motor, be sure that power is available and that electrical overload devices are installed and workable.
- Open the manual unloading valve in the discharge air line. If a valve is in the inlet piping, be sure it is open.
- Bump blower a few revolutions with driver to check that direction of rotation agrees with arrow near blower shaft, and that both coast freely to a stop.

After the preceding points are cleared, blower is ready for trial operation under “no-load” conditions. The following procedure is suggested to cover this initial operation test period.

- Start blower, let it accelerate to full speed, then shut off. Listen for knocking sounds, both with power on and as speed slows down.

- After blower comes to a complete stop, repeat above, but let blower run 2 or 3 minutes. Check for noises, such as knocking sounds.
- After blower comes to a complete stop, operate blower for about 10 minutes unloaded. Check oil levels. Observe cylinder and headplate surfaces for development of hot spots such as burned paint, indicating impeller rubs. Be aware of any noticeable increase in vibration.

Assuming that all trials have been satisfactory, or that necessary corrections have been made, the blower should now have a final check run of at least one hour under normal operating conditions. After blower is restarted, gradually close the discharge unloading valve to apply working pressure. At this point it is recommended that a pressure gauge or manometer be connected into the discharge line if not already provided, and that thermometers be in both inlet and discharge lines. Readings from these instruments will show whether pressure or temperature ratings of the blower are being exceeded.

During the final run, check operating conditions frequently and observe the oil levels at reasonable intervals. If excessive noise or local heating develops, shut down immediately and determine the cause. If either pressure rise or temperature rise across the blower exceeds the limit specified in this manual, shut down and investigate conditions in the piping system. Refer to the TROUBLESHOOTING CHECKLIST for suggestions on various problems that may appear.

The blower should now be ready for continuous duty operation at full load. During the first few days make periodic checks to determine whether all conditions remain steady, or at least acceptable. This may be particularly important if the blower is supplying air to a process system where conditions can vary. At the first opportunity, stop the blower and clean the temporary



DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP

# SECTION 6 ROOTS™ RAM™ AND RAM-J SERIES

## Operation

inlet protective screen. If no appreciable amount of debris has collected, the screen may be removed.

See comments under INSTALLATION. At this same time, verify leveling, coupling alignment or belt tension, and mounting bolt tightness.

Should operating experience prove that blower capacity is a little too high for the actual air requirements, a small excess may be blown off continuously 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 unsafe operation of the valve itself. If blower capacity appears to be too low, refer to the TROUBLESHOOTING CHECKLIST.

### Vibration Assessment Criteria

With measurements taken at the bearing locations on the housings, see chart below for an appropriate assessment guide for rotary lobe blowers rigidly mounted on stiff foundations.

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.

As shown on the chart below, the level of all pass vibration will determine the need to measure discrete frequency vibration levels and the action required.

ALL PASS VIBRATIONS(IN./SEC.)	DISCRETE FREQUENCY VIBRATION (IN./SEC.)	ACTION
0.45 or less	N/R	Acceptable
Greater than 0.45 but 1.0 or less	0.45 or less @ any frequency Greater than 0.45 @ any frequency	Acceptable Investigate
Greater than 1.0	Less than 1.0 Greter than 1.0	Investigate Investigate



DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP

# SECTION 6 ROOTS™ RAM™ AND RAM-J SERIES

## Troubleshooting Checklist

TROUBLE	ITEM	POSSIBLE CAUSE	REMEDY
No flow	1	Speed too low	Check by tachometer and compare with published performance.
	2	Wrong rotation	Compare actual rotation with Figure 1, change driver if wrong.
	3	Obstruction in piping	Check piping, valves, silencer to ensure open flow path.
Low Capacity	4	Speed too low	See item 1, if belt drive check for slippage and re-adjust tension.
	5	Excessive pressure rise	Check inlet vacuum and discharge pressure and compare with published performance.
	6	Obstruction in piping	See item 3.
Excessive Power	7	Excessive slip	Check inside of casing for worn or eroded surfaces causing excessive clearances.
	8	Speed too high	Check speed and compare with published performance.
	9	Excessive pressure rise	See item 5.
Excessive Power	10	Impeller rubbing	Inspect outside of cylinder for high temperature areas, then check for impeller contact at these points. Correct blower mounting, drive alignment.
	11	Scale, sludge, rust or product build-up	Clean blower appropriately.
	12	Inadequate lubrication	Check oil sump levels in gear and drive end headplates.
Damage to bearings or gears	13	Excessive lubrication	Check oil levels. If correct, drain and refill with clean oil of recommended grade.
	14	Excessive pressure rise	See item 5.
	15	Coupling misalignment	Check carefully. Re-align if questionable.
	16	Excessive belt tension	Re-adjust for correct tension.
Vibration	17	Misalignment	See item 15.
	18	Impellers rubbing	See item 10.
	19	Worn bearings/gears	Check gear backlash and conditions of bearings and replace as indicated.
	20	Unbalanced or rubbing impeller	Scale or process material may build up on casing and impellers, or inside impellers. Remove build-up to restore original clearances and impeller balance.
	21	Driver or blower loose	Tighten mounting bolts securely.
	22	Piping resonances	Determine whether standing wave pressure pulsations are present in the piping.
	23	Scale/sludge build-ups	Clean out interior of impeller lobes to restore dynamic balance.





DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP

# SECTION 6 ROOTS™ RAM™ AND RAM-J SERIES

## Troubleshooting Checklist

TROUBLE	ITEM	POSSIBLE CAUSE	REMEDY
Driver stops, or will not start	24	Casing strain	Re-work piping alignment to remove excess strain.
	25	Impeller struck	Check for excessive hot spot on headplate or cylinder. See item 10. Look for defective shaft bearing and/or gear teeth.
	26	Scale, sludge, rust or product build-up	Clean blower appropriately.
Excessive breather Blow-by or excessive oil leakage to vent area Excessive oil leakage in vent area	27	Broken seal	Replace seals.
	28	Defective O-ring	Replace seals and O-ring.
	29	Defective/plugged breather	Replace breather and monitor oil leakage.
	30	Oil level too high	Check sump levels in gear and drive headplates.
	31	Oil type or viscosity incorrect	Check oil to ensure it meets recommendations. Drain then fill with clean oil of recommended grade.
	32	Blower running hot	Check blower operating conditions to ensure they are within the operating limitations defined in this manual.



# SECTION 6

## ROOTS™ RAM™ AND RAM-J SERIES

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### Inspection & Maintenance

A good program of consistent inspection and maintenance is the most reliable method of minimizing repairs to a blower. A simple record of services and dates will help keep this work on a regular schedule. Basic service needs are:

- Lubrication
- Checking for hot spots
- Checking for increases or changes in vibration and noise
- Recording of operating pressures and temperatures

Above all, a blower must be operated within its specified rating limits, to obtain satisfactory service life.

A newly installed blower should be checked often during the first month of full-time operation. Attention thereafter may be less frequent assuming satisfactory performance. Lubrication is normally the most important consideration and weekly checks of lubricant levels in the gearbox and bearing reservoirs should be customary. Complete oil change schedules are discussed under LUBRICATION.

Driver lubrication practices should be in accordance with the manufacturer's instructions. If direct connected to the blower through a lubricated type coupling, the coupling should be checked and greased each time blower oil is changed. This will help reduce wear and prevent unnecessary vibration.

In a belted drive system, check belt tension periodically and inspect for frayed or cracked belts. In a new, and properly installed, unit there is no contact between the two impellers, or between the impellers and cylinder or headplates. Wear is confined to the bearings (which support and locate the shafts) the oil seals, and the timing gears. All are lubricated and wear should be minimal if clean oil of the correct grade is always

used. Seals are subject to deterioration and wear, and may require replacement at varying periods.

Piston ring seals (28) are designed to operate without rubbing contact, once temperature and thermal growth have stabilized. The stationary rings will rub the rotating sleeve (38) briefly as a result of temperature cycles that occur during the startup and shutdown of the unit. The sleeves are hardened and the rings are coated with dry lubricant that provides for temporary break in wear. Replace piston ring seals if they become excessively worn.

Shaft bearings are designed for optimum life under average conditions with proper lubrication and are critical to the service life of the blower. Gradual bearing wear may allow a shaft position to change slightly, until rubbing develops between impeller and casing. This will cause spot heating, which can be detected by observing these surfaces. Sudden bearing situations is usually more serious. Since the shaft and impeller are no longer supported and properly located, extensive general damage to the blower casing and gears is likely to occur.

Oil seals should be considered expendable items, to be replaced whenever drainage from the headplate vent cavity becomes excessive or when the blower is disassembled for any reason. Some oil seal leakage may occur since an oil film under the lip is required for proper operation. Periodically leaked oil should be wiped off from surfaces. Minor seal leakage should not be considered as indicating seal replacement.

Timing gear wear, when correct lubrication is maintained, should be negligible. Gear teeth are cut to provide the correct amount of backlash, and gears correctly mounted on the shafts will accommodate a normal amount of tooth wear



# SECTION 6

## ROOTS™ RAM™ AND RAM-J SERIES

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### Inspection & Maintenance

without permitting contact between lobes of the two impellers. However, too high an oil level will cause churning and excessive heating. This is indicated by unusually high temperature at the bottom of the gear housing. Consequent heating of the gears will result in loss of tooth-clearance, backlash and rapid wear of the gear teeth usually will develop. Continuation of this tooth wear will eventually produce impeller contacts (knocking), and from this point serious damage will be unavoidable if blower operation is continued. A similar situation can be produced suddenly by gear tooth fracture, which is usually brought on by sustained overloading or momentary shock loads.

Problems may also develop from causes other than internal parts damage. Operating clearances within a blower are only a few thousandths of an inch. This makes it possible for impeller interferences or casing rubs to result from shifts in the blower mounting, or from changes in piping support. If this type of trouble is experienced, and the blower is found to be clean, try removing mounting strains. Loosen blower mounting bolts and reset the leveling and drive alignment. Then tighten mounting again, and make sure that all piping meets blower connections accurately and squarely. Foreign materials sucked into the blower will also cause trouble, which can only be cured by disconnecting the piping and thoroughly cleaning the blower interior.

A wide range of causes and solutions for operating troubles are covered in the TROUBLE SHOOTING CHECKLIST. The remedies suggested should be performed by qualified mechanics with a good background. Major repairs generally are to be considered beyond the scope of maintenance, and should be referred to your authorized Roots distributor.

Warranty situations should not be repaired at all, unless specific

approval has been obtained through a Sales Office or the factory before starting work. Unauthorized disassembly within the warranty period may void the warranty.

# SECTION 6 ROOTS™ RAM™ AND RAM-J SERIES

## Figures

$$\text{Belt Pull lbs} = \frac{275000 \cdot \text{Motor HP}}{\text{Blower RPM} \cdot \text{Sheave Diameter}}$$

$$\text{Shaft Load (lb.in)} = \text{Belt Pull} \cdot \left( A + \frac{1}{4} \cdot \frac{\text{Sheave Width}}{2} \right)$$

\*Based on SF = 1.4 for v-belt drives. If higher SF belt is used, belt load should be increased proportionally and may exceed limits of the blower.

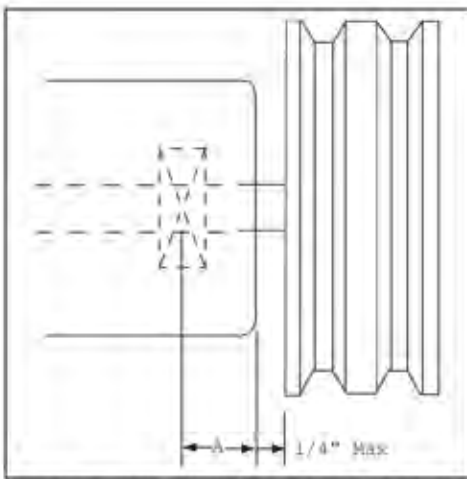


Figure 2 - Allowable Overhung Loads for V-belt Drive 400-600 RAM and RAM-J Blowers

FRAME SIZE	DIMENSION "A"		MIN. SHEAVE DIAMETER	MAX. SHEAVE WIDTH
	STANDARD UNIT	MAX. ALLOWABLE SHAFT LOAD (LB.-IN.)		
404, 406, 409, 412, 418	2.11	3,200	7.10	3.06
612, 616, 624	2.67	7,975	8.50	4.44

NOTE:

Arc of sheave belt contact on the smaller sheave not to be less than 170°.

Driver to be installed on the inlet side for vertical units, and on the drive shaft side for horizontal units.

Howden recommends the use of two or more 3VX, 5VX, 8VX matched set or banded belts and sheaves.

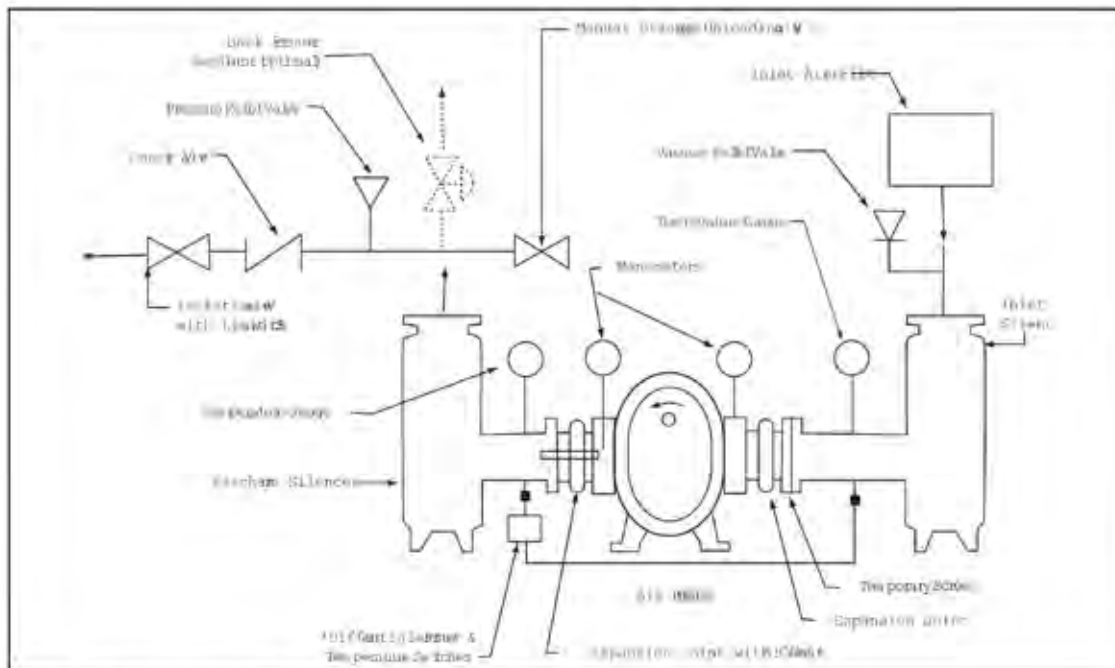


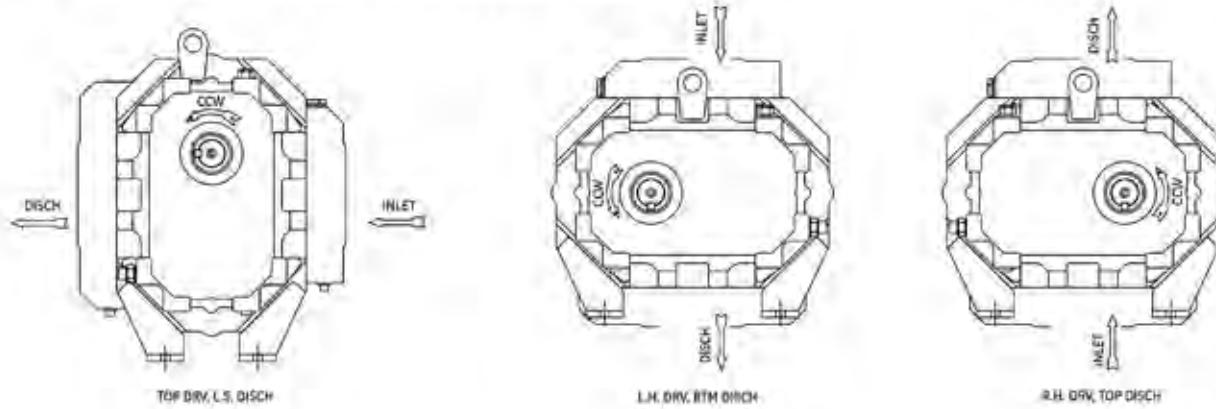
Figure 3 - Air Blower Installation with Accessories



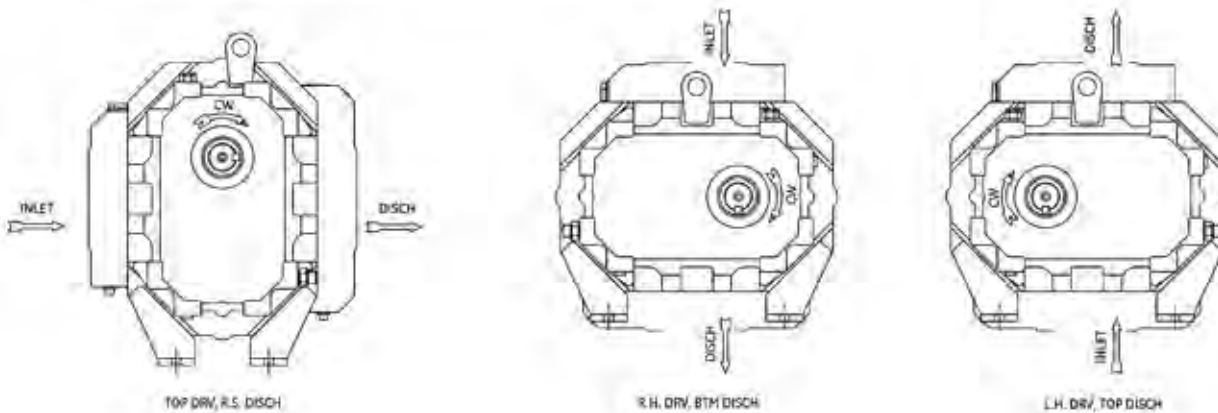
**DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP**

## Figures

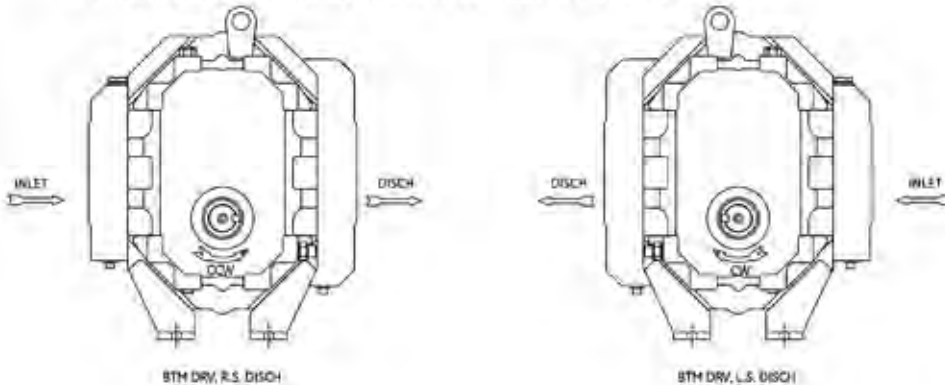
1. STANDARD ARRANGEMENT (3-WAY UNIVERSAL)  
EXTERNAL SIGHT GLASSES (37) & BREATHERS (21) MUST BE RELOCATED AS SHOWN  
FEET (76 & 77) & LIFTING LUGS (63) MUST BE RELOCATED AS SHOWN.



2. OPTIONAL ARRANGEMENT (3 WAY UNIVERSAL)  
EXTERNAL SIGHT GLASSES (37) & BREATHERS (21)  
FEET (76 & 77) & LIFTING LUGS (63) MUST BE RELOCATED AS SHOWN



3. BOTTOM DRIVE SHAFT ARRANGEMENT "SPECIAL ORDER" (3-WAY UNIVERSAL)  
**SPECIAL OGE OIL SLINGER REQUIRED FOR ASSEMBLY.**  
MAY BE CONVERTED TO HORIZONTAL CONFIGURATION AS PREVIOUSLY SHOWN





**DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP**

# SECTION 6

## ROOTS™ RAM™ AND RAM-J SERIES

### Tables

Table 1 - RAM, RAM-J WHISPAIR Blower

RAM™-J MAXIMUM ALLOWABLE OPERATING CONDITIONS								
FRAME SIZE	GEAR DIAMETER (IN.)	SPEED RPM	TEMP. RISE		DELTA PRESSURE		INLET VACUUM	
			°F	°C	PSI	mbar	INHG	mbar
404	4.5	4000	240	133	18	1241	16	539
406	4.5	4000	240	133	18	1241	16	539
409	4.5	4000	240	133	18	1241	16	539
412	4.5	4000	240	133	15	1034	16	539
418	4.5	4000	240	133	10	690	16	539
612	6	3000	230	128	18	1241	16	539
616	6	3000	230	128	15	1034	16	539
624	6	3000	230	128	10	690	16	539

Use a good grade of industrial type non-detergent, rust inhibiting, anti-foaming oil and of correct viscosity per Table 2. Roots synthetic oil (Roots P/N 813-106-) is specified and recommended. Howden does not recommend automotive type lubricants, as they are not formulated with the properties mentioned above.

Table 2 - Recommended Oil Grades

AMBIENT <sup>1</sup> TEMPERATURE °F (°C)	ISO VISCOSITY NO.
Above 90° (32°)	320
32° to 90° (0° to 32°)	220
0° to 32° (-18° to 0°)	150
Below 0° (-18°)	100

<sup>1</sup>Ambient temperature is defined as the temperature of the space in which the blower and drive are located.

Table 3 - Approximate Oil Sump Capacities

RAM™, RAM™-J APPROXIMATE OIL SUMP CAPACITIES				
ORIENTATION	GEAR BOX		DRIVE END	
	FL. OZ	LITERS	FL. OZ	LITERS
400 (horizontal)	36	1.06	19	0.56
400 (vertical)	18	0.52	9	0.27
600 (horizontal)	95	2.81	50	1.48
600 (vertical)	55	1.63	28	0.83



**DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP**

# SECTION 7 COMPONENT INFORMATION

## QR Code - Ordering Spare Parts

CAMCORP makes ordering replacement parts easier and faster with QR code stickers. All you need is a mobile device and you've got instant access to your equipment's common spare parts and part numbers in one location.

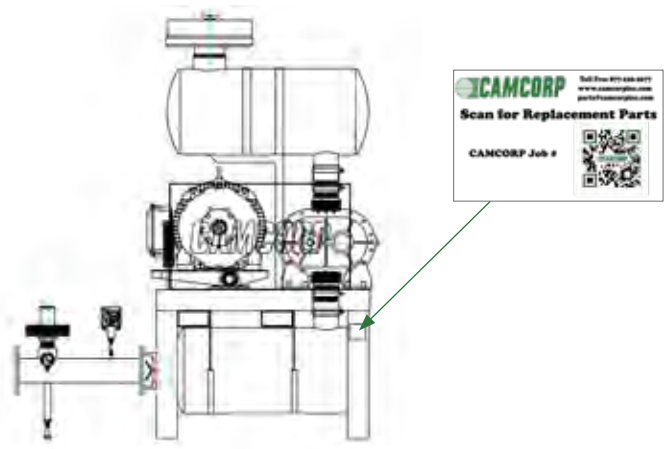
Here's how it works:

1. Locate the QR sticker on your dust collection or pneumatic conveying equipment.
2. Open your QR code reader app on your mobile device. You can download an app by searching "QR code reader" in the Google Play (Android) or App Store (Apple).
3. Hold your phone over the QR code and your spare parts list will appear complete with part numbers and CAMCORP Parts contact information.

Don't have a QR sticker on your equipment? Contact the CAMCORP Parts Department to request your sticker today.

## QR Code - Download Equipment Manual

Access to an electronic copy of this manual can be found by scanning the QR code sticker on your CAMCORP equipment. Simply follow the same instructions as Ordering Spare Parts.

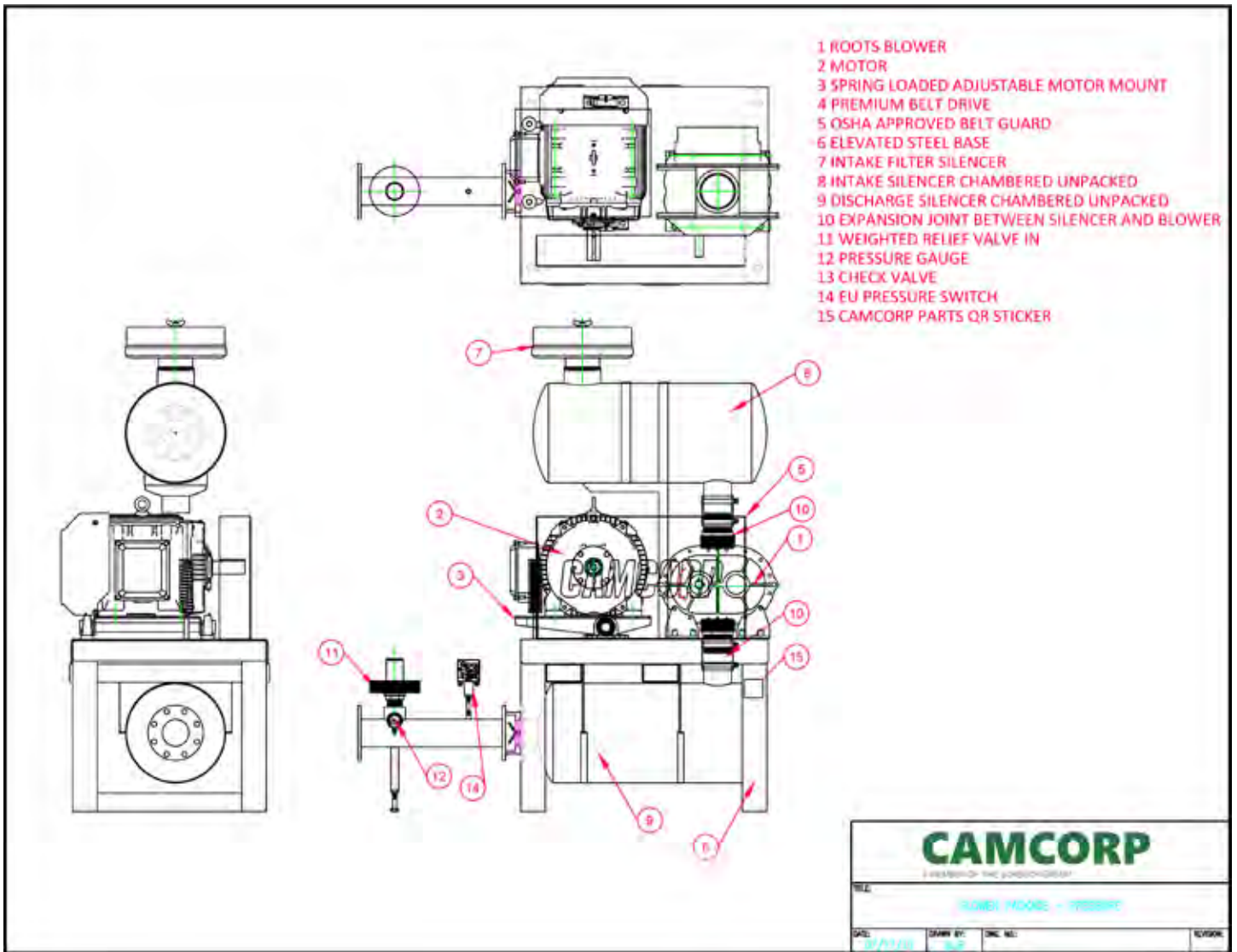






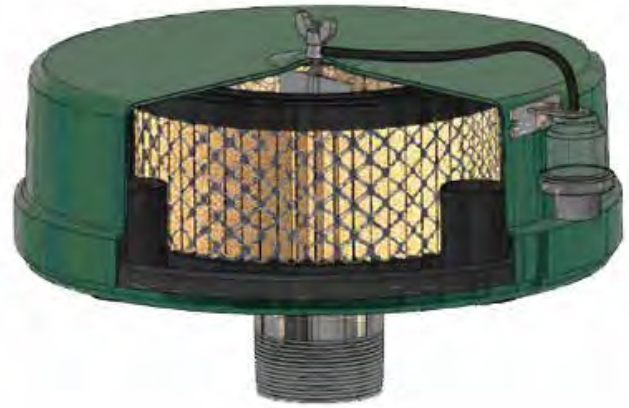
DO NOT FORGET TO PUT OIL IN BLOWER PRIOR TO START-UP

# SECTION 7 COMPONENT INFORMATION





# INTAKE FILTERS AND FILTER SILENCERS



## Description

The Series F64 Air Intake Filter and Filter Silencer is designed to mount directly on the inlet of an engine, blower or compressor. It will provide 16dB to 20dB noise reduction and the paper filter media has an efficiency of 99% on 1 micron particles.

## Service Life and Cleaning

The service life of the element is dependent upon the surrounding environment and cannot be predicted.

To prevent collapsing of the filter element, differential pressure across the filter element NOT exceed 15 inches of water column.

To extend service life, rap element gently to dislodge accumulated dirt. An alternate method is to direct compressed air (75 PSIG max) through the element opposite to the direction of air flow. THE FILTER ELEMENT MUST EVENTUALLY BE REPLACED.

## Paper Elements (Replaceable)

HOUSING SIZE	REPLACEMENT ELEMENT NUMBER
1" to 2 1/2"	500019
3" to 5"	500020
6"	500021
8"	500034

Efficiency: 99% on 1 micron particles and larger

MODEL	A CONNECTION SIZE	B	C	D	RATED CFM	WT	REPLACEMENT ELEMENT NUMBER
F64-1	1" NPT	10	4	7	35	9	500019
F64-1 1/2"	1 1/2" NPT				80	9	
F64-2	2" NPT				135	10	
F64-2 1/2"	2 1/2" NPT				180	10	
F64-3	3" NPT	16	5	8	285	20	500020
F64-4	4" NPT				520	20	
F64-5	5" NPT/FLG				750	23	
F64-6	6" flange	20	5	8	1235	40	500021
F64-8	8" flange	20	10	13	2125	50	500034



NOTE: Alternate filtration media and pre-filter wrap available. 90% on 75 micron particles and larger

# WEIGHTED RELIEF VALVES

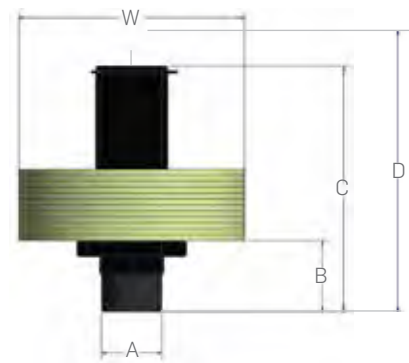


## Description

A weighted relief valve (WRV) protects your blower package by allowing excess air pressure to relieve at a predetermined set point. This design is very efficient, consistent and it will provide years of maintenance free operation. The weighted relief valve is easily installed in the vertical position on the discharge side of the silencer. The valve body is available in 2", 3", or 4" NPT connection sizes. The set point is controlled by removable weights which are available in either 0.5 PSI or 1.0 PSI increments.

Pressure models have standard male NPT connections. Available from 1 PSIG through 29 PSIG with a calibrated 0.5 PSIG increment per removable disc.

Vacuum canisters have standard female NPT connections. Available from 2" Hg through 30" Hg with a calibrated 1" Hg increment per removable disc.



VALVE ASSEMBLY				
PART NUMBER	NPT A	DIM B	DIM C	DIM D
2WRV	2"	2.31	7.81	9.25
3WRV	3"	3.18	8.70	9.75
4WRV	4"	3.34	9.83	10.5

WEIGHTS	
PART NUMBER	DIAMETER W
2W05PSI	6.75
2W1PSI	9.12
3W05PSI	10.50
3W1PSI	14.37
4W05PSI	13.50
4W1PSI	18.50

# Pressure

## Econ-O-Trol Switch

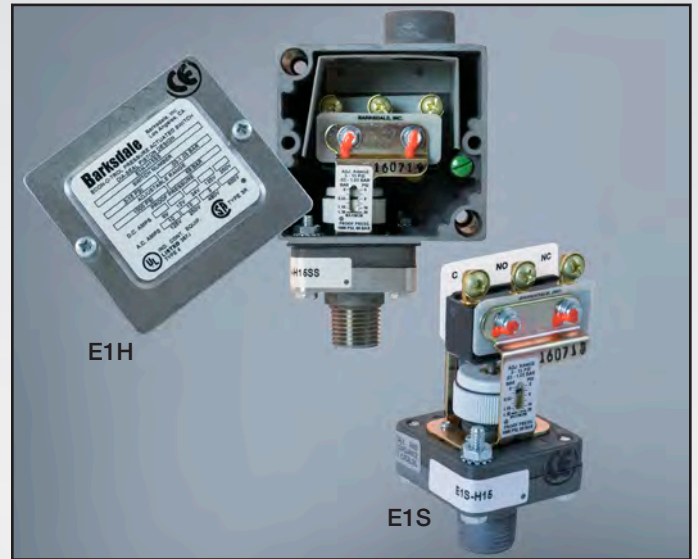
## E1S, E1H Series

### Features

- ▶ Superior resolution
- ▶ Long life
- ▶ Easy setpoint adjustment
- ▶ Ideal for pressure or vacuum applications
- ▶ NEMA 1, 3 & 4
- ▶ Stripped and housed versions available

### Applications

- ▶ Medical equipment
- ▶ Pump & compressor monitoring
- ▶ Air proving in HVAC systems
- ▶ Irrigation systems
- ▶ Engine monitoring
- ▶ Machine tools
- ▶ Water & sewage treatment facilities
- ▶ Pulp & Paper Mills
- ▶ Metal working
- ▶ Food & beverage
- ▶ Steel mills

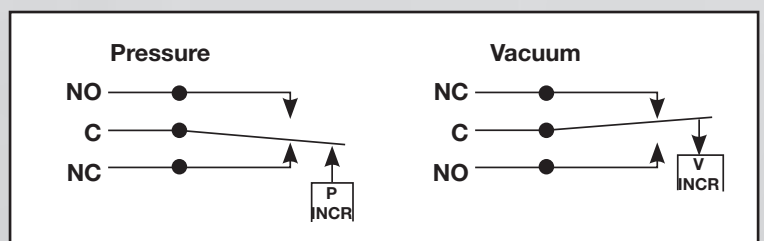


### General Specifications\*

<b>Accuracy:</b>	± 2% of the adjustable range
<b>Switch:</b> Type:	Single pole double throw (SPDT) snap action; single circuit
Rating:	Class H limit switch: 10 amps @ 125/250 VAC; 3 amps @ 480 VAC; 0.5 amps @ 24 VDC (standard).
<b>Wetted Parts:</b> Process Fitting:	Anodized aluminum (standard)
Seals & Diaphragms:	Buna-N (standard)
Enclosure:	Anodized aluminum (housed models)
<b>Electrical Connection:</b> Stripped Models:	Screw terminals
Housed models:	Screw terminals via 1/2" NPT female conduit connection
<b>Enclosure Ratings:</b> Stripped models:	NEMA 1
Housed models:	NEMA 4 & IP65
<b>Pressure Connection:</b> Stripped models:	1/2" NPT external with 1/8" NPT internal
Housed models:	1/4" NPT female
<b>Approvals:</b> UL:	Stripped models: UL recognized component (UR) Housed models: UL listed. File No. E42816
CSA:	All models and modifications shown are CSA listed under Guide 380-W-1.16, Class 3231, File LR22355
PED (European):	Compliant to PED 97/23/EC

<b>Temperature Range:</b> Operating:	-20° to +165°F (-29 to +74°C)
<b>Adjustment Setpoint:</b> Positive Pressure:	Turn self locking adjustment nut clockwise to increase setpoint; counterclockwise to decrease setpoint.
Vacuum:	Turn self locking adjustment nut counterclockwise to increase setpoint, clockwise to decrease setpoint (towards 30" Hg).
Adjustable Deadband (Optional):	Turn small self locking adjustment nut on limit switch counterclockwise to increase differential. As the differential is increased, the setpoint is also increased. Balance one adjustment against the other to obtain the desired setpoint.
<b>Options:</b>	-Plastic cover (stripped models only) -NEMA 4X enclosure (housed models only) -Cleaned for oxygen service -Manual reset -Adjustable deadband
<b>Shipping Weight:</b> Housed models:	1.5 lbs. approx.
Stripped models:	0.75 lbs. approx.

### Wiring Diagram

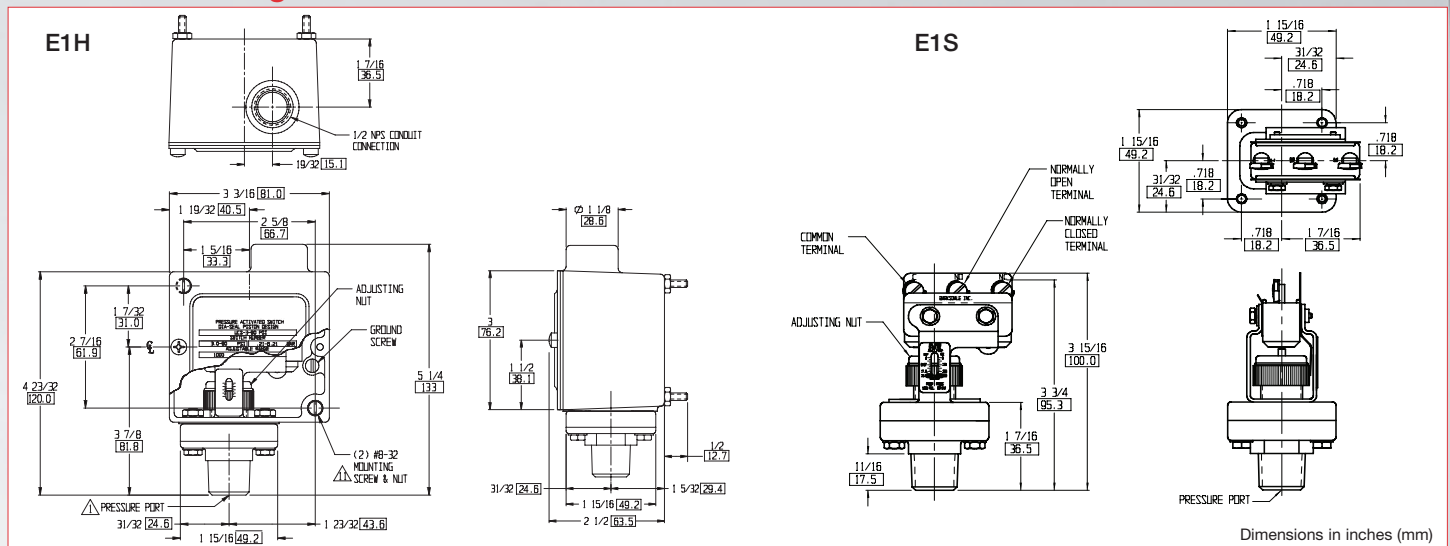


\* See product configurator for additional options.

# Econ-O-Trol Switch

# E1S, E1H Series

## Technical Drawing



## Product Configurator

Example **E1H -H 250 -P6 -PLS**

### Base Configuration

E1S	Stripped models
E1H	Housed models

### Limit Switch<sup>1</sup>

-B	10 amps @ 125/250/480 VAC; 2 amps @ 600 VAC; 0.05 amps @ 125 VDC; 0.03 amps @ 250 VDC
-BT <sup>2</sup>	15 amps @ 125/250/480 Vac (E1S Series only)
-H	10 amps @ 125/250 VAC; 3 amps @ 480 VAC (standard)
-M	10 amps @ 125/250 VAC; 3 amps @ 480 VAC; 0.5 amps @ 125 VDC; 0.25 amps @ 250 VDC
-R <sup>3</sup>	15 amps @ 125/250/480 VAC; 0.05 amps @ 125 VDC; 0.03 amps @ 250 VDC <b>ADJUSTABLE DEADBAND</b>
-G <sup>4</sup>	10 amps @ 125/250/480 VAC; 2 amps @ 600 VAC; 0.4 amps @ 125 VDC; 0.2 amps @ 250 VDC <b>MANUAL RESET</b> (Available only with housed version). Requires -RD option.
-GH	1 amp @ 125 VAC; gold contact

### Pressure Range

	Adjustable Range				Approx. Deadband <sup>5</sup> (Actuation Value) psi (bar)	Proof Pressure psi (bar)	
	Decreasing - psi (bar)		Increasing - psi (bar)				
	Min	Max	Min	Max			
<b>VAC<sup>6</sup></b>	.5" Hg	29" Hg	3.0" Hg	30" Hg	.3 - 2.5" Hg	30 psi	Fixed Deadband
<b>15</b>	.5 (.03)	14.2 (.98)	.6 (.04)	15 (1)	.1 - 1.2 (.01 - .08)	1000 (67)	
<b>90</b>	3 (.2)	82 (5.5)	3.5 (.2)	90 (6)	.5 - 8 (.03 - .5)	1000 (67)	
<b>250</b>	10 (.7)	230 (15)	11 (.7)	250 (17)	1 - 20 (.07 - 1.3)	1000 (67)	
<b>500</b>	25 (1.7)	472 (31)	29 (2)	500 (33)	4 - 28 (.3 - 1.9)	1000 (67)	
<b>VAC<sup>6</sup></b>	1" Hg	30" Hg				30 psi	Adjustable Deadband
<b>15</b>	1 (.07)	15 (1)				1000 (67)	
<b>90</b>	6 (.4)	90 (6)				1000 (67)	
<b>250</b>	15 (1)	250 (17)				1000 (67)	
<b>500</b>	35 (2.3)	500 (33)				1000 (67)	

Must select class R limit switch.  
Consult sales drawing for deadband charts

### NOTES:

- Consult sales drawing for specific deadband values
- Available on E1S Series only (terminals are on horizontal plane)
- To increase differential, turn small, self-locking adjusting nut counter-clockwise
- Add -LC suffix at end of -G -RD (manual reset) models for UL approval as limit controls (No UL without -LC suffix). -LC is not available in range 500.
- Deadband values indicated when used with the "H" limit switch
- Vacuum models are provided with 1/2" NPT External, 1/8" NPT Internal "Combo" fitting only on E1S models
- Not available on vacuum models
- Not available in range 500
- "-BR" models have a proof pressure of 500 psi
- "-PLS" models have a proof pressure of 400 psi
- "-Z1" option requires use with SS option (include suffix -SS-Z1 in the part number)

### Options

-E1	Plastic cover (E1S models only) (Not UL approved)
-FX	NEMA 4X enclosure (E1H models only)
-RD <sup>4</sup>	<b>Manual reset</b> (must select class G limit switch)
-Z1 <sup>11</sup>	Cleaned for oxygen service
-Sxxx	Factory preset (consult factory)

### O-Ring/Diaphragm Material

Blank	Buna-N
-T <sup>7</sup>	T
-V	Viton® diaphragm

### Pressure Connection (Material Option)

Blank	Anodized Aluminum (standard)
-F1	Impregnated fitting (not UL or CSA approved)
-F2	Nickel plated fitting
-SS <sup>7</sup>	316 Stainless steel fitting
-BR <sup>7,8,9</sup>	Brass fitting (Max adjustable pressure: 250 psi)
-PLS <sup>7,8,10</sup>	Polysulfone 40% glass filled; <b>for 1/8" NPT Internal with 1/2" NPT external thread type only.</b> (Max adjustable pressure: 250 psi)

### Pressure Connection (Thread Type)

E1S (Stripped models)	
Blank	1/8" NPT Internal with 1/2" NPT External Threads (standard)
-P4	1/4" NPT Internal Threads (Not available with -PLS option)
E1H (Housed models)	
Blank	1/4" NPT Internal Threads (standard) (Not available with -PLS option)
-P6	1/8" NPT Internal with 1/2" NPT External Threads





**Approvals for E1S/E1H Type Pressure Switches:**

E1S Models are UL Recognized Components Motor Controllers, Float and Pressure Operated, (UL File E42816, NKP22 / 7), and as Limit Control-Components (MH8150, MBPR2), E1H Models are UL Listed, Motor Controllers, Float and Pressure Operated (UL File E42816, NKPZ / 7); and as Limit Controls (UL File MH8150, MBPR)  
Both E1S & E1H Models are also CSA Certified (File No. LR22355, Class 3231-02), as Switches – Automatic Pressure Type.

**Maintenance/Cleaning**

**Maintenance**

The pressure switch is maintenance free. Checking the set points lies within the discretion of the user. The usual preventive maintenance work in accordance with the PED and normal safe use guidelines must always be carried out.

Please note that small setpoint drifts may occur during the initial use of the switch (run-in period). Larger or continuing setpoint drifts during the normal use of the switch may indicate that the switch is not installed correctly, is not being used within the specified limits, exceeds the design criteria, or is worn out. Inconsistent switching may also indicate diaphragm damage, caused by high cycle rates, overpressure, or media incompatibility. It should be replaced before the ultimate rupture of the diaphragm takes place. Please consult your supplier or Barksdale directly for guidelines.

**Cleaning**

Wipe with clean damp cloth only. Nameplate legibility may be impaired by use of chemical solvents!

**Operating life time**

Normal expected service life (expressed in the number of cycles over the full adjustment range) is approximately 1 million for the pressure switch. This may be extended to 2.5 million cycles max. if only a part of the adjustment range is used (about 20%).

Switch sensor life may also be effected negatively by:

- Media not compatible with the wetted materials.
- Too high switch cycling speed or more than 20 cycles per minute.
- System cycling pressure exceeding the top of the adjustable range.

The proof pressure must never be exceeded; otherwise the switch may be damaged. Careful selection of the pressure range can have a positive effect on the service life of the switch.

**Operating Instructions - Diaphragm Seal - Piston Pressure Switch Types: E1S/E1H**



1	Intended Applications .....	2
2	Safety Instructions .....	2
3	Standards .....	3
4	Warranty/Guaranty .....	3
5	Transport/Storage .....	3
6	Installation/Commissioning, Set Point Adjustment .....	4 & 5
7	Technical Data, Adjustable Ranges, Electrical Ratings .....	6 & 7
8	Approvals, Maintenance/Cleaning, Operating Life .....	8

**Barksdale**  
CONTROL PRODUCTS

Barksdale, Inc.

3211 Fruitland Ave.  
Los Angeles, CA 90058

Phone: 800-835-1060  
Fax: 323-589-3463  
email: sales@barksdale.com  
Internet: www.barksdale.com

Bulletin No.: 272313, H  
Date: 07-27-2017  
Specifications are subject to change without notice!

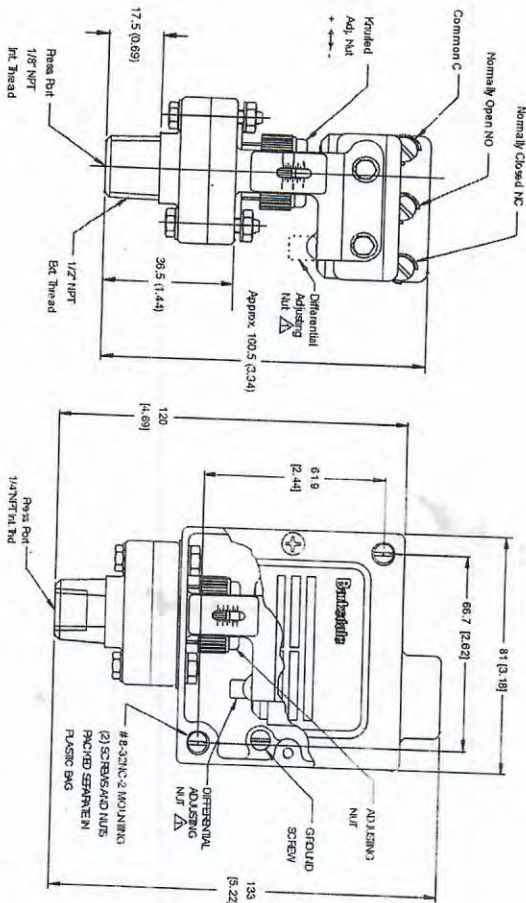




**Technical Data**

See data sheet

Dimensions in mm (inch)



**Fig. 1:** Diaphragm seal piston pressure switch type E1S...

This pressure switch has been UL accepted "For use on a flat surface of a Type 3R enclosure" under the following conditions:  
The switch must be installed in a 1/2" NPT conduit knockout in the bottom of the 3R enclosure and secured with a 1/2" NPT lock nut. The acceptability of the location of the switch must be in the end use application.

**Fig. 2:** Diaphragm seal piston pressure Housed model with UL Type 4 Rated enclosure.

Housed model with UL Type 4 Rated enclosure.

**WARNING**  
DO NOT Attempt to adjust switch if small, white, plastic cap (7/16" diameter) is damaged or missing! Metal under white cap is electrically live when switch is powered.

**IMPORTANT**  
Refers to important information essential to the user.

**Disposal**  
The equipment must be disposed of correctly in accordance with the local regulations for electric/electronic equipment.  
The equipment must not be disposed of with the household garbage!

**Standards**  
The standards applied during development, manufacture and configuration are listed in the CE conformity and manufacturer's declaration.

**Warranty/Guaranty**

**Warranty**  
Our scope of delivery and services is governed by the legal warranties and warranty periods.

**Terms of guaranty**  
We guaranty the function and material of the pressure switch under normal operating and maintenance conditions in accordance with the statutory provisions.

**Loss of guaranty**  
The agreed guaranty period will expire in case of:  
changes or modifications to the switch/housing/filling  
incorrect use,  
incorrect installation or  
incorrect handling or operation contrary to the provisions of these operating instructions.

No liability is assumed for any damage resulting there from, or any consequential damage.

**Transport/Storage**

**CAUTION**  
Severe shock and vibrations should be avoided during transport. Storage should be dry and clean.



**IMPORTANT**

To reach the adjustment knob for E/H pressure switches with housings, remove the cover (see Figure 8).

Allow pressure switch to reach the desired switch pressure.

Turn adjustment knob (nu) clockwise or counter clockwise to change the actuation point of the micro switch.

**IMPORTANT**

Please consult the wiring diagram for the contact status at atmospheric pressure (see Error! Reference source not found.).

**IMPORTANT**

Particularly important for small pressures! Set point adjustment must be performed in the installed position.

As a general rule, when installing a switch for the first time, it's best to cycle the system pressure up and down a few times (not to exceed the max. operating pressure) before verifying set point.

**Precise adjustment of set point to actuate on increasing pressure**

Lower the system pressure to 0 psi.

Increase pressure slowly and check if micro switch actuates at desired switch pressure.

If necessary, readjust by turning the adjustment knob (nu).

Repeat preceding steps until micro switch operates at desired switch pressure.

**Precise adjustment of set point to actuate on decreasing pressure**

Increase pressure up to a point clearly above the desired switch set point (Do Not exceed the maximum operating pressure).

Lower pressure slowly and check if micro switch actuates at desired switch pressure.

If necessary, readjust by turning the adjustment knob (nu).

Repeat preceding steps until micro switch operates at desired switch set point.

**Caution** — Do not force the adjustment knob against the micro switch or turn the adjustment knob above or below the specified pressure limits.

**IMPORTANT**

The adjustment of set points occurs for each set point as specified above.

**Wiring Code for all Types (Contact status: at atm. pressure)**



C = Common

NC = Normally Closed

NO = Normally Open

Fig. 3 Wiring Code

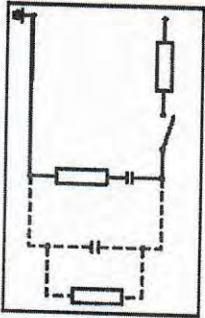


Fig. 3: Protection in case of capacitive loads  
R1: Protection against starting current rushes  
R2,R3: Protection against high discharge currents

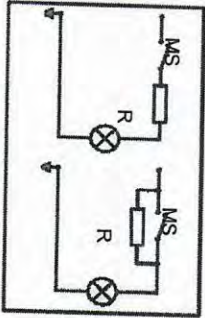


Fig. 4: Lamp load provided with resistance in parallel or series connection to switch of contacts

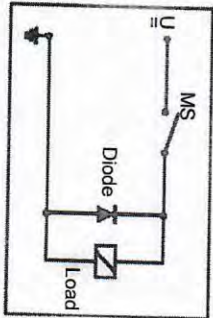


Fig. 5: Protection in case of continuous current and inductive load by recovery diode

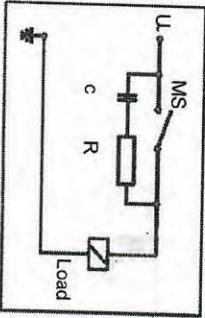


Fig. 6: Protection in case of alternating current and inductive load by RC-link

**Set point adjustment**

**IMPORTANT**

Factory-Provided: pressure switch point setting  
We confirm for pressure switches that have been factory set the setting will be detailed on the box label or nameplate.

Warranty is not applicable for any changes that may occur due to transportation or installation. For critical applications we recommend that the setting is checked and re-set if necessary after installation and wiring of the pressure switch.

In pressure switches, a displacement of the pressure sensing element occurs with a change in pressure. Following the displacement of the pressure sensing element operates a micro switch. Upon delivery of the product, the set points are likely to be found in the middle of the adjustable range. On request, fix set points may be adjusted by our factory. In this event, the point will be indicated on the type plate, box plate, or a separate plate. i = increasing, d = decreasing.  
The set point is adjusted by turning the adjustment knob (nu).



**Intended Applications**

The pressure switches are specifically applied for monitoring and controlling of operations using maximum and minimum pressures. A micro switch triggers an electrical signal when minimum or maximum pressures are reached.

<b>⚠ DANGER</b>	<p>The switch may only be used in the specified fields of application (see type label).</p> <p>The temperature has to be within the specified ranges, the pressure values and the electrical rating must not exceed the values specified.</p> <p>Observe also the applicable national safety instructions for assembly, commissioning and operation of the switch.</p> <p>The switch is not designed to be used as the only safety relevant element in pressurized systems according to DGR 97/23/EC.</p> <p>Without special provisions/actions, pressure switches must not be used for pure gas or hydrogen applications.</p>
-----------------	--

**Safety Instructions**

The safety instructions are intended to protect the user from dangerous situations and/or material damage. In the operating instructions the seriousness of the potential risk is designated by the following signal words:

<b>⚠ DANGER</b>	Refers to imminent danger to men. Non-observance may result in fatal injuries.
<b>⚠ WARNING</b>	Refers to a recognizable danger. Non-observance may result in fatal injuries, and destroy the equipment or plant parts.
<b>⚠ CAUTION</b>	Refers to a danger. Non-observance may result in light injuries and material damage to the equipment and/or to the plant.

**Adjustable Ranges Pressure Switches Type E1S.../E1H...**

Pressure range code	Adjustable range [psl]/Differential pressure		Max. operating pressure [psl]	Proof pressure* [psl]	Max. hysteresis of switch types (end of range)		
	Increasing pressure	Decreasing pressure			H, GH [psl]	M [psl]	
Pressure	15	0.6 15	0.5 14.2	15	550/1000	1.2	1.2
	90	3.5 90	3.0 82.0	90	550/1000	8.0	10.0
	250	11.0 250	10.0 230.0	250	550/1000	20.0	21.0
500	290 500		25.0 472.0	500	550/1000	28.0	40.0
	(Vacuum values shown in inches of mercury)						
Vacuum	3.0 30	0.5 29.7	30	30	30	0.3	0.6

\* Note: Designed for 1000psi proof pressure. For reasons of manufacturing technology only a proof pressure of 550psi is normally applied.

**Electrical Ratings Pressure Switch Type E1S.../E1H...**

Micro switch	Special Characteristics	Volt AC 50/60 Hz	Ind. Load A	Res. Load A	Volt DC	Ind. Load A	Res. Load A	Notes
H	Microswitch with silver contacts	125 250 480	10 10 3	10 10 10	6 10 24	0.5	0.5	Small hysteresis; high AC / low DC loads
M	Microswitch with silver contacts	125 250 480	10 10 3	10 10 10	12 24 250	5.00 1.00 0.25	15.0 2.0 0.4	Medium hysteresis; high AC and DC loads
GH	Microswitch with gold plated contacts for low voltage and low current	125	1	1	24	1.0	1.0	Low change-back values
R	Microswitch with adjustable differentials	125 250 480	15 15 15	15 15 15	125 250	0.05 0.03	0.4 0.2	Adjustable differential pressure

For other Microswitch options refer to main internet, [www.barksdale.com](http://www.barksdale.com)

**IMPORTANT**

We recommend using a pre-fuse of the maximum current rating from the table above according to the load switched.

We recommend gold plated contacts for all low voltage/power applications.



# PRODUCT INFORMATION PACKET



Model No: 254TTFCD6026  
Catalog No: GT1022A  
15, 1800, TEFC, 254T, 3/60/230/460  
Totally Enclosed Fan Cooled (TEFC)



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**Nameplate Specifications**

Output HP	15 Hp	Output KW	11.2 kW	
Frequency	60 Hz	Voltage	230/460 V	
Current	37.5/18.8 A	Speed	1772 rpm	
Service Factor	1.15	Phase	3	
Efficiency	92.4 %	Duty	Continuous	
Insulation Class	F	Design Code	B	
KVA Code	G	Frame	254T	
Enclosure	Totally Enclosed Fan Cooled		Overload Protector	No
Ambient Temperature	40 °C	Drive End Bearing Size	6309	
Opp Drive End Bearing Size	6209	UL	Listed	
CSA	Y	CE	Y	
IP Code	55			

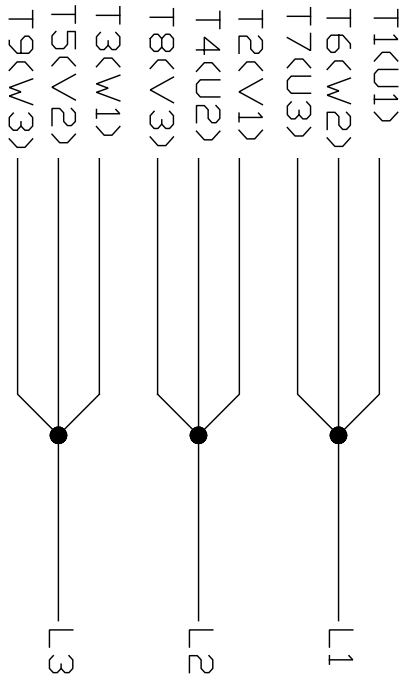
**Technical Specifications**

Electrical Type	Squirrel Cage Inverter Rated	Starting Method	Line Or Inverter
Poles	4	Rotation	Reversible
Mounting	Rigid base	Motor Orientation	Horizontal
Drive End Bearing	Ball	Opp Drive End Bearing	Ball
Frame Material	Cast Iron	Shaft Type	T
Overall Length	24.15 in	Shaft Diameter	1.625 in
Shaft Extension	4 in	Assembly/Box Mounting	F1/F2 Capable
Outline Drawing	B-SS620703	Connection Diagram	A-EE7308K

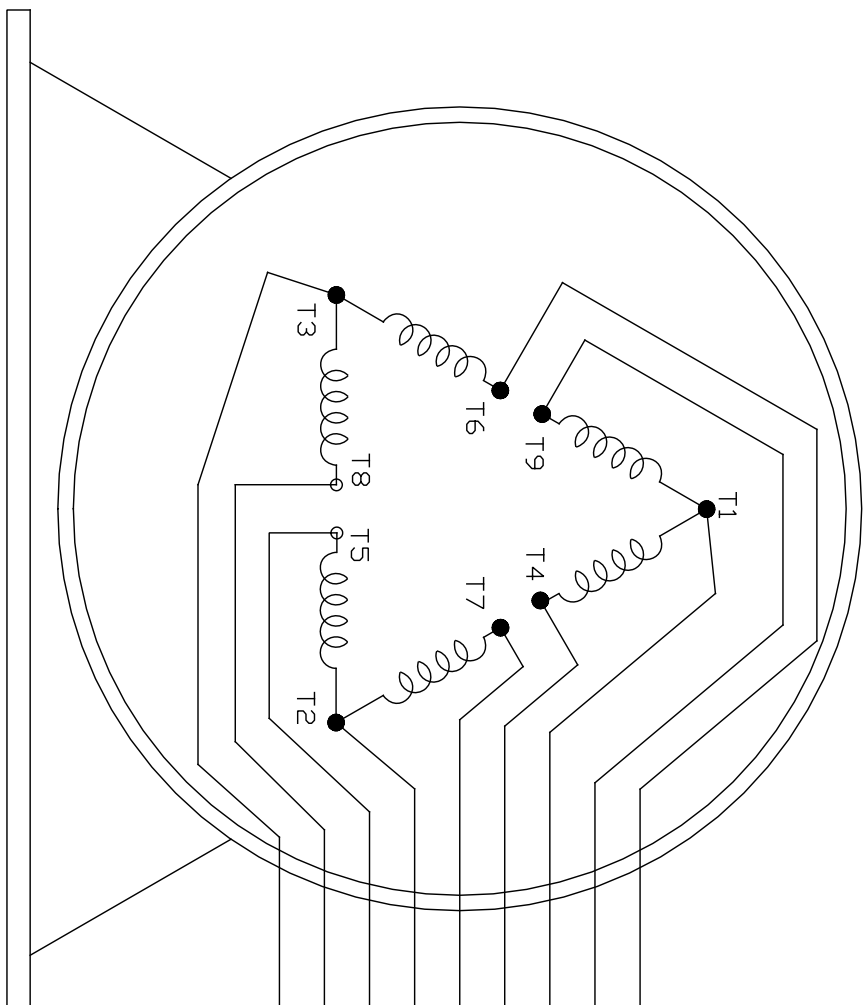
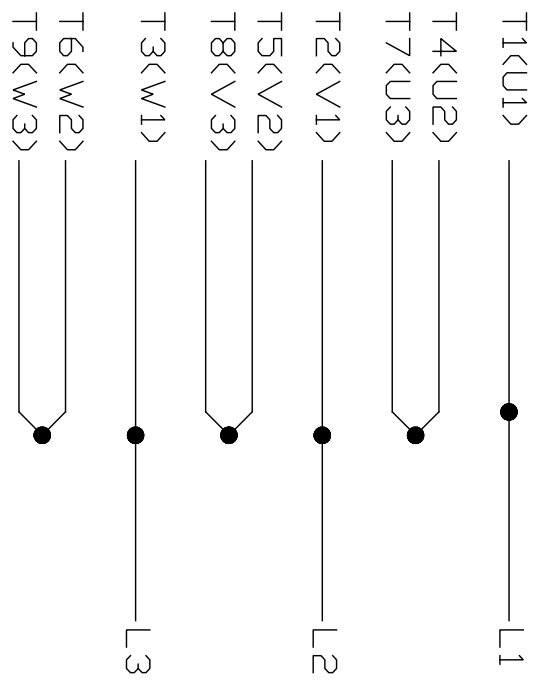
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LOW VOLTAGE



HIGH VOLTAGE



CORRECTED IEC MARKINGS		ECD-0111208	W/GJ 01-23-2017	EMH	TOLERANCES UNLESS SPECIFIED	REGAL		REGAL - BELOIT CORPORATION		DRAWN PGK 06-04-1997
RE-DRAWN WITH REGAL LOGO		ECD-0110493	W/GJ 09-30-2016	EMH X	±1	DELTA CONNECTION DIAGRAM		DELTA CON. - 3Ø - 9 LEADS		CHK ML 06-05-1997
ADDED IEC DESIGNATIONS		MU95020	TJW 4/30/2010	MJS .XX	±.02	TITLE		DELTA CON. - 3Ø - 9 LEADS		APPD GK 06-15-1997
REVISED HIGH VOLTAGE L2 WAS L3		CNS2600-354	MRB 09-21-1998	.XXX	±.005	MATERIAL		FINISH		SCALE
RE-DRAWN ON CADD			PGK 06-05-1997	.XXXX	±.0005	MAT'L.		FINISH		REF
REVISION			BY & DATE	CHK	±7/30"	FINISH		FINISH		FME
THIS DRAWING IN DESIGN AND DETAIL IS OUR PROPERTY AND MUST NOT BE USED EXCEPT IN CONNECTION WITH OUR WORK ALL RIGHTS OF DESIGN AND INVENTION ARE RESERVED THIS IS AN ELECTRONICALLY GENERATED DOCUMENT - DO NOT SCALE THIS PRINT				RFP		CAD FILE EE7308K		SIZE DRAWING NO. PAGE OF		PREV
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# Installation, Operation, and Maintenance Instructions

## NEMA 182T – 286T, IEC 112 -180 Permanent Magnet Motors Operated On Variable Frequency Drives (VFD)



[www.leeson.com](http://www.leeson.com)



[www.marathonelectric.com](http://www.marathonelectric.com)

**INSTALLER: PLEASE LEAVE THIS MANUAL FOR THE OWNER'S USE**  
**OWNER: READ AND SAVE THESE INSTRUCTIONS**

### SAFETY INSTRUCTIONS

- ▲ This is the safety alert symbol. It is used to alert you to potential personal injury hazards. Obey all safety messages that follow this symbol to avoid possible injury or death.
- ▲ **WARNING:** Warning indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.
- ▲ **CAUTION:** Caution indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.
- ▲ **NOTICE:** Notice indicates a situation not related to personal injury which, if not avoided, may result in motor or equipment damage.

▲ Before installing, using, or servicing this product, carefully read and fully understand the instructions including all warnings, cautions, & safety notice statements. To reduce risk of personal injury, death and/or property damage, follow all instructions for proper motor installation, operation and maintenance.

Although you should read and follow these instructions, they are not intended as a complete listing of all details for installation, operation, and maintenance. If you have any questions concerning any of the procedures, or if you have a safety concern not covered by the instructions, STOP, and call the appropriate motor company listed on the motor nameplate. The phone number can be found on the web site listed above.

## Table of Contents

### 1.0 SAFETY INFORMATION

- 1.1 Electrical Safety
- 1.2 Mechanical Safety
- 1.3 Environmental Safety

### 2.0 RECEIVING & INSPECTION

- 2.1 Initial Inspection
  - 2.1.1 Packing List & Inspect
  - 2.1.2 Turn Motor Shaft
  - 2.1.3 Check Nameplate
- 2.2 Handling
  - 2.2.1 Lifting Angle Limitations
- 2.3 Storage
  - 2.3.1 Bearing Lubrication
  - 2.3.2 Shaft Rotation
  - 2.3.3 Damp or Humid Storage Locations

### 3.0 INSTALLATION AND OPERATION

- 3.1 Location
  - 3.1.1 Selecting a Location
  - 3.1.2 Ambient Temperature Limits
  - 3.1.3 Construction Selection per Location
    - 3.1.3.1 Totally Enclosed
    - 3.1.3.2 Hazardous Locations Motors
- 3.2 Mounting Motor
  - 3.2.1 Rigid Base (Footed)
  - 3.2.2 Rigid Base Hole Selection -6 or 8 Hole Bases
  - 3.2.3 Vertical Mounting
- 3.3 Application Assembly to Motor
  - 3.3.1 General: Proper Alignment
  - 3.3.2 Direct Coupling
  - 3.3.3 Direct Connected
    - 3.3.3.1 Sheave Diameter Requirements
    - 3.3.3.2 Number of Belts
    - 3.3.3.3 Sheave Location
    - 3.3.3.4 Belt Tension
  - 3.3.4 Belted
    - 3.3.4.1 Sheave Diameter Requirements
    - 3.3.4.2 Number of Belts
    - 3.3.4.3 Sheave Location
    - 3.3.4.4 Belt Tension
- 3.3.5 Permanent Magnet Motor VFD Operation
  - 3.3.5.1 Overspeed Capability

- 3.3.5.2 Cable Lengths
- 3.3.5.3 VFD Grounding
- 3.3.5.4 Stray Voltage On Accessory Leads

### 3.3.6 Accessories

- 3.3.6.1 General
- 3.3.6.2 Brake Motors
- 3.3.6.3 Space Heaters
- 3.3.6.4 Thermal Protection
- 3.3.6.5 RTD Alarm & Trip Settings

### 3.3.7 Guards

### 3.4 Electrical Connections

- 3.4.1 Power Supply / Branch Circuit
  - 3.4.1.1 Fuses, Breakers, Overload Relays
  - 3.4.1.2 AC Power Supply Limits
- 3.4.2 Terminal Box
  - 3.4.2.1 Conduit opening
- 3.4.3 Lead Connections
- 3.4.4 Ground Connections
  - 3.4.4.1 Electrical Interference
- 3.4.5 Start Up
  - 3.4.5.1 Start Up – No Load Procedure
  - 3.4.5.2 Start Up – Load Connected Procedure

### 4.0 MAINTENANCE

#### 4.1 General Inspection

- 4.1.1 Ventilation
- 4.1.2 Insulation
- 4.1.3 Electrical Connections
- 4.1.4 Seal Condition
- 4.1.5 Safety Labels

#### 4.2 Lubrication and Bearings

- 4.2.1 Grease Type
- 4.2.2 Bearing Operating Temperature
- 4.2.3 Lubrication Interval
- 4.2.4 Lubrication Procedure
- 4.2.5 Lubrication Example

#### 4.3 Trouble Shooting


- 4.3.1 General Trouble-Shooting Warnings

## 1.0 SAFETY INFORMATION

### 1.1 ELECTRICAL SAFETY

#### **WARNING: ELECTRICAL SHOCK HAZARD**

Electrical connections shall be made by a qualified electrician in accordance with all applicable codes, ordinances and sound practices. Failure to follow these instructions could result in serious personal injury, death and/or property damage. Only qualified personnel who are familiar with the applicable National Code (USA = NEC) and local codes should install or repair electrical motors and their accessories.

 **WARNING: ELECTRICAL HAZARD:** Failure to connect motor and variable frequency drive in accordance with the drive manufacturer's documentation may result in serious injury, death, and/or property damage.

#### **WARNING: ELECTRICAL LIVE CIRCUIT HAZARD**

Do not touch electrically live parts. Disconnect, lockout and tag input power supply before installing or servicing motor (includes accessory devices). Use a voltmeter to verify that power is off before contacting conductors.

#### **WARNING: ELECTRICAL SHOCK HAZARD**

Shaft rotation produces voltage in PM motors even when motor is disconnected from power source. Do not open terminal box or touch unprotected terminals while the motor shaft is rotating. Failure to do so may cause serious injury or death to personnel.

#### **WARNING: ELECTRICAL HAZARD**

Shaft rotation produces voltage in PM motors even when motor is disconnected from power source. Do not operate the motor or allow equipment to back drive the motor above the maximum RPM listed on the motor nameplate. Failure to do so may cause serious injury or death to personnel or damage the motor or system equipment.

#### **WARNING: ELECTRICAL GROUNDING HAZARD**

Failure to properly ground motors, per the National Electrical Code (NEC) Article 430 and local codes may cause serious injury or death to

personnel. For general information on grounding refer to NEC Article 250. (Also see "Ground Connections section 3.4.4").

#### **WARNING: MAGNETIC FIELD HAZARD**

Permanent magnet motor rotors, when removed from the stator, expose surrounding personnel and equipment to powerful magnetic fields which may cause serious health hazards to persons with pacemakers, hearing aids, or other implanted electronic medical devices and may impact other electronic devices such as mobile phones, credit cards, etc.

#### **NOTICE: MOTOR NOT SUITED FOR OPERATION ON LINE POWER**

Permanent magnet (PM) motors can only be operated by a PM motor compatible VFD (Variable Frequency Drive). Connecting directly to line power may result in motor damage.

### 1.2 MECHANICAL SAFETY

#### **WARNING: LOOSE PARTS HAZARD**

Before starting the motor, remove all unused shaft keys and loose rotating parts to prevent them from flying off. Failure to follow these instructions could result in serious personal injury, death and/or property damage.

#### **WARNING: ROTATING PARTS HAZARD**

Keep extremities, hair, jewelry and clothing away from moving parts. Failure to follow these instructions could result in serious personal injury, death and/or property damage. See section 3.3.7.

#### **WARNING: DO NOT DISASSEMBLE:**

Due to powerful magnetic fields, disassembly and assembly of permanent magnet motors should only be performed by the manufacturer or specialized personnel authorized by the manufacturer. Only qualified personnel who are familiar with the applicable national codes, local codes and sound practices should install or repair electric motors and their accessories. See the Magnetic Field Hazard in section 1.1

## 1.3 ENVIRONMENTAL SAFETY

### **⚠ WARNING: HAZARDOUS LOCATIONS**

The NEC and the local authority having jurisdiction must be consulted concerning the installation and suitability of motors for use in Hazardous Locations, in accordance with NEC Article 500. The local authority having jurisdiction must make the final determination of what type of motor is required. The application and operation is beyond the control of the motor manufacturer. Failure to do so may cause serious injury or death to personnel.

## 2.0 RECEIVING AND INSPECTION

### 2.1 INITIAL INSPECTIONS

#### **⚠ WARNING: ELECTRICAL SHOCK HAZARD**

Shaft rotation produces voltage at motor leads and connected equipment even when motor is disconnected from power source. Do not open terminal box or touch unprotected terminals while the motor shaft is rotating. Failure to do so may cause serious injury or death to personnel.

**2.1.1 CHECK PACKING LIST AND INSPECT** the packaging to make certain no damage has occurred in shipment. If there is visible damage to the packaging, unpack and inspect the motor immediately. Claims for any damage done in shipment must be made by the purchaser against the transportation company.

**2.1.2 TURN MOTOR SHAFT** (see Electrical Shock Hazard above) by hand to be certain that it rotates freely. Note: Motor will not turn freely if leads are shorted together. User may feel small pulsations when turning shaft due to the magnets in rotor. Shaft seals and bearing seals may add drag.

**⚠ CAUTION:** Observe caution when working near threads or keyways. Finger or ring contact may cause injury.

**2.1.3 CHECK NAMEPLATE** for conformance with purchase order requirements and compliance with power supply and control equipment requirements.

### 2.2 HANDLING

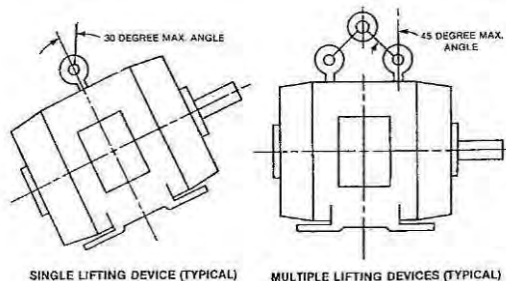
#### **⚠ WARNING: FALLING OBJECT HAZARD**

Eyebolts or lifting lugs, where provided, are intended for lifting only the motor and accessories mounted by the motor manufacturer (unless specifically stated otherwise on the motor). Utilizing the motor lifting provision to lift other components such as pumps and gear boxes could result in serious personal injury, death and/or property damage.

#### **⚠ WARNING: FALLING OBJECT HAZARD**

Before using the lifting provision, check the eyebolts and/or other lifting means to assure they are not bent or damaged and are completely threaded, seated & secured to the motor. Equipment to lift motor must have adequate lifting capacity. While lifting the motor, DO NOT stand under or in the vicinity of the motor. Failure to follow these instructions could result in serious personal injury, death and/or property damage.

#### 2.2.1 LIFTING ANGLE LIMITATIONS



**2.3 STORAGE:** Motors, not put into service immediately, must be stored indoors in a clean, dry location. Avoid locations with large temperature swings that will result in condensation. Motors must be

covered to eliminate airborne dust and dirt. If the storage location exhibits high vibration, place isolation pads under motor to minimize damage to motor bearings.

**2.3.1 BEARING LUBRICATION:** Bearings are grease packed at the factory; relubrication upon receipt of motor or while in storage is not necessary. If stored more than one year, add grease per lubrication instructions (Table 4-4) before start-up.

**2.3.2 SHAFT ROTATION:** (see Electrical Shock Hazard Warning in section 2.1) It is recommended that the motor shaft be rotated 5 to 10 rotations every three months to distribute the grease in the bearings. This will reduce the chance for corrosion to form on the bearing rolling elements and raceways. Note: User may feel small pulsations when turning shaft due to the magnets in rotor. Shaft seals and bearing seals may add drag.

**2.3.3 DAMP OR HUMID STORAGE LOCATIONS:** Treat unpainted flanges, shafts, and fittings with a rust inhibitor. Apply appropriate power to the motor's space heaters (if so equipped).

## 3.0 INSTALLATION AND OPERATION

### **⚠ WARNING: ELECTRICAL SHOCK HAZARD**

Only qualified personnel who are familiar with and understand the appropriate national codes, local codes and sound practices should install or repair electrical motors and their accessories. Installation should conform to the appropriate national code as well as local codes and sound practices. Failure to follow these instructions could result in serious personal injury, death and/or property damage.

### **⚠ WARNING: ELECTRICAL LIVE CIRCUIT HAZARD**

Do not touch electrically live parts. Disconnect, Lockout and Tag input power supply before installing or servicing motor (includes accessory devices). Use a voltmeter to verify that power is off before contacting conductors.

### **⚠ WARNING: ELECTRICAL SHOCK HAZARD**

Shaft rotation produces voltage at PM motor leads and connected equipment even when motor is disconnected from power source. Do not open terminal box or touch unprotected terminals while the motor shaft is rotating. Failure to do so may cause serious injury or death to personnel.

### **⚠ WARNING: ELECTRICAL SAFETY**

Refer to Section 1.0 for additional warnings before proceeding with installation and operation.

### 3.1 LOCATION

**3.1.1 SELECTING A LOCATION:** Consideration should be given to environment and ventilation. Motors should be installed in an area that is protected from direct sunlight, corrosives, harmful gases or liquids, dust, metallic particles, and vibration. A motor with the proper enclosure for the expected operating condition should be selected. Provide accessible clearance for cleaning, repair, service, and inspections (See section 3.1.3 for construction clearances). The location should be considered for possible future motor removal or motor handling. The free flow of air around the motor should not be obstructed.

**3.1.2 AMBIENT TEMPERATURE LIMITS:** The ambient temperatures of the air inlet to the motor should not exceed 40°C (104°F) or be less than -30°C (-22°F) unless the motor nameplate specifically states an ambient temperature outside of these limits. The ambient inside an enclosure built around the motor shall not exceed the nameplate ambient. For ambient temperatures outside of these limits consult the motor manufacturer.

### **NOTICE: INSULATION DEGRADATION WARNING**

Insulation at high temperatures ages at an accelerated rate. Each 10°C increase in temperature reduces the insulation life by one half.



### 3.1.3 CONSTRUCTION SELECTION PER LOCATION

**3.1.3.1 TOTALLY ENCLOSED MOTORS** are suitable for indoor or outdoor standard service applications. Severe duty construction is recommended for severe service applications.

**TEAO or AOM (Totally Enclosed Air Over)** motors must be mounted in the air stream. When the motor nameplate states a minimum airflow the motor must be mounted in an air stream meeting this minimum value.

**TEFC (Totally Enclosed Fan Cooled)** motors must meet a minimum distance equal to ½ the shaft height between the fan guard grill openings and the nearest obstruction.

**3.1.3.2 HAZARDOUS LOCATIONS MOTORS:** Not all motors covered by this manual are intended for hazardous duty locations. Motors intended for hazardous duty locations are labeled with the division and class.

#### **⚠ WARNING: HAZARDOUS LOCATIONS**

Hazardous Locations motors are intended for installations in accordance with NEC Article 500. For all installations involving Hazardous Locations motors, consult the applicable national codes, local codes, and the authority having jurisdiction. Failure to do so may cause serious injury or death to personnel.

**Division 2 Installations – Class I only:** Use only motors that are CSA Certified and bear the CSA Certification Mark. These motors include a phrase on the main motor nameplate that indicates the motor is CSA Certified for Class I, Division 2 / Zone 2 locations.

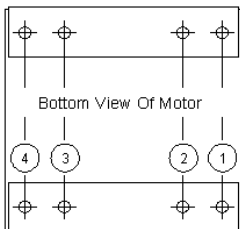
#### **⚠ WARNING: EXPLOSION HAZARD**

A motor should never be placed in an area with a hazardous process or where flammable gases or combustible materials may be present unless it is specifically designed and nameplated for this type of service. Hazardous Locations motors are intended for installations in accordance with NEC Article 500. For all installations involving Hazardous Locations motors, consult the NEC, local codes, and the authority having jurisdiction. Failure to follow these instructions could result in serious personal injury, death and/or property damage. (For other limitations see section 1.3).

### 3.2 MOUNTING MOTOR

**3.2.1 RIGID BASE (FOOTED):** The motor must be securely installed to a rigid foundation or a mounting surface to minimize vibration and maintain alignment between the motor shaft and the load's shaft. The mounting surfaces of the four mounting pads must be flat within 0.01 inches for 210 frame & smaller; 0.015 inches for 250 frame & larger. [IEC 0.25 mm for 130 frame & smaller, 0.38 mm for 160 frame & larger]. This may be accomplished by shims under the motor feet. For special isolation mounting, contact manufacturer for assistance

#### 3.2.2 RIGID BASE HOLE SELECTION -6 OR 8 HOLES



Location 1 and 3 holes for short frame:  
(NEMA) 182, 213, 254, 284  
(IEC) 112S, 132S, 160M, 180M

Location 2 holes are for F1,  
F2 Conversion (if provide)

Location 1 and 4 holes for long frames:  
(NEMA) 184, 215, 256, 286  
(IEC) 112M, 132M, 160L, 180L

#### 3.2.3 VERTICAL MOUNTING

#### **⚠ WARNING: FALLING OBJECT HAZARD**

The lifting provision on standard horizontal footed motors is not designed for lifting the motor in a vertical shaft up or shaft down position. (see Diagram 2.2.1). Doing so may cause the motor to

fall. Lifting method / provisions for mounting a rigid base (footed) motor vertically is the responsibility of the installer.

**VERTICAL SHAFT DOWN:** Most standard horizontal motors through 449 Fr. (excluding brake motors) can be mounted in a vertical shaft down orientation. For vertical brake motors see section 3.3.6.2.

#### VERTICAL SHAFT UP:

**⚠ WARNING: HAZARDOUS LOCATIONS VERTICAL MOUNT:** Hazardous locations motors must **NOT** be mounted vertically shaft up without approval by the motor manufacturer. Without proper retaining provisions the rotor may move axially and contact components, creating a spark hazard.

**Belted or Radial Load when mounted vertically:** The following frame sizes / constructions with applied (axial) down loads within the limit stated are acceptable when mounted vertical shaft up.

**Table 3-1 Belted or Radial Load Applications (All speeds)**

Frame Size	Enclosure	Construction	Shaft Up OK	Max Applied Down Load2
180	TEFC	All	Yes	35 lbs
210	TEFC	All	Yes	40 lbs
250	TEFC	All	Yes	40 lbs
280	TEFC	Cast Iron	Yes	30 lbs

Notes:

The max applied down load is any applied load external to the motor, including such things as sheave weight, fan loads, axial belt force, pump load, etc. If the application is direct drive with no applied radial load or is beyond the limits listed, consult the motor manufacturer.

### 3.3 APPLICATION ASSEMBLY TO MOTOR

#### NOTICE: EQUIPMENT DAMAGE

Do not connect or couple motor to load until correct rotational direction is established.

**3.3.1 GENERAL: PROPER ALIGNMENT** of the motor and driven equipment minimizes vibration levels, maximizes bearing life, and extends the overall life of the machinery. Consult the drive or equipment manufacturer for more information.

#### NOTICE: BEARING FAILURE

During assembly do **NOT** force components onto the shaft. Striking or hammering the component may result in bearing damage.

**3.3.2 DIRECT COUPLING:** Use flexible couplings if possible.

For applications that apply radial, axial or moment loading on the motor shaft see section 3.3.3.

#### NOTICE: BEARING FAILURE

Unless approved by the motor manufacturer, do **NOT** direct couple a vertical shaft up motor or roller bearing motor. Direct coupling a vertical shaft up motor or a motor with a roller bearing may result in bearing damage.

**3.3.3 DIRECT CONNECTED:** Radial loading for direct connected equipment (gears, fans etc.) must be approved by the motor manufacturer unless within the maximum overhung load limits (Table 3-2). Combined loading (axial, radial and/or moments) must be approved by motor manufacturer. For belted loads see section 3.3.4.

**Table 3-2 Maximum Radial Load (pounds force) @ Middle of the Shaft Extension Length**

NEMA Frame	Motor Rated RPM			
	3600	1800	1200	900
182T	187	230	261	287
184T	193	237	273	301
213T	319	317	470	510
215T	327	320	480	533
254T	500	631	729	793
256T	510	631	736	820
284T	-	866	990	1100
286T	-	871	1005	1107

Values based on 26,280 hrs B-10 Life  
For "End of Shaft" Load multiply value by 0.88

### 3.3.4 BELTED

The goal of any belted system is to efficiently transmit the required torque while minimizing the loads on the bearings and shafts of the motor and driven equipment. This can be accomplished by following four basic guidelines:

1. Use the largest practical sheave diameter.
2. Use the fewest number of belts possible.
3. Keep sheaves as close as possible to support bearings.
4. Tension the belts to the lowest tension that will still transmit the required torque without slipping. V-belts may squeal initially in high starting torque applications.

#### 3.3.4.1 Sheave Diameter Guidelines

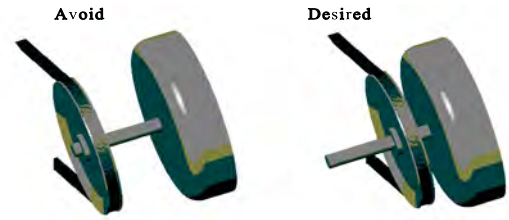
In general, smaller sheaves produce greater shaft stress and shaft deflection due to increased belt tension. See Table 3-3 (next page) for recommended minimum sheave diameters. Using larger sheaves increases the contact with belts which reduces the number of belts required. It also increases the belt speed, resulting in higher system efficiencies. When selecting sheaves, do not exceed the belt manufacturer's recommended maximum belt speed, typically 6,500 feet per minute for cast iron sheaves. Determine belt speed by the following formula:

$$\text{BELT SPEED (Ft/min)} = \frac{\text{Shaft RPM} \times 3.14 \times \text{Sheave Dia (inches)}}{12}$$

**Figure 1**



**Figure 2**



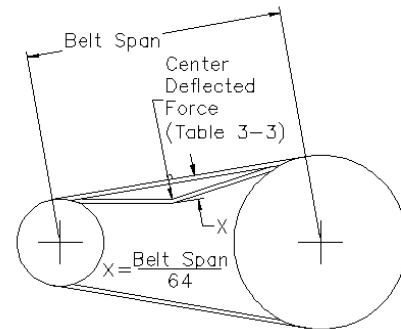
#### 3.3.4.4 Belt Tension

##### **⚠ WARNING: EQUIPMENT FAILURE**

Excessive belt tension may lead to bearing failure and/or shaft failure. Failure to properly tension belts may result in serious personal injury, death, and/or property damage. Belt tension must be adjusted using a belt tension gage. Adjusting belt tension by "feel" (i.e., pushing on belt with fingers or hand) may result in excessive belt tension.

In general, belt tensions should be kept as loose as possible while still transmitting the required torque without slipping. Belt tensions must be measured with a belt tension gage. These inexpensive gages may be obtained through belt manufacturers or distributors. V-belts may squeal initially in high starting torque applications.

Proper belt tension is determined by measuring the force required to deflect the center of the belt a given distance. The proper deflection (in inches) is determined by dividing the belt span in inches by 64. Calculate the proper deflection and then see Table 3-3 (next page) for the required "Average Deflected Force" to achieve that deflection.



After tensioning the belt, rotate the sheaves for several rotations or operate the system for a few minutes to seat belts into the grooves, then re-tension the belts. New belts will stretch during use, and should be retensioned after the first eight hours of use.

#### 3.3.4.2 Number of Belts

In general, use the fewest number of belts that will transmit the required torque without slipping. See Table 3-3 (next page) for recommended maximum number of belts. Each belt adds to the tension in the system, which increases load on the shafts and bearings. Belts are most efficient when operated at or near their rated horsepower.

If the sheaves have more grooves than the number of belts required, use the grooves closest to the motor.

#### 3.3.4.3 Sheave Location

Install sheaves as close to the housing as possible to increase the bearing life of the motor and driven equipment.

### 3.3.5 PERMANENT MAGNET MOTOR VFD (Variable Frequency Drives) OPERATION

##### **⚠ CAUTION: Power Factor Correction Capacitors**

Placing power factor correction capacitors between the motor and VFD may cause personal injury and significant damage to the VFD. Power factor correction capacitors should never be installed between the VFD and the motor and should not be installed at VFD input unless approved by VFD manufacturer.

##### **NOTICE: MOTOR NOT SUITED FOR OPERATION ON LINE POWER**

PM motors can only be operated by a PM motor compatible VFD. Connecting directly to line power may result in motor damage. Consult VFD installation and operation manual for additional instructions and safety information.

**Table 3-3 Recommended Minimum Sheave Diameters, Belt Type, Number of Belts and Deflected Force**

Motor Hp	1200 rpm				1800 rpm				3600 rpm			
	Min Sheave Dia (in)	Belt Type	Max # of Belts	Avg. Deflected Force (lbs)	Min Sheave Dia (in)	Belt Type	Max # of Belts	Avg. Deflected Force (lbs)	Min Sheave Dia (in)	Belt Type	Max # of Belts	Avg. Deflected Force (lbs)
0.75	2.2	3VX	1	3.4	2.2	3VX	1		2.2	3VX	1	
1	2.4	3VX	1	4.0	2.2	3VX	1	3.1	2.2	3VX	1	
1.5	2.4	3VX	2	3.1	2.4	3VX			2.2	3VX	1	2.5
2	2.4	3VX	3	2.8	2.4	3VX	2	2.9	2.4	3VX		
3	3.0	3VX	2	3.3	2.4	3VX	3	2.9	2.4	3VX	2	2.3
5	3.0	3VX	3	4.0	3.0	3VX	3	3.7	2.4	3VX	3	2.5
7.5	3.8	3VX	4	4.7	3.0	3VX	4	4.1	3.0	3VX	2	4.2
10	4.4	3VX	4	5.4	3.8	3VX	4	4.3	3.0	3VX	3	3.8
15	4.4	3VX	5	5.4	4.4	3VX	4	5.4	3.8	3VX	3	4.4
20	5.2	3VX	6	6.0	4.4	3VX	6	4.8	4.4	3VX	3	5.0
25	6.0	3VX	7	5.6	4.4	3VX	7	5.2	4.4	3VX	4	4.7
30	6.8	3VX	7	5.9	5.2	3VX	7	5.3				

**Notes:**

- The ratings listed above assume normal frame size assignments per NEMA MG-1 (2009) Table 13.2. Horsepower is the nameplate motor horsepower, and RPM is the motor (driver) speed.
- Minimum sheave diameters are from NEMA standards where applicable.
- For variable speed applications or values outside these recommendations, consult motor manufacturer.**
- Selections are based on a 1.4 belt service factor, 5 to 1 speed reduction and various Power Transmission Manufacturers' catalogs.
- These selections are for Narrow V-belt sections only. Consult motor manufacturer for details on conventional V-belt sections (A, B, C, D and E), or other belt types.
- "Average Deflected Force" is per section 3.3.4.4 of this document and is the force required to deflect the center of a belt 1/64 of the belt span distance. Tolerance on this force is ±1 lbf for forces ≤10 lbs, and ±2 lbs for forces >10 lbs as measured utilizing a belt tension gage.
- When more than one belt is required, the belts must be a matched set (matched for length).
- If possible, the lower side of the belt should be the driving side to increase the length of wrap on the sheave.
- Do not exceed nameplate maximum RPM.

**NOTICE: VFD / Motor Setup**

It is the responsibility of the startup personnel during set up of the VFD / motor system to properly tune the drive to the motor for the specific application per the VFD user manual. The correct voltage boost, volts per hertz, and overload current level settings are application dependent and unique to each motor design. Current setting shall not exceed nameplate service factor amps. Failure to connect over temperature devices (when provided) will void the warranty.

**3.3.5.1 Overspeed Capability**

Do not exceed nameplate maximum RPM without first contacting manufacturer.

**⚠ WARNING: ELECTRICAL HAZARD**

Shaft rotation produces voltage in PM motors even when motor is disconnected from power source. Do not operate the motor or allow equipment to back drive the motor above the maximum RPM listed on the motor nameplate. Failure to do so may cause serious injury or death to personnel or damage the motor or system equipment.

**3.3.5.2 Cable Lengths:** These motors are equipped with an insulation system designed for use with variable frequency drives. For optimum insulation life, limit VFD to motor cable lengths as documented in Table 3-5. For additional information, or for installations requiring longer cable runs, please contact the motor manufacturer.

**Table 3-5 Max Cable Lengths**

These values are based on 3 kHz carrier frequency. Add suitable VFD output-side filters when exceeding the listed values.

Frame Size	230V	460 V	575 V
NEMA 180-280	2000 ft.	2000 ft.	650 ft.
IEC 112-180	600 m.	600 m.	200 m.

**3.3.5.3 VFD Grounding:** See Grounding section 3.4.4

**3.3.5.4 Stray Voltage on Accessory Leads**

VFDs will couple stray voltage to accessories such as RTDs, thermistors, thermostats and space heaters. The leads of these elements must be properly insulated and control input circuits must be designed to withstand this voltage.

**3.3.6 ACCESSORIES / PROVISIONS**

**3.3.6.1 General:** Carefully read and understand the accessory manufacturer's instructions, supplied with motor. Contact the manufacturer for additional information.

**3.3.6.2 Brake Motors**

**⚠ WARNING: Backup Brake System**

Failure of the brake may put people in the vicinity of the motor at risk for serious personal injury or death, or cause damage to nearby equipment. If people or equipment will be in the vicinity of the motor, a backup system should be supplied.

**⚠ WARNING: Vertical Motor Premature Brake Failure**

Motors with brakes that are designed for vertical applications are equipped with springs to support the brake pressure plate. Mounting a horizontal brake motor vertically shaft up or down may require a pressure plate spring modification. Failure to modify the brake for the vertical application may result in premature brake failure, creating a risk of serious personal injury or death and/or equipment damage. If in question, consult brake literature or brake manufacturer.

**⚠ WARNING: DO NOT CONNECT BRAKE SOLENOID to the output of a VFD.** The brake solenoid must be wired to 50/60 Hz line power for proper operation. Failure to do so may result in brake damage, potentially leading to serious injury, death, or equipment damage.

**3.3.6.3 Space Heaters**

Motors provided with space heaters have two leads that are brought into the conduit box or into an auxiliary box. These leads are marked "H1", "H2" ("H3", "H4" if a second space heater is supplied). See the space heater nameplate on motor for heater rating.

**⚠ WARNING: DIVISION 2 EXPLOSION HAZARD**

The space heater temperature rating when used in Class I, Division 2 motors shall **NOT** exceed 80% of the auto ignition temperature of the hazardous gas or vapor. See the space heater nameplate on motor for heater Temperature Code and heater rating. Failure to follow this instruction could result in serious personal injury, death and/or property damage

### 3.3.6.4 Thermal Protection

**General Information:** When thermal protection is provided, "WITH OVERHEAT PROTECTIVE DEVICE" will be stamped on the nameplate. The motor is provided with an overheat protective device that does not directly open the motor circuit. Motors nameplated with this phrase have either thermostats, thermistors or RTDs. The leads to these devices are routed into the motor conduit box or into an auxiliary box. The lead markings are defined on the nameplate.

**THERMOSTAT:** The circuit controlled by the thermostats must be limited to a maximum of 600 volts and 360 volt-amps. See connection decal provided inside the terminal box cover. Failure to connect these over temperature devices (when provided) will void the motor warranty.

### THERMISTERS OR RESISTANCE TEMPERATURE DETECTORS (RTDs)

These sensors are to be connected to a solid state resistance monitoring device designed for use with thermistors or RTDs. Failure to connect these over temperature devices (when provided) will void the motor warranty.

### 3.3.6.5 RTD Alarm & Trip Settings

Tables 3-6 & 3-7 are suggested initial RTD alarm and trip settings. For motors found to operate significantly below these values the settings may be reduced accordingly.

**Table 3-6 Winding RTD – Temperature Limit (8C)  
40 8C Max Ambient**

Temperature (degrees C)	
Alarm	Trip
130	140

**Table 3-7 Bearing RTD – Temperature Limit (8C)  
40 8C Max Ambient**

Bearing Type	Alarm	Trip
Standard bearings	110	115
Motors specified with heat stabilized bearings to 150 C	130	135

### 3.3.7 GUARDS

#### **⚠ WARNING: ROTATING PARTS HAZARD**

When devices are assembled to the motor shaft, be sure to install protective devices such as belt guards, chain guards, and shaft covers. These devices must protect against accidental contact with extremities, hair, and clothing. Consider the application and provide guarding to protect personnel. Remove all unused shaft keys and loose rotating parts to prevent them from flying off and causing bodily injury. Failure to follow this warning could result in serious personal injury, death and/or property damage.

## 3.4 ELECTRICAL CONNECTIONS

#### **⚠ WARNING: ELECTRICAL HAZARDS**

Before proceeding read Section 1.1 on Electrical Safety. Failure to follow the instructions in Section 1.1 could result in serious personal injury, death and/or property damage

**⚠ WARNING: ELECTRICAL SHOCK HAZARD:** Voltage may be present at the motor terminals even after the motor has stopped rotating. To assure there is no voltage at motor, remove input power from VFD and follow VFD manufacture documentation for voltage decay time before servicing motor. Failure to follow this instruction could result in serious personal injury or death.

## NOTICE: MOTOR NOT SUITED FOR OPERATION ON LINE POWER

Permanent magnet motors can only be properly operated by a variable frequency drive (VFD). Attempting to run in bypass mode (across the line) may cause motor damage.

### 3.4.1 POWER SUPPLY / BRANCH CIRCUIT

#### **⚠ WARNING: POWER SUPPLY INCOMPATIBILITY HAZARD**

Check power supply to make certain that voltage, frequency and current carrying capacity are in accordance with the motor nameplate and VFD. Connecting the VFD to the wrong power source could result in serious personal injury, death and/or property damage

#### **⚠ WARNING: BRANCH CIRCUIT SUPPLY HAZARD**

Motor and control wiring, fusing, overload protection, disconnects, accessories and grounding must always conform to the applicable electrical codes as well as local codes and sound practices.

#### 3.4.1.1 Fuses, Breakers, Overload Relays

Consult variable frequency drive (VFD) operating manual and applicable electric codes for branch circuit protection sizing.

#### **⚠ WARNING: PROTECTIVE DEVICE DISABLED HAZARD**

DO NOT bypass or disable these or other protective devices. Protection removal could result in serious personal injury, death and/or property damage.

#### 3.4.1.2 AC Power Supply Limits

PM motors are designed to operate with variable frequency drives with rated input voltage 600 VAC or less. Drive RMS output voltage should not exceed motor nameplate voltage for which the motor is connected.

#### NOTICE: REDUCED MOTOR PERFORMANCE

Operation outside of these limits will degrade motor performance and increase operating temperature.

### 3.4.2 TERMINAL BOX

#### **⚠ WARNING: ELECTRICAL SHOCK HAZARD**

Shaft rotation produces voltage in PM motors even when motor is disconnected from power source. Do not open terminal box or touch unprotected terminals while the motor shaft is rotating. Failure to do so may cause serious injury or death to personnel.

#### 3.4.2.1 Conduit Opening

For ease of connections, motors are typically provided with large terminal boxes. Most motors have conduit access in 90 degree increments, the terminal box conduit opening is typically provided via knockouts, holes with covers, or the terminal box is rotatable. Fabricated conduit boxes may have a removable plate for the installer to provide correctly sized hole(s).

### 3.4.3 LEAD CONNECTIONS

Electrical connections are to be made per nameplate connection diagram or separate connection plate. In making connections follow the applicable electrical code as well as local codes and practices.

#### **⚠ WARNING: ELECTRICAL CONNECTION HAZARD**

Failure to correctly connect the motor leads and grounding conductor can result in serious personal injury or death. Motor lead connections can short and cause damage or injury if not well secured and insulated.

### 3.4.4 GROUND CONNECTION(S)

#### **⚠ WARNING: ELECTRICAL GROUNDING HAZARD**

For general information on grounding (USA) refer to NEC Article 250. Improper grounding of an inverter fed motor may result in frame voltages in excess of 500 Volts. In making the ground connection, the installer must make certain that a good electrical connection is obtained between motor and grounding lead. Failure to properly ground motors, per the applicable national code (such as NEC Article 430) and local codes may cause serious injury or death to personnel.

Equalize ground potential between the motor and driven equipment if the driven equipment and motor are not mounted to the same metallic base plate.

#### 3.4.4.1 Electrical Interference

Due to high switching frequencies of variable frequency drives, use a low resistance ground cable that is low impedance at high frequencies. A shielded motor power cable with a complete circumferential braided or copper film ground jacket around the power leads is recommended to minimize electrical interference. Secure this ground to both the motor's primary ground and the variable frequency drive ground.

**Primary "Internal" Ground:** A grounding conductor must be connected to the grounding terminal provided in the terminal housing. This grounding terminal is either a ground screw, ground lug, or a tapped hole to be used with a separately provided ground screw. The internal grounding feature is accessible inside the terminal housing and must be used as the primary grounding connection.

**Secondary "External" Ground:** Some motors are provided with a supplemental grounding terminal located on the external surface of the motor frame or feet. This external terminal is for supplemental grounding connections where local codes permit or require such connection.

### 3.4.5 START UP

**⚠ WARNING: LOOSE & ROTATING PARTS HAZARD**  
Before proceeding read Section 1.2 on Mechanical Safety. Failure to follow the instructions could result in serious personal injury, death and/or property damage

**⚠ WARNING: ELECTRICAL LIVE CIRCUIT HAZARD**  
Shaft rotation produces voltage in PM motors even when motor is disconnected from power source. Do not open terminal box or touch unprotected terminals while the motor shaft is rotating. Failure to do so may cause serious injury or death to personnel

**⚠ WARNING: ELECTRICAL SHOCK HAZARD**  
Be certain that all connections are secure and the conduit box cover is fastened in place before electrical power is applied. Failure to follow these instructions could result in serious personal injury, death, and/or property damage.

**⚠ WARNING: EXCESSIVE SURFACE TEMPERATURE HAZARDOUS LOCATIONS**  
Motors with the temperature code stated on the nameplate are designed to operate within this limit. Improper application or operation can cause the maximum surface temperature to be exceeded. A motor operated in a Hazardous Location that exceeds this surface temperature limit increases the potential of igniting hazardous materials. Therefore, motor selection, installation, operation, and maintenance must be carefully considered to ensure against the following conditions: (1) Motor load exceeds service factor value, (2) Ambient temperature above nameplate value, (3) Voltages outside of limits in Section 3.4.1.2, (4) Loss of proper ventilation, (5) VFD operation exceeding motor nameplate rating, (6) Altitude above 3300 feet / 1000 meters, (7) Severe duty cycles, (8) Repeated starts, (9) Motor stall, (10) Motor reversing, and (10) Single phase operation. Failure to follow these instructions could result in serious personal injury, death and/or property damage.

**⚠ CAUTION: USER CONTACT OF HOT SURFACE**  
Normal motor surface temperatures may exceed 90 ° C (194° F). Touching the motor frame may cause discomfort or injury. Surface temperatures should only be measured with suitable instruments and not estimated by hand touch.

#### 3.4.5.1 Start Up - No Load Procedure

**⚠ WARNING: ROTATION HAZARD**  
Incorrect motor rotation direction can cause serious or fatal injury or equipment damage. Verify rotation direction before coupling to driven equipment.

1. **Check Instructions:** Before startup carefully read and fully understand these instructions including all warnings, cautions, and safety notice statements.

#### 2. Motor out of storage after more than three months:

Check winding insulation integrity with a Megger. If winding resistance to ground is less than 1.5 Meg-ohms consult the local authorized service shop before energizing the motor.

3. **Check Installation: Mechanical** - Check tightness of all bolts and nuts. Manually rotate the motor shaft to ensure motor shaft rotates freely. Note: Motor will not turn freely if power leads are shorted together. User may feel small pulsations when turning shaft due to the magnets in rotor. Shaft & bearing seals will add drag.

**Electrical** - Inspect all electrical connections for proper terminations, clearance, mechanical tightness and electrical continuity. Be sure to verify connections are made per the nameplate connection diagram or separate connection plate. Replace all panels and covers that were removed during installation before energizing the motor.

#### 4. Energize Motor: Check Rotation

If practical, check motor rotation before coupling to the load. If motor has a rotational arrow, only operate the motor in the rotation identified. Energize VFD and momentarily jog motor to verify direction of rotation. If opposite rotation is required, (a) select reverse rotation from VFD or (b) de-energize VFD, remove power, then reconnect motor leads for reverse rotation. Repeat jog cycle and ensure proper rotation.

#### 5. Record No Load Amps, Watts & Voltage:

Recommend - To establish a baseline value check and record the no load amps, watts, and voltage.

### 3.4.5.2 Start Up – Load Connected Procedure

1. **Check Instructions:** Before startup carefully read and fully understand these instructions including all warnings, cautions, & safety notice statements.
2. **Coupling Installation:** Check that the connected equipment is properly aligned and not binding. Check that all guards and protective devices are properly installed.
3. **Energize Motor:** When all personnel are clear of the machine, apply power and verify that the load is not transmitting excessive vibration back to the motor through the shaft or the foundation. Verify that motor amps are within nameplate rating. The equipment can now be fully loaded and operated within specified limits as stated on the nameplate.

## 4.0 MAINTENANCE

**⚠ WARNING: ELECTRICAL SHOCK HAZARD:** Voltage may be present at the motor terminals even after the motor has stopped rotating. Disconnect power to the VFD and verify VFD DC output voltage is zero before performing service or maintenance. Failure to follow this instruction could result in serious personal injury or death.

**⚠ WARNING: ELECTRICAL SHOCK HAZARD**  
Electrical connections are to be made by a qualified electrician in accordance with all applicable codes, ordinances and sound practices. Failure to follow these instructions could result in serious personal injury, death and/or property damage. Only qualified personnel who are familiar with the applicable national codes, local codes and sound practices should install or repair electric motors and their accessories.

**⚠ WARNING: ELECTRICAL LIVE CIRCUIT HAZARD**  
Do not touch electrically live parts. Disconnect, lockout and tag input power supply before installing or servicing motor (includes accessory devices).

**⚠ WARNING: ELECTRICAL LIVE CIRCUIT HAZARD**  
Shaft rotation produces voltage in PM motors even when motor is disconnected from power source. Do not open terminal box or touch unprotected terminals while the motor shaft is rotating. Failure to do so may cause serious injury or death to personnel

**⚠ WARNING: DISASSEMBLY APPROVAL REQUIRED**  
Due to powerful magnetic fields, disassembly and assembly of permanent magnet motors should only be performed by the manufacturer or specialized personnel authorized by the manufacturer.

**⚠ WARNING: MAGNETIC FIELD HAZARD**  
Permanent magnet motor rotors contain powerful magnetic fields. Exposure to magnetic field may cause serious health hazards to persons

with pacemakers, hearing aids, or other implanted electronic medical devices and may impact other electronic devices such as mobile phones, credit cards, etc.

**⚠ WARNING: ELECTRICAL SAFETY**

Refer to Section 1.0 for additional warnings before proceeding with maintenance.

**4.1 GENERAL INSPECTION**

Inspect the motor approximately every 500 hours of operation or every three months, whichever occurs first. Keep the motor clean and the ventilation and fin openings clear. The following steps should be performed at each inspection:

**4.1.1 VENTILATION:** Check that the ventilation openings and/or exterior of the motor are free of dirt, oil, grease, water, etc, which can accumulate and block motor ventilation. If the motor is not properly ventilated, overheating can occur and cause early motor failure.

**4.1.2 INSULATION:** To monitor motor insulation, disconnect motor from the VFD and use a “Megger” to take periodic readings. Record the Megger readings. If winding resistance to ground is less than 1.5 Meg-ohms consult the local authorized service shop before re-energizing the motor.

**4.1.3 ELECTRICAL CONNECTIONS:** With all power off and motor stopped, check all electrical connectors to be sure that they are tight.


**4.1.4 SEAL CONDITION:** When supplied, check the condition of shaft seals and replace if necessary.

**4.1.5 SAFETY LABELS:** Do not remove or cover safety labels. Inspect and clean safety labels to maintain visibility. Replace labels if they are no longer readable.

The lubricating ability of grease (over time) depends primarily on the type of grease, the size of the bearing, the speed at which the bearing operates and the severity of the operating conditions. Longer bearing life can be obtained if the listed recommendations are followed:

NOTE: If lubrication instructions are provided on the motor nameplate, the nameplate instructions will supersede these instructions. Motors marked “Permanently Lubricated” do not require additional service”.

**NOTICE: BEARING / MOTOR DAMAGE**

Lubricant should be added at a steady state of moderate pressure. If added under heavy pressure, bearing shield(s) may collapse. Over greasing bearings  greatly increases bearing friction and can cause premature bearing and/or motor failure.

**4.2.1 GREASE TYPE (unless nameplate states otherwise)**  
**Nameplate Ambient Temperature between -30°C (-22°F) to 65°C (150°F) inclusive:** Recommended grease for standard service conditions is Polyrex EM (Exxon Mobil). Equivalent and compatible greases include: Texaco Polystar RB, Rykon Premium #2, Pennzoil Pen 2 Lube, Chevron SRI & Mobil SHC 100.

**Nameplate Ambient Temperature below -30°C (-22°F):** Special low temperature grease is recommended, such as Aeroshell 7 or Beacon 325 for ball bearings and Mobil SHC 100 for roller bearings.

**Nameplate Ambient Temperature above 65°C (150°F):** Dow Corning DC44 or equivalent, a special high temperature grease is required. Note that Dow Corning DC44 grease does not mix with other grease types.

**4.2.2 BEARING OPERATING TEMPERATURE**

**⚠ CAUTION: HOT SURFACE**

The external surface temperature of the end shield (bracket) bearing hub may reach 100° C (212° F) during normal operation. Touching this surface may cause discomfort or injury. Surface temperatures should only be measured with suitable instruments and not estimated by hand touch.

For RTD settings see Table 3-7.

**4.2 LUBRICATION & BEARINGS**

**4.2.3 LUBRICATION INTERVALS (For motors with regreasing provisions)**

**Eq. 4.2 Lubrication Interval = [(Table 4-1) hrs] x [Interval Multiplier (Table 4-2)] x [Construction Multiplier (Table 4-3)]**  
 Recommended lubrication intervals are shown in Table 4-1. These values are based on average use.

**Table 4-1 Lubrication Intervals**

NEMA / [IEC] Frame Size	Operating Speed – RPM (See Table 3.4 for Maximum Operating Speed)					
	<7200	<5400	<4500	<3600	<1800	<1200
180 [110]	2500 Hrs.	4000 Hrs	5000 Hrs	6000 Hrs.	17000 Hrs.	20000 Hrs.
210-250 [130-160]		2500 Hrs	4000 Hrs	5000 Hrs.	12000 Hrs.	16000 Hrs.
280 [180]		2000 Hrs	3000 Hrs	4000 Hrs.	10000 Hrs.	14000 Hrs.

**Seasonal Service:** If motor remains idle for more than six months, Lubricate at the beginning of the season, then follow lubrication interval.  
**Do not exceed maximum safe operating speed without manufacturer’s approval**

**Table 4-2 Service Conditions**

**Use highest level Multiplier:** Maximum Ambient Temperature and Contamination are independent factors

Severity of Service	Maximum Ambient Temperature	Atmospheric Contamination	Multiplier
Standard	Less than 40° C (104° F)	Clean, Slight Corrosion, indoors, less than 16 hrs per day	1.0
Severe	Above 40° C (104° F) to 50° C	Moderate dirt or Corrosion or outdoors or more than 16 hrs per day	0.5
Extreme	Greater than 50° C or Class H Insulation	Severe dirt or Abrasive dust or Corrosion	0.2



**Table 4-3 Construction Multiplier**

Construction	Multiplier
Angular Contact or Roller Bearing	0.5
Vertical Motor	0.5
All others	1.0

**Table 4-4 Relubrication Amounts**

Frame Size		Volume		
NEMA	IEC	Cu. In.	Fluid oz	ml
180	110	0.50	0.28	8.0
210	130	0.75	0.42	12.5
250	160	1.00	0.55	16.0
280	180	1.50	0.83	25.0

For regreasing while operating multiply volume by 125%.

**4.2.4 LUBRICATION PROCEDURE  
(For Motors with Regreasing Provisions)**

**NOTICE: BEARING DAMAGE WARNING**

Added grease must be compatible with the original equipment's grease. If a grease other than those stated in 4.2.1 is to be utilized, contact the motor manufacturer. Nameplate information supersedes section 4.2.1 (GREASE TYPE). New grease must be free of dirt. Failure to follow these instructions and procedure below may result in bearing and/or motor damage.

**NOTICE: GREASE DRAIN PLUGGED**

Old grease may completely block the drain opening and must be mechanically removed prior to regreasing. Forcing a blocked drain open by increased greasing pressure may collapse bearing shields and / or force excess grease through the bearings and into the motor.

For an extremely dirty environment, contact the motor manufacturer for additional information.

**LUBRICATION PROCEDURE:**

1. Clean the grease inlet plug or zerk fittings prior to regreasing.
2. (If present) Remove grease drain plug and clear outlet hole blockage.
3. Add grease per Table 4-4
4. Re-install grease inlet and drain plugs (if removed).

**4.2.5 EXAMPLE: LUBRICATION**

Assume - NEMA 286T (IEC 180), 1750 RPM Vertical motor driving an exhaust fan in an ambient temperature of 43° C and the atmosphere is moderately corrosive.

1. Table 4-1 list 10,000 hours for standard conditions.
2. Table 4-2 classifies severity of service as "Severe" with a multiplier of 0.5.
3. Table 4-3 lists a multiplier value of 0.5 for "Vertical"
4. (Eq. 4.2) Interval = 10,000 hrs x 0.5 x 0.5 = 2500 hrs
5. Table 4-4 shows that 1.5 cubic inch of grease is to be added.

**Relubricate every 2,500 hrs of service with 1.5 cubic inch of recommended grease.**

**4.3 TROUBLE-SHOOTING**

**⚠ WARNING: READ INSTRUCTIONS:**

Before trouble-shooting a motor, carefully read and fully understand the warnings, cautions, & safety notice statements in this manual. Failure to do so could cause severe injury, death, and/or equipment damage

**4.3.1 GENERAL TROUBLE SHOOTING**

**⚠ WARNINGS:**

1. **Disconnect power to the VFD and verify VFD DC output voltage is zero before performing service or maintenance.**
2. **Always keep hands, hair, and clothing away from moving parts.**
3. **Be sure required safety guards are in place before starting equipment.**
4. **If the problem persists, contact the manufacturer.**

**Motor Trouble-shooting Cause / Corrective Action - Table 4-5**

**⚠** Before conducting any trouble-shooting, be sure to read and follow all safety warnings and instructions. Failure to do so could cause severe injury, death, and/or equipment damage.

Issue	Likely Cause	Corrective Action
<b>Motor fails to start upon initial installation</b>		
<b>A</b>	Low or no input voltage to VFD.	(1) Ensure that rated input voltage is present at VFD. Ref. Section 3.4.1.2. (2) Check line fuses. Ref. Section 3.4.1.1.
<b>B</b>	Motor leads are not connected or miswired in conduit box or at VFD output terminals.	(1) Match motor lead wiring to motor nameplate connection diagram for operating voltage. Ref. Section 3.4.3. (2) Check continuity between VFD and motor terminals. Ref. Section 3.4.5.
<b>C</b>	Driven load exceeds motor/VFD capacity. VFD may trip on overload fault.	(1) Verify that VFD current / torque limit setting equals motor rated service factor amps (these parameters may be set to zero at the factory for safety purposes). Ref Section 3.3.5 (2) Verify that motor and VFD rating are adequate for application.
<b>D</b>	Load is jammed or motor is binding. VFD trips on overload fault.	(1) Verify that motor & load turn freely. Ref. Section 3.4.5. (2) Disconnect motor from load & ensure motor turns freely. Ref. Section 3.4.5. (3) Verify that motor starts when disconnected from load. Ref. Section 3.4.5. (4) Remove excessive / binding load if present.
<b>E</b>	Acceleration time set too short.	Increase acceleration to maximum acceptable time for the application.
<b>F</b>	VFD programmed incorrectly. VFD trips on overload fault.	(1) Repeat checks listed above. (2) Consult VFD service manual. Ref. Section 3.3.5.

### Motor has been running, then slows down, stalls, or fails to restart

<b>A</b>	Drive has faulted.	Check fault codes on VFD and follow VFD troubleshooting procedures. Ref Section 3.3.5.
<b>B</b>	Supply voltage to VFD has drooped or has become severely unbalanced.	(1) Check fuse or reset circuit breaker. Ref. Section 3.4.1.1. (2) Verify that rated and balanced supply voltage has been restored at VFD input before restarting motor. Measure VFD input voltage after motor has reached set speed during restart. Ref. Section 3.4.1.2.
<b>C</b>	Motor is overloaded. VFD trips on overload.	(1) Verify that motor & load turn freely. Ref. Sections 3.3.5 and 3.4.5.
<b>D</b>	Motor bearings are seized.	(2) Disconnect motor from load & ensure motor turns freely. Ref. Section 3.4.5. (3) Verify that motor starts when disconnected from load. Ref. Section 3.4.5.
<b>E</b>	Load is jammed. VFD trips on overload.	(4) Remove excessive / binding load if present. (5) Motor may have overheated. Check thermostats and if tripped, allow motor to cool before attempting to restart. Ref. Section 3.3.6.4.
<b>F</b>	VFD will not restart motor after tripping.	(1) Check fault codes on VFD and follow VFD troubleshooting procedures. (2) Verify that VFD input voltage is balanced and within limits. Ref. Section 3.4.1. (3) Remove excessive mechanical load if present.
<b>G</b>	Rotor magnets have been partially demagnetized due to excessive heat or excessive current.	To diagnose, motor must be cooled to room temperature. Disconnect motor shaft from load and motor leads from VFD. Ref. Section 4.0. Connect AC volt meter across T1 and T2 motor leads. Drive motor at a speed below rated speed and measure both voltage generated and actual RPM. The voltage per 1000 rpm should match the nameplate value within 10%.

### Motor takes too long to accelerate

<b>A</b>	Acceleration rate set too long.	(1) Decrease acceleration setting in VFD. (2) Make sure motor is wired to match VFD output voltage. (3) Verify motor nameplate voltage matches VFD output voltage. Ref. Section 3.4.1.2.
<b>B</b>	Supply voltage has drooped or become severely unbalanced.	Ensure that steady state supply voltage at VFD input terminals is within limits. Ref. Section 3.4.1.2. Correct as needed.
<b>C</b>	Load exceeds motor/VFD capability.	(1) Verify the motor rating and VFD current capability are sized correctly for the load. (2) Set current / torque limit setting to match the maximum motor capability. Ref. Section 3.4.5. (3) Disconnect motor from load & ensure motor turns freely. Ref. Section 3.4.5.

### Motor rotates in the wrong direction

<b>A</b>	Motor lead wiring is reversed or commanded direction is reversed at VFD.	(1) Interchange any two motor leads between motor and VFD output terminals. Ref. Section 4.0. (2) Program direction change in VFD.
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### VFD trips repeatedly on overload or motor over-temperature fault

<b>A</b>	Load exceeds motor/VFD capability.	(1) Verify the motor rating and VFD current capability are sized correctly for the load. (2) Set current / torque limit setting to match the maximum motor capability. Ref. Section 3.4.5. (3) Disconnect motor from load & ensure motor turns freely. Ref. Section 3.4.5.
<b>B</b>	Ambient temperature too high.	Confirm that ambient at motor does not exceed value stamped on motor nameplate. Reduce ambient as needed. Ref. Section 3.1.2.
<b>C</b>	Motor cooling fins and/or vent openings blocked.	Remove foreign materials – clear vent openings, fan guard air inlets and frame fins (TEFC motors). Ref. Section 4.1.1.
<b>D</b>	Insufficient Air Flow.	TEAO (Totally Enclosed Air Over) motors: Measure airflow next to motor surface and obtain minimum requirements from motor manufacturer. Ref. Section 3.1.3.1.
<b>E</b>	Load acceleration time is set too short.	Increase acceleration time as needed.
<b>F</b>	Start/stop time (duty cycle) is too short or too frequent.	(1) Increase acceleration/deceleration times. (2) Reduce the number of start/stop cycles.

### Motor Vibrates

<b>A</b>	Motor misaligned to load.	Realign load.
<b>B</b>	Load out of balance.	(1) Ensure that load is dynamically balanced. (2) Verify that motor shaft is not bent. Uncouple motor from load and inspect motor shaft. Rule of thumb is 0.002" runout for shafts extension lengths up to 3.00". Add 0.0005" per every additional inch of shaft length beyond 3.00".
<b>C</b>	Uneven tension on multiple belts.	(1) Belts are not evenly worn. Realign motor to load and replace all belts. Ref. Section 3.3.4. (2) A mix of new and used belts is used. Replace multiple belt applications with a complete set of matched belts. Ref. Section 3.3.4.
<b>D</b>	Driven load operating at resonant point / natural frequency.	(1) De-energize motor and record vibration as load coasts from 100% speed to 0 RPM. If vibration drops immediately, vibration source is electrical. If levels do not drop immediately, source is mechanical. (2) If electrical sources, program skip frequencies to bypass resonant points. (3) If mechanical, redesign system to operate below the resonant point.



<b>E</b>	Uneven, weak or loose mounting support.	Shim, strengthen or tighten where required.
<b>F</b>	Motor bearings worn.	Uncouple motor from load and rotate shaft by hand. Ref section 2.1.2. If you hear noise or feel roughness, have bearings replaced. Ref Section 4.0. For motors with regreasing provisions, add grease per relubricating instructions. Ref. Section 4.2.3. If noise persists contact motor manufacturer.
<b>G</b>	Motor out of balance.	Motor is balanced at the factory and will remain balanced in operation. If motor balance is in question, remove motor from application and send to a motor manufacturer authorized service shop for inspection. Do not attempt to disassemble motor in the field.

### **Bearings repeatedly fail**

<b>A</b>	Load to motor may be excessive or unbalanced.	(1) If belt drive, check system per section 3.3.4. (2) Other than belting, check loading on motor shaft. An unbalanced load will also cause the bearings to fail. (3) Check run-out of mating components, such as a C-face and pump flange.
<b>B</b>	Bearings contaminated.	Motor enclosure not suitable for environment. Replace with correct enclosure construction.
<b>C</b>	Incorrect grease or bearings for ambient extremes.	See section 4.2.1.

### **Motor makes a rubbing, grinding, or squealing noise**

<b>A</b>	Contact between rotating and stationary components.	Isolate motor from load. To locate point of contact turn motor shaft by hand. Ref. Section 2.1.2. If point of contact is not located, contact motor manufacturer authorized service shop.
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### **VFD trips on Ground Fault**

<b>A</b>	VFD trips at low speed during starting. Voltage boost is set too high.	Reduce boost, repeat auto tune.
<b>B</b>	Condensation forms on motor winding.	Remove source of moisture. Dry out motor. Add space heaters to motor. Ref. Section 3.3.6.3 and 4.0.
<b>C</b>	Motor winding is shorted to ground.	Disconnect leads at motor conduit box and Megger motor leads to ground. Ref. Section 4.1.2. If resistance is less than 1.5 mega-ohms, remove motor from service. Service shop must check for excessive moisture or contamination on windings or short to ground.

### **Motor shaft cogs**

<b>A</b>	Shaft cogs when turned by hand.	Motor leads are shorted together inside conduit box producing braking torque. Isolate all leads and repeat shaft turning by hand. Ref. Section 3.4.5.1.
<b>B</b>	Shaft cogs when operated by VFD.	Voltage boost is excessive. Reduce boost. Repeat auto tune.

### **VFD trips during deceleration**

<b>A</b>	VFD cannot absorb regenerated power.	(1) Add dynamic brake resistors or change VFD to line-regenerative design. For multi-drive installations, connect drives in common bus configuration to share regenerated power. (2) Increase capacity of dynamic braking circuit.
<b>B</b>	Deceleration time is set too fast. VFD's dynamic braking circuit overloads.	Increase deceleration time to reduce regenerated energy.

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