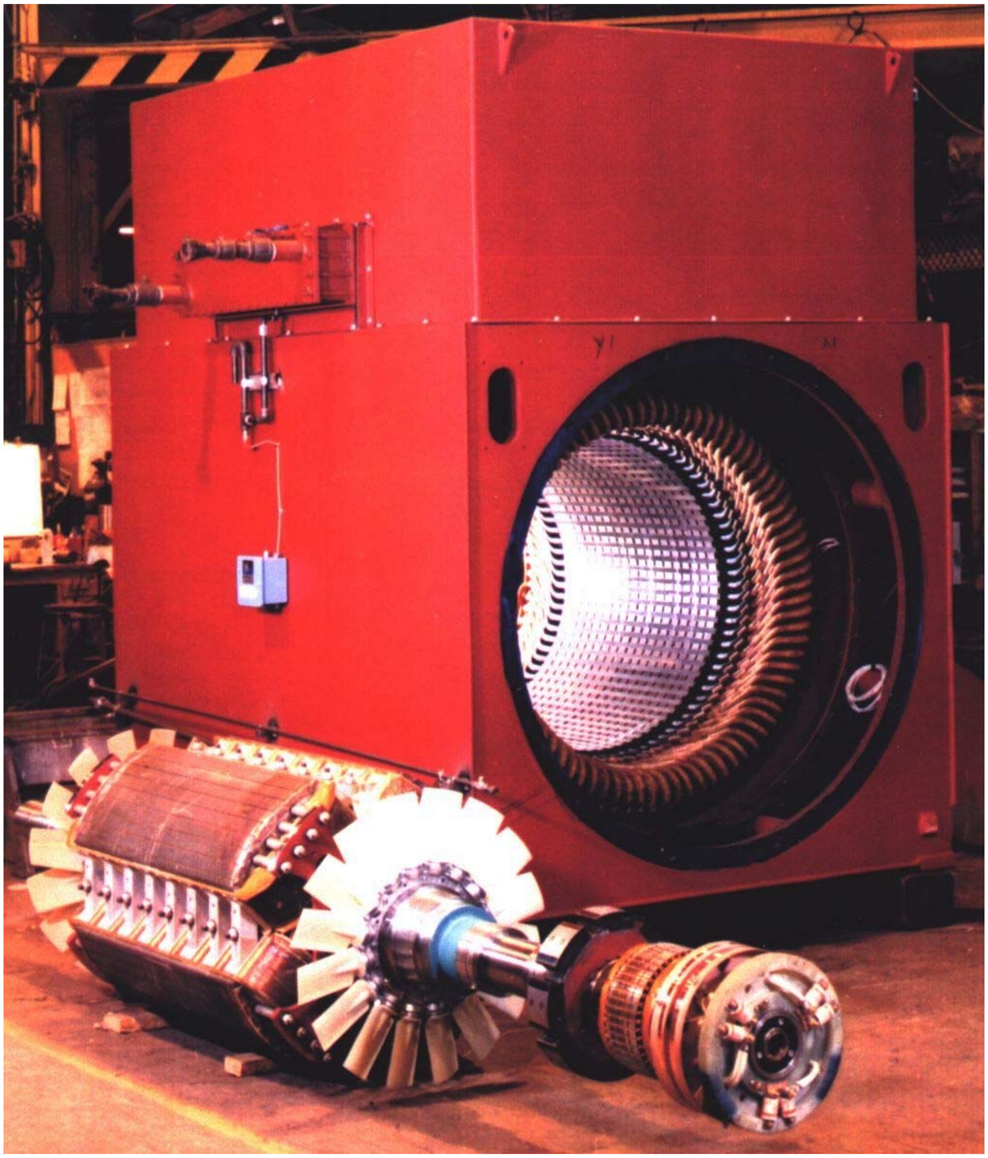
# Horizontal Synchronous Brushless Generator Operation and Maintenance Manual



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(Cover Photograph represents typical construction only)

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# Introduction to Equipment

## Manual Scope and Content

The large variety of components and subsystems that can be supplied with an Hyundai Ideal horizontal, synchronous generator necessitates that this manual be modular in nature. Specific sections are added, as appropriate, depending on the type of machine involved and on the options and accessories installed on your machine. The applicability of a particular section is based on the Order - Technical Specification. In the case of accessories and subassemblies, OEM manuals and/or catalog cuts are furnished with this manual.

### Reference Specifications

The Outline Drawing in the "Drawing and Specifications" section list performance, construction and reference information for the equipment supplied in this order. This information takes precedence over all other information, except technical bulletin information published after the publication date of this manual. The manual publication date appears on the format cover of this manual.

### Personnel requirements

All personnel who work with this Hyundai Ideal Electric equipment should be experienced in the handling, use and maintenance of industrial generators. They must read and thoroughly understand all of this manual, especially:

- The safety precautions at the beginning of the manual.
- The Outline Drawing in the drawing section of this manual.
- Those paragraphs pertaining to the functions and procedures they perform.

### Service Variations

The instructions provided in this manual are recommendations based upon the equipment design, applications and maintenance experience of Hyundai Ideal Electric. Circumstances at a particular installation may require modification of some procedures. Before performing modified procedures, consult with Hyundai Ideal Electric.

## Equipment Definition and Description

Refer to the Outline Drawing for construction, performance and specification information for the equipment covered by this manual. Each major component of the equipment is defined in the Outline Drawing and in the Specifications.

# Receiving, Handling and Storage

## Introduction

This section provides information on receiving, handling and storage of the Hyundai Ideal Electric machine described on the title page of this manual. The section is written for personnel experienced in the handling of heavy machinery.

# Receiving

This machine has been carefully tested, inspected and prepared for shipment before leaving the factory. Upon receipt, inspect the shipment for damage and ensure that all accessories are present.

If damage has occurred or parts are missing, file a claim with the transportation company immediately and promptly contact Hyundai Ideal Electric.

The following instructions apply upon initial receipt of the equipment. Review the safety precautions in the front of this manual before working with equipment.

**WARNING: Ensure that hoists, chains, cables and other lifting equipment are in good repair and of sufficient capacity to handle loads without injury to personnel or damage to equipment. Securely attach lifting equipment. Before lifting, be sure that load is balanced. Refer to the Outline Drawing listed in the "Drawing and Specifications" section on page 59 for equipment center of gravity and weight.**

a) Lifting. Use cargo lifting equipment such as a crane or forklift to unload the machine. Refer to "Handling" instructions on page 5.

b) Initial storage. Immediately place the equipment under cover, as packing is generally not suitable for outdoor storage. Refer to storage instructions on page 6.

# Handling

Use cargo lifting equipment such as a crane or forklift to unload the machine. Prior to handling heavy machinery, ensure that all lifting devices, cranes, slings, etc.., are in good repair and of sufficient capacity to safely handle loads without injury to personnel or damage to equipment. Refer to Outline Drawing (see “Drawings and Specifications” on page 59) for machine and component weights and for what is required for lifting or cribbing

**CAUTION: When using slings to lift rotating machinery, use spreaders or lifting beams to maintain a vertical lift in each sling to prevent damage to the equipment**

1. Handle the equipment carefully, using spreaders to prevent binding and damage to the equipment. Before lifting, be sure the load is balanced.
2. Lift assembled unit with a suitable hoist and sling, using lifting lugs provided. Any special requests for lifting or cribbing not specified in the Outline Drawing should be avoided unless approved by Hyundai Ideal Electric Company.
3. When lifting the unit, use the lifting lugs provided and protect the windings from damage. Be aware that certain lifting lugs are intended for the maintenance and installation of component parts and are designed to lift only the weight of those parts. The correct lifting locations for the complete unit are identified on the Outline Drawing.
4. When handling the rotor alone, support the rotor by slings or blocks under the shaft or a cradle under the poles, but never around an excitation device, on journals or at the extreme ends of the shaft.
5. In addition, protect polished shaft surfaces (*i.e.* bearing area or journals, proximity probes, etc.) from marring.

# Storage Prior to Installation (Less than 6 months)

## Initial Storage

If the unit is not to be placed into service immediately, inspect machined areas such as shaft extensions, fit surfaces, machined feet and sole plates for rust. Remove all traces of rust and moisture and protect the surfaces with a coating of grease or heavy oil. Coating surfaces with grease without removal of rust or moisture will not prevent further damage.

The unit should be kept in a clean, dry, vibration-free area protected from low temperatures and rapid or extreme variations in temperature or humidity since they can cause moisture to condense on the interior metal and windings of the machine.

## Preparation

If the equipment has been exposed to low temperatures, do not unpack or uncover until the machine attains a temperature nearly equal to that of the area in which it is to be installed. This is to prevent condensation and subsequent moisture problems. The unit should also be protected from rodents and other wildlife.

Immediately place the equipment under cover, as packing is generally not suitable for outdoor storage. Cover equipment with plastic tarps, and ensure that adequate ventilation is provided to allow moisture to escape. Protect all electrical equipment from condensation or freezing. The temperature of the equipment should be maintained above the dew point temperature of the surrounding air, using space heaters.

## Space Heaters

Space heaters keep the interior temperature slightly above ambient and minimize the possibility of condensation. If so equipped, immediately energize space heaters upon receipt of the equipment. Refer to the Outline and Interconnection Drawings for power requirements. If the equipment does not have integral space heaters, utilize portable electrical heaters. If the unit is to be in storage more than a few months, additional action may be required (see “Extended Storage” on page 8).

## Lubrication

Upon arrival at their destination, the machine bearings should be immediately filled with oil to their proper level and the shaft turned a few times by hand to avoid damage to the bearings due to rust or corrosion.

If the storage period is to be 30 days or less, the bearings and bearing housings of units using oil lubrication need not be treated to prevent rust and corrosion.

If the storage or standing idle period is to be greater than 30 days, the bearing housings should be filled to the proper level with preservative-type oil that meets military specification MIL-I-21260 or consult your oil supplier's industrial applications engineer for recommendation of the proper type preservative to use (see "Lubrication of Sleeve Bearings" for lubrication instructions and specifications). The unit should be turned a few times to make sure the preservative oil coats the bearings.

**CAUTION: Cleanliness is the most important consideration in the care of bearings. Use extreme caution to prevent foreign matter from entering the bearing by way of the lubricant or when servicing the bearings.**

## Inspection

Equipment in storage should be visually inspected and meggered at frequent intervals and a log kept of pertinent data.

# Extended Storage

Anytime the equipment will be stored for **six months or more**, prepare and store units as instructed in ”Storage Prior to Installation (Less than 6 months)” on page 6, and follow the additional procedures listed below. Adequate precautions taken during storage will prevent deterioration of equipment and help avoid a long dry out procedure prior to start-up.

Generally, with long term storage,

- The insulation resistance should be checked and logged monthly.
- All critical machined surfaces must be protected from corrosion with an application of preservative oil or grease.
- The bearing housings, if oil lubricated, should be filled to their normal operating level with a preservative oil. The shafts should be unblocked and rotated a few revolutions every month and the shaft should be stopped in a different position each time.
- Turn off the water supply to water cooler. Drain the cooler by use of the vent and drain plugs.
- Keep space heaters energized during storage.
- Contact Hyundai Ideal for additional extended storage recommendations.

Before starting the equipment after storage, refer to “Commissioning” on page 15. It is suggested that equipment removed from extended storage be inspected by an Hyundai Ideal Electric Company service representative prior to start-up to make certain the equipment is in suitable (as shipped) condition.

# Installation

## Introduction

Equipment location requirements are described in this section. Also included are foundation design considerations and installation instructions. Instructions are written for personnel experienced in the installation of heavy machinery.

# Location

The ambient and environmental conditions at the site must correspond to the degree of protection with which the machine was designed and are satisfactory for safe operation.

Also, ensure that there will be adequate space around the machine to permit the free flow of cooling air and adequate space for installation and maintenance.

Maintenance will be minimized and service life increased if unnecessary dirt, dust, moisture, splashing liquids and similar hazards are excluded from the area in which the machine is located. Refer to “Enclosure” on page 69 for information regarding any enclosure.

# Foundation

Refer to the Outline Drawing on page 59 for clear space requirements below the machine and to aid in foundation design. The following items are foundation design considerations.

## Mounting

The unit should be mounted on a foundation or base that is suitable for the equipment and level (within 0.002" per foot). The foundation must be designed to be substantial and rigid. It should be constructed of reinforced concrete or steel girders built with sufficient stiffness to prevent vibration. It must be designed to not only support the static weight of the equipment, but also to withstand the weight reactions and other forces involved when the machine is running. Concrete foundation elevations should be such to allow a minimum of one inch of grout between the top of the foundation and the sole plate or machine base.

## Foundation Bolts

The correct location of foundation bolts is essential. Ensure that the machine is located with respect to magnetic center when setting axial separation.

It is recommended that foundation bolts be set in recessed pockets to allow some deflection, if required. These pockets will eventually be filled with grout after the final alignment. (Refer to the Outline Drawing or the actual hole locations on the machine to establish the location and bolt pattern of the foundation bolts).

## Alignment

Foundation placement is critical to the smooth operation of the machine. Design consideration for the alignment of the equipment with the driving equipment will prevent subsequent coupling difficulties.

For long-term operation, free of vibration and/or bearing problems, alignment at normal operating conditions should be performed as follows:

a) The alignment can be checked either optically or with a dial indicator from the shaft of the generator to that of the prime mover by turning the coupling half.

b) After final alignment and a run-in period of at least four hours, the alignment should be checked again. The limits for proper alignment depend on factors such as application, coupling, operating speed and bearing type.

c) When the alignment limits are satisfied, the machine should then be doweled.

# Installation Procedure

The following is a procedural guide for equipment installation. Refer to “Handling” on page 5 for equipment handling procedures and safety precautions, and ensure that the frame is not twisted or bowed when being set on the foundation.

## Placement and Leveling

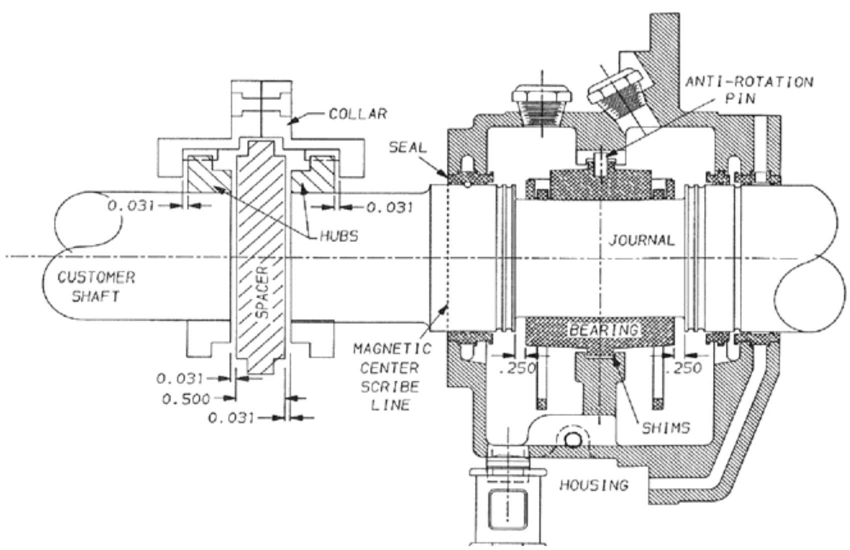
Adjust the level of the generator frame in the foundation with the leveling jackscrews provided at the bottom of the machine. Lubricate jackscrews before lifting machine weight.

## Lubrication

Refer to the machine nameplate for lubrication specifications and fill oil to proper level. See “Lubrication of Sleeve Bearings” on page 52 for lubrication instructions and specifications.

## Limited End Float Coupling Setup

With oil in the bearings, and the unit secured from operation and uncoupled, verify that the shaft free float is equidistant about the magnetic center mark. Position the shaft so the magnetic center mark is flush with the seal face. Set the unit so the coupling faces are the proper distance apart. After aligning unit radially and angularly, re-verify shaft axial position. Place the proper size spacer between the coupling hubs and make up coupling flanges. When properly set-up, the total axial freeplay in the coupling is considerably less than the available distance between journal shoulders and the bearing ends, thus preventing contact and subsequent bearing damage. (Dimensions given in drawing below are for illustration only.)



## Electrical Installation

The following is a guide for the installation and hookup of the machine electrical systems. Included are tests and procedures to measure insulation resistance and a ground test to insure safe installation and operation. Observe the safety precautions at the front of this manual.

**WARNING: De-energize applicable electrical circuitry connected with the main leads and tag: "OUT OF SERVICE. DO NOT CHANGE POSITION OF SWITCH EXCEPT BY ORDER OF INSTALLATION SUPERVISOR." Use a voltmeter or voltage tester to ensure circuit is de-energized before contacting electrical circuits.**

## Frame Grounding

Ensure that the frame of the unit is properly grounded in accordance with the applicable national and local electrical codes. Hyundai Ideal provides at least 2 pads with 3/8" to 1/2" size tapped holes on the frame which must be used. (See installation drawing listed in drawing section on page 59). In any case, the NEC and/or local codes shall be the final authority.

## Insulation Resistance

1. Check that the nameplate voltage and frequency correspond to voltage and frequency on the drawings to insure proper wire size and protection.
2. Before start-up, measure insulation resistance of the windings with an insulation megohm instrument, (megger) or other suitable instrument. When meggering the field or exciter armature windings, either disconnect the windings from the semi-conductors or apply shorting jumpers across the semi-conductors.

   Insulation resistance is a variable factor depending upon the temperature of the insulation, the relative humidity of the air and the moisture content and cleanliness of the winding at the time of the test; refer to "Winding Insulation" on page 44 for detailed explanations and instructions regarding winding insulation. If available, it is preferable to compare the measured data with the original factory test data. If factory test data is not available, compare the measured data to the following typical and conservative values for a new machine with clean windings:

| Machine Rated Voltage | Typical Insulation Resistance |
|---|---|
| 125 to 250 Volts | 1 Megohm |
| 251 to 600 Volts | 5 Megohms |
| 601 to 2299 Volts | 10 Megohms |
| 2300 to 5000 Volts | 20 Megohms |
| 5001 to 15,000 Volts | 40 Megohms |

**Note: These values are more conservative than IEEE values. If insulation resistance is lower than the minimum safe resistance, refer to "Winding Dry Out Process" on page 48 for winding dry out procedure**

3. Check that any surge arrestors or surge capacitors are disconnected from the stator leads for they will drastically lower the measured insulation resistance if used when meggering the stator windings.
4. With 500 VDC applied to test the rotor, the insulation resistance measurement should be 0.5 megohm minimum. This and the preceding values are the insulation resistance measurements taken at one minute and apply for an insulation temperature of 20°C (68°F). If the insulation resistance is below the minimum, measure the Polarization Index (PI), which is the ratio of the megger reading at ten minutes to that of one minute (see page 46). If PI is less than 2.5, the winding should be dried out.

The following list displays the recommended test voltages per machine rated voltage.

| Machine Rated Voltage | Recommended Test Voltage |
|---|---|
| 480 Volts & Below | 500 Volts |
| 481 to 2400 Volts | 1000 Volts |
| 2401 to 4200 Volts | 2500 Volts |
| 4201 to 15,000 Volts | 5000 Volts |

**Caution: After meggering, be sure to ground each phase of the winding until it has completely discharged.**

5. Check that connections are correct according to the wiring diagrams.
6. When connecting main leads to the machine leads, make sure the leads are correctly identified as to phase.

# Commissioning

## Introduction

This section provides suggested preoperational and operational checks to be performed at startup. These are guidelines only; additional checks may be required by location and specific application of equipment.

# Preoperational Checks

The following are general checks that should be performed ***prior to machine start-up***.

## High Potential Testing

All machines manufactured by Hyundai Ideal Electric have received a high potential test in accordance with the applicable NEMA or IEC Standards. This standard test is performed (depending on voltage) with 3.5 to 7.0 times the normal operating phase voltage to ground.

> **WARNING: Due to the extreme level of this voltage, which is not seen in service, it is possible to cause irreversible damage to the insulation without proper safeguards.**

*Hyundai Ideal does not recommend repeating this test in the field and will not be responsible for the repair should a failure occur during a field high potential test.* If an acceptance test is desired, the insulation resistance and polarization index tests described in this section are recommended.

## Voltage Regulator System

Check the wiring of the automatic voltage regulator (AVR) system. If the AVR has been supplied by Hyundai Ideal, a voltage regulator interconnection diagram or wiring diagram will be included with this manual (see “Drawings and Specifications” on page 59).

> **NOTE: Many of these components have tap selectable voltages and/or jumper selection of voltage. Before operating the AVR system for the first time check each component for the correct voltage selection. Failure to do so may result in damage to the AVR system. Refer to the manufacturer's instruction manuals for the individual AVR components for setup and operating instructions.**

## Bearings

Check the bearings for proper lubrication. A lubrication nameplate is affixed to the machine that states the proper lubricant to be used. Refer to "Hyundai Ideal Horizontal Sleeve Bearings" on page 51 for bearing and lubrication information, respectively.

## Rotation

For proper ventilation and lubrication, most machines are designed for one direction of rotation. To ensure proper rotation:

1. Check that the direction of rotation of the prime mover matches that anticipated for the machine. The proper rotation is usually noted on the Outline Drawing.

2. Check for free rotation of the rotor through at least one complete revolution. This can be accomplished by using a bar for leverage when it is placed between coupling or flange bolts or in another location that will not cause any damage.

### Heat Exchangers

If so equipped, start and check for proper coolant flow. See “Enclosure” on page 69 for other enclosure information.

## Additional Pre-Operational Checks (Configuration Dependent)

The following are pre-start checks that can depend on how the machine is equipped. Otherwise, these checks may be considered general and miscellaneous.

### Mechanical Check-Out

1. Check for mechanical looseness anywhere on the machine. Ensure that foundation bolts and coupling bolts are tight. Typical torque values for SAE grade 5 bolts are as follows:

| Bolt Diameter (inches) | Torque (foot-pounds.) | Bolt Diameter (inches) | Torque (foot-pounds) |
|---|---|---|---|
| 1/4 | 10 | 1-1/4 | 1,105 |
| 5/16 | 19 | 1-3/8 | 1,500 |
| 3/8 | 33 | 1-1/2 | 1,775 |
| 7/16 | 54 | 1-5/8 | 2,425 |
| 1/2 | 78 | 1-3/4 | 3,150 |
| 9/16 | 114 | 1-7/8 | 4,200 |
| 5/8 | 154 | 2 | 4,550 |
| 3/4 | 257 | 2-1/4 | 6,550 |
| 7/8 | 382 | 2-1/2 | 7,175 |
| 1 | 587 | 2-3/4 | 13,000 |
| 1-1/8 | 794 | 3 | 16,000 |

2. Supply the proper grade oil to the bearings by operating the oil circulation system (if so equipped) or by pouring oil on the journals and load zone. Attach or position a bar where shaft, fan or other component damage will not occur when the bar is used to rotate the rotor. While supplying oil to the bearings and barring the rotor,

check the air gap to determine concentricity of the rotor and stator within a uniform clearance of 10%.

3. Examine the air gap and interior of the machine for loose bolts, nuts, or tools. Remove any foreign objects.
4. Ensure that there is sufficient clearance (refer to parts/air gap) for all moving parts.
5. If so equipped, check that oil-cooling system is correctly connected to the plant water supply and that cooling water is turned on.
6. If so equipped, check fittings and piping of the oil cooling system for leaks.
7. Ensure that space heaters have been turned off.

## Electrical Check-Out

1. **Stator leads and cables**. Check for mechanical damage, proper taping of connections; correct paralleling of cables and proper termination.
2. **Current transformer (CT) circuits**. Check the integrity of all current transformer circuits.
   - Remove all shorting jumpers or screws from the current transformers.
   - Verify loop continuity of the cross-current, current transformer (CCCT), instrumentation and differential current transformer circuits.
3. **Control and protective switchgear circuits**. Check the integrity of all switchgear circuits.

## Mechanical Run

1. Prime mover representative to prove stability of governor.
2. Prime mover representative to prove emergency shutdowns and overspeed governor.
3. Check for excessive vibration or heating. If vibration is present, search for misalignment or loose foundation bolts. Eliminate the cause of vibration before proceeding.
4. Check for oil leaks.
5. Check for any unusual noise originating from the generator.
6. Check bearing and stator winding temperatures to be sure they stay within acceptable limits (for the first several hours of operation ).

# Initial Start-Up

## Ventilation

1. Bring the generator up to full speed with the voltage regulator system switched off.
2. Check all air inlets and outlets for proper airflow and remove any obstructions.

## Voltage Regulator System

If a manual voltage control is installed, check it by performing the following sequence:

1. Turn the voltage control to minimum and switch on the manual control.
2. Slowly bring the voltage up to rated.
3. Return the voltage to minimum.
4. Switch to the automatic voltage regulator. The voltage should now be controlled by the voltage adjust potentiometer or the motor operated potentiometer.
5. Check the range of control above and below rated voltage. If the rated voltage position is not centered on the potentiometer rotation, a coarse adjustment control is available internal to the AVR. Refer to the AVR manual for adjustment procedure.

## Phase Rotation

Observe that the generator phase rotation matches the bus phase rotation. The following procedure may be used to verify that the phase rotation is correct and that the synchroscope in functioning correctly. Refer to Figure I-1 for illustration.

**Test 1** - This test will verify synchroscope wiring and bus connections leading to the generator are correct and also verify bus phase rotation.

a. Disconnect generator, secure leads, and isolate.

b. Apply rated voltage to bus and close breaker labeled A on Figure I-1.

c. Connect phase rotation meter as shown and observe rotation.

d. Observe synchroscope, (SYN). Instrument should read 12 o'clock.

e. Open breaker, A, and remove (rack out) from the energized position.

**Test 2** - This test will verify that the incoming generator and the bus phase rotation are correct and that the synchroscope is correctly monitoring the incoming machine vs. the bus source.

a. Reconnect the generator.

b. Bring the generator to rated speed and voltage.

c. Observe phase rotation as shown on phase rotation meter. Phase rotation must be in the same direction as observed in Step 1 above.

d. Observe synchroscope. The hand will rotate clockwise when the generator frequency is higher than that of the bus or counter clockwise if slower than the bus frequency.

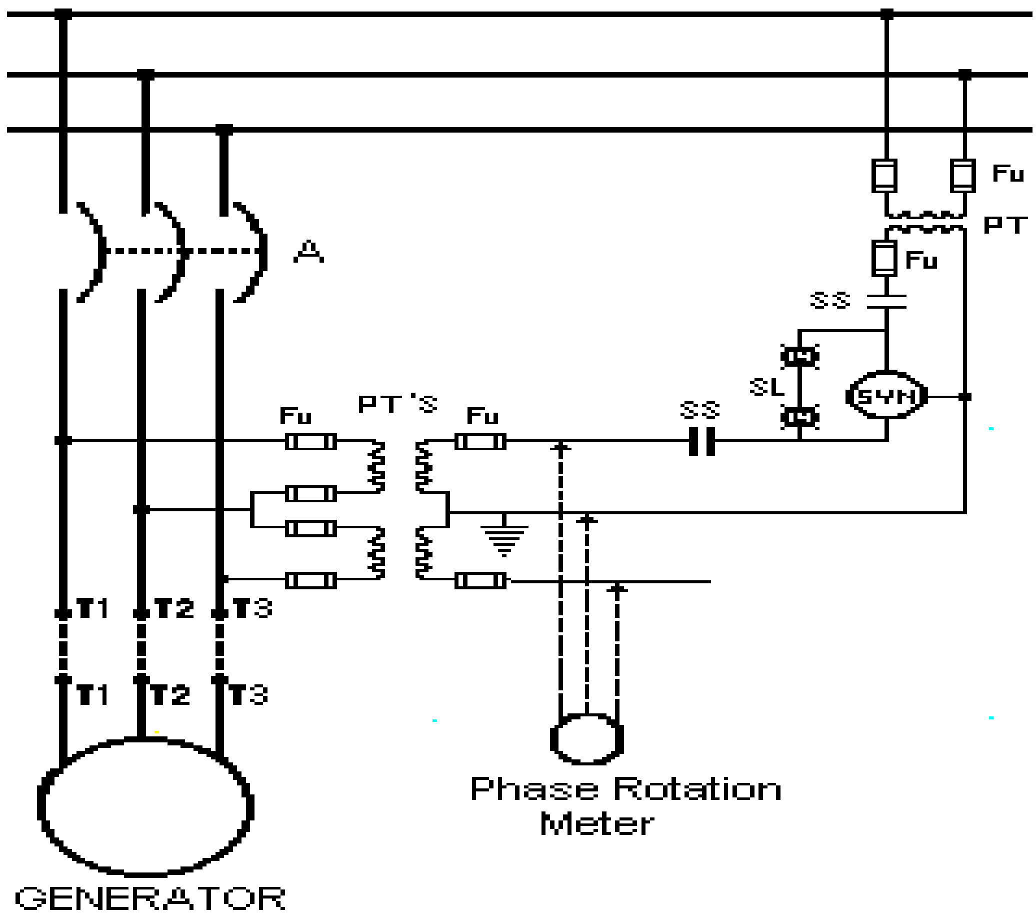



Figure I-1. Phase Rotation Test

# Operation

## Effects of Ambient Temperature

Generator output is normally limited by the temperature rise of the windings above a specified ambient air temperature. The sum of the temperature rise and the ambient is called the total winding temperature.

**It is this total temperature which is the limiting factor in determining machine output.** Thus, if a generator is operated in a lower than rated ambient, the maximum safe output may be increased.

For example, a generator is rated for an 80°C temperature rise above a 40°C ambient (120°C total temperature). If this generator is operated in a 30°C ambient, the temperature rise may be allowed to increase to 90°C (120°C total temperature) allowing an increase in output. Likewise, for ambient temperatures above the rated ambient, the allowable temperature rise and output are reduced.

Figure I-2 is a curve of output in percent of rated versus ambient temperature for a generator rated at 40°C ambient. Note that rated output (100%) occurs at 40°C ambient.

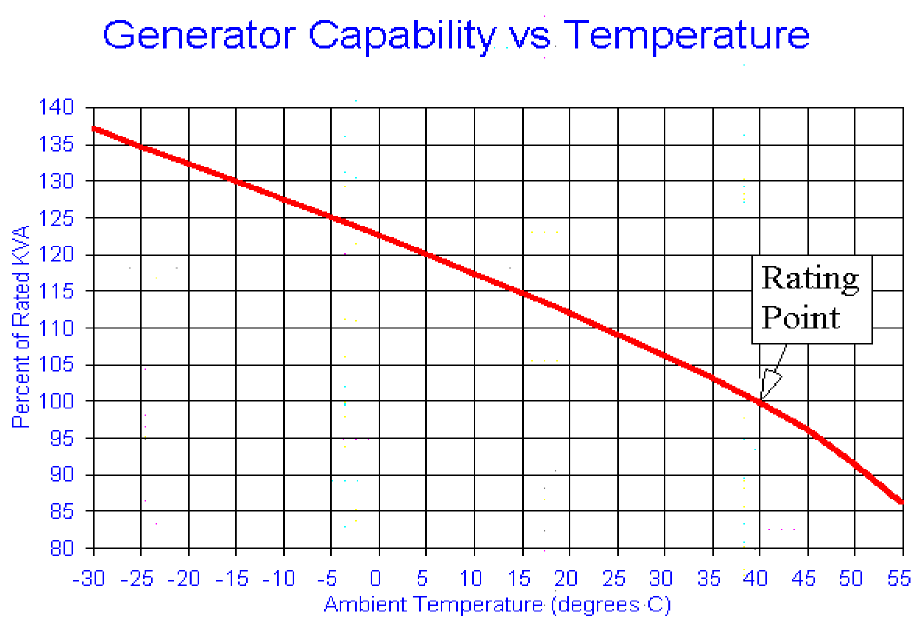



Figure I-2. Capability and Ambient Temperature Curve

# Reactive Capability

The reactive capability curve (Fig. I-3) defines the limits of operation of a synchronous generator in terms of the kilowatt and kilovar output. The vertical or "Y" axis gives the reactive power output (kilovars) in percent of the rated KVA of the generator. The horizontal or "X" axis gives the real power output (kilowatts) in percent of the rated KVA of the generator

Power factor is represented by radial lines from the origin of the "X" and "Y" axes. Lagging or overexcited power factors are on the upper half of the graph and leading or underexcited power factors on the lower half.

The curve is composed of three distinct segments as described below:

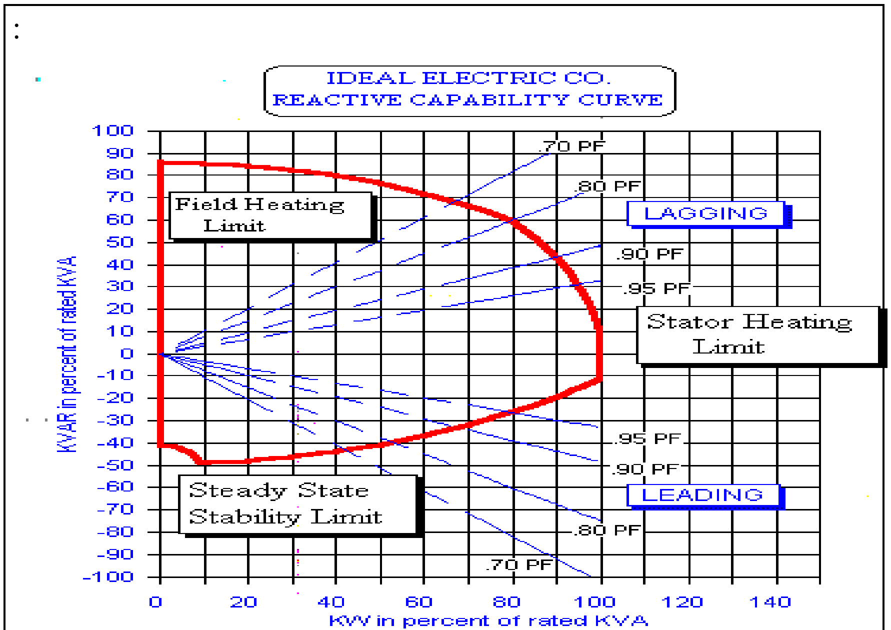


Figure I-3. Reactive Capability Curve

a) The **uppermost segment** from the "Y" axis to rated power factor curve represents the **field-heating** limit. This is the limit of operation based on operating at rated field current. The intersection of this segment with the "Y" axis gives the maximum KVAR output of the generator (in percent rated KVA) at zero power factor lagging as for synchronous condenser operation.

b) The **center segment** of the curve from rated power factor down to the next intersection point is the **stator-heating** limit. This segment is a curve of constant KVA; thus the stator current and also the stator heating are constant.

c) The **lower segment** is the **steady state stability** limit. Operation outside of this curve would result in pulling out of step with the connected system causing severe electrical and mechanical transients. For this reason, it is recommended that the generator be operated within this limit by a sufficient margin.

The extreme end of the curve at zero power factor leading represents the maximum line charging capacity of the generator with zero excitation.

The small upward curved section near the vertical axis indicates that with zero excitation there is still a significant residual voltage, which reduces the line charging capacity.

It should be noted that, as shown in the typical curve of Fig. I-3, for a generator rated at 0.80 PF, rated kW output is shown as 80% of rated KVA on the horizontal axis.  Thus, the maximum leading power factor at rated kW output is shown as 0.95 PF at the intersection of the curve and the 80% KVA line.

# Paralleling (Synchronizing)

To place the generator on line it must be properly paralleled (synchronized) with the utility. The following conditions must be met to successfully synchronize the machine.

- The generator and utility voltages must be matched. This will minimize the reactive load transient when the breaker is closed.
- The generator frequency must be slightly higher than the utility frequency. This ensures that the generator will pick up a small amount of positive kW load.

These conditions can be met as follows:

1. The voltages can be matched by observing the generator and Bus utility voltmeters.
2. The machine frequency is adjusted while observing the synchroscope or synchronizing lights. For paralleling, the synchroscope should be turning slowly in the fast, CW direction. This means that the incoming source (generator) speed is slightly higher and it will pick up a small amount of load.
3. When the synchroscope is at the 11 o'clock position, place the breaker control switch in to close. The synchroscope should stop at 12 o'clock and the kW and current meters should show indications of some load being on the machine.
4. At about 30% load, the pf should be observed and changes made to the auto volts adjusting potentiometer to obtain the desired pf. If the VAR/pf controller is operating this will not be necessary.
5. Load can be added as desired by adjusting the governor for the desired load.

# Neutral Currents and Grounding

Current flowing in the neutral of a wye-connected generator can arise from one or more of several causes:

## Ground Fault

Ground (earth) faults produce extremely high currents to ground, which return through the generator neutral. The generator reactances and any impedance in series between ground and the generator-neutral limit these currents.

**CAUTION: If a fault should develop internal to the generator stator windings, the high current can cause extensive damage to not only the windings but also the stator core iron. To minimize this damage, generators are often grounded through a neutral grounding transformer and secondary resistor. This high resistance grounding is often designed to limit the fault current to 10 amps or less. While continued operation might be permissible due to the low fault current with this type of grounding, it is not recommended since the windings are subjected to high phase to ground voltages due to neutral offset and transient voltages in the case of arcing faults.**

## Unbalanced Loads

Unbalanced single-phase (phase to neutral) loads are another cause of neutral currents. Generators intended for service where a certain amount of unbalanced single phase loading is expected normally have the neutral either solidly grounded or grounded through a neutral grounding reactor. These systems are especially susceptible to harmonic currents in the generator neutral as discussed in the following section.

## Harmonic Currents

Neutral currents due to faults or unbalanced loading are at the fundamental frequency produced by the generator. Often harmonic currents, which are triple frequency (principally the third harmonic, but also all odd multiples of three such as the ninth, fifteenth, etc.), are found in the generator neutral. These harmonic currents may be as high as 50% or more of the generator rated current.

Most salient pole generators produce a certain amount of triple frequency voltage. Triple harmonic voltages appear in the phase to neutral waveform, but since they are "in phase" in all three phases they do not appear in the phase to phase voltage.

A generator could theoretically be designed to produce zero triple harmonic voltage at no load through shaping of the pole face. However, due to armature reaction, which causes changes in the air gap flux under load, this generator would still produce triple harmonic voltages at load.

Another way to eliminate the generation of third harmonic voltage is through the use of a stator winding with a two thirds (67%) winding pitch. This has the disadvantages of being a less efficient winding, increasing the fifth and seventh harmonics, and increasing the cost of the generator. For these reasons, Hyundai Ideal prefers to use a pitch nearer five-sixths (83%) minimizing the fifth and seventh harmonics and resulting in an improved waveform for the phase to phase voltage.

Since triple harmonic voltages only appear in the phase to neutral waveform, they can only produce a harmonic current if there is a path from phase to neutral (Or a path from phase to ground if the neutral is grounded).

Several common paths for harmonic voltages occur when:

a) Multiple generators are paralleled on a common bus with the neutrals of all generators grounded. If all generators are identical and operating at equal loads they produce harmonic voltages, which are equal in magnitude, and phase which results in no net voltage to cause circulating currents.

b) However, if the generators are operating at different loads, the phase angle of the harmonic voltages differ by a multiple of the load angle of the generators, resulting in a net voltage which circulates current through the neutral.

c) A generator is connected to a wye connected transformer with both generator and transformer neutrals grounded.

d) A generator is connected to a long underground cable that has a high capacitance from phase to ground.

Neutral currents can be controlled by either eliminating the multiple paths from neutral to ground which provide a ground current loop or by inserting sufficient impedance in the generator neutral to limit the neutral current to a safe value.

A safe value for the generator would be 10% harmonic current per phase which when combined with the full load fundamental current would result in only a 1% increase in the RMS current over the full load current. Since the harmonic currents in each phase are additive in the neutral, this represents a maximum harmonic current in the neutral of 30% of the generator rated current.

Current of this magnitude would exceed the continuous current capability of the neutral grounding device. For this reason the neutral grounding device must be selected not only on the basis of fault current, but also considering the potential harmonic current.

# Inspection & Troubleshooting

## Introduction

This section provides inspection and troubleshooting information for the Hyundai Ideal Electric equipment identified on the title page of this manual. The following troubleshooting chart and the associated troubleshooting notes provide or reference the information required to identify and correct troubles that occur during operation. This section is written for personnel experienced in the troubleshooting and repair of industrial equipment. A thorough understanding of the machine supplied, as specified on the Outline Drawing, will make it easier to correct problems that occur.

**WARNING: Troubleshooting procedures may require that checks be made while the power is on. Use extreme care to prevent contact with live circuit parts. The voltages associated with this equipment are high enough to cause severe injury or death. Take precautions for high voltage during operation, and observe all safety regulations listed at the beginning of this manual.**

# Inspection

Inspect the equipment before starting:

- at the initial installation startup
- after any idle period
- whenever the machine has been shut down for maintenance or repair

Refer to "Commissioning" on page 15 for preoperational and operational checks.

# Troubleshooting Guide

The following is a general guide for troubleshooting Hyundai Ideal Electric machines. The particular machine that has been shipped may or may not have some of the accessories and/or conditions referenced herein.

## Troubleshooting Analysis Chart

| PROBABLE /CAUSE | REMEDY/REFERENCE |
|---|---|
| ***MECHANICAL NOISE*** | |
| System transmitted vibration | Investigate nearby equipment and remove or dampen vibration. |
| Loose bearing brackets | Securely fasten bearing brackets. |
| Dry or noisy bearings | Inspect the bearing lubricant and monitor bearing noise and temperature levels. Repair or replace as required. |
| ***EXCESSIVE VIBRATION (field current on)*** | |
| Short-circuited field windings | Contact Hyundai Ideal. |
| ***EXCESSIVE VIBRATION (field current off)*** | |
| Prime mover vibrating | Refer to prime mover equipment manual and correct cause of vibration. |
| Misaligned drive coupling | Realign coupling. |
| Fan/Baffle rub | Realign/recenter baffle. |
| Loose bearing brackets | Securely fasten bearing brackets. |
| Dynamic imbalance | Check and adjust rotor balance. |
| Rotor shaft bent or otherwise damaged | Contact Hyundai Ideal. |
| Brake pad rubbing on brake surface | Release brake or check braking/jacking system operation. |
| ***OVERHEATING*** | |
| Impaired ventilation (internal or external) | Clean vents and remove any internal or external obstructions. |
| Space heaters on during operation | Turn off space heaters. |
| Overload or unbalanced load on unit | Check for excessive or unbalanced load and remove. |
| Generating unit overvoltage | Reduce generator to rated voltage. |
| Excessive field current | Reduce excitation amps. |
| Defective stator windings | Check field and stator windings for open or |

| | |
|---|---|
| | shorted circuits. |
| Unbalanced stator currents | Refer to unbalanced stator currents symptom. |

***HIGH BEARING TEMPERATURE***

| | |
|---|---|
| Misaligned drive coupling | Realign coupling. |
| Loss of or insufficient bearing lubricant | Fill bearing housing with fresh lubricant and monitor bearing temperature. |
| Worn or dirty bearing lubricant | Drain and inspect the bearing lubricant. Refill bearing housing with fresh lubricant and monitor bearing temperature. |
| Rough journal | Contact Hyundai Ideal. |
| Poorly fitted bearing | Scrape and refit bearing. |
| Excessive external thrust install new | Remove thrust or contact Hyundai Ideal to bearing suitable for thrust. |
| High temperature cooling water | Check water temperature and flow. Correct to values shown on the Outline Drawing. |
| Oil heater on during operation | Turn off oil heater. |
| Loss of or insufficient coolant in oil cooling system or cooling system malfunction | Fill system with fresh coolant and check operation. |

***UNBALANCED STATOR CURRENTS***

| | |
|---|---|
| Meters out of calibration | Check with auxiliary meters. Repair or replace as required. |
| Unbalanced single phase loads on the generator | Check load and remove the excess or unbalanced portion. |
| Stator incorrectly connected | Refer to Interconnection Diagram and reconnect. |

***INSUFFICIENT OR LACK OF OUTPUT VOLTAGE***

| | |
|---|---|
| Voltmeter inoperative or out of calibration | Check with auxiliary meters. Repair or replace meters as required. |
| Short circuit in output line | Check for current flow with no output voltage. |
| Wet field or stator windings | Check field and stator windings. Clean and dry as required. |
| Open circuit in field or stator windings | Check field and stator windings for open or shorted circuits. |
| No voltage to field | Check static exciter, regulator and fuses. |
| Prime mover operating under speed | Check speed with tachometer. Refer to prime mover manual and adjust or repair as |

| | |
|---|---|
| | required. |
| Open circuit in DC ammeter shunt | Check with auxiliary ammeter. Repair or replace meters or shunt as required. |
| Overload or unbalanced load on unit | Check for source of excessive or unbalanced load and remove. |
| Field flashing required | Refer to excitation manual. |
| Voltage regulator malfunction | Refer to excitation manual. |
| Reversed field coil | Refer to connection diagram and reconnect field coil. |
| Excessive line drop | Use larger wire in lines. |
| Power factor low | Remove some of the inductive load from the line. |
| Defective excitation circuit | Refer to excitation manual. |
| Field current too low | Reset generator or exciter and check excitation circuit. |
| Poor stator connections | Poor connections will be hot. Clean and reconnect leads securely. |

***EXCESSIVE OR HIGH VOLTAGE***

| | |
|---|---|
| Voltmeter out of calibration | Check with auxiliary meters. Repair or replace as required. |
| Voltage regulator circuit | Check sensing circuit fuses and/or connections |
| Overload or unbalanced load on unit | Check load and remove the excess or unbalanced portion. |
| Defective excitation circuit | Refer to excitation manual. |
| Field current too high | Reset generator or exciter and check excitation circuit. |
| Prime mover operating overspeed | Check speed with tachometer. Refer to prime mover manual and adjust or repair as required. |
| Voltage regulator malfunction | Refer to excitation manual. |

***FLUCTUATING VOLTAGE***

| | |
|---|---|
| Fluctuating prime mover speed | Check speed with tachometer. Refer to prime mover manual and adjust or repair as required. |
| Load on generating unit fluctuating | Stabilize load if possible. |
| Field current fluctuating | Adjust stability control on voltage regulator. |
| Loose connections to line terminals | Poor connections will be hot. Clean and reconnect leads securely. |

| | |
|---|---|
| Short circuit in field or stator windings | Check field and stator windings for shorted circuits. |

***LOW INSULATION RESISTANCE***

| | |
|---|---|
| Wet field or stator windings | Check field and stator windings. Clean and dry as required. |

***INSULATION FAILURE***

| | |
|---|---|
| Mechanical or electrical damage or extreme contamination | Contact Hyundai Ideal. |

***INCOMPLETE SYNCHRONIZATION CYCLE***

| | |
|---|---|
| Field flashing required | Refer to excitation manual. |
| Exciter is not up to proper voltage before current is applied to generator field | Decrease exciter resistance to allow voltage to build up faster. |

***STATOR FRAME GIVES SHOCK WHEN TOUCHED***

| | |
|---|---|
| Grounded stator or field coil circuit | Check field and stator windings for grounded circuits. |
| Improper frame ground | Ground frame to station ground grid. |

# Bearing Malfunctions

## Maintenance of Bearings

When bearing overheating, noise or vibration occur, shut down the system and perform the following corrective actions.

**WARNING: Before replacing components or making adjustments inside the equipment, make sure the power is disconnected and the power source tagged to warn of a potentially dangerous situation. De-energize applicable electrical circuitry connected with the main leads and tag, "OUT OF SERVICE, DO NOT CHANGE POSITION OF SWITCH EXCEPT BY ORDER OF SUPERVISOR". Use a voltmeter or voltage tester to ensure circuit is de-energized before contacting electrical circuits.**

1. Verify that the proper oil level and type have been maintained. If the level is low, replenish it with the proper type. See "Lubrication of Sleeve Bearings" on page 52 for lubrication instructions and specifications. If there has been a sudden or unexpected loss of lubricant, investigate and correct the cause.
2. If lubricant maintenance does not correct the bearing malfunction, the bearing must be disassembled and inspected. Before removing the bearing, inspect it for proper alignment and seating while it is still in place.
3. Verify that the bearing temperature monitoring system is operating properly.
4. Repair or replace the bearing according to the instructions on page 51.
5. Verify proper oil supply pressure and flow.

# Rotor Adjustments

Although rotor adjustments may be performed by experienced personnel, it is recommended that rotor balance and alignment be performed by an Hyundai Ideal Electric Service Representative. For rotor alignment and balancing instructions, contact the Hyundai Ideal Electric Service Department.

# Impaired Ventilation

Cooling can be impaired by obstructions on or near the ventilation openings in the frame and/or passages inside the machine. When applicable, high water inlet temperature and low water flow or pressure can reduce the cooling effect of the ventilating air drawn through the machine by the cooling fans. Cooling requirements are specified on the Outline Drawing in the “Drawings and Specifications” section. After investigating and correcting these problems, inspect the cooling fans for damage and proper orientation for rotation.

# Cable Connections

- Check all cables and cable connections to be sure they are connected securely and have no wear, breaks or corrosion.
- Clean corrosion; repair minor wear and insulation breaks.
- Replace any damaged wires, or cables or connection hardware.

# Direction of Rotation

The direction of rotation is established in the design and construction specifications. If it is necessary to change the direction of rotation, consult with Hyundai Ideal Electric Company before starting modifications.

# Insulation Failure

Complete failure of winding insulation is a result of catastrophic mechanical or electrical damage, or of extensive contamination of the windings. In most cases, the only repair is rewinding of the damaged coils. Before attempting repair or cleaning of this extent, consult with Hyundai Ideal Electric.

## Damage to Insulation

There are several events that could cause catastrophic electrical or mechanical damage to winding insulation. In some cases, duration or repetition results in cumulative damage. The following list is not exhaustive but the items indicate the extremity of damage that would cause complete insulation failure.

- Mechanical Damage
- Excessive or prolonged overvoltage
- Prolonged overheating
- Excessive or prolonged vibration
- Lightning surge
- Shock loading or out-of-phase synchronization

## Contamination

Winding contamination by moisture, dirt, oil or other chemicals would have to be extensive to cause complete insulation failure. The cleaning required to remove this contamination may damage the insulation. Before attempting to clean unusual or extreme contamination from the windings, consult with Hyundai Ideal Electric.

# Routine Inspection and Maintenance

## Introduction

This section contains routine maintenance procedures and performance instructions to be accomplished on a scheduled or condition monitoring basis. Routine and preventative maintenance tasks and the frequency at which they should be performed are described in the paragraphs starting on page 40.

Maintenance and overhaul requirements of any component vary depending upon the nature of the service and the running time required by the installation. In keeping with good maintenance practices, the operator must be aware of proper equipment operating standards, monitor equipment, performance and take corrective action when necessary.

This section presents inspection and maintenance procedures according to when they should be performed:

- On a routine basis
- Every week
- Every six months
- Every year.

The following warnings must also be observed:

**WARNING: Use approved personnel protective equipment to protect eyes and face when using compressed air for cleaning, cooling or drying. Do not direct airstream toward yourself or toward another person. Maximum allowable pressure is 30 psi.**

**WARNING: Use any cleaning solution in an open or well-ventilated area; avoid breathing fumes. Keep away from open flames. Do not use a wire brush or a steel blade scraper to clean parts. Do not use gasoline, fuel oil or kerosene for cleaning.**

## Routine Inspection

Inspection and service should be systematic. Frequency of inspection and degree of thoroughness may vary and will have to be determined by the maintenance engineer. They will be governed by:

a. The priority of the machines in the production scheme

b. Percentage of day the machine operates

c. Nature of service

d. Environment.

An inspection schedule must, therefore, be elastic and adapted to the needs of each plant.

## Routine Maintenance

Any routine maintenance policy should include the following steps:

Make periodic inspections, giving special attention to

- Cleanliness
- Bolts and Fasteners
- Bearings
- Abnormal heating

Keep the machine free of metal dust, dirt, oil and water. If conditions are severe, open machines might require a certain amount of cleaning each day.

Inspect and tighten fasteners, bolts and nuts external to the machine.

## Weekly Maintenance

Unless performance indicates otherwise, the following inspections should be performed on a weekly basis:

a) Check lubrication in the bearings.

b) Check that the bearings are not leaking.

c) Examine starter, switch, fuses, and other controls.

d) Start machine and see that it accelerates up to speed in normal time

## Biannual Maintenance

The following inspections should be performed at least every six months:

a) Clean the machine thoroughly, blowing dirt out of the windings. If windings are lashed (tied) to a ring, or have blocks (wedges) between the windings on the end turns, these points should be checked to make sure all tie down points are secure.

b) Inspect and/or clean the excitation devices. When significantly worn, replace the parts that are subjected to wear.

c) Check for proper operation of the excitation devices.

d) Drain, wash out, and renew the lubricant in the bearings if contamination is evident.

e) Inspect and tighten connections on machine and control.

f) Check current input and compare to normal.

g) Run machine and examine critically for noise, vibration or other abnormal conditions.

## Annual Maintenance

a) Inspect and tighten connections on machine and control.

b) Check current input and compare with normal.

c) Clean out any dirt accumulation that may be in air gap.

d) Check the air gap.

e) Test insulation with a megger.

## Maintenance Log

It is recommended that a log be kept of routine and corrective maintenance performed. The log should include:

- Date
- Task Performed
- Person recording data
- Observations
- Pertinent Comments

There should be a record card for every machine in the plant. All repair work with its cost, and every inspection can be entered on the record. In this way, excessive amounts of attention or expense will show up and the causes can be determined and corrected. Each time the machine is meggered, the results should be placed on the machine record.

## Cleaning the Machines

- A systematic and periodic cleaning of machines is desirable. While some machines are installed where dust, dirt and moisture are not present, most are located where some sort of dirt accumulates in the windings.
- Some dusts are highly abrasive and actually cut insulation during their first passage through the ventilating ducts. Fine cast iron dust quickly penetrates most insulating materials. Hence, the desirability of cleaning the machines periodically.
- **If conditions are severe, open machines might require a certain amount of cleaning each day.** For less severe conditions, weekly inspection and partial cleaning are desirable.
- For weekly cleaning, dry compressed air (about 25 to 30-psi pressure) should be used to clean the machine. Care must be taken to direct the air so that dust will not be pocketed in the various corners. Where conducting and abrasive dusts are present, even lower pressure may be necessary, and suction is to be preferred, as damage can easily be caused by blowing the dust and metal chips into the insulation.
- In cleaning a machine, heavy dirt and grease should be first removed with a heavy stiff brush, wooden or fiber scrapers, and cloths. Rifle cleaning brushes can be used in the air ducts.

# Maintenance as Required

## Frame Inspection and Cleaning

With machine in service, inspect for dripping water, oil or acid leaks, excessive dirt or dust, loose parts or anything that would interfere with ventilation or moving parts. Keep the interior and exterior of the machine free from dirt, oil and grease.

1. First remove heavy dirt and grease with a heavy stiff brush, wooden or fiber scrapers and cloths. Rifle cleaning brushes can be used in the air ducts.
2. Dry dust and dirt may be blown off using dry compressed air at moderate pressure. Use care in directing air so that dust will not be pocketed in various corners.

**WARNING: Use cleaning solution in an open or well-ventilated area; avoid breathing fumes. Keep away from open flames. Do not use a wire brush or a steel blade scraper to clean parts. Do not use gasoline, fuel oil or kerosene for cleaning.**

3. Grease, oil and sticky dirt can be removed easily with a safe type, commercial cleaning solvent. Flammable fluids are not recommended. The best method of application is spraying. Use care not to soak bearing or winding insulation.

**WARNING: Use approved personnel protective equipment to protect eyes and face when using compressed air cleaning, cooling or drying. Do not direct airstream toward yourself or toward another person. Maximum allowable pressure is 30 psi.**

## Clean Windings

See “Cleaning Windings” on page 47 and follow instructions.

# Winding Insulation

## Care of Insulation

**Care of insulation goes hand in hand with lubrication as the two major features of a sound generator maintenance program and probably the two most vulnerable parts of the machine.**

- Windings are insulated with a high resistance material to prevent leakage and short circuits. If insulation is cracked, damaged, wet or dirty, the machine will not operate properly.
- Machines should always be stored in a dry, clean place until ready for installation. Heat should be supplied to protect the machine against alternate thawing and freezing or other temperature changes that cause moisture condensation on the machine parts or insulation.
- Machines that have been long in transit, in a moist atmosphere, or idle for an extended period of time, should be thoroughly dried out before being placed in service. (Check insulation resistance values). Since condensation sometimes occurs as a result of a difference in machine temperature and that of the surrounding air, the machines should be kept warm at all times to prevent this condition. (See "Receiving, Handling and Storage" section and continuously operate heaters or machine at a minimum of 5 degrees "C" above ambient temperature.)

Low voltage current can be passed through the windings or, as an alternative, electric heaters can be utilized for protective purposes.

In the case of extended idle periods, tarpaulins, with a vent at top to permit moisture to escape, may be stretched over the machine and small heaters put inside to maintain the proper temperatures. It is essential that there be a circulation of warm, dry air over any windings that may have absorbed moisture. Fans, set to blow over the heaters, will give good results.

## Insulation resistance

The insulation resistance of a winding is its resistance measured in megohms by direct voltage applied to the winding. Insulation resistance measurements can help to determine if a winding is suitable for satisfactory operation or if a high potential ground test should be performed.

## Factors Affecting Insulation Resistance

Insulation resistance is affected by winding temperature, moisture, damage and dirt, as well as the type and assembly of insulation material.

A low value of insulation resistance will result from foreign matter distributed throughout the windings or from a concentrated weak spot(s) in the insulation. Such a weakness may not affect insulation resistance at low voltage but may be the cause of breakdown upon application of normal working voltage. Carefully investigate for causes of low insulation resistance or sudden changes in insulation resistance.

A high value of insulation resistance usually indicates satisfactory insulation but is not proof that the insulation is free from mechanical or physical weakness. Periodic cleaning and visual inspection are necessary regardless of the insulation resistance value.

## Test Apparatus and Voltage

Measure insulation resistance with and insulation megohm instrument or other suitable instrument. Under normal conditions, the measurement of insulation resistance is considered a non-destructive test. However, it is a voltage test and the voltage value and characteristic of the testing apparatus should be selected accordingly, particularly for low voltage or wet machines.

## Insulation Resistance Measurement Records

It is essential to keep complete records of insulation resistance values to assist in determining the condition of the insulation. It is impossible to set a fixed value for the minimum permissible insulation resistance on a machine. Machines can operate satisfactorily over extended periods of time with low insulation resistance, but only to the extent of how much is known about the history of the particular insulation, its condition and resistance to determine if it is in a condition to operate satisfactorily.

## Insulation Resistance Measurements

Insulation resistance measurements will vary with the length of time of application of the test voltage and with the magnitude of the voltage. The rise in readings will be rapid when the voltage is first applied and decrease as time elapses. The rate and magnitude of this rise is an indication of the condition of the insulation.

Resistance of a dry winding in good condition may continue to increase for hours; however, fairly steady value is usually reached in 10 to 15 minutes. If the winding is wet or dirty, the steady value will be reached in a much shorter time.

**NOTE: For optimum maintenance and the best analysis of the condition of insulation, measure insulation resistance regularly at the same temperature, voltage and duration of applied voltage; keep accurate records of each insulation resistance measurement. 60 seconds application of the recommended test voltage direct current (see voltage tables in "Installation" section, Insulation Resistance subsection on page 13) is recommended for short time single readings where comparisons with earlier and later data are to be made. When no previous insulation resistance data is available, refer to "Polarization Index".**

## Polarization Index

The Polarization Index (PI) can be used to help determine the condition of winding insulation on which no previous insulation resistance data is available. The increase in insulation resistance during application of a test voltage is used to evaluate the cleanliness and dryness of a winding or when drying can be terminated.

- Take resistance readings after one minute and ten minutes of applying the recommended test voltage continuously (refer to voltage tables in "Insulation Resistance" on page 13 for correct voltage).
- Divide the ten minute reading by the one minute reading to obtain the Polarization Index. The Polarization Index for Class B or F insulation should be 2.5 or higher.

## Safe Values of Insulation Resistance

After the insulation resistance has reached a consistent level, determine if it is a safe operating value. It is preferable to compare the measured data with the original factory test data. If the factory test data is not available, compare the measured data to the average typical values given by the voltage tables in "Insulation Resistance" on page 14.

These typical values given in the tables are more conservative than IEEE Code values. Since insulation resistance varies widely with temperature and humidity from day to day and from machine to machine, a considerable amount of experience and judgment is required to know a machine is safe to energize.

## Corrective Procedures

If insulation resistance is lower than acceptable, clean and dry out the windings. See "Cleaning Windings" (page 47) for cleaning procedures and "Winding Dry Out Process" (page 48) for dry out procedures. It is good practice to dry out all units 2300 volts and above.

If insulation resistance is lower than acceptable after cleaning and drying the windings, major repair or equipment replacement may be required.

# Cleaning Windings

Insulated windings should be kept reasonably clean of dirt, oil, metal particles and other contaminants. A film of dirty oil tends to accumulate particles that may interfere with satisfactory ventilation of the machine. Access the rotor and stator assemblies and then clean windings using one or all of the following methods.

**WARNING: Use cleaning solution in an open or well-ventilated area; avoid breathing fumes. Keep away from open flames. Do not use a wire brush or a steel blade scraper to clean parts. Do not use gasoline, fuel oil or kerosene for cleaning.**

## Vacuum Cleaning

To remove dust, dirt and particles the use of suction is preferable to blowing out with compressed air, since there is less possibility of damage to insulation and less chance of blowing conducting or harmful particles into areas that may later result in damage during operation.

## Compressed Air Cleaning

Use compressed air to blow out loose dust and particles from inaccessible areas such as air ducts and between stator end turns.

## Solvent Cleaning

Oil and grease are not harmful to insulation but they do accumulate dust. Remove oil or grease with a cloth moistened, but not dripping, with a safety type, commercial cleaning solvent.

# Winding Dry Out Process

Moisture in the machine will affect the insulation resistance of the windings. Heat and circulate of dry air are necessary to remove moisture from insulation. Various methods for applying such heat are discussed in the following paragraphs, but regardless of the drying method employed**, *a number of precautions must be observed*:**

### Precautions:

1. Do not hurry the drying operation. Drying may take many hours or even days. In all cases, positive air circulation must be provided with ample ventilation for the escape of moisture.
2. Raise the temperature slowly and control it continuously; keep a close check on insulation temperature. If the machine has permanently installed temperature detectors, they may be used to check temperature or thermometers may be placed on some of the hottest parts of the equipment where they can be readily observed.

> **CAUTION: Never allow the internal temperature of the coils to exceed the boiling point of water. Temperatures above this point may convert the moisture to steam, creating internal pressure which may damage the insulation. The temperature limit on the surface of the winding and insulation is 185°F (85°C). It is therefore necessary to raise the temperature slowly and control it continuously.**

3. Provide ventilation. In all cases, positive air circulation must be provided with ample ventilation for the escape of moisture.
4. Careful observation and regular insulation resistance checks will determine when safe operating conditions have been reached (See "Observing the Progress of Dryout", page 50). Erratic readings or failure of the insulation resistance to increase normally may indicate an insulation fault or damage requiring repair before energizing the machine.

## Methods of Applying Heat

### a. Oven Drying

Small equipment that can readily be moved may be dried in baking ovens. When no oven is available, a temporary oven may be constructed around the equipment using sheet iron, insulating board or a tarpaulin cover, making sure that provisions have been made for the escape of moisture. Heat may be introduced by means of electric heaters, infrared rays, hot-air furnaces, steam coils, radiators, and stoves**. Use of an open flame is not recommended.**

The temperature of air in the oven must not reach temperatures which will damage the insulation. **It is recommended that the air temperature not exceed 220°F (105°C**).

**CAUTION: These precautions must be observed if permanent damage to the insulation is to be avoided.**

## b. Drying with Circulating Currents

One of the most effective means of drying out a piece of electrical equipment is by passing current through the windings. Suitable sources of low voltage power are exciter sets or arc welding sets. Drying should be accomplished using the following guidelines:

1. Voltage must be adjusted to limit the current in the windings to a safe value - no more than 50% of rated amperes. An adjustable voltage source is desirable.
2. Either A.C. or D.C. current may be used in the stator windings of A.C. generators or motors - except that A.C. should be used **only** when the rotor is removed to prevent excessive heating of the rotor. D.C. current should be used for field windings. **Limit the observable temperature on the surface of the coils to 185°F (85°C).**
3. Do not introduce current to a winding through slip rings. Apply power directly to the field leads.
4. Measure the current with a clip-on ammeter.

One of the simplest means of drying out an A.C. generator, which is in running condition (including bearing lubrication and cooling systems), is by short circuiting the stator leads, driving the machine at speed, and applying partial excitation to the field. This is a very effective method for drying out both the rotor and stator of an alternator. The action of the revolving field also helps circulate air and carry away moisture.

Again, it is necessary to observe the temperatures very closely and avoid overheating. In general, less than half of the normal rated exciting current will circulate ample heating current in the stator.

**CAUTION: Be sure that all steps are performed and all precautions taken to prevent personal injury or serious damage to the machine.**

## Observing the Progress of Dryout

**NOTE: Careful observation of the properties of the insulation during drying is the only means of determining when safe operating conditions have been reached.**

1. Take insulation resistance checks every one to four hours; keep a record of these readings.
2. It must be remembered that two effects are present - increased temperature, which lowers insulation resistance, and drying, which increases insulation resistance. Due to the temperature effect, the insulation resistance may initially decrease before the drying effect increases the resistance.
3. Drying should continue until insulation resistance values show no abrupt changes, and do not increase more than 5% over an 8-10 hour period. ***Erratic readings or failure of the insulation resistance to increase normally may indicate an insulation fault or damage requiring repair before energizing the machine.***

## Space Heaters

Enclose the machine with a covering and turn on space heaters. For further heating, insert auxiliary heating units to raise the temperature. Electric heaters, infrared rays, hot-air furnaces, steam coils, radiators or stoves may be used to provide heat. Use of an open flame is not recommended.

## Forced Air

A portable forced air heater can be used by directing heat to the drive end air vents of the machine. Run the machine with no load and without excitation. Heat at point of entry should not exceed 150$^{o}$F (66$^{o}$C).

# Hyundai Ideal Horizontal Sleeve Bearings

## Description

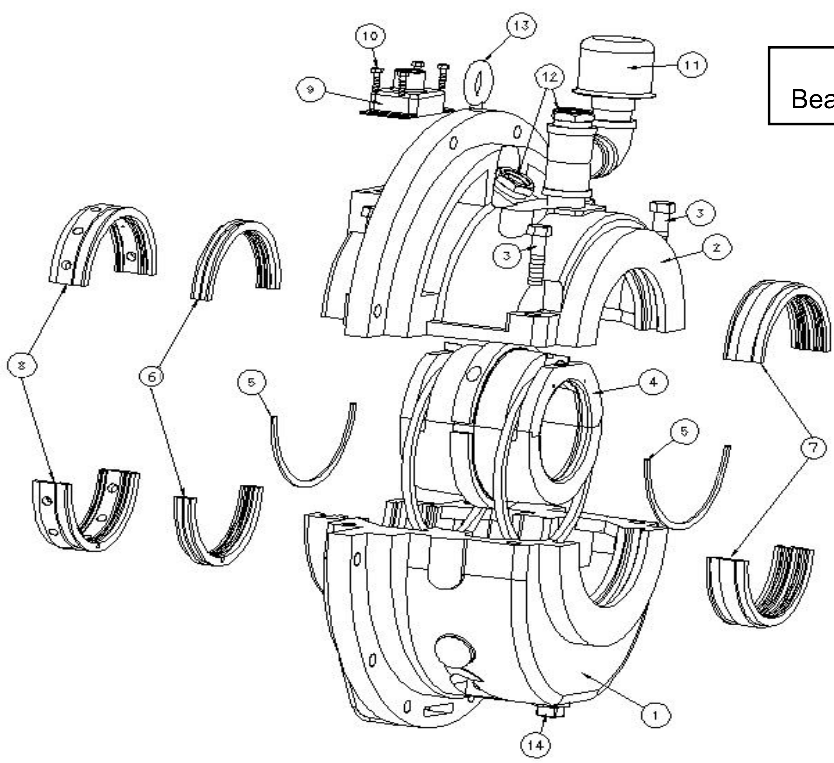
Hyundai Ideal Electric sleeve bearings are of the split babbitt type. A one-to-one ratio of journal length to diameter assures minimum operating temperature and long bearing life.

The center point support in the housing provides self-aligning characteristics and helps to assure full utilization of the bearing surface.

One or two oil rings, each fitted with a wiper, carry an adequate supply of oil to the top of the bearing ensure adequate distribution of oil to the bearing surfaces regardless of the direction of the radial load on the bearing. Depending on the application, oil may be required from an external lubrication system. See the Outline Drawing for specifics.

The entire sleeve bearing is split to allow convenient service of the bearing without disturbing the alignment of the machine on its base or without removing the coupling.

Exploded View
Bearing Housing Assembly




| NO | DESCRIPTION | QTY |
|---|---|---|
| 1 | BEARING HOUSING | 1 |
| 2 | BEARING CAP | 1 |
| 3 | HEX HEAD CAP SCREW | 4 |
| 4 | BEARING ASSEMBLY | 1 |
| 5 | SHIM SET | 2 |
| 6 | INNER OIL SEAL | 2 |
| 7 | OUTER OIL SEAL | 2 |
| 8 | AIR PRESURE OIL SEAL | 2 |
| 9 | HOUSING AIR VENT | 1 |
| 10 | HEX HEAD CAP SCREW | 4 |
| 11 | BREATHER | 1 |
| 12 | SIGHT GLASS | 2 |
| 13 | EYE BOLT | 1 |
| 14 | PIPE PLUG | 1 |
| | | |

## Lubrication of Sleeve Bearings

The bearings and bearing housings of machines using oil lubrication normally do not need to be treated to prevent rust and corrosion, due to moisture condensation, if the storage period is 30 days or less.

When the period of storage or standing idle exceeds 30 days, the bearing housings should be filled to the proper level with "preservation-type" oil that meets military specifications MIL-L-21260 or consult your oil supplier's industrial applications engineer for his recommendation of the proper type preservative oil to use.

When the bearing housings are filled with preservative oil, the machine should be turned to make sure the preservative oil coats the journals. If it is not possible to use power to turn the rotor, turn it over a few turns by hand.

Bearing housings that have been filled to the proper level with preservative oil should be drained and refilled with the proper grade of bearing oil before putting the machine into service.

**CAUTION: Cleanliness is the most important consideration in the care of bearings. Use extreme caution to prevent foreign matter from entering the bearing by way of the lubricant, or when servicing the bearings.**

Consult the lubrication chart in this section for specific recommendations as to type and viscosity of oil for various manufacturers. The recommended oil viscosity for each bearing oil sump of a machine is usually stamped on a nameplate mounted on the bearing housing. Machines are shipped from the factory dry to avoid spillage during shipment.

**CAUTION: Upon arriving at its destination, the machine bearings should be immediately filled with oil to their proper level and turned a few times by hand to avoid damage to the bearings due to rust or corrosion.**

## Oil Level

The oil sight gages have two marks. With the machine idle, fill the bearing through the upper bearing section until the oil level reaches the high mark. When oil level drops to the low mark when the machine is idle, oil should be added.

## Air Pressure Adjustment

The bearings are equipped to equalize air pressures around the housings and prevent oil leakage. This is accomplished by supplying the bearings with air from the pressure side of the fan to maintain atmospheric pressure, or slightly above, in the bearing housing.

The proper pressure adjustment has been made before the machine was shipped from the factory. This adjustment will result in the running oil level being 1/8 inch above the stationary level. **As a minimum, the stationary oil level should be between the high and low marks on the oil sight gage.**

Should it become necessary to adjust the pressure balance, proceed as follows:

a) Ensure that the oil level in the bearings is to the high mark on the oil sight gage. If the level is below the high mark, with the machine idle, take this opportunity to replenish the oil.

b) Start the machine, and allow it to reach full speed.

c) Loosen the screws holding the air adjusting plate - located on the bearing bracket below the bearing housing - and move the plate up or down as needed, so that the oil is 1/8 inch above the oil level before the machine was started.

d) Tighten the screws holding the air adjusting plate securely. This will give a pressure in the bearing housing slightly greater than atmospheric pressure.

## Changing Oil

When the oil becomes dirty or contaminated, drain it off by removing the drain plug The plug is usually located at the bottom or side of the bearing housing. Flush the bearing with warm, light grade, clean oil until the outcoming oil is clean. Refill to the proper level with oil of the recommended type and viscosity.

**CAUTION: Make sure that dirt or foreign particles are not permitted to enter the oil sump chamber.**

## Bearing Replacement

When replacing sleeve bearings:

a) Remove the top half of the bearing housing and take the bearing apart.

b) Jack up, or otherwise lift, the shaft to take the load off of the lower half of the bearing. The lower half of bearing can then be rolled out.

**CAUTION: Before jacking up the shaft, loosen the bearing housing cap bolts on the opposite bearing. This is to prevent this bearing from being wedged in its housing and resulting in damage when the unit is started.**

c) When the new bearing is installed, but before installing the top half of the bearing housing, check to see that there is clearance on each side of the bearing between the bearing shell and the bearing housing seat. The bearing should never be so tight in its seat that it cannot be easily rotated slightly when the weight of the shaft or journal is removed.

d) Check the clearance between the shaft and the bearing using feeler gages or plasti-gages. As the bearings become worn, the amount of wear will be reflected in the clearance.

e) The shaft is scribed at the outer end of the bearing housing to indicate the magnetic center position of the rotor. With the bearing cap or top half of the bearing housing removed and the rotor located endwise so that the mark on shaft is in line with the bearing housing, position the bearing in center between the shaft thrust shoulders.

f) Shifting the bearing along the shaft, measure the maximum and minimum distances from the center boss (on the outer diameter of the bearing) to the finished outer end of the housing.

g) Place the bearing locating shims on the sides of the boss so that the bearing is centered within the shaft journal. Bend the outermost shim (which should be the shim that extends beyond 180°) tabs so that it and the other shims will be locked in position when the bearing halves are assembled.

**CAUTION: Always make sure bearings are adjusted so that they are in the center of the shaft bearing journal while operating.**

When replacing a bearing that has failed, and the shaft shows signs of rubbing the seals,

a) Use special care in fitting the bearing in its housing.

b) Check the shaft for runout to make sure that the shaft has not been distorted due to concentrated local heating.

c) After replacing bearings and running the machine for a short period of time, it is recommended that the bearing or bearings be disassembled and inspected for wear pattern. The wear pattern should be distributed quite evenly over at least 60% of the projected area of the bearing. If necessary, the bearing should be fitted by scraping to obtain a good wear pattern.

d) Clean the mating surfaces of the bearing housing thoroughly and coat with Permatex or similar sealer. The top half of the bearing housing should then be replaced.

## Oil Change Interval

The recommended oil change interval is as follows:

| RECOMMENDED OIL CHANGES | |
|---|---|
| OPERATING TEMPERATURE OF BEARING (°F) | TIME BASED ON AVERAGE SERVICE CONDITIONS |
| 100 to 140 | At Least Once Per Year |
| 140 to 165 | At Least Every 6 Months |
| 165 to 175 | At Least Every 3 Months |

## LUBRICATION RECOMMENDATIONS

### Commonly Used Industrial Lubricant Viscosity Equivalents

| | | | | |
|---|---|---|---|---|
| ISO Viscosity Grade | 32 | 46 | 68 | 150 |
| SAE Viscosity Number (approx.) | 10W | 10 | 20 | 40 |
| Viscosity SUS @ 100°F | 135-165 | 194-236 | 284-346 | 630-770 |
| Kinematic Viscosity Centistokes @ 40°F | 28.8-35.2 | 41.4-50.6 | 61.2-74.8 | 135-165 |
| Saybolt Viscosity SUS @ 104°F (40°C) (approx.) | 150 | 215 | 315 | 700 |

### Manufacturers' Brand or Trade Names by ISO Viscosity Grade (ISO VG)

| Manufacturer | ISO VG 32 | ISO VG 46 | ISO VG 68 | ISO VG 150 |
|---|---|---|---|---|
| Amoco Oil Company (Std. Oil of Indiana) | American Ind. Oil #32 | American Ind. Oil #46 | American Ind. Oil #68 | American Ind. Oil #150 |
| Ashland Oil Company (Valvoline Oil Division) | ETC (R&O) #15 | ETC (R&O) #20 | ETC (R&O) #30 | ETC (R&O) #70 |
| Atlantic-Richfield Company | Duro 32 | Duro 46 | Duro 68 | Duro 117 or 150 |
| BP Oil Company | Energol Hlp 32 | Energol Hlp 46 | Energol Hlp 68 | Energol Hlp 150 |
| Chevron USA Inc. | Chevron OC Turbine Oil 32 | Chevron OC Turbine Oil 46 | Chevron OC Turbine Oil 68 | Chevron OC Turbine Oil 150 |
| Cities Service Inc. | Citgo Pacemaker 32 | Citgo Pacemaker 46 | Citgo Pacemaker 68 | Citgo Pacemaker 150 |
| Conoco Inc. | Dectol R&O Oil 32 | Dectol R&O Oil 46 | Dectol R&O Oil 68 | Dectol R&O Oil 150 |
| Exxon Company, USA | Terresstic 32 or 33 | Terresstic 46 | Terresstic 68 | Terresstic 150 |
| Getty Refining & Marketing Co.<br>Eastern Region<br>Central Region | Veedol Aturbrio 50<br>Skelvis MP #150 | Veedol Aturbrio 58<br>Skelvis MP #10 | Veedol Aturbrio 60<br>Skelvis MP #20 | Veedol Aturbrio 71<br>Skelvis MP #40 |
| Gulf Oil Corporation | Gulf Harmony 32 | Gulf Harmony 46 | Gulf Harmony 68 | Gulf Harmony 150 |
| E.F. Houghton & Company | Hydro-Drive MIH Light | Hydro-Drive MIH 10 | Hydro-Drive MIH 20 | Hydro-Drive MIH 40 |
| Kendall Refining (Div. of Witco Chem. Corp.) | Hyken Golden | Kenoil R&O 047 EP | Kenoil R&O 053 EP | Kenoil R&O 080 EP |
| Mobil Oil Corporation | DTE Light | DTE Medium | DTE Heavy Medium | DTE Oil Extra Heavy |
| Pennzoil Company | AW Hyd Oil 32 | AW Hyd Oil 46 | AW Hyd Oil 68 | AW Hyd Oil 150 |
| Phillips Petroleum Company | Magnus Oil 32 | Magnus Oil 46 | Magnus Oil 68 | Magnus Oil 150 |
| Shell Oil Company | Turbo 32 | Turbo 46 | Turbo 68 | Turbo 150 |
| Standard Oil Company (Ohio) Boron Oil Company | Industron 44 | Industron 48 | Industron 53 | Industron 66 |
| Stewart-Warner Corporation Alemite Division | Hyd. HD Oil #0 | Hyd. HD Oil #1 | Hyd. HD Oil #2 | Hyd. HD Oil #3 |
| Southwestern Petroleum Corp. | Swepco Ind. Oil 702-1 | Swepco Ind. Oil 702-1 | Swepco Ind. Oil 702-2 | Swepco Ind. Oil 702-4 |
| Sun Petroleum Products Co. | Sunvis 916 | Sunvis 921 | Sunvis 931 | Sunvis 975 |
| Texaco Inc. | Regal Oil R&O 32 | Regal Oil R&O 46 | Regal Oil R&O 68 | Regal Oil R&O 150 |

| | | | | |
|---|---|---|---|---|
| Union Oil Co. of California<br>Western Region<br>Eastern Region | Turbine Oil 32<br>Unax RX 32 | Turbine Oil 46<br>Unax RX 46 | Turbine Oil 68<br>Unax RX 68 | Turbine Oil 150<br>Unax RX 150 |

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# Recommended Spare and Replacement Parts

## Introduction

To assure quality and compatibility with equipment in the field, spare and replacement parts should be ordered through Hyundai Ideal Electric Company. For parts and service quotations, contact the Hyundai Ideal Electric Company AMS Department at the following address:

HYUNDAI IDEAL ELECTRIC
After Market Services Department (AMS)
330 East First Street
Mansfield, Ohio 44903
Phone: (419) 522-3611
Fax: (419) 522-9386

### Parts Identification

When referring to any item supplied by Hyundai Ideal Electric Company in writing or verbally, use the correct part name and number references to avoid confusion. Identify all items by the Hyundai Ideal Electric part name/description and part number as they appear on the Outline and Assembly Layout Drawings. It is important to reference the shop order number (S.N.#) and installation on which the item was originally supplied. The shop order number is stamped on the unit nameplate.

### Return Shipping Instructions and Limitations

Contact the Hyundai Ideal Electric Company Parts Department before attempting to return ship any item. All items returned to Hyundai Ideal Electric must be accompanied by a Return Shipment Order or the shipment will be refused at the expense of the sender. Hyundai Ideal Electric will issue specific packing and shipping instructions with the Return Shipment Order.

## Recommended Spare Parts

The recommended spare parts list follows. These parts are also illustrated on the Assembly Layout Drawing in the "Drawings and Specifications" section. Key factors in determining the items and quantities listed are component use in overall system, impact of component failure on generator downtime, estimated component life and component availability. The bearing parts are recommended as a minimum to be stocked during the first year of operation to assure continuous power generation with minimum downtime. The specific part numbers for these bearings are located on the Layout Drawing.

### Generator

| Hyundai Ideal Part Number | Quantity | Item |
|---|---|---|
| For spare parts see Layout Drawing later in the manual. | | |
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# Drawings and Specifications

## Associated Drawings

The following drawings have been selected from the manufacturing drawings for this generator to supplement the manual text. The drawings are included at reduced size in this section.

| List of Drawings | |
|---|---|
| **Description** | **Drawing Number** |
| Outline Drawing | 5065A0-B76 |
| Layout Drawing | 5065C0-B46 |
| Accessory Interconnection Diagram | 430550-E25 |
| Incoming Line Cubicle Drawing | 14DSB-2404 |
| Mass Elastic Diagram | B-MED-1834 |
| Sole Plate Grouting & Install | C64320 |

## Specification of Equipment

The specifications for this generator are described below.

| Item | Description |
|---|---|
| Serial number | 071059 |
| Product Code | 065SAB04T67 |
| Description and Ratings | 11,676 KVA, 9,341 KW, .80 PF, 1,800 RPM, 3 Phase, 60 Hertz |
| Electrical Features | 12,470 Volts, WYE connected, 6 Leads, 80°C rise by resistance |
| Mechanical Features | Renk Sleeve Bearings, TEWAC Enclosure |
| Accessories | Sole Plates, RTDs, Space Heaters, Vibration Equipment, Leak Detector |

## List of Catalog Inserts

The following catalog inserts for components included with the horizontal synchronous generator begin immediately after the drawings and specifications listed in the previous tables.

| List of Components |
|---|
| Renk EM Bearing Manual (Ring Oiled) |
| IOM Thermofin RCP HX |
| Minco Resistance / Temperature Table 0.00385 100ohm PT |
| Chromalox Space Heater S & SE |
| Bently Nevada 990 5mm 8mm |
| Warrick Leak Detector Type 2 |
| |

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# Disassembly and Assembly of Generator

## Introduction

Always consult the applicable cross-sectional drawing before starting to disassemble the machine. Time should be taken to outline exactly what is to be done. All parts on the cross-sectional drawing are numbered along with a description of each part. When starting your disassembly, check all mating parts for match marks. If there are none in evidence, take a punch or scribe and match mark parts as you disassemble them.

**WARNING: De-energize applicable electrical circuitry connected with the main leads and tag "OUT OF SERVICE. DO NOT CHANGE POSITION OF SWITCH EXCEPT BY ORDER OF SUPERVISOR". Use a voltmeter or voltage tester to ensure circuit is de-energized before contacting electrical circuits.**

### Disassembly

1. Disconnect all power and accessory leads. All wiring should be marked for replacement. Disconnect all conduit from the generator.
2. Disconnect the generator as allowed per the items' physical locations on the layout drawing.
3. Use extreme care when disassembling the bearings. Once they are removed and cleaned, wrap them in paraffin paper to protect them from moisture or dirt.

### Assembly

To assemble the generator, reverse disassembly procedure. There are several areas in which extreme caution must be taken:

1. Parts should be completely cleaned before installing them. Wipe all mounting surfaces with a clean cloth and coat with a thin film of mineral oil.
2. Inspect the bearings before assembling.
3. Remount bearings.

4. Reconnect all leads as tagged during disassembly or according to the interconnection diagram.

## Generator Checkout

After the unit is assembled, test the generator. Perform operational checks as were completed for initial startup .

If bearings were replaced, perform a no load running test until the temperature is established. Do not allow the temperature to rise above $60^{o}$C.

# Brushless Excitation

## Introduction/Description

A brushless synchronous machine is one with an A.C. exciter whose armature is mounted on the main shaft, and whose A.C. output is rectified by a rotating rectifier bridge and fed directly into the field of the synchronous machine. Commutators, collectors, brushes and brush riggings are thereby eliminated. This greatly simplifies the maintenance of the machines.

# Flashing

The generating equipment is brought up to speed and can be either automatically or manually flashed. Flashing consists of applying a D.C. Voltage to the exciter field, thus providing initial excitation for start up. When this occurs, the generator voltage builds up and is regulated by the voltage regulator. At this time, the load can be applied and the voltage regulator automatically maintains voltage regardless of load changes.

If the generator is brought up to speed and no output voltage appears:

- Check to make sure that the field has been flashing.
- Place a voltmeter across the exciter field terminals and proceed through the starting cycle. The flashing source has to remain on the exciter long enough to start the A.C. voltage build up.

**CAUTION: Polarity of flashing source is important. Damage to rectifiers may result if flashing with wrong polarity.**

Brushless exciters built recently do not usually require field flashing as described earlier. The steel in these exciters retains the residual magnetism and, upon rotation, the exciters start to build up voltage. These exciters may require flashing after extended periods of idleness.

If the voltage rises and then falls when the flashing is removed, there are several basic checks to perform:

a) Check the fuses connected in series with the regulator input power.

b) Check the fuses on the regulator chassis.

c) Recheck the interconnection to the exciter. These units are all tested and adjusted at the factory and if properly installed and connected should operate satisfactorily.

If all of the above are found to be in working order, the static regulator manual should be consulted for troubleshooting.

d) Finally, the rotating rectifiers should be checked (see page (67)). These rectifiers will normally last the lifetime of the machine but occasionally may fail due to high-shock shipping damage, a defective rectifier cell that did not show up during test, improper paralleling, as well as overload. It is not possible to tell by looking at the rectifier whether it has failed. Each rectifier should be disconnected from its mounting and the circuit and tested separately. Most rectifiers have bolted connections, though some may have solder connections.

**CAUTION: Extreme care should be taken that no more heat is applied than absolutely necessary to do the job. When reinstalling rectifiers, care should be taken to insure a clean surface so the rectifier draws down on the heat sink squarely. When tightening the base of the rectifier cell, the proper torque value is important. Too much pressure could cause the cell to fracture and too little pressure could cause poor contact and improper operation.**

# Testing Individual Rectifiers

A battery, test light or analog VOM are required to test a rectifier. Do not use a megger or digital VOM.

Battery and test light:

1. Disconnect the rectifier cell completely.
2. Connect the battery and light in series
3. Connect in series with the rectifier cell.
4. Reverse connection to the cell. The test light should light on only one of the connections.
5. If it lights in both, then the rectifier cell is shorted out and must be replaced. If the light does not light in either direction, the rectifier is defective and should be replaced.

Similarly, when a VOM is used:

1. The resistance of the rectifier should be much higher in one direction than the other (10,000 ohms or more).
2. Each rectifier (both rotating and stationary) should be checked individually and defective cells replaced with rectifiers of the same rating. Even when rectifier bridges are used, the only positive test of the rectifier is to check each one individually.

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# Enclosure

## a) Totally Enclosed, Water -To-Air Cooled (TEWAC) Enclosure (IP54)

### Description

This horizontal synchronous generator is equipped with an enclosure that recirculates air for cooling. The air flow is created by the internal fans that are mounted on the rotor. The air then flows through the rotor and stator to provide cooling. As the air exits the stator, it enters a cooling coil. The hot air then transfers its heat to the water in the coils. After exiting the cooling coil (or heat exchanger), the air is then drawn back into the machine to repeat the cycle.

The totally-enclosed, water-to-air cooled (TEWAC) enclosure provides the air flow path, heat transfer and protection that is required for the generator.

## b) Open (IPOO), Open Dripproof (IP12), and Dripproof Guarded (IP22) Enclosures

### Description

This equipment is designated as an open machine. An open machine is one which has no ventilation restrictions or added degree of protection other than that required by mechanical construction. External cooling air is permitted to enter over and around the windings of the machine. This equipment contains the degree of protection required by the customer. Progressive degrees of protection are provided with open dripproof (ODP) and dripproof-guarded enclosures.

According to NEMA MG 1:

> An open dripproof machine is an open machine in which the ventilating openings are so constructed that successful operation is not interfered with when drops of liquid or solid particles strike or enter the enclosure at any angle from 0 to 15 degrees downward from vertical. The machine is protected against solid objects greater than 2 inches.
>
> A dripproof-guarded machine is an open-dripproof machine in which all openings giving access to live metal or rotating parts (except smooth rotating surfaces) are

limited in size by the structural parts or by screens, baffles, grilles, expanded metal or other means to prevent accidental contact with hazardous parts.

# c) NEMA Weather Protected Type II Enclosure (IPOW)

## Description

The machine enclosure has been constructed to meet the requirements of the NEMA specification which follows:

A weather protected machine is a guarded machine with its ventilating passages so constructed as to minimize the entrance of rain, snow and air-borne particles to the electric parts. Furthermore, a weather-protected Type II machine shall have its ventilating passages at both intake and discharge so arranged that high-velocity air and air-borne particles blown into the machine by storms or high winds can be discharged without entering the internal ventilating passages leading directly to the electric parts of the machine shall be arranged by baffling or separate housings as to provide at least three abrupt changes in direction, none of which shall be less than 90 degrees. In addition, an area of low velocity not exceeding 600 feet per minute shall be provided in the intake air path to minimize the possibility of moisture or dirt being carried into the electric parts of the machine.

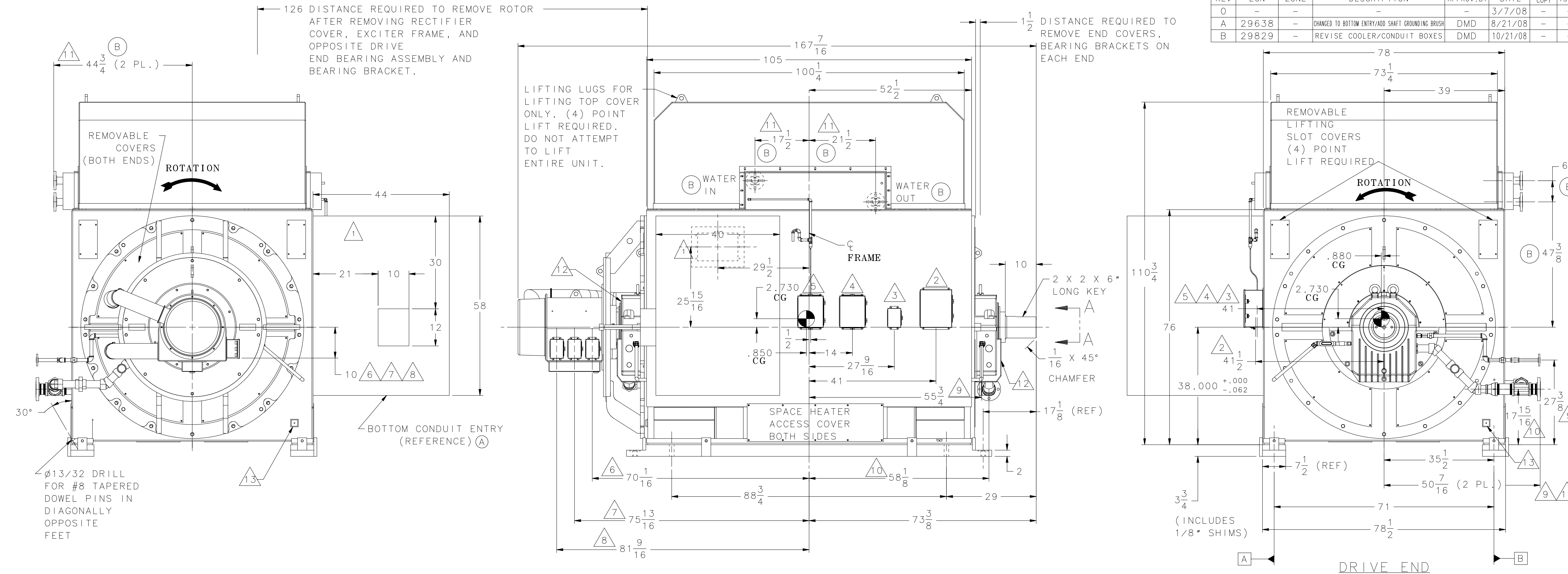
Note - Removable or otherwise easy to clean filters may be provided instead of the low velocity chamber.

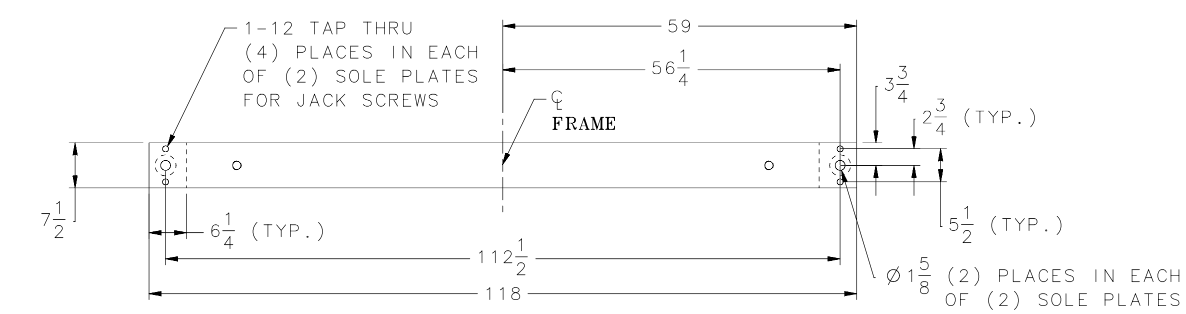
# d) Totally-Enclosed, Air-to-Air Cooled (CACA or TEAAC) Enclosure

## Description

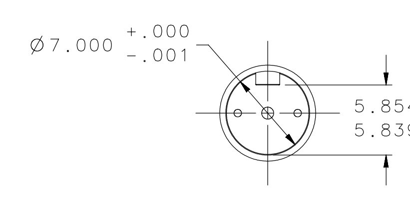
This machine is equipped with an enclosure that recirculates air for cooling. The air flow is created by internal fans which are mounted on the rotor. The internal air flows through the rotor and stator to provide cooling. As the internal air exits the stator, it flows on the outside of the cooling coil tubes. The heat, which the internal air has absorbed, is transferred to external air flowing inside the coil tubes. After exiting the cooling coil (or heat exchanger) section, the internal air is drawn by the fans and returns into the machine to repeat the cooling cycle. The totally enclosed, air-to-air cooled (CACA or TEAAC) enclosure provides the air flow path, heat transfer and protection that is required for the machine.

| REV | ECN | ZONE | DESCRIPTION | APPROV. BY | DATE | MICRO COPY | ISSUE |
|---|---|---|---|---|---|---|---|
| 0 | - | - | - | - | 3/7/08 | - | - |
| A | 29638 | - | CHANGED TO BOTTOM ENTRY/ADD SHAFT GROUNDING BRUSH | DMD | 8/21/08 | - | - |
| B | 29829 | - | REVISE COOLER/CONDUIT BOXES | DMD | 10/21/08 | - | - |




FOOT DETAILS (NEAR SIDE SHOWN)




VIEW A-A

1. INCOMING LINE CUBICLE DETAIL, SEE DRAWING 14DSB-2404.
2. ONE HOLE FOR 1" CONDUIT FOR STATOR, BEARING TEMPERATURE DETECTOR LEADS.
3. ONE HOLE FOR 1" CONDUIT FOR GENERATOR FRAME SPACE HEATER LEADS. (B)
4. ONE HOLE FOR 1" CONDUIT FOR VIBRATION PROXIMITORS LEADS, (2) PER BEARING. (B)
5. ONE HOLE FOR 1" CONDUIT FOR LEAK DETECTOR.
6. ONE HOLE FOR 1" CONDUIT FOR PERMANENT MAGNETIC ALTERNATOR LEADS
7. ONE HOLE FOR 1" CONDUIT FOR EXCITER FRAME SPACE HEATER LEADS.
8. ONE HOLE FOR 1" CONDUIT FOR FOR EXCITER FIELD LEADS.
9. OIL SUPPLY CONNECTION IS 3/4", 150# SST FLANGE.
10. OIL RETURN CONNECTION IS 3", 150# RAISED FACED FLANGE. SIGHT FLOW INDICATORS ARE PROVIDED ON EACH BEARING DRAIN LINE.
11. COOLER CONNECTIONS ARE 2", 150#-RFSO RAISED FACED FLANGES. WATER (B) REQUIREMENTS ARE 300 GPM OF 86°F CLEAN FILTERED WATER IN. PRESSURE DROP THRU COOLER IS 8.00 PSI. WATER TEMPERATURE OUT OF COOLER IS 91.9°F.
12. ONE BEARING IS ELECTRICALLY INSULATED FROM GROUND. NO CUSTOMER CONNECTIONS SHOULD BE MADE TO THE INTERNAL BEARING SHELL IN ORDER TO PRESERVE THE INTEGRITY OF THE INSULATION. THE DRIVE BEARING IS PROVIDED WITH A GROUND STRAP AND SHAFT GROUND BRUSH.
13. TWO GROUNDING PADS WITH 5/16-18 X 3/4" DP. TAPPED HOLES LOCATED DIAGONALLY OPPOSITE OF EACH OTHER.

(A) 14. SHAFT GROUNDING BRUSH

CERTIFICATION FOR: DRESSER-RAND COMPANY
1106 WASHINGTON STREET
BURLINGTON, IA 52601

S/N 071059-01/-02 CUSTOMER NUMBER -

TYPE "SAB" HORIZONTAL, BRUSHLESS SYNCHRONOUS GENERATOR RATED AS FOLLOWS:

11,676 KVA, 9,341 KW, .80 P.F., 1800 RPM, 3 PHASE, 60 HERTZ, 12,470 VOLTS, WYE CONNECTED, 6 LEADS, 80°C RISE BY RESISTANCE ABOVE A 40°C AMBIENT, CONTINUOUS DUTY, CLASS "F" INSULATION
STANDARD PHASE SEQUENCE 1,2,3, FOR CLOCKWISE ROTATION FACING NON-DRIVE END.

| FOOT LOADS | STATIC LOAD | FULL LOAD TORQUE | SHORT CIRCUIT TORQUE |
|---|---|---|---|
| A | 30485 LBS ▽ | 35425 LBS ▽ | 72969 LBS ▽ |
| B | 30485 LBS ▽ | 25545 LBS ▽ | 11998 LBS △ |

THIS UNIT IS EQUIPPED WITH SLEEVE BEARINGS ALLOWING A NOMINAL 1/2 INCH TOTAL END FLOAT. MAXIMUM TOTAL COUPLING END FLOAT MUST BE .19 INCHES PER NEMA MG 1-2003 20.29.2

ESTIMATED WEIGHTS
STATOR........ 39,670 LBS
ROTOR......... 16,800 LBS
COOLER......... 2,000 LBS
COOLER COVER... 1,550 LBS
ICLC BOX......... 950 LBS

TOTAL ........ 60,970 LBS (±10%)

AIR REQUIREMENT 13,500 CFM INTERNAL

VERTICAL THERMAL GROWTH 2.9 MILS

| | OPPOSITE DRIVE END BEARING OIL REQUIREMENTS | DRIVE END BEARING OIL REQUIREMENTS |
|---|---|---|
| VISCOSITY | ISO VG46 | ISO VG46 |
| PRESSURE | 15-20 PSI | 15-20 PSI |
| FLOW | 1.90 GPM PER BRG | 1.90 GPM PER BRG |
| MAX. OIL IN TEMP. | 140°F | 140°F |
| LOSSES | 12,636 BTU/HR/BRG | 12,636 BTU/HR/BRG |

WORKING TOLERANCES UNLESS OTHERWISE SPECIFIED

| MACHINING | FABRICATION | FINISH |
|---|---|---|
| ±.01 THRU 2.00" ±.015 OVER 2.00 THRU 10.00" ±.03 OVER 10.00" ANGLE ±0.5° | ±.12 THRU 24.00" ±.24 OVER 24.00" | 125 MICRO INCHES |

ALL DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED
ALL THREADS TO BE CLASS 2 UNIFIED



FILE NO. 1C-10 LIBRARY A0 REF NO. 5065A0-B74

FIRST USED ON 071059 HIEC ORDER No.

| | BY | DATE |
|---|---|---|
| DR. | NJK | 3/7/08 |
| CK. | NJK | 3/7/08 |
| APP. | BSH | 3/7/08 |
| APP. | | |

HYUNDAI IDEAL ELECTRIC CO. MANSFIELD OPERATION 330 EAST FIRST STREET MANSFIELD, OHIO 44902-7780

TEWAC 21520-4-40 / BE 13-3 / PMA 13-3

# OUTLINE

RENK BEARINGS EM 22-225

SIZE D — DRG NO. 5065A0-B76 — SCALE — WEIGHT — SHEET 1 OF 1

| REV | ECN | ZONE | DESCRIPTION | APPROV.BY | DATE | MICRO COPY | ISSUE |
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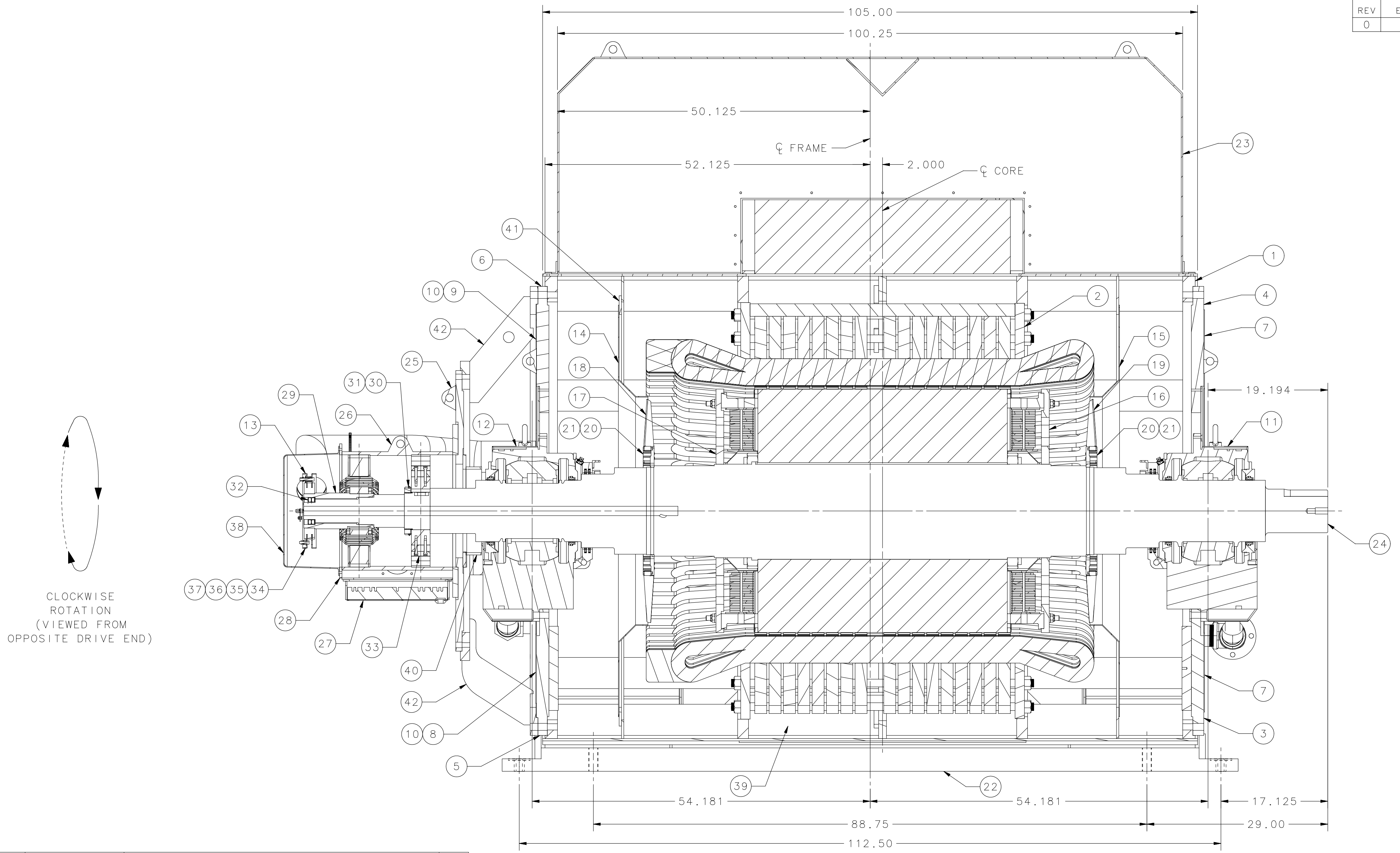



| ITEM | PART NUMBER | NAME OF PART | PCS |
|---|---|---|---|
| 1 | 5065F3-A06PA | FRAME ASSEMBLY | 1 |
| 2 | 5065F4-A07PA | STATOR PACK ASSEMBLY | 1 |
| 3 | 4065B4-A20PA | LOWER BEARING BRACKET DE | 1 |
| 4 | 4065B4-A23PA | UPPER BEARING BRACKET DE | 1 |
| 5 | 4065B4-A25PA | LOWER BEARING BRACKET ODE | 1 |
| 6 | 4065B4-A24PA | UPPER BEARING BRACKET ODE | 1 |
| 7 | 330030-A63PA | BEARING BRACKET COVER DE (UPPER/LOWER) | 4 |
| 8 | 330030-A66PA | BEARING BRACKET COVER ODE VENTED (LOWER) | 1 |
| 9 | 330030-A91PA | BEARING BRACKET COVER ODE VENTED (UPPER) | 1 |
| 10 | 330030-A62PA | BEARING BRACKET COVER ODE (UPPER/LOWER) | 2 |
| 11 | 106129 | BEARING ASSY EMZLB 22-225 (DE) | 1 |
| 12 | 106130 | BEARING ASSY EMZLQ 22-225 (ODE) | 1 |
| 13 | BE13-394A | EXCITER ARMATURE ASSEMBLY | 1 |
| 14 | 5065B6-A35RA | BAFFLE (ODE) | 1 |
| 15 | 5065B6-A35RB | BAFFLE (DE) | 1 |
| 16 | C69434GR3 | BALANCE RING (DE) | 1 |
| 17 | C69434GR3 | BALANCE RING (ODE) | 1 |
| 18 | 30300L30-7.7 | FAN BLADE (ODE) | 22 |
| 19 | 30300R30-7.7 | FAN BLADE (DE) | 22 |
| 20 | 430051-A17PL | FAN MOUNTING HUB | 2 |
| 21 | 30305 | FAN BLADE CLAMP | 44 |

| ITEM | PART NUMBER | NAME OF PART | PCS |
|---|---|---|---|
| 22 | 430010-A62PA | SOLE PLATE | 2 |
| 23 | 5065C8-A41RA | TOP COVER | 1 |
| 24 | 5065D1-B10RA | SHAFT | 1 |
| 25 | 4018E0-A46PA | EXCITER FRAME ADAPTER | 1 |
| 26 | 5018F6-A67PA | EXCITER & PMA FRAME | 1 |
| 27 | 430032-A24PA | EXCITER PAN COVER | 1 |
| 28 | 4018C0-A64RA | EXCITER LAYOUT | 1 |
| 29 | 430460-A13RA | ARMATURE SLEEVE | 1 |
| 30 | 100305 | LOCKNUT (AN30) | 1 |
| 31 | 100328 | LOCKWASHER (W30) | 1 |
| 32 | 34600A | RINGFEDER LOCKING ASSEMBLY | 1 |
| 33 | 5021P1-A01RA | PMA ROTOR | 1 |
| *34 | D66787D2GR10 | RECTIFIER ASSEMBLY | 1 |
| *35 | 32355F | RECTIFIER | 3 |
| *36 | 32355R | RECTIFIER | 3 |
| *37 | 102147 | SURGE PROTECTOR | 1 |
| 38 | 430033-A09RA | RECTIFIER COVER | 1 |
| 39 | 430034-A04PDN | ACCESS COVER, SPACE HEATERS | 2 |
| 40 | 4021E0-A09RA | SEAL RING | 1 |
| 41 | 4065F7-B50PA | BAFFLE ADAPTER RING | 1 |
| 42 | 5065E9-A29PA | EXCITER BRACKET | 1 |

* RECOMMENDED SPARE PARTS

PRODUCT CODE (MAIN BOM) ........... 065SAB04T67-28
OUTLINE DRAWING .................. 5065A0-B76
MASS ELASTIC DIAGRAM .............. B-MED-1834
ACCESSORY INTERCONNECTION DIAGRAM .. 430550-E25
INCOMING LINE CUBICLE DRAWING ...... 14DSB-2404

| TYPE | RATING | SPEED | PHASE | HERTZ | VOLTS | AMPS | FRAME | S/N |
|---|---|---|---|---|---|---|---|---|
| SAB | 9341 KW | 1800 RPM | 3 | 60 | 12470 | 541 | 21520-4-41 | 071059-01&02 |
| STATOR | ROTOR | FIELD | ARMATURE | PMA STATOR | PMA ROTOR | CUSTOMER | END USER | |
| 26567 | 25153 | 25682 | 25681 | 23919 | 23918 | DRESSER-RAND | SMART PAPER | |

| WORKING TOLERANCES UNLESS OTHERWISE SPECIFIED | | |
|---|---|---|
| MACHINING | FABRICATION | FINISH |
| ±.01 THRU 2.00" ±.015 OVER 2.00 THRU 10.00" ±.03 OVER 10.00" ANGLE ±0.5° | ±.12 THRU 24.00" ±.24 OVER 24.00" | 125 MICRO √ INCHES |

ALL DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED
ALL THREADS TO BE CLASS 2 UNIFIED



FILE NO. 2N#2-5 | LIBRARY C0 | REF NO. 5065C0-B45

FIRST USED ON 071059 HIEC ORDER No.

| | BY | DATE |
|---|---|---|
| DR. | NJK | 09/02/08 |
| CK. | NJK | 09/02/08 |
| APP. | DMD | 09/17/08 |
| APP. | | |

HYUNDAI IDEAL ELECTRIC CO.
MANSFIELD OPERATION
330 EAST FIRST STREET
MANSFIELD, OHIO 44902-7700

21520-4-41 / BE13-3 / PMA13-3

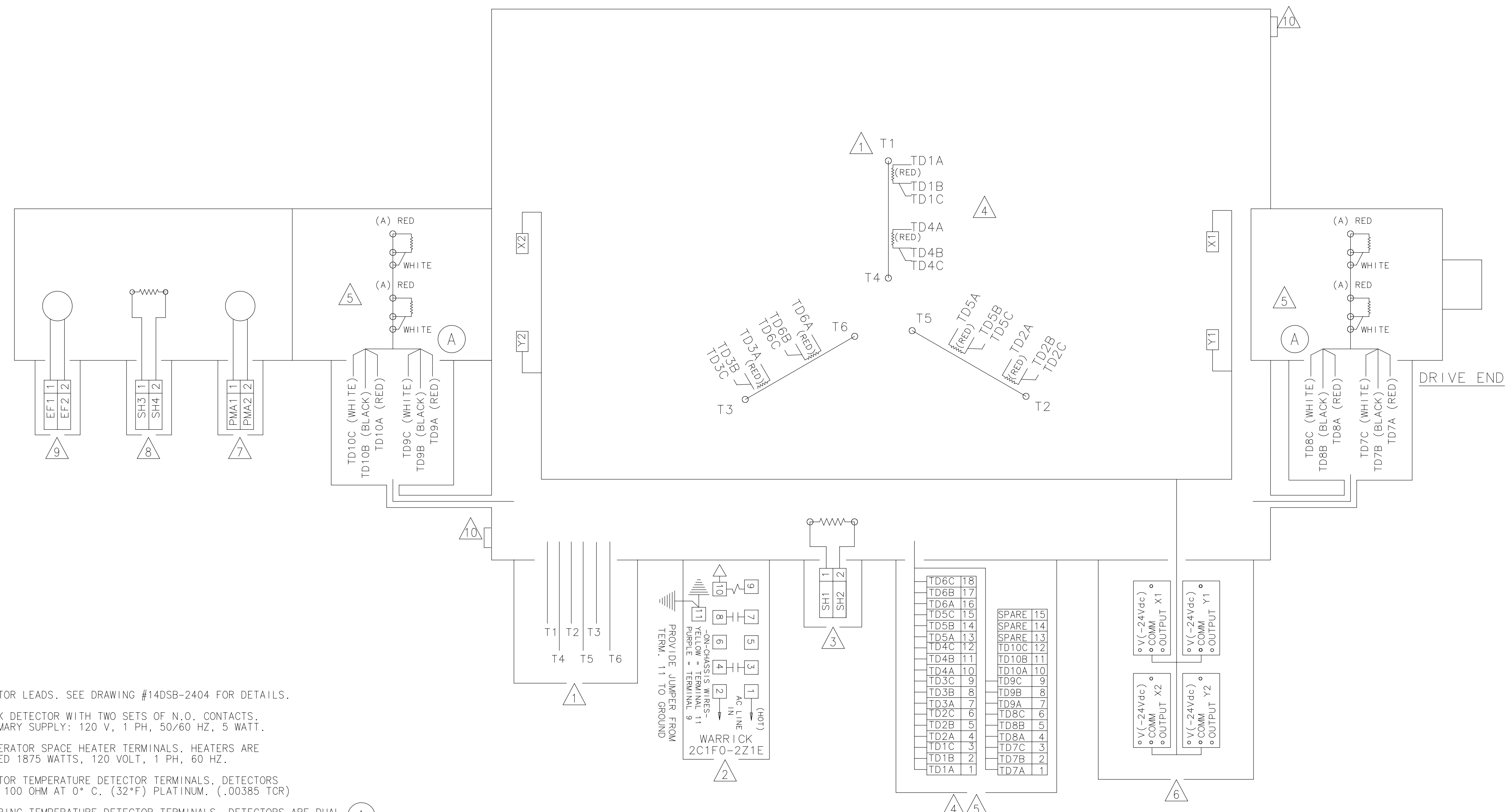
# LAYOUT

RENK EM 22-225 SLEEVE BEARINGS

SIZE D | DRG NO. 5065C0-B46

SCALE | WEIGHT | SHEET 1 OF 1

| REVISIONS | | | | | |
|---|---|---|---|---|---|
| REV | ZONE | ECN | DESCRIPTION | DATE | APP. |
| 0 | | | | 3/7/08 | |
| A | | 29638 | ADD DUAL RTD'S | 8/21/08 | |




1. STATOR LEADS. SEE DRAWING #14DSB-2404 FOR DETAILS.
2. LEAK DETECTOR WITH TWO SETS OF N.O. CONTACTS. PRIMARY SUPPLY: 120 V, 1 PH, 50/60 HZ, 5 WATT.
3. GENERATOR SPACE HEATER TERMINALS. HEATERS ARE RATED 1875 WATTS, 120 VOLT, 1 PH, 60 HZ.
4. STATOR TEMPERATURE DETECTOR TERMINALS. DETECTORS ARE 100 OHM AT 0° C. (32°F) PLATINUM. (.00385 TCR)
5. BEARING TEMPERATURE DETECTOR TERMINALS. DETECTORS ARE DUAL ELEMENT 100 OHM AT 0° C. (32°F) PLATINUM. (.00385 TCR) (A)
6. VIBRATION DETECTORS BENTLY NEVADA 3300 SERIES. PROBES WITH 990 SERIES TRANSMITTERS (2) PER BEARING.
7. PERMANENT MAGNET ALTERNATOR TERMINALS.
8. EXCITER SPACE HEATER TERMINALS. HEATERS ARE RATED 100 WATTS, 120 VOLTS, 1 PH, 60 HZ.
9. EXCITER FIELD TERMINALS.
10. GROUND PADS.

NOTE:
ALL WIRING TO BE IN ACCORDANCE WITH ENG1148



REF.: 430550-D64
LIB.: PROD/30550
FILE: 25A

FIRST USED ON
071059
IEC ORDER No.

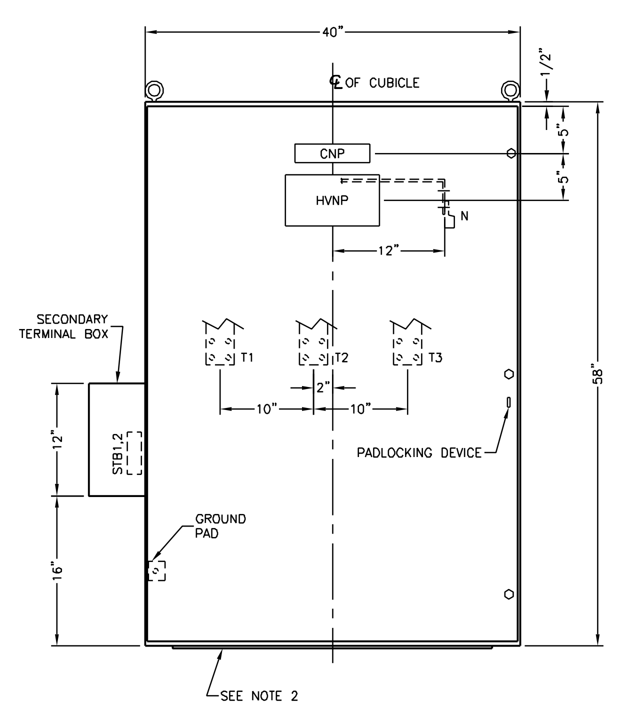
| | BY | DATE |
|---|---|---|
| DR. | NJK | 3/7/08 |
| CK. | NJK | 3/7/08 |
| APP. | BSH | 3/7/08 |
| APP. | | |

IDEAL ELECTRIC CO.
330 EAST FIRST STREET
MANSFIELD , OHIO 44902-7700

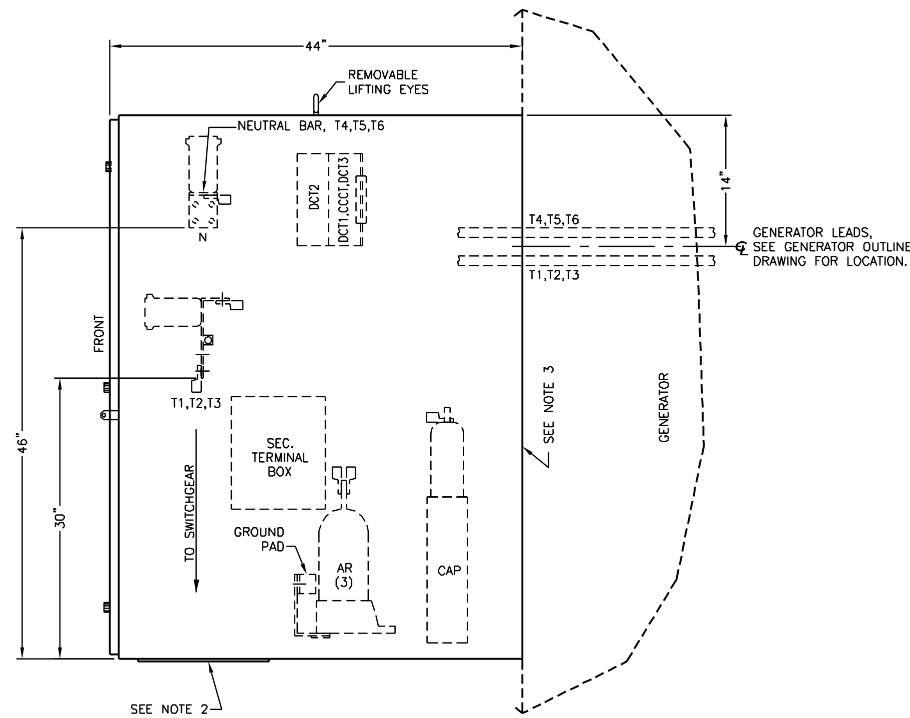
# ACCESSORY INTERCONNECTION DIAGRAM

SIZE C | DRG NO. 430550-E25
SCALE NONE | WEIGHT | SHEET 1 of 1

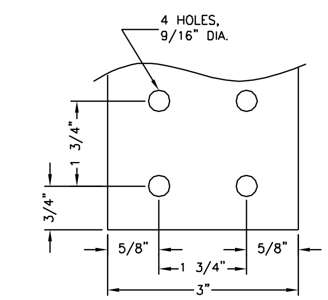
| REV. | DESCRIPTION | BY |
|---|---|---|
| 0 | FEB. 22, 2008 | HGM |
| 1 | MAY 19, 2008<br>CHANGED TO BOTTOM ENTRY | HM |
| 2 | MAY 29, 2008<br>REV'D GROUND CONNECTION ON DCT'S | HM |



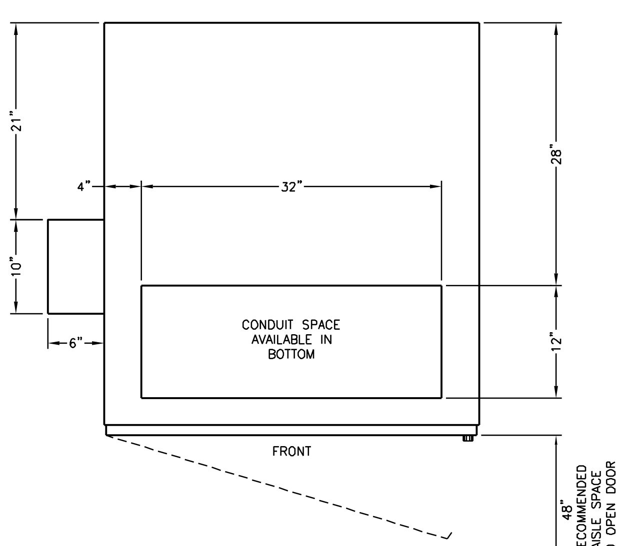

FRONT VIEW




RIGHT SIDE VIEW




ENLARGED VIEW OF CUSTOMER TERMINATIONS
STANDARD NEMA BOLT HOLE SPACING.




BASE PLAN

**DEVICE LEGEND**

| | |
|---|---|
| AR | LIGHTNING ARRESTER, GENERAL ELECTRIC, 15 KV, CAT.# 9L11ZGB015S |
| CAP | SURGE CAPACITOR, GENERAL ELECTRIC, 13.8 KV, CAT.# 18L0012WH |
| CCCT, DCT | CURRENT TRANSFORMER, INSTRUMENT TRANSFORMER INC., MODEL 780, 400:5 RATIO, CAT.# 780-801 |
| CNP | COMPANY NAMEPLATE |
| HVNP | HIGH VOLTAGE NAMEPLATE |
| STB | SHORTING TERMINAL BLOCK, GENERAL ELECTRIC, TYPE EB27 4 POLE AND 6 POLE |

**NOTES:**

(1) INDOOR ENCLOSURE.

(2) REMOVABLE COVER PLATE, PURCHASER TO DRILL FOR CONDUIT ENTRANCE.

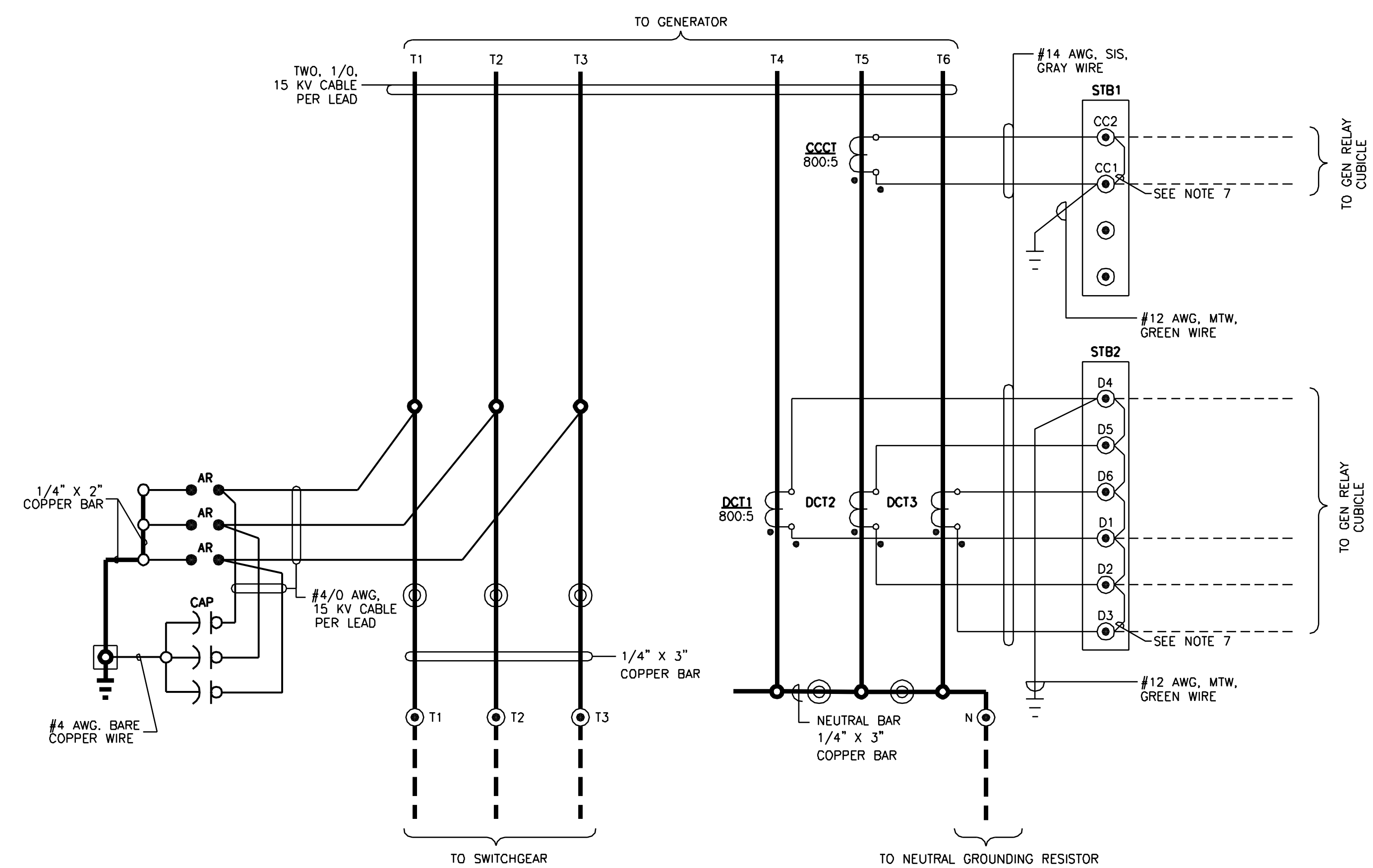
(3) GASKET REAR OF CUBICLE FOR MOUNTING TO GENERATOR.

(4) ◉ INDICATES TERMINAL FOR CUSTOMER CONNECTION.

(5) ALL WIRING SHOWN DOTTED ON WIRING DIAGRAM TO BE SUPPLIED BY OTHERS.

(6) WEIGHT APPROXIMATELY 950 LBS.

(7) CUSTOMER TO REMOVE APPROPRIATE JUMPERS WHEN CONNECTIONS ARE MADE, GROUND COMMON SIDE.




WIRING DIAGRAM

CAUTION:

ANY INSTALLATION, OPERATION, INSPECTION OR MAINTENANCE OF THE EQUIPMENT COVERED BY THIS DOCUMENT MUST BE PERFORMED BY QUALIFIED PERSONS WHO ARE THOROUGHLY TRAINED AND WHO UNDERSTAND ANY HAZARD THAT MAY BE INVOLVED. THIS DOCUMENT HAS BEEN PREPARED ONLY FOR SUCH QUALIFIED PERSONS AND IS NOT INTENDED TO BE A SUBSTITUTE FOR ADEQUATE TRAINING AND EXPERIENCE IN SAFETY PROCEDURES FOR THIS TYPE OF EQUIPMENT.
BEFORE PERFORMING THE OPERATIONS DESCRIBED IN THIS DOCUMENT THE NECESSARY SAFETY PROCEDURES RELATIVE TO THIS TYPE OF EQUIPMENT MUST BE CARRIED OUT.



ALL DIMENSIONS ARE IN INCHES, UNLESS OTHERWISE NOTED.
TOLERANCE OF ±1/16" EXCEPT AS NOTED.

ASSEMBLY AND WIRING DIAGRAM
INCOMING LINE CUBICLE, 15 KV
DRESSER RAND
SMART PAPER, HAMILTON, OHIO

| | |
|---|---|
| DRAWN BY: HGM | CHECKED BY: KJS |

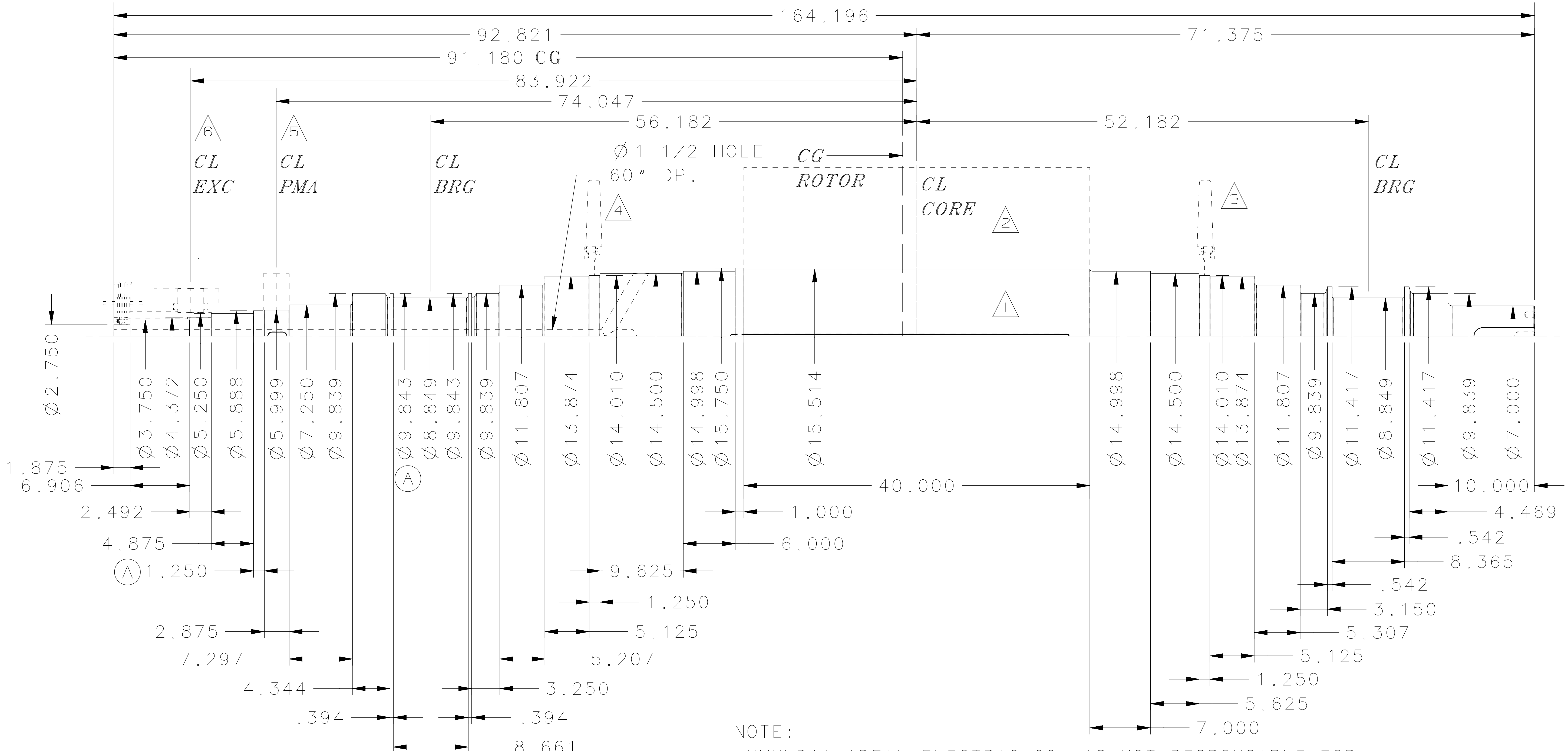
SCALE: 1"=10"
S.N. 071059-03/04

HYUNDAI-IDEAL ELECTRIC COMPANY
MANSFIELD, OHIO
USA

14DSB-2404

DSB2387

| REV | ECN | ZONE | DESCRIPTION | APPROV.BY | DATE | MICRO COPY | ISSUE |
|---|---|---|---|---|---|---|---|
| 0 | - | - | - | - | 3/7/08 | - | - |
| A | 29638 | - | REVISE DIMENSIONS | DMD | 8/21/08 | - | - |




NOTE:
HYUNDAI IDEAL ELECTRIC CO. IS NOT RESPONSIBLE FOR TORSIONAL COMPATIBILITY OF THE SYSTEM.

| ITEM | DESCRIPTION | WT. LBS. | LB.FT². | COMMENTS |
|---|---|---|---|---|
| | TOTAL | 22450 | 15755 | |
| 6 | EXCITER | 120 | 40 | |
| 5 | PMA | 50 | 10 | |
| 4 | FAN ASSY | 60 | 30 | |
| 3 | FAN ASSY | 60 | 30 | |
| 2 | ROTOR ASSY | 16800 | 14735 | |
| 1 | SHAFT | 5360 | 910 | ENG 1221-3 |

ALL DIMENSIONS ARE SHOWN IN INCHES UNLESS SPECIFIED OTHERWISE.



FIRST USED ON 071059
HIEC ORDER No.

| | BY | DATE |
|---|---|---|
| DR. | NJK | 3/7/08 |
| CK. | NJK | 3/7/08 |
| APP. | BSH | 3/7/08 |
| APP. | | |

HYUNDAI IDEAL ELECTRIC CO.
MANSFIELD OPERATION
330 EAST FIRST STREET
MANSFIELD, OHIO 44902-7700

21520-4-40 / BE13-3 / PMA13-3

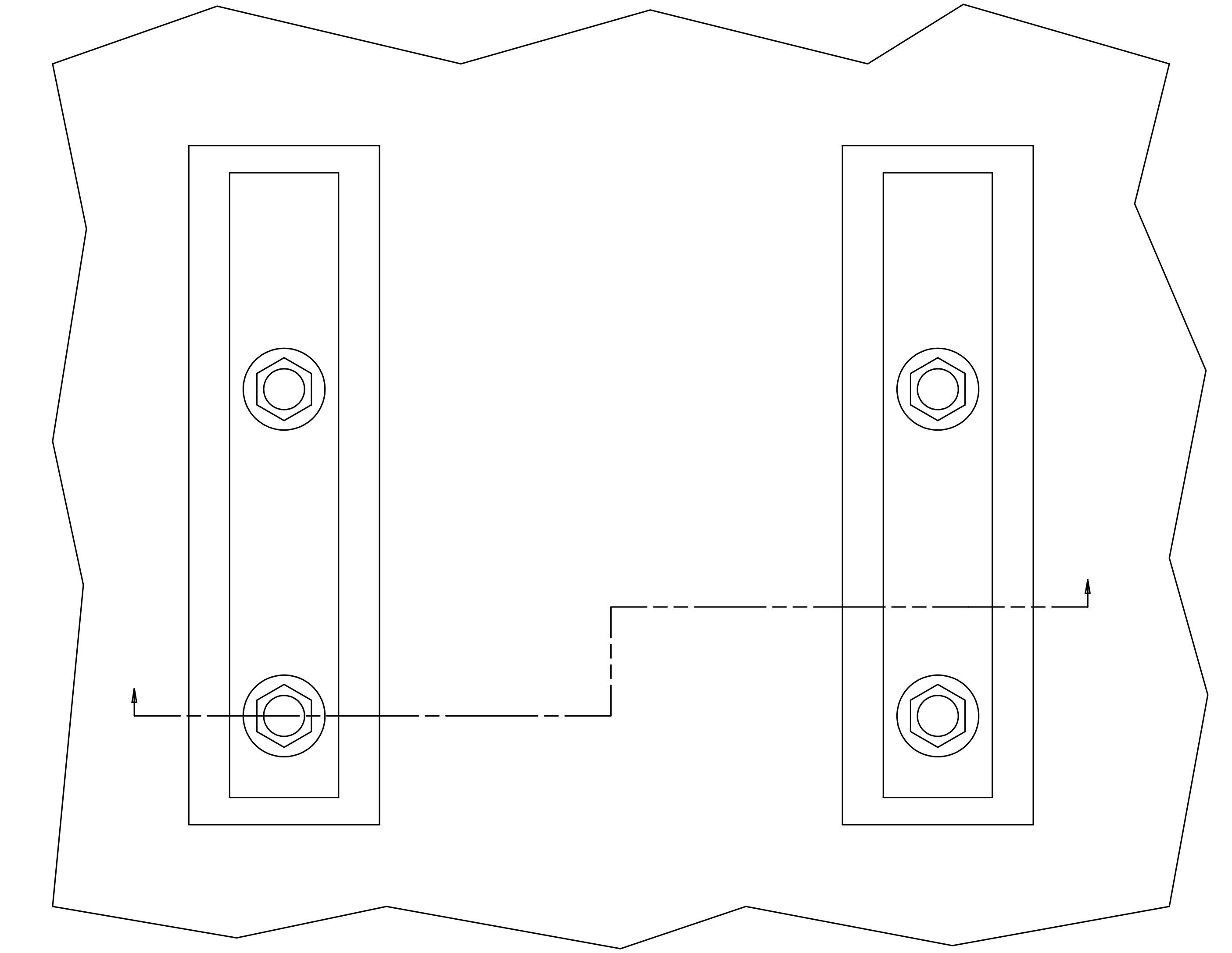
# MASS ELASTIC DIAGRAM

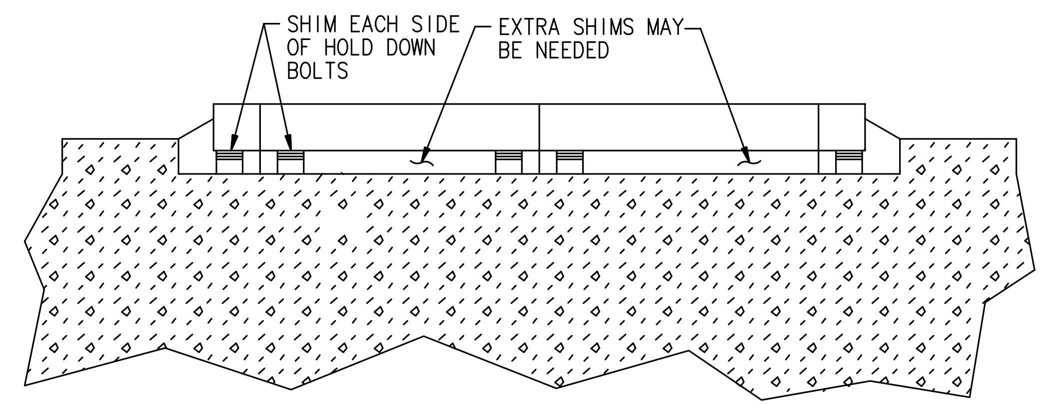
9341 KW @ 1800 RPM RENK 22-225

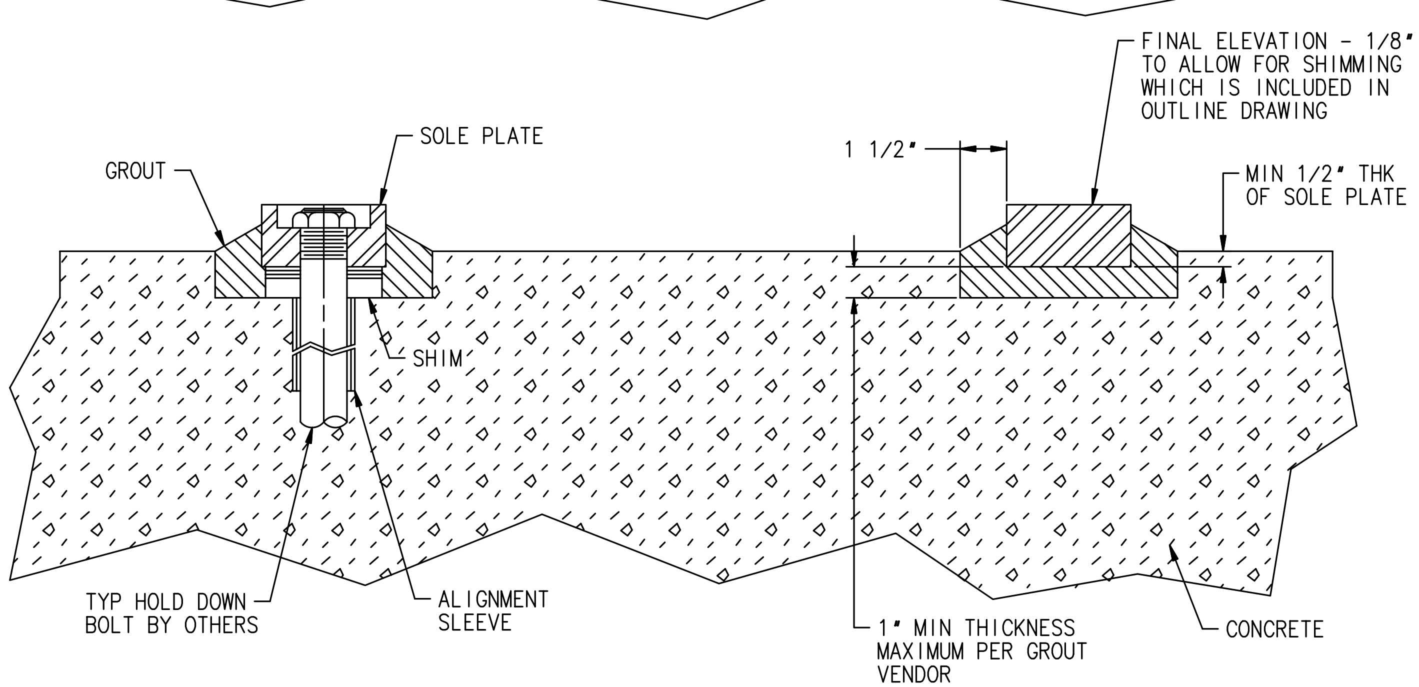
SIZE B | 3D | DRG NO. B-MED-1834

SCALE | WEIGHT | SHEET 1 OF 1

| REV | ECN | ZONE | DESCRIPTION | APPROV.BY | DATE | MICRO COPY | ISSUE |
|---|---|---|---|---|---|---|---|
| 0 | - | - | - | - | 01-12-89 | | |
| A | 25737 | - | REDRAWN TO CAD | DLC/ | 09-19-01 | | |
| B | 26293 | A-4 | HR-C DWG No.SN 021001 | DLK/ | 09-24-02 | | |






GENERAL ASSEMBLY AND ERECTION NOTES:

THIS NOTE WILL APPLY TO CIRCULAR SOLE PLATES AS WELL AS STRAIGHT ONES.

UNLESS SPECIFICALLY ORDERED AND DESIGNED TO BE SELF SUPPORTING, SOLE PLATES ARE TO BE USED AS/AND CONSIDERED SPACERS ONLY, BETWEEN THE FOUNDATION AND THE MACHINE. WITHOUT ADEQUATE SUPPORT, SOLE PLATES CAN WARP OR DISTORT WHEN BEARING THE WEIGHT OF THE MACHINERY. ADEQUATE SUPPORT MUST BE PROVIDED USING LEVELING PLATES AND SHIMS BETWEEN THE SOLE PLATE AND FOUNDATION, ESPECIALLY AT LOAD POINTS SUCH AS STATOR FEET AND BEARING PEDESTALS.

THE MINIMUM ALLOWABLE GROUTING THICKNESS UNDER SOLE PLATES MUST BE NOT LESS THAN ONE INCH. SOLE PLATES MUST BE SET PARALLEL/LEVEL AND FLAT. THE FOUNDATION BOLTS SHOULD BE DRAWN DOWN TIGHT TO ASSURE THERE IS NO WARPAGE OR DISTORTION OF THE SOLE PLATE OF FRAME.

A RICH NON-SHRINK GROUT SHOULD BE USED, PREFERABLE A COMMERCIAL PREPARATION. WATER SHOULD BE ADDED SPARINGLY TO PROVIDE A STIFF MIXTURE. THE FOUNDATION SURFACE SHOULD BE ROUGH AND CLEAN THEN WETTED AND THE GROUT SHOULD BE RAMMED UNDER THE SOLE PLATES TO PROVIDE A SOLID VOID FREE FILL.

FOUNDATION:

THE FOUNDATION MUST BE DESIGNED TO BE SUBSTANTIAL AND RIGID. IT SHOULD BE CONSTRUCTED OF REINFORCED CONCRETE OR STEEL GIRDERS BUILT WITH SUFFICIENT STIFFNESS TO PREVENT VIBRATION. IT MUST BE DESIGNED TO NOT ONLY SUPPORT THE STATIC WEIGHT OF THE EQUIPMENT, BUT ALSO TO WITHSTAND THE WEIGHT REACTIONS AND OTHER FORCES INVOLVED WHEN THE MACHINE IS RUNNING. CONCRETE FOUNDATION ELEVATIONS SHOULD BE SUCH TO ALLOW A MINIMUM OF ONE INCH GROUT BETWEEN THE TOP OF THE FOUNDATION AND THE SOLE PLATE OR MACHINE BASE.

CORRECT LOCATION OF FOUNDATION BOLTS IS A MUST. PRIOR TO SETTING THE MACHINE, VERIFY THE LOCATION AND BOLT PATTERN OF THE FOUNDATION BOLTS WITH REFERENCE TO THE OUTLINE DRAWING FURNISHED OR TO THE ACTUAL HOLE LOCATION OF THE EQUIPMENT BEING SET. IT IS RECOMMENDED THAT FOUNDATION BOLTS BE SET IN RECESSED POCKETS TO ALLOW SOME DEFLECTION, IF REQUIRED. THESE POCKETS WILL EVENTUALLY BE FILLED WITH GROUT AFTER THE FINAL ALIGNMENT.

SHIMMING NOTE:

SHIMPACK THICKNESS BETWEEN SOLE PLATE EQUIPMENT SHOULD BE KEPT TO A MINIMAL AMOUNT, PREFERABLE 1/8" OR LESS. WHEN SHIMPACKS EXCEED MORE THAN 1/16" THICK, DO NOT USE LARGE STACKS OF THIN SHIMS. THE STACKS SHOULD BE REPLACED WITH PLATE STEEL OF APPROPRIATE THICKNESS.

C-0868-9312-013-C

| WORKING TOLERANCES UNLESS OTHERWISE SPECIFIED | | |
|---|---|---|
| MACHINING | FABRICATION | FINISH |
| ± .01 THRU 2.00"<br>± .015 OVER 2.00 THRU 10.00"<br>±.03 OVER 10.00"<br>ANGLE ±0.5° | ± .12 THRU 24.00"<br>± .24 OVER 24.00" | 125 MICRO INCHES |
| ALL DIMENSIONS IN INCHES UNLESS OTHERWISE SPECIFIED | | |
| ALL THREADS TO BE CLASS 2 UNIFIED | | |



FILE NO. 65 | LIB: FR/FAB/30010 | REF NO. -

FIRST USED ON C

IEC ORDER No.

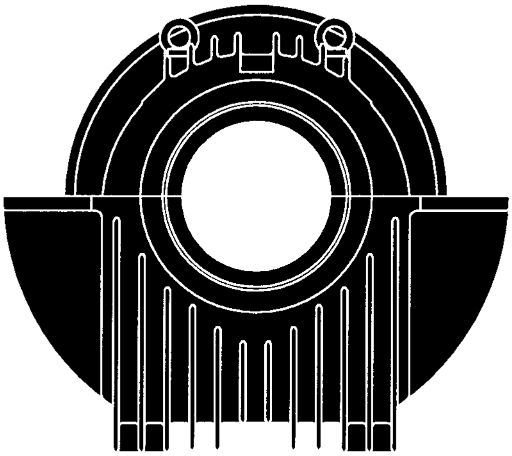
| | BY | DATE |
|---|---|---|
| DR. | B.C. | 01-12-89 |
| CK. | | |
| APP. | | |
| APP. | | |

**IDEAL ELECTRIC CO.**
330 EAST FIRST STREET
MANSFIELD , OHIO 44902-7700

RECOMMENDED SOLE PLATE INSTALLATION & GROUTING

SIZE C | DRG NO. C64320

SCALE | WEIGHT | SHEET 1 OF 1



# Slide Bearings TYPE EM

# with self lubrication

RENK AKTIENGESELLSCHAFT
Werk Hannover
Weltausstellungsallee 21
D - 30539 Hannover
Telephone: (0511) 8601-0
Telefax: (0511) 8601-266
e-mail: renk_hannover@renk.de
http:\\www.renk.de

**Contents**

# Bearing Coding

| ❶ Type | ❷ Housing | ❸ Heat Dissipation | ❹ Shape of Bore and Type of Lubrication | ❺ Thrust part | ❻ Size - Diameter |
|---|---|---|---|---|---|
| E | M - centre flange mounted bearing | N - natural cooling<br><br>W - water cooling ( finned cooler in oil sump ) | L - plain cylindrical bore with loose oil ring | Q - without thrust part (non-locating bearing )<br><br>B - plain sliding sufaces with oil grooves (locating bearing)<br><br>E - taper land faces for one sense of rotation (locating bearing)<br><br>K - taper land faces (locating bearing) | 9 80≤D≤100<br><br>11 100≤D≤125<br><br>14 125≤D≤160<br><br>18 160≤D≤200<br><br>22 200≤D≤250<br><br>28 250≤D≤315 |

***Example for bearing coding:***

| ❶ | ❷ | ❸ | ❹ | ❺ | ❻ |
|---|---|---|---|---|---|
| E | M | N | L | Q | 22-200 |

*Type EM slide bearing with centrally flange-mounted housing, natural cooling, plain cylindrical bore with loose oil ring, non locating bearing without thrust part, size 22, diameter 200.*

**Shaft seals**

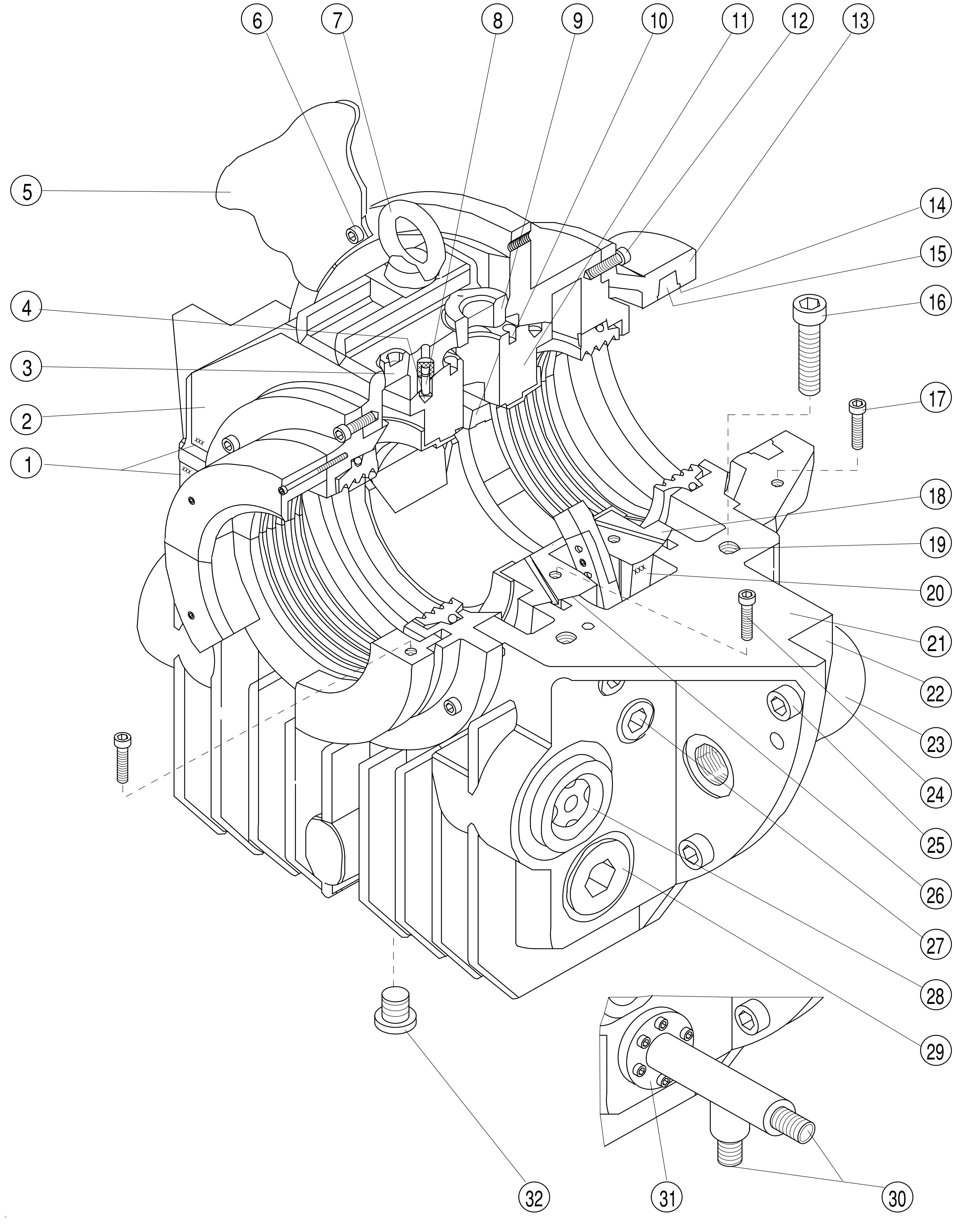
Type 10 - floating labyrinth seal (IP 44)
Type 11 - floating labyrinth seal with dust flinger (IP 54)
Type 12 - floating labyrinth seal with baffle (IP 55)

Type 20 - rigid labyrinth seal ( IP 44)
Type 21 - rigid labyrinth seal with dust flinger(IP 54)
Type 22 - rigid labyrinth seal with baffle (IP 55)

# General Drawing

# Slide Bearing EM

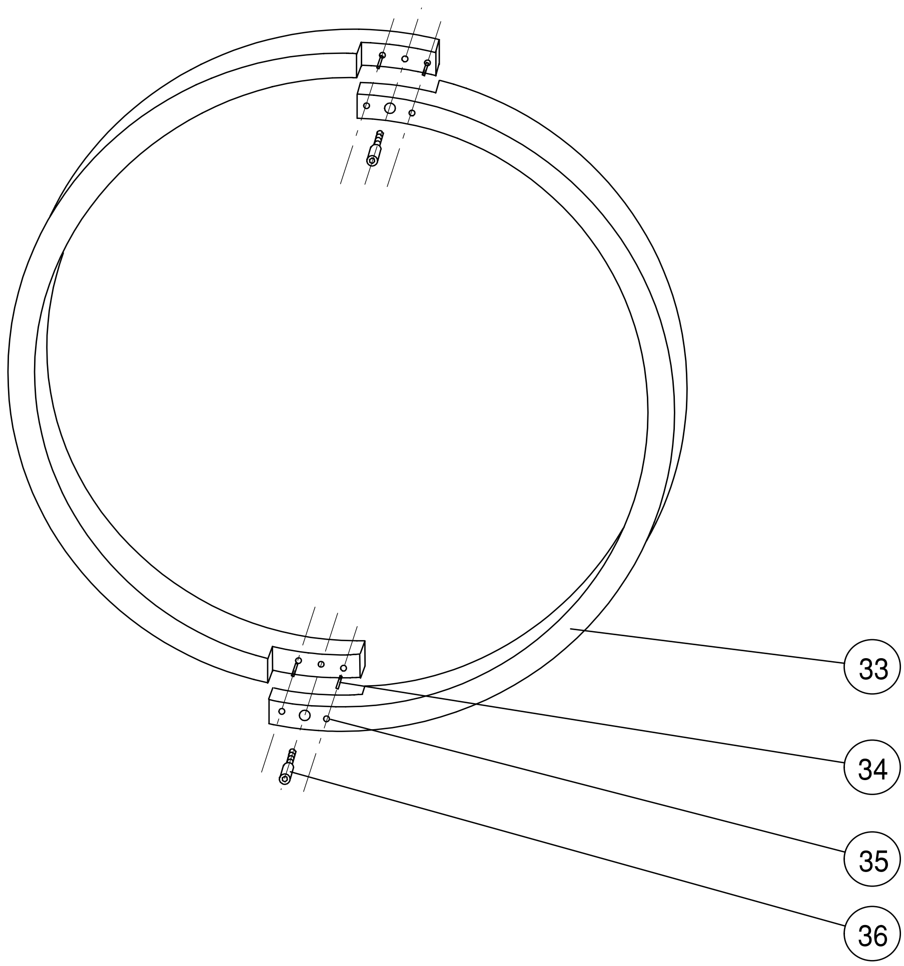
# with self lubrication


1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32

| | |
|---|---|
| 1 | Engraved numbers - housing |
| 2 | Top half of the housing |
| 3 | Oil filling hole |
| 4 | Positioning pin nut |
| 5 | Plate ( Assembly opening ) |
| 6 | Screw |
| 7 | Eye bolt |
| 8 | Positioning pin |
| 9 | Top sight glass |
| 10 | Tapped hole ( in the top and bottom halves of the shell, up size 14 ) |
| 11 | Top half of the shell |
| 12 | Screw |
| 13 | Machine seal |
| 14 | Hamp packing seal groove |
| 15 | Hamp packing |
| 16 | Screw (split line of the housing) |
| 17 | Screw (split line of the machine seal) |
| 18 | Bottom half of the shell |
| 19 | Tapped hole |
| 20 | Engraved number - shell |
| 21 | Bottom half of the housing |
| 22 | Recess |
| 23 | Pressure equalizing hose |
| 24 | Screw (split line of the shell) |
| 25 | Screw |
| 26 | Spherical seating |
| 27 | Tapped hole for temperature measurement of the journal part |
| 28 | Oil sight glass |
| 29 | Tapped hole for the oil sump temperature measurement |
| 30 | Outlet/Inlet cooling water (Type E.T..) |
| 31 | Cooler ( Type E.T..) |
| 32 | Hexagon head plug (Oil drain plug) |

# General Drawing of the

# Loose Oil Ring


33
34
35
36

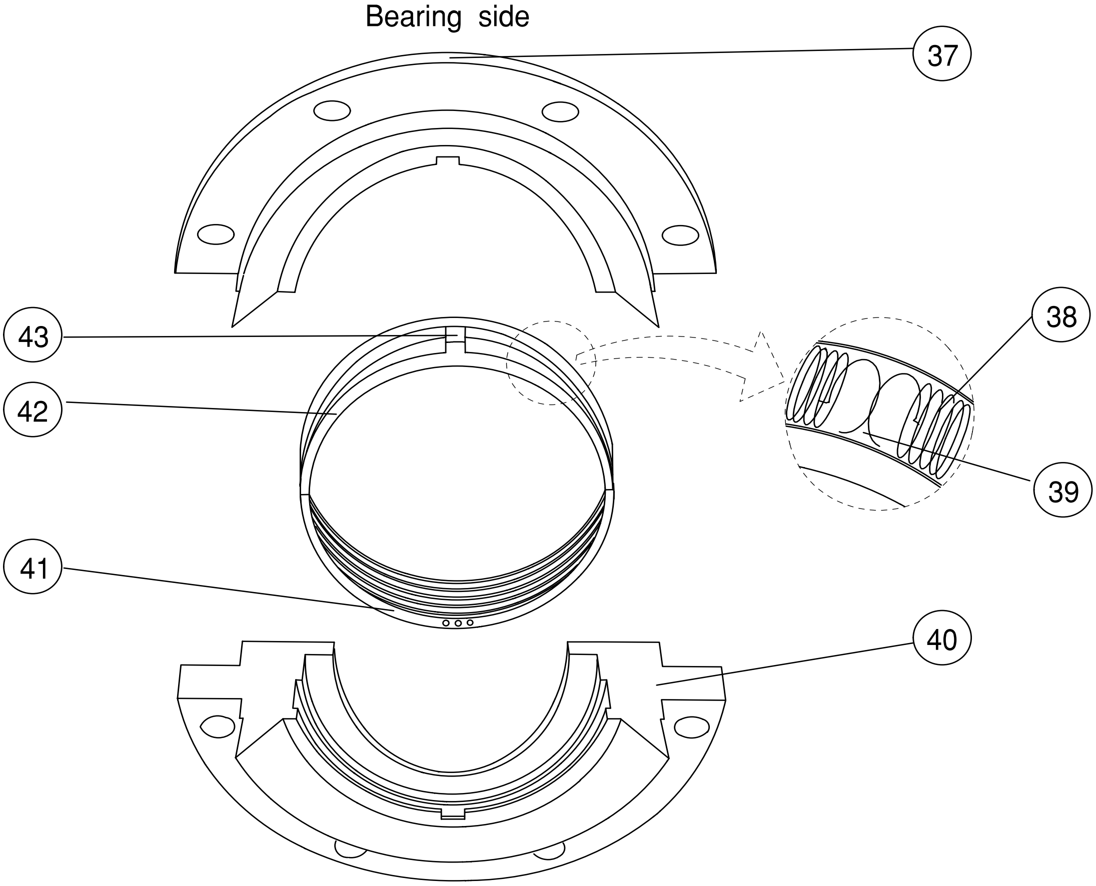
| | |
|---|---|
| 33 | Loose oil ring |
| 34 | Dowel pin |
| 35 | Hole |
| 36 | Screw |

# General Drawing of the

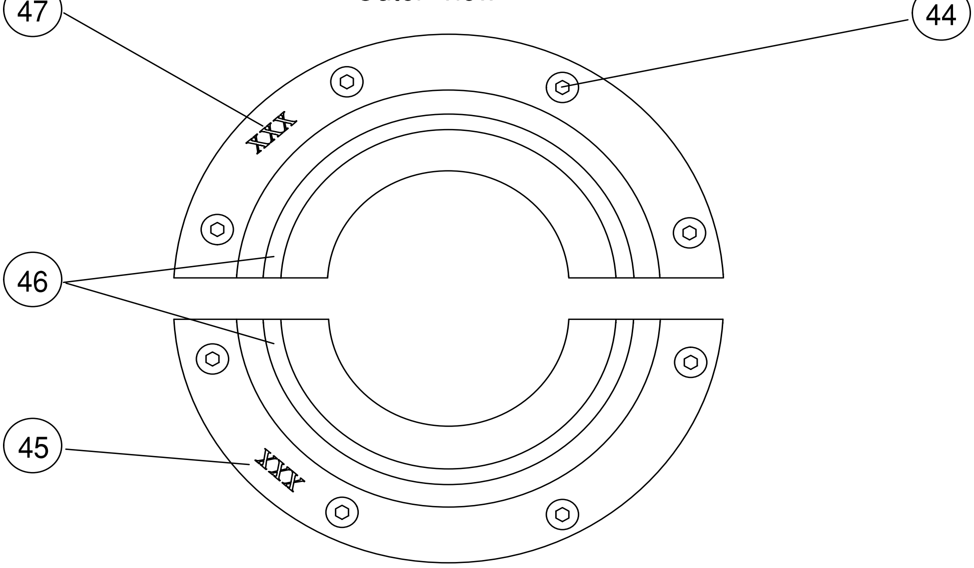
# Floating Labyrinth Seal

# with Seal Carrier

Bearing side



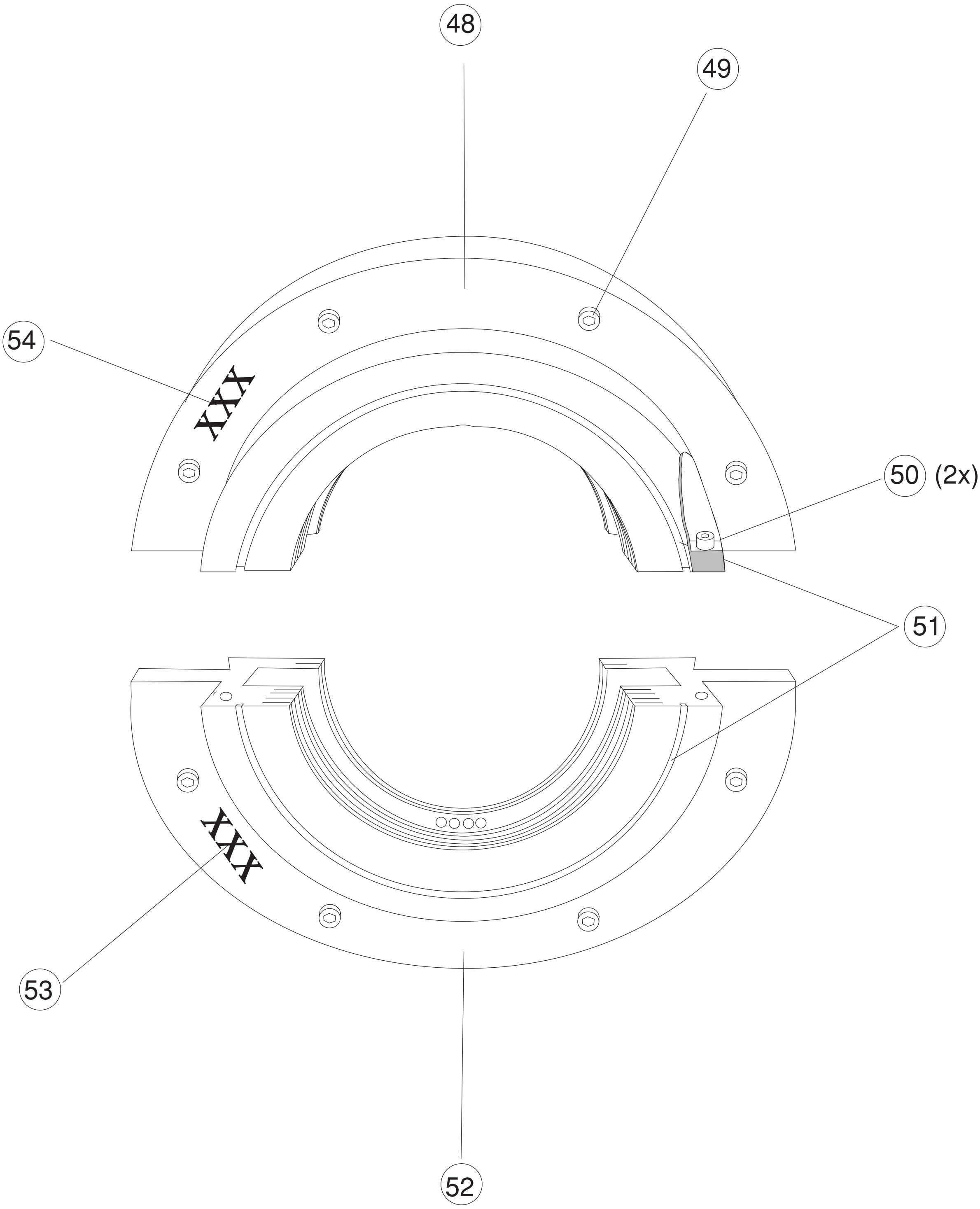

Outer view



| | |
|---|---|
| 37 | Seal carrier - top half |
| 38 | Garter spring |
| 39 | Groove |
| 40 | Seal carrier - bottom half |
| 41 | Bottom half of the seal |
| 42 | Top half of the seal |
| 43 | Anti - rotation pin |
| 44 | Screw |
| 45 | Engraved number |
| 46 | Groove ( Type 11 ) |
| 47 | Engraved number |

## General Drawing of the

## Rigid Labyrinth Seal

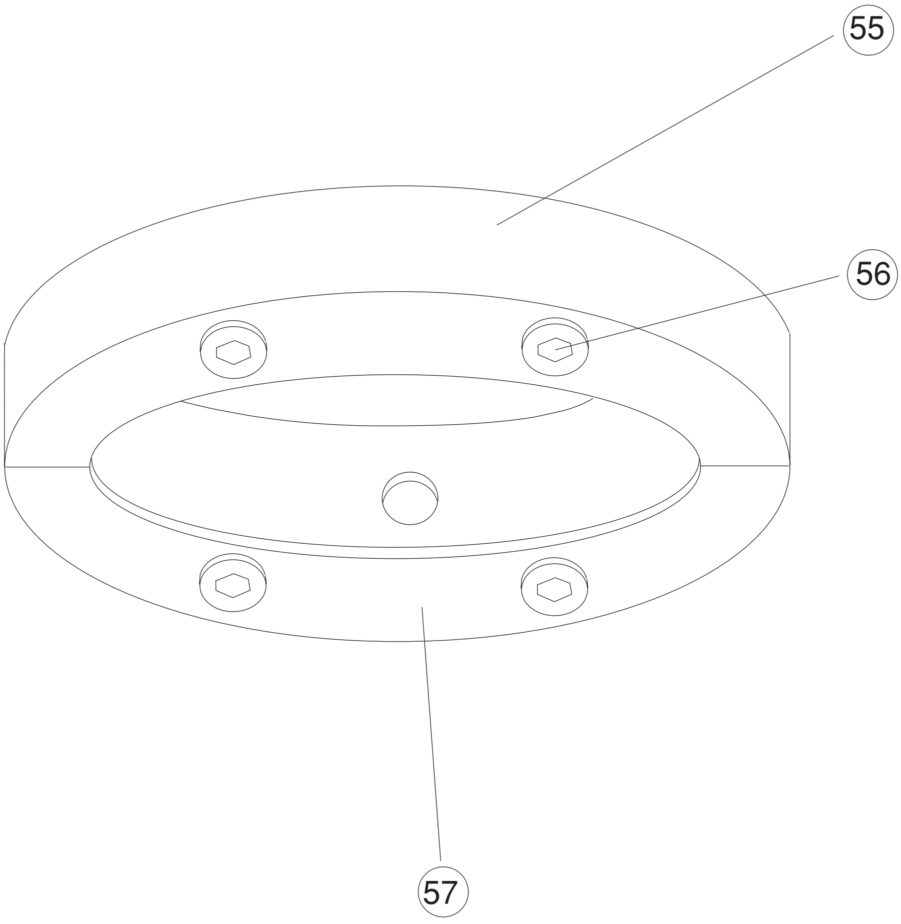


48
49
54
XXX
50 (2x)
51
XXX
53
52

| | |
|---|---|
| 48 | Rigid labyrinth seal - top half |
| 49 | Screw |
| 50 | Screw (split line) |
| 51 | Groove ( Type 21 ) |
| 52 | Rigid labyrinth seal - bottom half |
| 53 | Engraved number |
| 54 | Engraved number |

## General Drawing

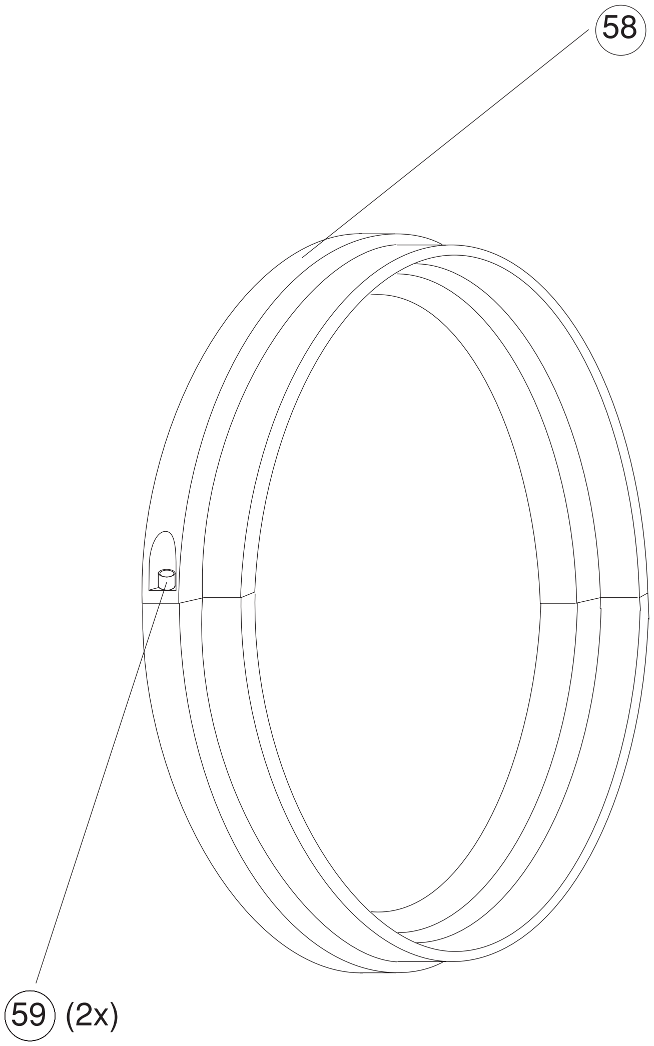
## Baffle


55
56
57

| | |
|---|---|
| 55 | Baffle - top half |
| 56 | Screw |
| 57 | Baffle - bottom half |

# General Drawing of the

# Dust Flinger


58
59 (2x)

| | |
|---|---|
| 58 | Dust flinger |
| 59 | Screw (split line) |

## 1 Considerations for Use

The instructions for installation and operation are addressed to qualified technical personnel (fitters, mechanic installers, mechanical engineers).

Read these instructions carefully before starting assembly.

Slide bearings of type EM are almost universally used in the engineering industry. Therefore it is not possible to provide detailed information on all possible types and range of applications for these bearing types. For instance, the position of the connection points for supply and monitoring equipment is determined by the place of application ( in the following called " installation " ). Please keep ready the guidelines with the technical documentation before starting assembly and operation of the slide bearings.

Additional technical documentation with detailed information is supplied in case of special design bearings. Please contact RENK Export or Domestic Department for supplementary information on bearings. Please indicate the bearing coding and the full reference number, too.

Following indications should be observed when reading these instructions.

Safety instructions are marked as follows:

**Danger!**
Warning of dangers for personnel.
Example: Warning of injury

**Attention!**
Warning of damage for the bearing or installation.

Useful recommendations and additional information are framed.

**EMW...**

This is how chapters, instructions or recommendations are marked when referring to a single type or size of a bearing.

*Example: Slide bearing type EM with water cooler*

- Instruction follows.

• Beginning of an enumeration.

( ) This is how the different parts of a bearing as described in the general drawings ( numbers ) are marked in the text.

– Use the enclosed check-list before starting assembly or operation. Copies available on request.
– The check list provides the experienced mechanical fitters of RENK bearings with the necessary instructions for installation and operation.

## 2 Safety Instructions

**Danger!**
The installation and operation of the slide bearings should be carried out by:
- persons nominated by the safety representative
- persons correspondingly trained and instructed
- persons with knowledge on appropriate standards, regulations and accident prevention rules
- persons with knowledge on first-aid measures and local rescue centers.

**Warning of injury!**
Before starting work on the bearing:
- Switch off the installation.
- Make sure the installation is not in operation.

Never lift or transport machines, etc.by the bearing eye bolts. These are only intended for assembly and dismantling of the bearing !

**Warning of injury!**
Do not grab such heavy bearing parts as the housing during assembly or dismantling work. This could result in bruising or injury to hands !

**Attention!**
All metal parts of a slide bearing consisting of top and bottom part such as the housing, shells, shaft seals are marked by engraved numbers. Fit together only the parts with the same number.

**Attention!**
In case
- the admissible bearing temperature exceeds 15 K
- inadmissible vibrations occur
- unusual noises or odours are noticed
- monitoring equipment triggers alarm

shut down the installation and inform the maintenance personnel in charge.

**Attention!**
Do not operate the bearing below the transition speed values indicated in the bearing calculation, thus avoiding inadmissible operating conditions, which could lead to damage to the bearing.

## 3 Preparatory Work

### 3.1 Tools and equipment

– Following tools and equipment are necessary:

- Allan key set
- Wrenching key set
- Open-jawed spanner set
- Feeler gauges ( up 0,05 mm )
- Caliper gauge
- Emery paper, plain scraper
- Oil stone
- Lifting equipment
- Permanent sealing compound ( e.g. Curil T )
- Clean (close weave) rags
- Oil with the correct viscosity (see bearing type plate)
- Detergents
- Liquid screw locking compound ( e.g. LOCTITE 242 )
- Liquid sealing compound and Teflon-tape

### 3.2 Use of lifting equipment

**Warning of injury!**

Before transport or lifting check if the eye bolts are tight ! Insecure eye bolts could result in bearing becoming loose.

Before moving the bearing by the eye bolts make sure that the split line screws are tightened, otherwise the bottom half of the bearing could become detached.

Make sure that the eye bolts are not exposed to bending stress, otherwise the bolts could break.

Follow exactly the instructions for the use of lifting equipment.

– Use lifting equipment for assembly or transport of the following items:

| Transport/Assembly of: | Use lifting equipment for the following bearing sizes |
|---|---|
| Whole bearing unit | 9-28 |
| Top half of the housing | 14-28 |
| Bottom half of the housing | 11-28 |
| Shells | 14-28 |

Following steps are to be observed before using the lifting equipment:

**Whole bearing unit**

– Check if the screws are tight (16):

| Bearing size | 9 | 11 | 14 | 18 | 22 | 28 |
|---|---|---|---|---|---|---|
| Torque [Nm] for $\mu_{tot}$ (lightly oiled) | 40 | 69 | 170 | 330 | 570 | 1150 |

– Check if the eye bolts (7) are tight.
– Connect the lifting equipment to the eye bolts (7).

**Top half of the housing**

– Check if the eye bolts (7) are tight.
– Connect the lifting devices to the eye bolts (7).

**Size 22 and 28**

Sizes 22 and 28 are delivered equipped with an assembly device.

When not in use this assembly device is located in the "parking position" behind the flange and as such it is not allowed to use it as transport device.

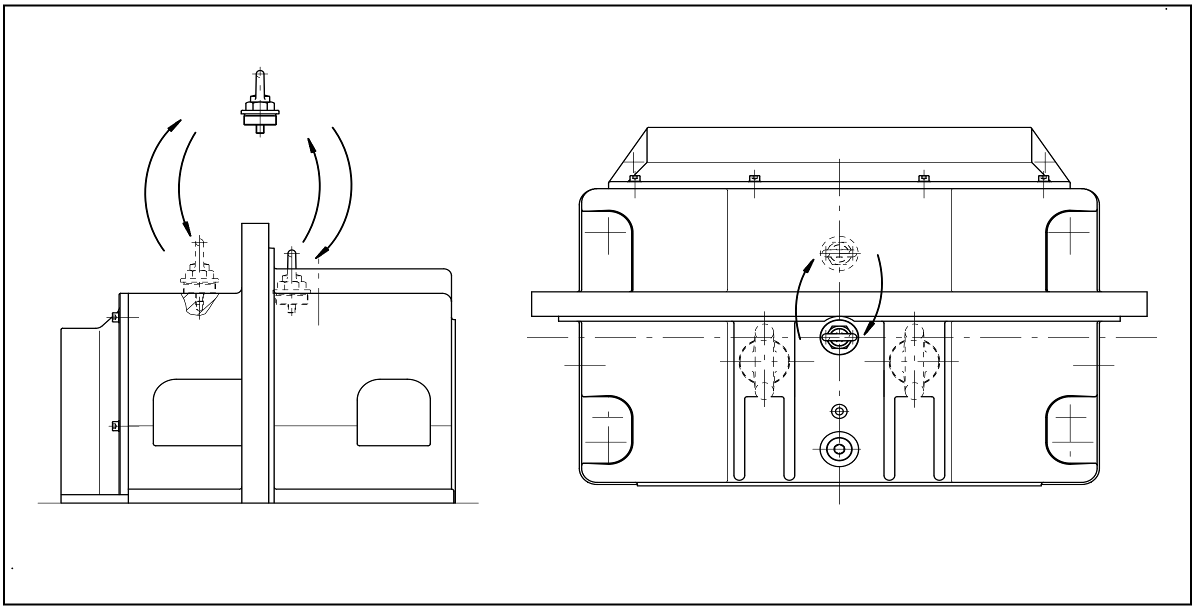


Illustration 1: Assembly device

To mount the top half of the housing remove the top sight glass and screw in the assembly device.

By using the appropriate lifting equipment and with the help of the assembly device it is possible to lift and mount the top half of the housing in a straight position.

After assembling the top half of the housing put the assembly device back into the "parking position" behind the flange and screw in the top sight glass.

**Bottom half of the housing**

– Screw two eye bolts (7) with suitable threads tight into the cross-placed opposite tapped holes (19).

| Bearing size | 9 | 11 | 14 | 18 | 22 | 28 |
|---|---|---|---|---|---|---|
| Tapped hole | M 10 | M 12 | M 16 | M 20 | M 24 | M 30 |

– Connect the lifting equipment to the eye bolts (7).

**Shells**

– Screw two eye bolts or screw hooks with suitable threads tight into the tapped holes (10):

| Bearing size | 14 | 18 | 22 | 28 |
|---|---|---|---|---|
| Tapped hole | M 8 | M 12 | M 12 | M 16 |

– Connect the lifting equipment to the eye bolts or to the screw hooks.

### 3.3 Dismantling of the bearing

**Attention**
Make sure that the work place and the parts to be assembled are clean. Contamination and damage to the bearing, especially to the working surfaces, have a negative influence on the operating quality and could lead to premature failure.

#### 3.3.1 Dismantling of the shaft seal - outboard side

– Dismantle the shaft seals of the bearing. Proceed according to the sealing type:

**Type 10 Type 11**

**Floating labyrinth seal (Type 10)**
**Floating labyrinth seal with dust flinger (Type 11)**

– Loosen and remove all screws (44).
– Simultaneously take away in axial direction both top half (37) and bottom half (40) of the seal carrier from the housing.
– Lift off the top half of the seal carrier (37) and take out the floating labyrinth seal from the bottom half of the seal carrier (40).
– Remove the protective cardboard (for transport protection) from the floating labyrinth seal.
– Proceed as indicated for sizes • 9-11
•14-28

**Size 9 -11**

– Take hold of the floating labyrinth seal with both hands. Press out the protective cardboard with both thumbs.

**Size 14-18**

– Take both halves of the seal (41)(42) by the split line.Pull both halves apart, till you can press out the protective cardboard. Remove carefully by pressing along the edge of the split line.

**Warning of injury!**
During dismantling of the floating labyrinth seal hold on tight to the tensioned garter spring (38) which otherwise could bounce back and lead to injury.

– Take both seal halves (41), (42) and pull them apart by approximately 20 mm.
– Open the garter spring (38).

**Type 12**

**Floating labyrinth seal with baffle (Type 12)**

– Disconnect the top half of the baffle (55) and the bottom (57). To do so, loosen the screws (56).
– Further proceed as in the case of type 10 and 11 seal.

**Type 20 Type 21**

**Rigid labyrinth seal (Type 20)**
**Rigid labyrinth seal with dust flinger (Type 21)**

– Untighten all screws (49) and remove them.
– Simultaneously remove in axial direction both top and bottom (48), (52) halves of the rigid labyrinth seal.
– Remove the screws (50).
– Separate the top half of the rigid labyrinth seal (48) from the bottom half (52) and take out the protective cardboard (used for safe transport).

**Type 22**

**Rigid labyrinth seal with baffle (Type 22)**

– Separate the top and bottom half (55), (57) of the baffle, by untightening the screws (56).
– Further proceed as in the case of types 20 and 21.

3.3.2 Dismantling of the machine seal

- Loosen the hose clamps at the bottom half of the housing.
- Pull off the pressure equalizing hose (23).
- Loosen the screws (17) at the split lline of the machine seal and turn them out.
- Loosen the screws (12) and remove the seal parts.

3.3.3 Dismantling of the housing

**Size 22 and 28**

- Replace the top sight glass (9) by the assembly device. The top half of the housing can be lifted and transported by using the assembly device, well tight, and the appropriate lifting equipment.
- Unscrew the screws (16) and lift the top half of the housing (2).
- Take out both top (11) and bottom (18) halves of the shell from the bottom half (21) of the housing.

**Attention!**
Do not damage the thrust and radial working surfaces!

- Unscrew the screws (24) and separate top and bottom half of the shell (11), (18) without using any tools or other devices.

**EMW..**

The cooler (31) is already assembled and does not have to be removed for cleaning purposes.

3.3.4 Dismantling of the shaft seal - machine-side

The machine side seal is of Type 10, floating labyrinth seal.

- Remove the floating labyrinth seal from the bottom half of the housing.
- Notice the anti-rotation pin at the split line of the bottom half of the housing.
- Remove the protective cardboard (for transport protection) from the floating labyrinth seal.
- Proceed as indicated for sizes • 9-11
  •14-28

**Size 9 -11**

- Take hold of the floating labyrinth seal with both hands. Press out the protective cardboard with both thumbs.

**Size 14-18**

- Take both halves of the seal (41), (42) by the split line. Pull both halves apart, till you can press out the protective cardboard. Remove carefully by pressing along the edge of the split line.

**Warning of injury!**
During dismantling of the floating labyrinth seal hold on tight to the tensioned garter spring (38) which otherwise could bounce back and lead to injury.

- Take both seal halves (41), (42) and pull them apart by approximately 20 mm.
- Open the garter spring (38).

3.4 Cleaning of the bearing

**Attention!**
Use only non-aggressive detergents, such as for instance:
- VALVOLINE 150.
- Alcaline cleaning compounds (pH-value 6 to 9, short reaction time).

**Warning of injury!**
Please observe the instructions for the use of the detergents.

**Attention!**
Never use cleaning wool or fibrous cloth. Residues of such materials left in the bearing could lead to excessive temperatures.

– Clean the following parts thoroughly, to remove all residues of preservation :

- inside the top half of the housing (2)
- inside the bottom half of the housing (21)
- all plain parts of the top and bottom half of the housing (2),(21)
- top half of the shell (11)
- bottom half of the shell (18)
- sealing surfaces of the top (37) and bottom (40) half of the seal carrier or of the rigid labyrinth seal
- loose oil ring (33).

3.5 Checks

– Please check if there is any visible damage. Check the split line and the working surfaces in particular.

The loose oil ring (33) should show absolutely no burrs or have no shoulders.

**Insulated Bearings**

– Check the insulating layer of the spherical seating (26).
– If necessary, change the damaged parts.

## 4 Assembly of the Bearing

**Attention!**
Remove all impurities or other objects such as screws, nuts, etc. from inside the bearing.If left inside they could lead to damage to the bearing. Cover up the opened bearing during work breaks.

**Attention!**
Carry out all assembly operations without making use of force.

**Attention!**
Secure all screws of the housing at the split line and flange with a liquid screw locking compound (e.g. LOCTITE 242) for all housing, split line and flange screws.

### 4.1 Assembly of the machine seal

- Fit the bottom half of the machine seal around its locating spigot on the bottom half of the housing.
- Align the split lines of the housing and of the seal in true alignment.
- Tighten the screws (12) by using the following torque value:

- Fit the top half of the machine seal around its locating spigot on the top half of the housing.
- Align the split lines of the housing and of the seal in true alignment.
- Tighten the screws (12) by using the following torque value:

| Bearing size | 9 | 11 | 14 | 18 | 22 | 28 |
|---|---|---|---|---|---|---|
| Tapped hole | M 6 | M 6 | M 6 | M 8 | M 8 | M 8 |
| Torque [Nm] | 8 | 8 | 8 | 20 | 20 | 20 |

- Place the pressure equalizing hoses (23) between the machine-side seal (13) and the bottom half of the housing into the clamps and tighten them.

4.2 Assembly opening for bearing fittting

The machine shield is designed in two versions:

• Split machine shield:

In this case the bottom half has a thick wall and is provided with a recess to permit the fitting of the housing. The top half of the machine shield can have either the thick wall or only a thin sheet. In both cases, after completed bearing installation, the top half of the machine shield is fastened to the top half of the housing.

• Non-split machine shield:

In this case the bottom half is provided with a recess to permit the fitting of the bottom half of the housing. The top half is provided with a greater opening which is used as assembly opening for the bearing. The following graph shows the minimum values necessary for the different bearing sizes.

| Bearing size | 9 | 11 | 14 | 18 | 22 | 28 |
|---|---|---|---|---|---|---|
| Diameter of the mounting recess [mm] | 375 | 450 | 530 | 630 | 800 | 1000 |
| Flat surface of the bottom half /Radius**$Ru_{min}$**[mm] | 215 | 255 | 305 | 360 | 455 | 565 |
| Flat surface of the top half /Radius **$Ro_{min}$** [mm] | 240 | 280 | 310 | 360 | 455 | 565 |
| Opening height **H** [mm] | 195 | 230 | 280 | 330 | 415 | 515 |
| Opening width **A** [mm] | 135 | 150 | 85 | 95 | 120 | 155 |

**Attention!**
The flat surface of the bottom half $Ru_{min}$ must not be lower than 4 mm.

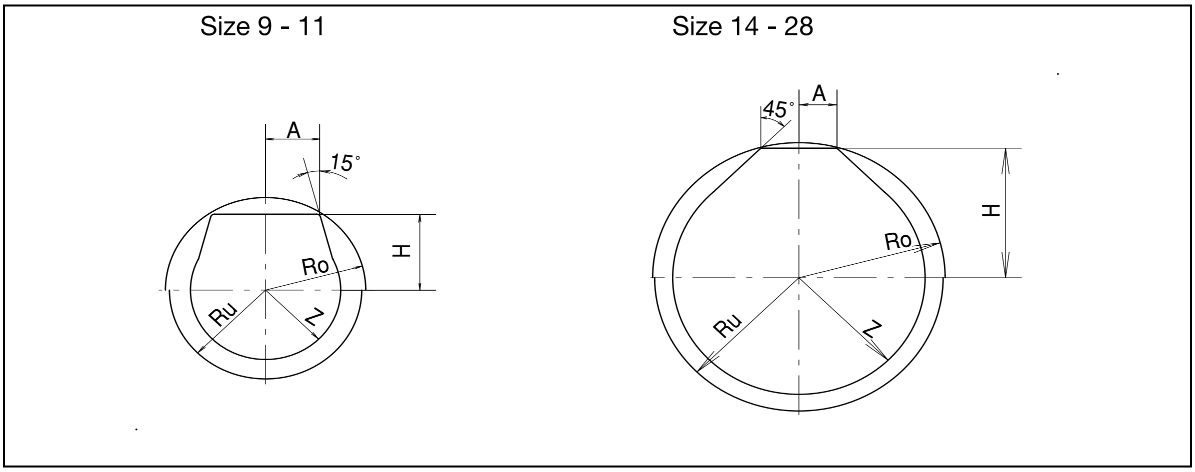



Illustration 2: Assembly opening slide bearing type EM

After completed bearing installation the remaining opening is covered by a thin metal plate (5).

4.3 Assembly of the bottom half of the housing into the machine shield

**Attention!**
The lifting equipment should not come into contact with the seal and working surfaces of the shaft.

- Lift the shaft high enough to give room for the assembly operations.
- Protect the shaft against unintended movement.
- Place the bottom half of the housing with the spigot (22) into the mounting recess of the machine shield.
- Tighten the flange screws to the following torque rates. Use only 8.8 quality screws.

| Bearing size | 9 | 11 | 14 | 18 | 22 | 28 |
|---|---|---|---|---|---|---|
| Suitable flange screws | M 10 | M 12 | M 16 | M 20 | M 24 | M 30 |
| Torque [Nm]for $\mu_{tot}$ (lightly oiled) | 40 | 69 | 170 | 330 | 570 | 1150 |

4.4 Fitting in the bottom half of the shell

**EM..E**

**Attention!**
Mounting the bottom half of the shell (not marked with an arrow) correctly will ease the assembly of the top half shell (marked with an arrow) (see chapter 4.7).

- Apply some lubricant to the spherical seating (26) in the bottom half of the housing (21) and to the working surfaces of the shaft. Use the same type of lubricant as indicated for bearing operation
( see type plate ).
- Place the bottom half of the shell (18) on the working surface of the shaft. Turn the bottom half of the shell (18) into the bottom half of the housing (21) with the split line surfaces of both halves in true alignment.

In case the bottom half of the shell doesn`t turn in easily, check the position of the shaft and the alignment of the housing

**EM..B,**
**EM..K**
**EM..E**

**Attention!**
These operations should be carried out most carefully. The thrust parts of the bottom shell must not be damaged.

- Lower down the shaft till it sits on the bottom half of the shell (18).

4.5 Assembly of the shaft seal - machine-side

The machine-side shaft seal is, as standard, a floating labyrinth seal. The integrated seal groove is in the top and bottom halves of the housing.

**Warning of injury!**
During assembly hold the garter spring ends securely to avoid them suddenly releasing and causing possible injury !

Check the movement of the floating labyrinth seal on the shaft in the seal area outside the housing.

– Put the garter spring (38) around the shaft and hook both ends into each other.
– Put both halves of the seal (41),(42) in their place on the shaft.
– Put the garter spring (38) into the groove (39).
– Turn the floating labyrinth seal on the shaft.

**Attention!**
The floating labyrinth seal should turn easily on the shaft. A jammed seal could lead to overheating during operation and even to shaft wear.
If the floating labyrinth seal jams,
- dismantle the seal and
- remove the worn parts of the seal carefully, by using emery paper or a plain scraper.

– Dismantle the floating labyrinth seal.
– Apply Curil T to the guide surfaces of the integrated seal groove in the bottom half of the housing.

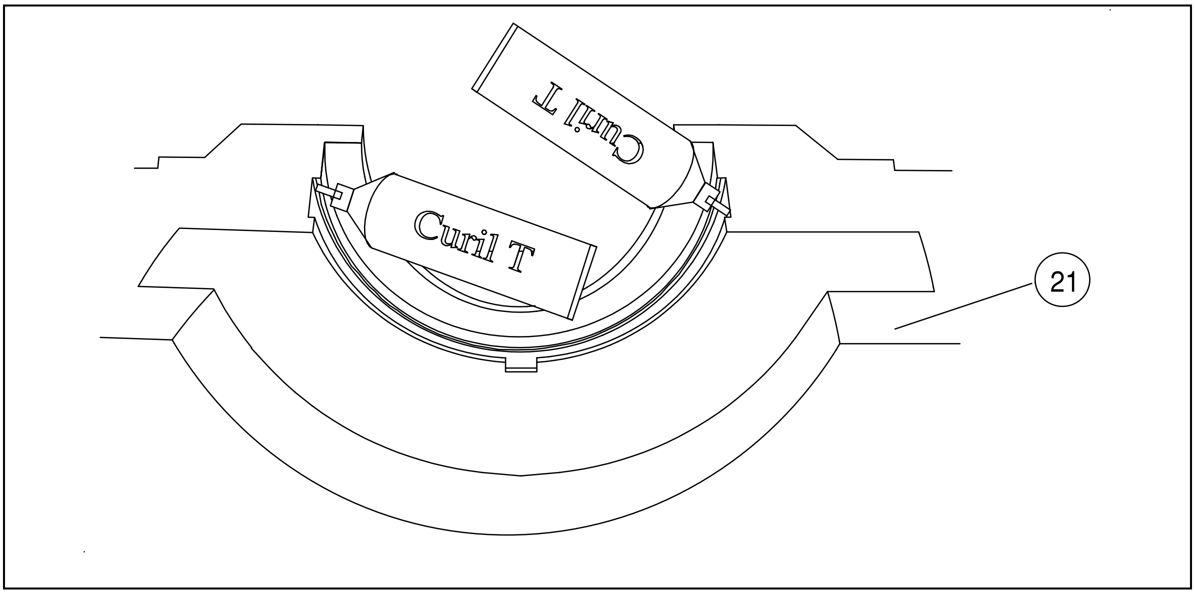



Illustration 3: Application of Curil T to the integrated seal groove

– Apply a uniform layer of Curil T to the guide surfaces and on the split line surfaces of both halves of the seal (41), (42).

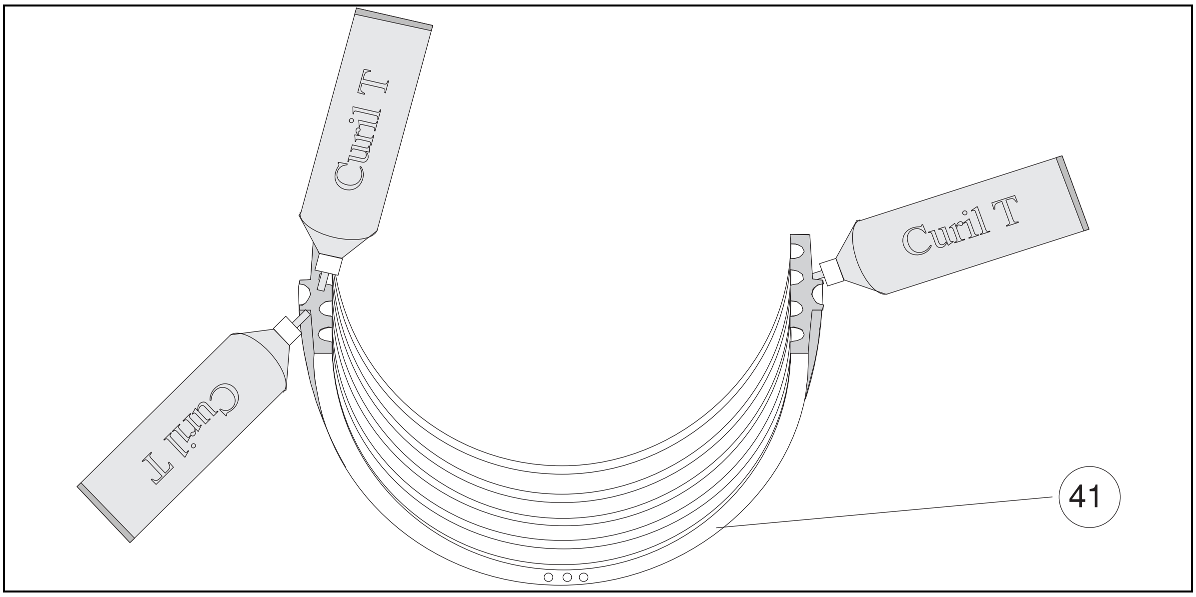



Illustration 4: Application of Curil T to the floating labyrinth seal

| |
|---|
| Please observe the instructions for the use of Curil T. |

– Place the bottom half of the seal (41) with the labyrinths onto the shaft.
– The oil return holes at the bearing side must be clear and open.
– Turn the seal in opposite direction from the anti-rotation pin into the groove of the housing until the split lines of the bottom half of the housing and the bottom half of the seal match each other.
– Remove the residue of Curil T.
– Push the garter spring into the integrated seal groove between the bottom half of the housing and the seal until both ends jut out from the split line.
– Place the top half of the seal with the cam facing the inside of the bearing on the bottom half of the seal.
– Stretch the garter spring till both ends can be hooked.

4.6 Installation of the loose oil ring

- Open both split lines of the loose oil ring (33) by untightening and removing the screws (36). Separate both halves of the loose oil ring (33) carefully without using any tools or other devices.

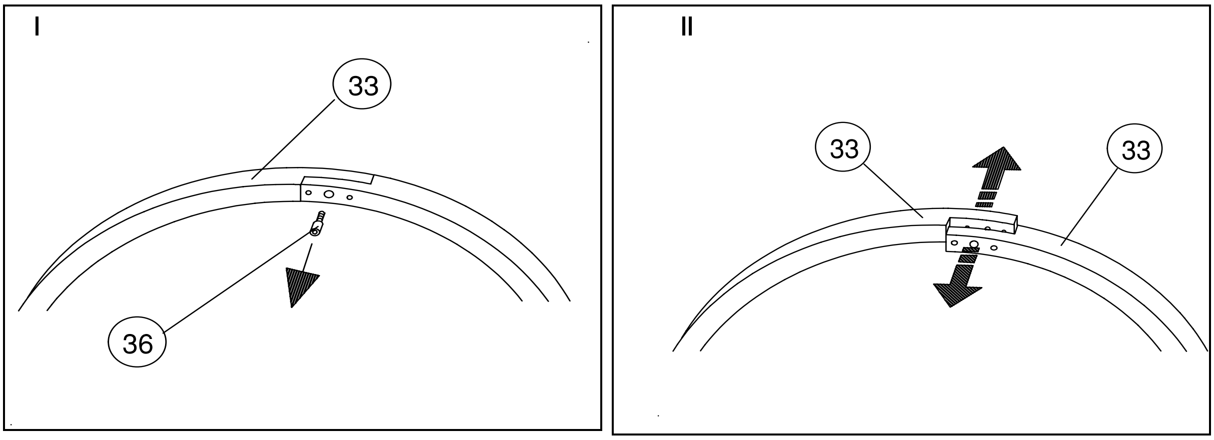



Illustration 5: Opening of the loose oil ring

- Place both halves of the loose oil ring into the shell groove encircling the shaft.Press the positioning pin (34) of each split line into the corresponding hole (35).
- Adjust both halves of the loose oil ring till the split lines match each other.

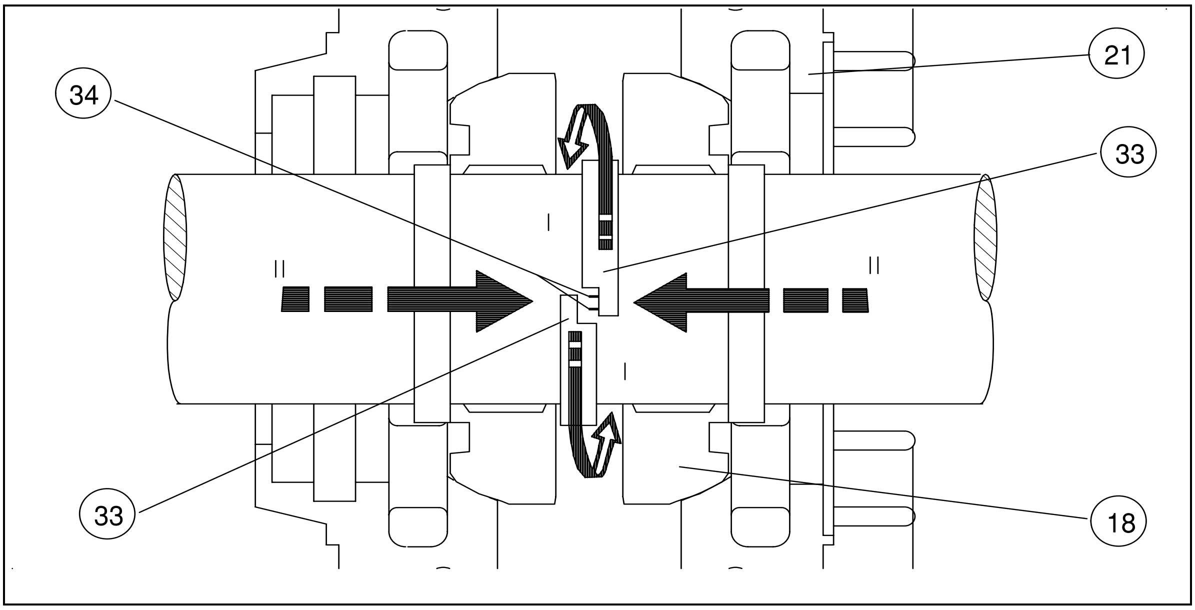



Illustration 6: Installation of the loose oil ring

- Tighten the screws (36) to the following torque rates:

| Bearing size | 9 | 11 | 14 | 18 | 22 | 28 |
|---|---|---|---|---|---|---|
| Torque [Nm] | 1,4 | 1,4 | 1,4 | 2,7 | 2,7 | 2,7 |

4.7 Fitting in the top half of the shell

- Apply some lubricant to the working surfaces of the shaft. Use the same type of lubricant as indicated for bearing operation (see type plate).
- Check if the engraved number (20) on the bottom half of the shell corresponds with the engraved number (20) on the top half of the shell.
- Place the top half of the shell (11) on the shaft; both engraved numbers(20) should be on one side.

**Attention!**
An incorrectly placed shell could jam the shaft thus leading to the damage of both shaft and bearing.

**EM..B, EM..K, EM..E**

**Attention!**
Place the top half of the shell carefully on the shaft. The thrust parts of the top half of the shell should not be damaged.

insulated bearings

In the case of bearings arranged for insulation monitoring, connect the black cable for insulation monitoring to the shell.

According to the bearing type, there are two possibilities of connection.

1. The black cable is provided with a cable connector.

- Plug the cable with the cable connector into the counterpart available on the top of the shell.
- Lead the cable through the cable gland in the bottom half of the housing and out of the bearing.
- Tighten the cable gland oil-tight.

2. The black cable is provided with an eyelet.

- Fasten the cable with the eyelet to the split line of the shell, by using one of the shell joint bolts.
- Lead the cable through the cable gland in the bottom half of the housing and out of the bearing.
- Tighten the cable gland oil-tight.

- Tighten up the screw (24) to the following torque rates:

| Bearing size | 9 | 11 | 14 | 18 | 22 | 28 |
|---|---|---|---|---|---|---|
| Torque [Nm] | 8 | 8 | 20 | 69 | 69 | 170 |

- Check the split line of the shell by using a feeler gauge. The split line gap should be less than 0,05 mm. If the split line is greater than this, dismantle both top (11) and bottom (18) halves of the shell. Rework the split line surfaces of the top (11) and bottom (18) half of the shell with an oil stone.
- Check the mobility of the loose oil ring (33).

Marine bearings

A guide bush in the top half of the shell secures the function of the loose oil ring.

- Check the mobility of the loose oil ring (33) in the guide bush.

**EM..E**

Shells with taper land faces suitable only for one direction of rotation are marked with an arrow on the top half shell, which indicates the sense of rotation of the shaft.

The arrow indicates the allowed direction of shaft rotation after completion of the bearing assembly.

- Before mounting the top half of the housing check that the proposed direction of rotation of the shaft corresponds to the direction indicated by the arrow on the top half of the shell.
- If the directions match, continue the assembly of the bearing.
- If the directions do not match, the shell must be disassembled, re-aligned and mounted again.

**Attention!**
A wrongly placed shell, without observance of the direction of rotation of the shaft, impairs the operational safety of the bearing.

4.8 Assembly of the top half of the housing

- Check the true alignment of the split lines of the shell (11), (18) and bottom (21) half of the housing.

The positioning pin (8) in the top half of the housing fits in the corresponding hole (4) in the shell.

- Check if the engraved numbers (1) on the top and bottom halves of the housing correspond.
- Clean the split line surfaces of the top and bottom halves of the housing.
- Apply Curil°T over the whole surface of the split line of the bottom half (21) of the housing.

Please observe the instructions for the use of Curil T.

- Place the top half of the housing carefully into the machine shield, without touching the seals or the shell.

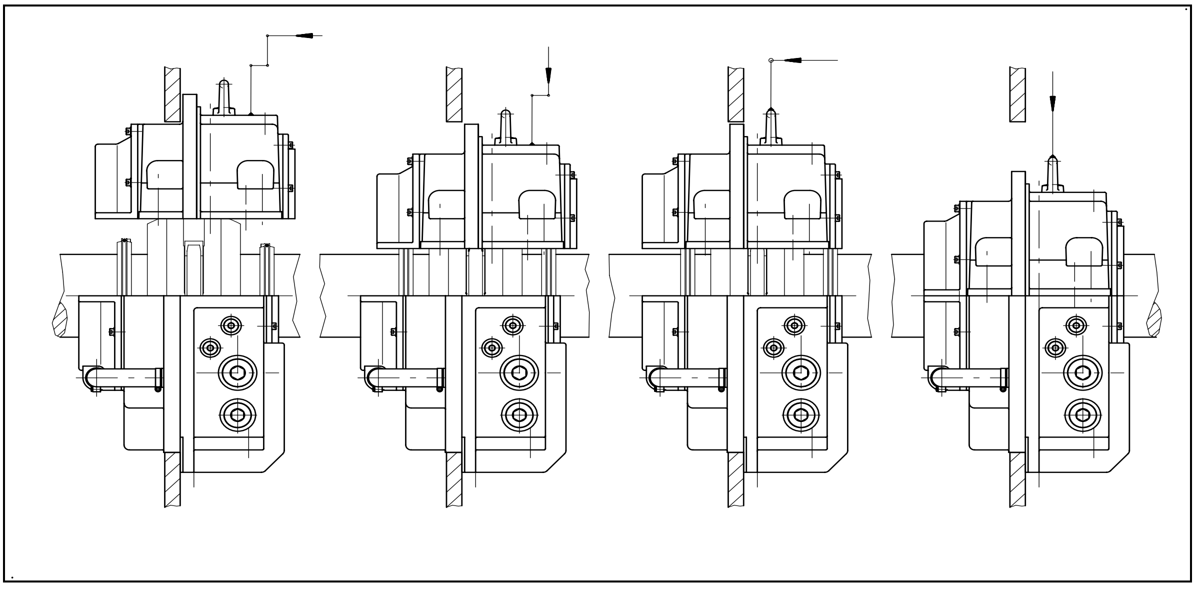


Illustration 7: Assembly of the top half of the housing

- Lower the top half of the housing (2) vertically on the bottom half of the housing (21). Lower the top half of the housing (2) till the split line of the housing is not visible any more.
- Gently hit the bottom half of the housing (21) with a nylon hammer, thus ensuring the alignment of the spherical seating.
- Insert the screws (16). Tighten them crosswise to the following torque rates:

| Bearing size | 9 | 11 | 14 | 18 | 22 | 28 |
|---|---|---|---|---|---|---|
| Torque [Nm] | 40 | 69 | 170 | 330 | 570 | 1150 |

- Hand-tighten the screws at the split line of the machine seal.

**Size 22 and 28.**

- Unscrew the assembly device and put it back into its "parking position" behind the flange. Tighten the assembly device by using the following torque: 40 Nm.
- Replace the top sight glass and screw it hand-tight.

insulated bearings

Insulation monitoring

In the case of electric insulated bearings provided with insulation monitoring, the cable coming out of the housing must be connected in a professional manner.

According to the type supplied, please follow the assembly instructions given below.

a) The cable is very short and provided with a further cable connector at the end of it.
This cable is ready for connection to the housing.
The bottom half of the housing is provided with the counterpart.

- Plug the cable connector into the counterpart.

**Attention!**
This connection bypasses the electrical insulation of the bearing.
In the case of electric machines, make sure at least one bearing is electrically insulated.

To check the electrical insulation, interrupt the connection cable - housing. Check the electrical resistance with a suitable measuring instrument. Make sure that both bearings and the coupling are electrically insulated.

b) The cable has a free end. In this case the customer has to make the connection.

**Attention!**
If only one bearing is insulated, the end of the cable must not be earthed.

Any further connection depends on the customer's requirements related to the insulation monitoring and can not therefore be described here.

## 5 Assembly of the Seals - Outboard Side

– Assemble the outboard side seals.
  Proceed according to the seal type used.

- Floating labyrinth seal (Type 10) Chapter 5.1
- Floating labyrinth seal with dust flinger (Type 11) Chapter 5.2
- Floating labyrinth seal with baffle (Type 12) Chapter 5.3

- Rigid labyrinth seal (Type 20) Chapter 5.4
- Rigid labyrinth seal with dust flinger (Type 21) Chapter 5.5
- Rigid labyrinth seal with baffle (Type 22) Chapter 5.6

**Type 10**

### 5.1 Floating labyrinth seal (Type 10)

**Warning of injury!**
During assembly hold the garter spring ends securely to avoid them suddenly releasing and causing possible injury !

Check the movement of the floating labyrinth seal on the shaft.

– Put the garter spring (38) around the shaft and hook both ends into each other.
– Put both halves of the seal (41),(42) in their place on the shaft.
– Put the garter spring (38) into the groove (39).
– Turn the floating labyrinth seal on the shaft.

**Attention!**
The floating labyrinth seal should turn easily on the shaft. A jammed seal could lead to overheating during operation and even to shaft wear.
If the floating labyrinth seal jams,
- dismantle the seal and
- remove the worn parts of the seal carefully, by using emery paper or a plain scraper.

– Dismantle the floating labyrinth seal.

– Apply a uniform layer of Curil T to the guide surfaces and on the split line surfaces of both halves of the seal (41), (42).

| |
|---|
| Please observe the instructions for the use of Curil T. |

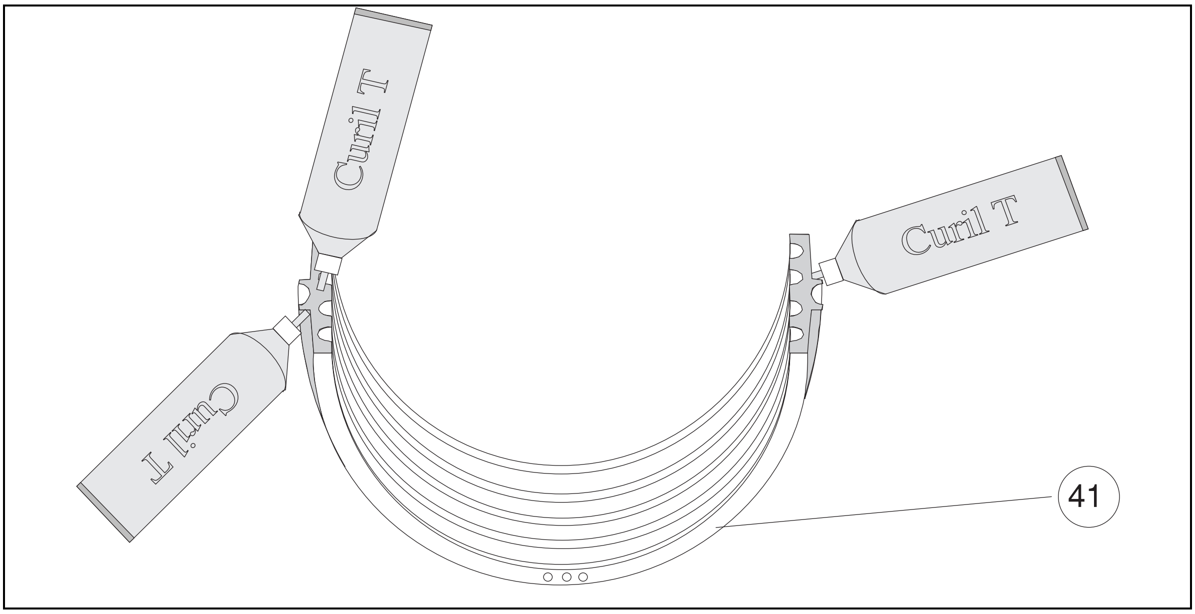



Illustration 8: Application of Curil T to the floating labyrinth seal

– Press the bottom half of the seal (41) against the shaft.
– Place the top half of the seal (42) on the shaft and align both halves of the seal to each other.
– Place the garter spring (38) into the groove (39) and stretch until both ends can be hooked.

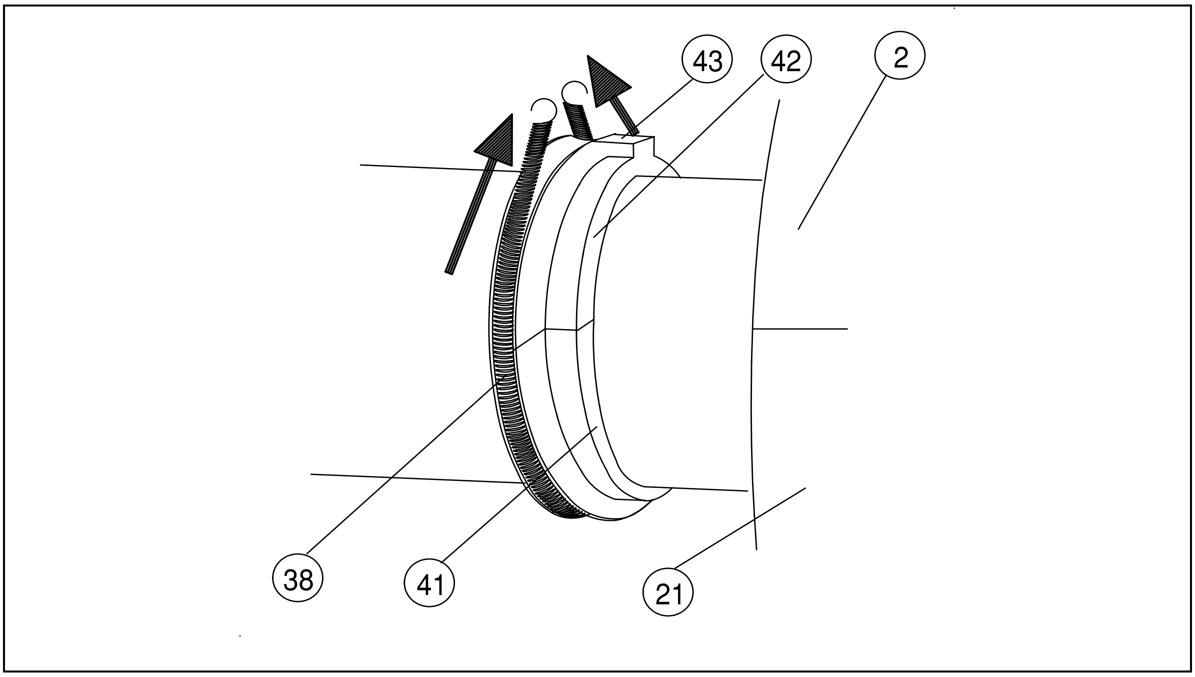


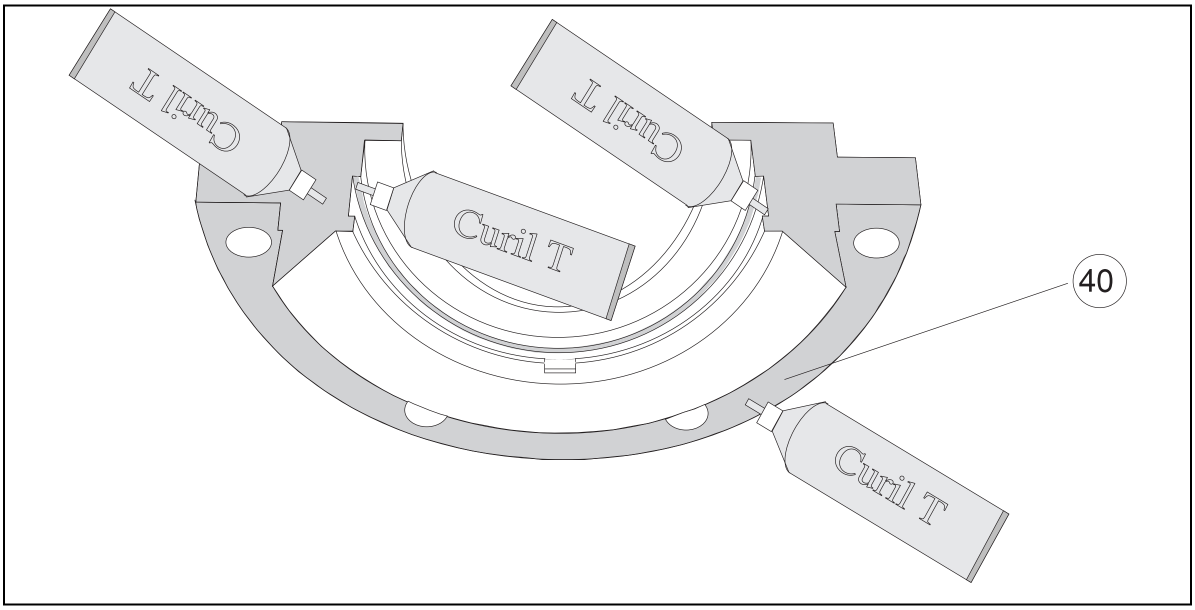

Illustration 9: Assembly of the floating labyrinth seal

– Place in true alignment the split line of the floating labyrinth seal and the split line of the seal carrier.
– Check that both engraved numbers (45) and (47) on top and bottom halves of the seal carrier (37), (40) correspond.

– Clean the following parts:
- the seal surfaces of the top (37) and bottom (40) half ofthe seal carrier (the groove of the floating labyrinth seal, the flange surfaces)
- the split line surfaces of the top (37) and bottom half (40) of the seal carrier
- the flange surfaces of the housing.

– Apply a uniform layer of Curil T to :
- the lateral surfaces of the groove at the top (37) and bottom half (40) of the seal carrier
- the flange surfaces of the top (37) and bottom (40) half of the seal carrier
- the split line surfaces of the bottom half of the seal carrier (40).

| Please observe the instructions for the use of Curil T. |
| --- |




Ilustration 10: Application of CurilT to the seal carrier

– Place the top half of the seal carrier (37) on the top half of the seal (42). Press the bottom half (40) of the seal carrier against it. Push the shaft seal completely into the housing.

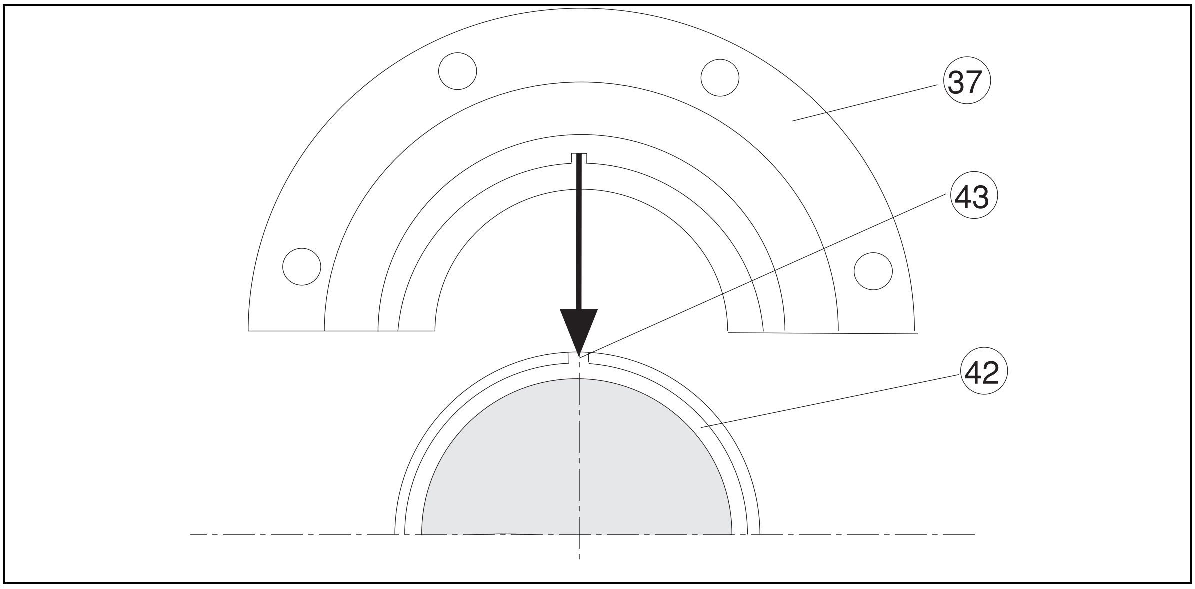



Illustration 11 Assembly of the seal carrier

– Place in true alignment the split lines of the seal carrier and the housing.
– Tighten up the screws (44) to the following torque rates:

| | | | | | | |
|---|---|---|---|---|---|---|
| Bearing size | 9 | 11 | 14 | 18 | 22 | 28 |
| Torque [Nm] | 8 | 8 | 8 | 20 | 20 | 20 |

Type11

5.2 Floating labyrinth seal with dust flinger (Type 11)

– Assemble the floating labyrinth seal with dust flinger as described in Chapter 5.1, Floating labyrinth seal type 10.
– Place both halves of the dust flinger (58) in front of the shaft seal around the shaft. Loosely screw in the screws (59) of the flinger.

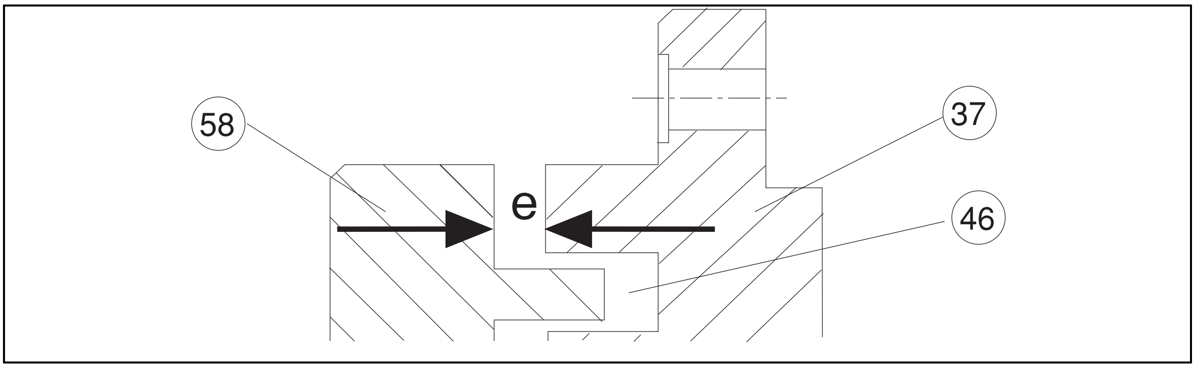



Illustration 12: Clearance between dust flinger and seal carrier

EM..Q

– Push the dust flinger (58) into the groove (46) of the seal carrier.
– Set the clearance "e" at the following figure around the whole unit:

**maximum longitudinal extension of the shaft in operation + 1 mm**

(Parameters indicated in the Technical Documentation of the Installation).

– Tighten up both screws (59) to the following torque rates:

| | | |
|---|---|---|
| Seal diameter [mm] | 80-140 | >140 |
| Torque [Nm] | 7 | 18 |

EM..B
EM..K
EM..E

– Push the dust flinger (58) into the groove (46) of the seal carrier.
– Set the clearance "e"at **1 mm** around the whole unit.
– Tighten both screws (59) to the following torque rates:

| | | |
|---|---|---|
| Seal diameter [mm] | 80-140 | >140 |
| Torque [Nm] | 7 | 18 |

**Type 12**

5.3 Floating labyrinth seal with baffle (Type 12)

- Assemble the floating labyrinth seal with baffle as described in Chapter 5.1, type10.
- Apply a uniform layer of Curil T to the flange surfaces of the top half (55) and bottom half (57) of the baffle.
- Screw
  - the top half of the baffle (55) onto top half of the seal carrier (37)
  - the bottom half of the baffle (57) onto bottom half of the seal carrier (40).
- Tighten the screws (56) to the following torque rates:

| | | |
|---|---|---|
| Seal diameter [mm] | 80-140 | >140 |
| Torque [Nm] | 4 | 10 |

**Type 20**

5.4 Rigid labyrinth seal (Type 20)

- Check if the engraved numbers (53) and (54) on the bottom half (52) and top half (48) of the rigid labyrinth seal correspond.
- Clean
  - the flange surfaces of the top half (48) and bottom half (52) of the rigid labyrinth seal
  - the split line surfaces of the top half (48) and bottom half (52) of the rigid labyrinth seal
  - the flange surfaces of the housing.
- Apply a uniform layer of Curil T to the following parts:
  - the flange surfaces of the top (48) and bottom half (52) of the rigid labyrinth seal
  - the split lines of the bottom half (52) of the rigid labyrinth seal.

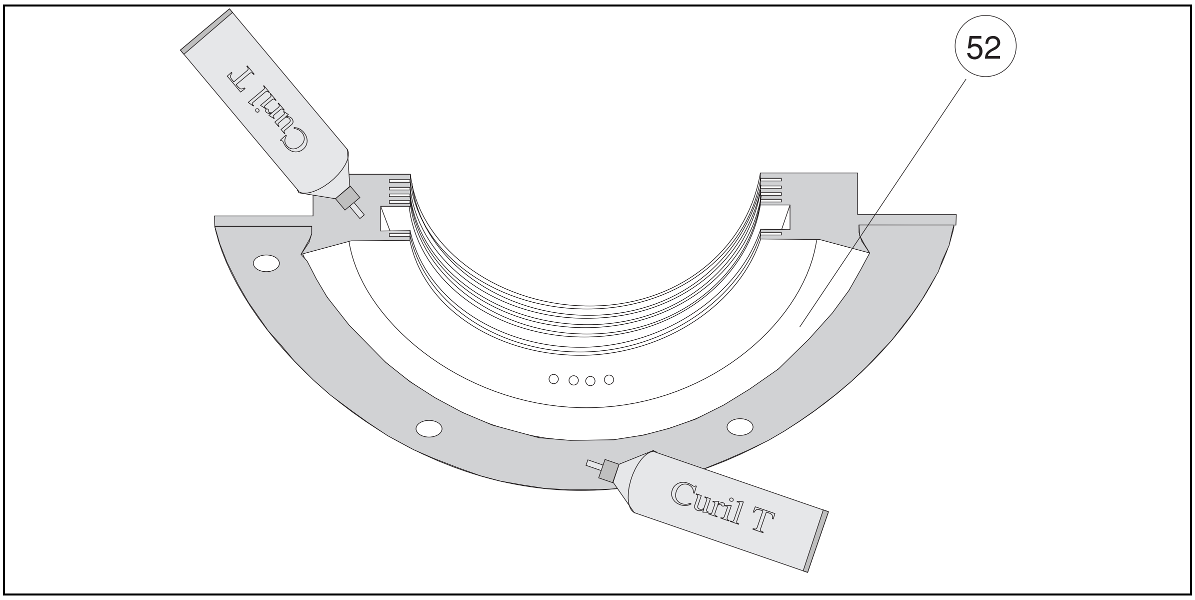



Illustration 13: Application of Curil T to the rigid labyrinth seal

- Place the top half (48) of the rigid labyrinth seal on the shaft and press slightly the bottom half (52) of the rigid labyrinth seal from below against it. Lightly push the rigid labyrinth seal completely into the housing.
- Tighten the screws (50) of the labyrinth seal.

– Place in parallel alignment the split line of the rigid labyrinth seal and the split line of the housing. Press the rigid labyrinth seal slightly from below against the shaft. Adjust the rigid labyrinth seal in such a way that the clearance "f" between the shaft and the rigid labyrinth seal at both split lines has the same figure.

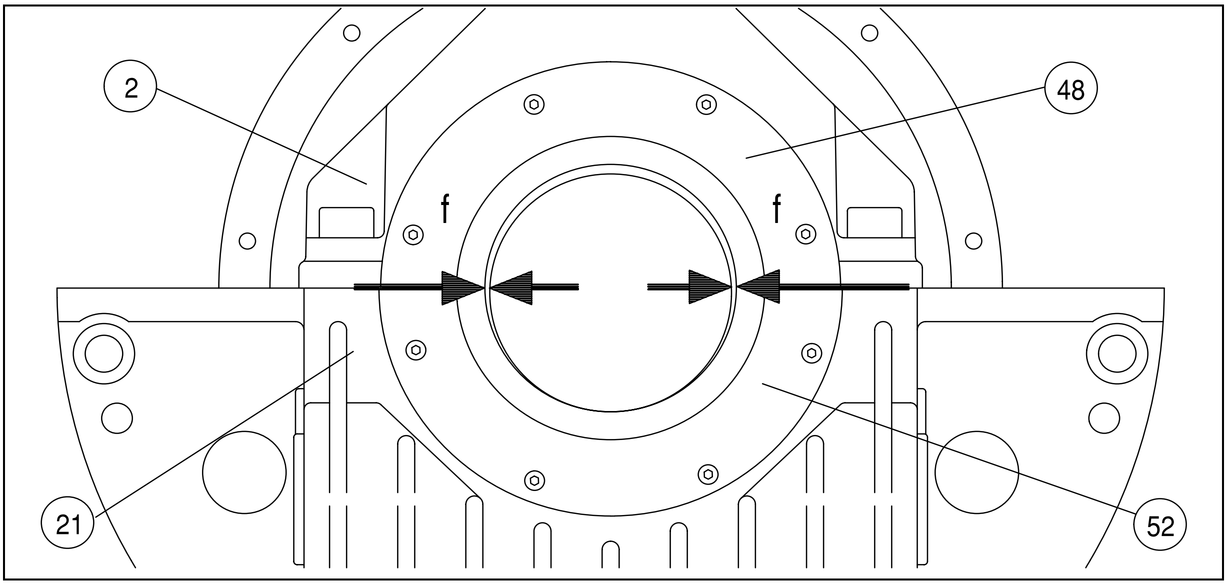



Illustration 14: Alignment of the rigid labyrinth seal

– Tighten the screws (49) to the following torque rates:

| Bearing size | 9 | 11 | 14 | 18 | 22 | 28 |
|---|---|---|---|---|---|---|
| Torque [Nm] | 8 | 8 | 8 | 20 | 20 | 20 |

**Type 21**

## 5.5 Rigid labyrinth seal with dust flinger (Type 21)

- Assemble the rigid labyrinth seal with dust flinger as described in Chapter 5.4, type 20.
- Place both halves of the dust flinger (58) round the shaft, in front of the rigid labyrinth seal. Mount both screws (59) loose.

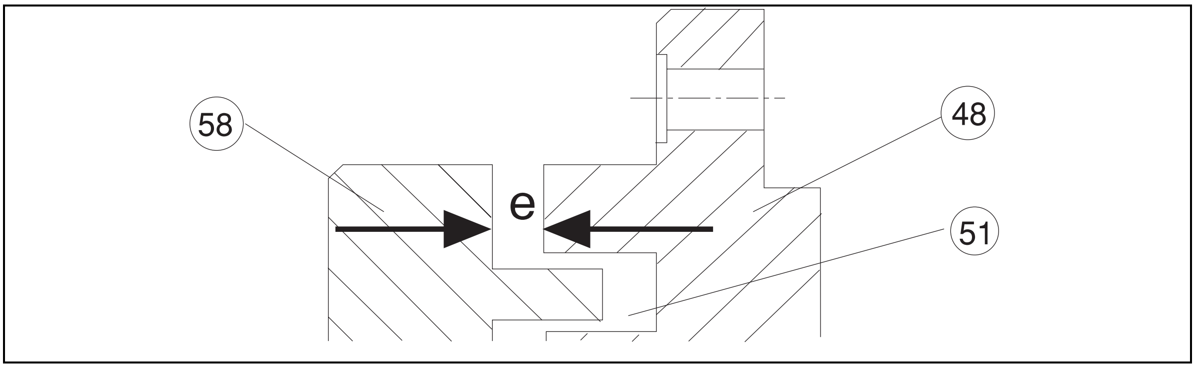



Illustration 15: Clearance between dust flinger and rigid labyrinth seal

**EM..Q**

- Push the dust flinger (58) into the groove (51) of the rigid labyrinth seal.
- Set the clearance "e" at the following figure around the whole unit.

**maximum longitudinal extension of the shaft in operation + 1 mm**

(Parameters are indicated in the Technical Documentation of the Installation).

- Tighten both screws (59) to the following torque rates:

| | | |
|---|---|---|
| Seal diameter [mm] | 80-140 | >140 |
| Torque [Nm] | 7 | 18 |

**EM..B, EM..K EM..E**

- Push the dust flinger (58) into the groove (51) of the rigid labyrinth seal.
- Set the clearance "e" at **1 mm** around the whole unit.
- Tighten both screws (59) to the following torque rates:

| | | |
|---|---|---|
| Seal diameter [mm] | 80-140 | >140 |
| Torque [Nm] | 7 | 18 |

**Type 22**

## 5.6 Rigid labyrinth seal with baffle (Type 22)

- Assemble the rigid seal with baffle as described in Chapter 5.4, type 20.
- Apply a uniform layer of Curil T to the flange surfaces of the top half (55) and bottom half (57) of the baffle.
- Screw
  - the top half of the baffle (55) to the top half (48) of the rigid labyrinth seal
  - the bottom half of the baffle (57) to the bottom half (52) of the rigid labyrinth seal.
- Tighten the screws (56) to the following torque rates:

| | | |
|---|---|---|
| Seal diameter [mm] | 80-140 | >140 |
| Torque [Nm] | 4 | 10 |

## 6 Instructions for Assembly of Peripheral Equipment

### 6.1 Temperature measurement

– Fix suitable thermo sensors:

- into one of the tapped holes (27) for temperature measurements of the journal parts
- into one of the tapped holes (29) for temperature measurements of the oil sump

Proceed as follows:

– Take out the screw plugs from the connection holes.
– Place the thermo sensor into the bore by using Teflon tape or sealing compound.
– Connect the thermo sensor at the temperature monitoring equipment of the installation (see the Technical Documentation of the Installation for connecting and adjustement).

EMW..

### 6.2 Water supply

Following requirements should be observed before connecting the cooler (31):

- water velocity of maximum 1,5 m/s in the cooling water inlet
- water pressure of maximum 5 bar
- adjusting tap on inlet
- outlet of cooling water is under no pressure.

The direction of the cooling water passage in the cooler (31) is arbitrary.

### 6.3 Closing of the assembly opening

After completed bearing assembly and before starting operation close the assembly opening of the machine shield (with the thin metal plate (5)).

## 7 Bearing Insulation

These bearings are delivered insulated. The electrical insulation is assured by:

- plastic coating of the spherical seatings (26)
- shaft seals made out of non-conducting materials
- insulated positioning pin (8)
- insulated screwed connections for thermometers.

| It is not necessary to insulate the pipelines. |
|---|

– Mark the insulated bearing with the delivered plate " Insulated shells".Install the plate in a visible place by using two grooved drive studs.

## 8 Operation

### 8.1 Filling up lubricating oil

> **Attention!**
> Make sure that no impurities get into the bearing.

– Tighten all screw plugs in the tapped holes (27), (28), (32) to the necessary torque rates:

| Screw plug threads | G 3/8 | G 1/2 | G 3/4 | G 1 | G 1 1/4 | G 1 1/2 | G 2 | G 2 1/2 |
|---|---|---|---|---|---|---|---|---|
| Torque [Nm] for plugs with moulded on plastic seal | 30 | 40 | 60 | 110 | 160 | 230 | 320 | 500 |
| Torque [Nm] for plugs with elastic seal | 34 | 60 | 85 | 130 | 240 | 300 | 330 | 410 |

– Check that:

- the top sight glass (9) is tight, the screws should be hand-tight
- oil sight glass (28) is tight, the screws should be hand-tight.

In the case thermo sensors or / and oil sump thermometers are used:

– Check that they are tight (according to the manufacturer's instructions).

– Remove the screw plugs from the oil filling hole (3).
– Use a lubricant with the viscosity indicated on the bearing type plate. Fill the lubricant through the oil filling hole (3) up to the middle point of the oil sight glass (28).

The oil level limits are as follows:

**minimum oil level:** **bottom of the oil sight glass**

**maximum oil level:** **top of the oil sight glass**

> **Attention!**
> - Not enough lubricant leads to temperature rises and thus to damages to the bearing.
> - Too much lubricant leads to leakages. In the case of bearings with lubrication by loose oil ring too much lubricant could have a considerable breaking effect on the oil rings, thus leading to damages to the bearing.

– Tighten the screw plug into the oil filling hole (3) to the following torque rates:

| Bearing size | 9 | 11 | 14 | 18 | 22 | 28 |
|---|---|---|---|---|---|---|
| Torque [Nm] | 30 | 30 | 30 | 40 | 60 | 60 |

– Remove the protective layer from the top sight glass (9).

8.2 Trial run

– Before the trial run, check the following:
- oil level (see Chapter 8.1)
- if the temperature monitoring equipment works
- **EMW..** if the water cooling installation works.

The bearing is ready for operation.

– Supervise the bearing during the trial run (5-10 operating hours).
Pay special attention to:
- oil level (see Chapter 8.1)
- bearing temperature
- sliding noises of the shaft seals
- tightness
- occurrence of inadmissible vibrations.

**Attention!**
If the bearing temperature exceeds the calculated value by 15 K (see bearing calculation) stop the installation immediately. Carry out an inspection of the bearing as described under Instructions for Service and Inspection of the Slide Bearings Type EM with self lubrication.

## 9 Glossary

**Baffle**
With bearing types 10 and 20 the baffles are assembled externally in front of the shaft seals. The baffle, made of reinforced polyamide, protects the bearing from dust and water.

**Rigid labyrinth seal**
The rigid labyrinth seal (type 20) is used with slide bearings type E with high oil throughput.It corresponds to the protective system IP44 and is made of an aluminium alloy.
The rigid labyrinth seal is built of two halves, flanged at the housing.The labyrinths that wipe out the lubricant are arranged into two groups.The first two labyrinths , installed inside keep back most of the lubricant. Five further labyrinths protect the bearing from outside.They prevent the lubricant overflow and the ingress of impurities.The overflow lubricant is collected into a chamber between the both groups of labyrinths.Through the return bores the lubricant flows back into the bearing.

**Spherical seating**
The spherical seating is a special feature enabling the alignment of the shell in the housing.The shell is seated on two spherical seatings. The advantages of the spherical seating are:
- easy at assembly
- good heat transfer from the shell to the housing
- suitable for such applications with high thrust or journal loads.

**Dust flinger**
In the case of bearing types 10 and 20 a light alloy ring is clamped on the shaft in front of the shaft.This ring fits into a groove in the seal carrier or the rigid labyrinth seal, thus building a labyrinth. The labyrinth protects the shaft exit against low pressure that could otherwise " absorb " the lubricant. Low pressure occurs for instance in the case of rotating discs, such as couplings or cooling discs.

**Floating labyrinth seal**
The floating labyrinth seal (type 10) in the seal carrier is used as a shaft seal in the case of bearings type E operating under normal conditions. It prevents the lubricant and lubricant mist coming out and the ingress of impurities. The floating seal has a high capacity of resistance to wear. It is made of a high-performance, high temperature stability and electrically insulated plastic material.The floating seal consists of two halves held together by a garter spring. Both ends of the spring are hooked together. In the case of slide bearings type EM the floating seal is mounted into a two-piece seal carrier. The groove allows for radial movement of up to 1 mm. The seal is thus insensitive to shaft radial displacement or deflection. The sealing effect is produced by the baffles wiping off the lubricant from the shaft. The lubricant flows back into the bearing via oil return opening.

**Machine seal**
In the case of the flange mounted bearings, the machine seal reduces the influence of positive and negative pressure in the machine thus preventing leakages at the inner seal area. The space between the machine seal and the bearing housing must always be vented to atmospheric pressure. The size of the gap between shaft and machine seal influences the sealing effect.

# OPERATION & MAINTENANCE

## Removable Coverplate Coolers

### 1.0 DESCRIPTION

Thermofin "Removable Coverplate Coolers" coils have been designed for the efficient cooling of air using a glycol water mixture or water as the heat carrying medium.

### 2.0 INSTALLATION AND OPERATION

2.1 All vents and drains supplied with cooler should be in place when coolers are installed.

2.2 All pipe joints, drain cocks and coverplate must be tight.
( All bolts in the water boxes must be tightened up evenly before filling )

2.3 Make certain the fluid supply system has been flushed and is clean before starting operation. Avoid flushing the system through the coils. The use of strainers and settling tanks in pipe lines is recommended to avoid sand or sediment being deposited in coils.

2.4 Always start to circulate the tube side fluid before starting air flow. This will minimize the tube stresses.

2.5 When starting operation, vent the system until all air is removed and repeat as often as necessary to prevent air binding and to maintain design coil performance.

2.6 Dirt on the outside surface of the tubes also greatly reduces the heat transfer capacity of the Coolers and should be removed. Instructions for cleaning the outside are given in paragraph 5.

2.7 When shutting down the unit, stop air gas flow first and fluid supply last.

2.8 When cooler is shut down, drain it thoroughly to eliminate the possibility of sludging or of freezing in cold weather.

## 3.0 PERFORMANCE

If coil fails to meet specified performance, check the following:

3.1 Air vents • Be certain no air binding is present in the coil(s).

3.2 Dirty fluid • Be certain all lines are clean • Check and clean strainers.

3.3 Dirty fins • Be certain finned surfaces are clean and free of obstructions.

3.4 Counterflow • Be certain coils are properly connected.

3.5 Operating conditions • Check inlet and outlet fluid temperatures, fluid flow, pump capacity, air flow and inlet temperature against design conditions.

3.6 Control system • Be sure mixing or control valves are of proper size and capacity and that the control system functions properly.

3.7 Consult Thermofin if further assistance is required.

## 4.0 MAINTENANCE

A regular cleaning schedule should be adopted for strainers in pipe line and for finned surfaces. At least an annual check and/or cleaning should be timed in advance of the coils severest operation season or semi-annually for coils in year round operation.

**<u>CATION:</u>** No maintenance should be done on the coolers until personnel are certain that all pressure is off the equipment and the unit is drained.

### 4.1 <u>Finned Surface Cleaning</u>

**a)** A pressure washer ( 2000 à 3000 Psig.) can be used to clean the finned surface of the tubes.

**b)** A light solution of especially formulated caustic for aluminum can be used with the pressure washer to remove the excess oil or other dirt of the same type.

**c)** When cleaning the unit with a pressure washer each surface of air circulation have to be done making sure to finish the operation in the same direction that the unit is operating.

4.2 **Inside Cleaning**

**a)** Remove both ends unit covers.

**b)** A first mechanical cleaning of the inside of the tube can be performed by inserting a circular metal brush by one end of the unit and pushing it through the tube while rotating it. .

**c)** The cleaning operation can be completed by using pressurised water in each tube in order to removed any small particles that could remained.

**d)** It is important to complete the exercise with a visual inspection to confirmed the efficiency of the procedure.

4.3 **Leaking tube joints**

**a)** If tube become loose on the tube sheet, they can be tightened with proper Tube Rolling Expander.

**b)** It is recommended that tube rolling be done only by mechanics with previous experience and proven skill. The mechanics should be very careful in using the expander. Excessive rolling thins and may work harden the liner tubes and result in permanent leaking joint.

**CAUTION:** Do not expand the tube beyond the tube sheet.
Do not expand tubes that are not found to be leaking

These instructions are intended only for general use. If any difficulties are encountered with these coils in particular installations, it is ***recommended*** that ***Thermofin*** be contacted for specific instructions or consultation before attempting on site corrections.

MINCO

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# RTD Resistance Vs. Temperature Table

PLATINUM : PE TCR = 0.00385

$R_0$ = 100

A = 0.0039083 B = -5.775E-07 C = -4.183E-12

Values are in °C

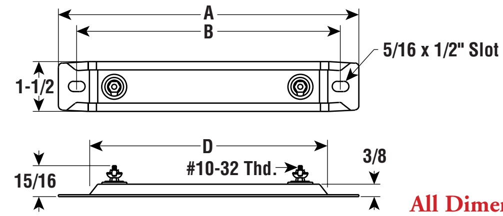
| Ohms | +0 | +1 | +2 | +3 | +4 | +5 | +6 | +7 | +8 | +9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 100 | 0.0000 | 2.55963 | 5.12119 | 7.68470 | 10.2502 | 12.8176 | 15.3869 | 17.9583 | 20.5315 | 23.1068 |
| 110 | 25.6840 | 28.2633 | 30.8445 | 33.4277 | 36.0128 | 38.6000 | 41.1892 | 43.7804 | 46.3736 | 48.9688 |
| 120 | 51.5661 | 54.1653 | 56.7666 | 59.3699 | 61.9753 | 64.5827 | 67.1922 | 69.8037 | 72.4173 | 75.0330 |
| 130 | 77.6507 | 80.2705 | 82.8923 | 85.5163 | 88.1423 | 90.7705 | 93.4007 | 96.0330 | 98.6675 | 101.304 |
| 140 | 103.943 | 106.584 | 109.226 | 111.872 | 114.519 | 117.168 | 119.820 | 122.473 | 125.129 | 127.787 |
| 150 | 130.447 | 133.110 | 135.774 | 138.441 | 141.110 | 143.781 | 146.454 | 149.130 | 151.807 | 154.487 |
| 160 | 157.169 | 159.854 | 162.541 | 165.229 | 167.921 | 170.614 | 173.310 | 176.008 | 178.708 | 181.410 |
| 170 | 184.115 | 186.822 | 189.531 | 192.243 | 194.957 | 197.673 | 200.392 | 203.112 | 205.836 | 208.561 |
| 180 | 211.289 | 214.019 | 216.752 | 219.487 | 222.224 | 224.964 | 227.706 | 230.450 | 233.197 | 235.947 |
| 190 | 238.698 | 241.452 | 244.209 | 246.968 | 249.729 | 252.493 | 255.259 | 258.028 | 260.799 | 263.572 |
| 200 | 266.348 | 269.127 | 271.908 | 274.691 | 277.477 | 280.266 | 283.057 | 285.850 | 288.646 | 291.445 |
| 210 | 294.246 | 297.049 | 299.855 | 302.664 | 305.475 | 308.289 | 311.106 | 313.925 | 316.746 | 319.570 |
| 220 | 322.397 | 325.227 | 328.059 | 330.893 | 333.731 | 336.571 | 339.413 | 342.258 | 345.106 | 347.957 |
| 230 | 350.810 | 353.666 | 356.525 | 359.386 | 362.250 | 365.117 | 367.986 | 370.859 | 373.734 | 376.611 |
| 240 | 379.492 | 382.375 | 385.261 | 388.150 | 391.042 | 393.936 | 396.833 | 399.733 | 402.636 | 405.542 |
| 250 | 408.450 | | | | | | | | | |

# S & SE

## 1-1/2" Wide

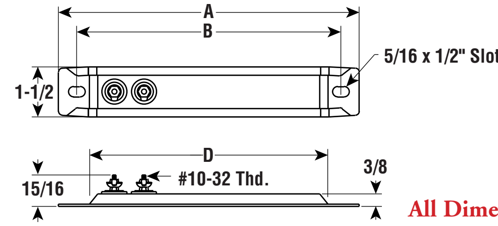
- One Terminal, Each End (type S)
- Two Terminals, One End (type SE)
- 8 - 71-7/8" Lengths
- 150 - 3,000 Watts
- 120 and 240 Volt
- 6 - 21 W/In²

### *Dimensions (type S)*




*All Dimensions in Inches*

### *Dimensions (type SE)*




*All Dimensions in Inches*

### *Applications*

Strip heaters are used for heat transfer by conduction or convection to heat liquids, air, gases and surfaces. See guidelines in the Strip Heater Overview section.

### *Specifications and Ordering Information*

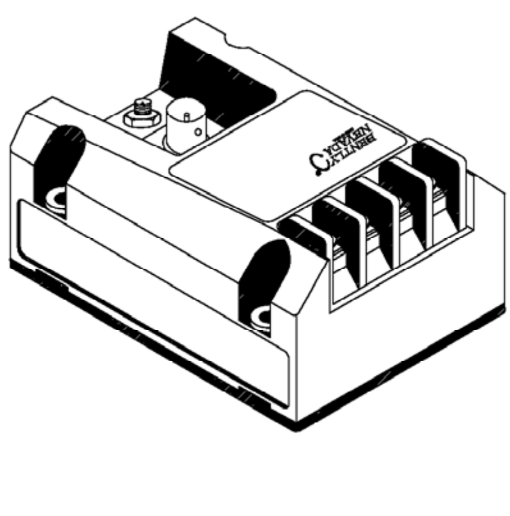
| Dimensions (In.) | | | Rust-Resisting Iron Sheath | | | | | | | Chrome Steel Sheath | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 120V | | 240V | | | | | 120V | | 240V | | Wt. |
| A | B | D | Watts | W/In² | Model | Stock | PCN | Stock | PCN | Watts | W/In² | Model | Stock | PCN | Stock | PCN | (Lbs.) |
| 8 | 7 | 6-1/2 | 150 | 10 | **S-815** | **S** | **131115** | **S** | **131123** | 250 | 17 | **S-802** | **S** | **131473** | **S** | **131481** | 0.7 |
| 9-1/2 | 8-1/2 | 8 | 200 | 10 | **S-920** | **S** | **131131** | **S** | **131140** | 300 | 15 | **S-903** | **S** | **131490** | **S** | **131502** | 0.8 |
| 12 | 11 | 10-1/2 | 250 | 9 | **S-1225** | **S** | **131158** | **S** | **131166** | 250 | 9 | **S-1202** | **S** | **131510** | **S** | **131529** | 0.9 |
| 12 | 11 | 10-1/2 | — | — | — | — | — | — | — | 500 | 17 | **S-1205** | **S** | **131537** | **S** | **131545** | 0.9 |
| 14 | 13 | 12-1/2 | 300 | 8 | **S-1430** | **S** | **131174** | **S** | **131182** | 500 | 14 | **S-1405** | **S** | **131553** | **S** | **131561** | 1.1 |
| 15-1/4 | 14-1/4 | 13-3/4 | 325 | 8 | **S-1532** | **S** | **131190** | **S** | **131203** | 500 | 12 | **S-1505** | **S** | **131570** | **S** | **131588** | 1.2 |
| 17-7/8 | 16-7/8 | 16-3/8 | 375 | 8 | **S-1837** | **S** | **131211** | **S** | **131220** | 500 | 10 | **S-1805** | **S** | **131596** | **S** | **131609** | 1.4 |
| 17-7/8 | 16-7/8 | 16-3/8 | 500 | 10 | **S-1850** | **S** | **131238** | **S** | **131246** | 750 | 15 | **S-1807** | **S** | **131617** | **S** | **131625** | 1.4 |
| 17-7/8 | 16-7/8 | 16-3/8 | — | — | — | — | — | — | — | 1,000 | 20 | **S-1801** | **S** | **131633** | **S** | **131641** | 1.4 |
| 19-1/2 | 18-1/2 | 18 | 500 | 9 | **S-1950** | **S** | **131254** | **S** | **131262** | 500 | 9 | **S-1905** | **S** | **131650** | **S** | **131668** | 1.5 |
| 19-1/2 | 18-1/2 | 18 | — | — | — | — | — | — | — | 750 | 13 | **S-1907** | **S** | **131676** | **S** | **131684** | 1.6 |
| 19-1/2 | 18-1/2 | 18 | — | — | — | — | — | — | — | 1,000 | 18 | **S-1901** | NS | 131692 | **S** | **131705** | 1.6 |
| 21 | 20 | 19-1/2 | 500 | 8 | **S-2050** | **S** | **131270** | **S** | **131289** | 500 | 8 | **S-2005** | NS | 131713 | **S** | **131721** | 1.8 |
| 23-3/4 | 22-3/4 | 22-1/4 | 250 | 4 | **S-2425** | **S** | **131297** | **S** | **131300** | 500 | 7 | **S-2405** | **S** | **131730** | **S** | **131748** | 1.9 |
| 23-3/4 | 22-3/4 | 22-1/4 | 500 | 7 | **S-2450** | **S** | **131318** | **S** | **131326** | 750 | 10 | **S-2407** | **S** | **131756** | **S** | **131764** | 1.9 |
| 23-3/4 | 22-3/4 | 22-1/4 | — | — | — | — | — | — | — | 1,000 | 14 | **S-2401** | **S** | **131772** | **S** | **131780** | 1.9 |
| 23-3/4 | 22-3/4 | 22-1/4 | — | — | — | — | — | — | — | 1,500 | 21 | **S-2415** | **S** | **131799** | **S** | **131801** | 1.9 |
| 25-1/2 | 24-1/2 | 24 | 750 | 10 | **S-2575** | **S** | **131334** | **S** | **131342** | 1,000 | 12 | **S-2501** | NS | 131810 | **S** | **131828** | 2 |
| 26-3/4 | 25-3/4 | 25-1/4 | 700 | 8 | **S-2670** | NS | 131350 | **S** | **131369** | 750 | 9 | **S-2607** | NS | 131836 | **S** | **131844** | 2.1 |
| 30-1/2 | 29-3/8 | 28 | 750 | 8 | **S-3075** | NS | 131377 | **S** | **131385** | 750 | 8 | **S-3007** | **S** | **131852** | **S** | **131860** | 2.1 |
| 33-1/2 | 32-3/8 | 31 | 750 | 7 | **S-3375** | NS | 131393 | **S** | **131406** | 1,000 | 10 | **S-3301** | NS | 131879 | **S** | **131887** | 2.6 |
| 35-7/8 | 34-3/4 | 33-3/8 | 1,000 | 7 | **S-3610** | **S** | **131414** | **S** | **131422** | 1,000 | 9 | **S-3601** | **S** | **131895** | **S** | **131908** | 2.8 |
| 38-1/2 | 37-3/8 | 36 | 1,000 | 8 | **S-3810** | **S** | **131430** | **S** | **131449** | 1,000 | 8 | **S-3801** | NS | 131916 | **S** | **131924** | 3 |
| 42-1/2 | 41-3/8 | 40 | 1,250 | 9 | **S-4312** | **S** | **131457** | **S** | **131465** | 1,500 | 11 | **S-4301** | NS | 131932 | **S** | **131940** | 3.4 |
| 25-1/2 | 24-1/2 | 24 | 500 | 6 | **SE-2550** | — | — | NS | 130260 | — | — | — | — | — | — | — | 2.06 |
| 33-1/2 | 32-3/8 | 31 | 750 | 7 | **SE-3375** | **S** | **130331** | — | — | — | — | — | — | — | — | — | 2.69 |
| 38-1/2 | 37-3/8 | 36 | 800 | 7 | **SE-3880** | **S** | **130374** | — | — | — | — | — | — | — | — | — | 3.19 |
| 53-7/8 | 52-3/4 | 51-3/8 | — | — | — | — | — | — | — | 1,500 | 9 | **SE-54** | — | — | **S** | **130964** | 4.5 |
| 53-7/8 | 52-3/4 | 51-3/8 | — | — | — | — | — | — | — | 2,500 | 14 | **SE-54** | — | — | **S** | **130980** | 4.5 |
| 63-7/8 | 62-3/4 | 61-3/8 | — | — | — | — | — | — | — | 1,800 | 9 | **SE-64** | — | — | **S** | **131000** | 5.88 |
| 63-7/8 | 62-3/4 | 61-3/8 | — | — | — | — | — | — | — | 3,000 | 14 | **SE-64** | — | — | **S** | **131027** | 5.88 |
| 71-7/8 | 70-3/4 | 69-3/8 | — | — | — | — | — | — | — | 2,000 | 8 | **SE-72** | — | — | **S** | **131035** | 6 |
| 71-7/8 | 70-3/4 | 69-3/8 | — | — | — | — | — | — | — | 3,300 | 12 | **SE-72** | — | — | **S** | **131043** | 6 |
| **MONEL® Sheath** | | | | | | | | | | | | | | | | | |
| 8 | 7 | 6-1/2 | 150 | 10 | **SE-815M** | **S** | **259995** | — | — | — | — | — | — | — | — | — | — |

**Stock Status:** **S** = stock AS = assembly stock NS = non-stock **To Order—**Specify model, PCN, watts, volts and quantity.

Part Number 123655-01
Revision E, November 2003

# 990 Transmitter System

## Manual



BENTLY
Nevada

The following ways of contacting Bently Nevada are provided for those times when you cannot contact your local Bently Nevada representative:

| | |
|---|---|
| Mailing Address | 1631 Bently Parkway South<br>Minden, NV  89423<br>USA |
| Telephone | 1 775 782 3611<br>1 800 227 5514 |
| Fax | 1 775 215 2876 |
| Internet | www.bently.com |

# Related Documents

The following documents contain additional information about the transmitter system that you may find helpful when you install the transducer. This manual refers to these documents by number.

**Installing the Transducer**

AN013 Guidelines for Grounding Bently Rotating

**Machinery Information Systems**

AN015 Installation of electrical equipment in hazardous areas

**Transducer Installation Accessories**

31000/32000 Proximity Probe Housing Manual

**Electrical and Mechanical Runout**

AN002 "Glitch": Definition of and Methods for Correction, including Shaft Burnishing to Remove Electrical Runout.

**Reference**

157771 Performance Specifications for the 990

133055-01 Bently Nevada Glossary

**Customer Service**

Bently Nevada provides product service throughout the world. If you cannot contact your local product service representative, call the Bently Nevada corporate headquarters:

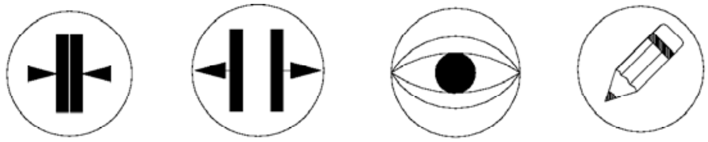
From within the USA:800-227-5514 Monday through Friday, 8:00 a.m. to 5:00 p.m. Pacific time.

International telephone: 775-782-3611 Anytime.

775-782-9253 FAX

**Symbols**

This manual uses the following symbols:



Connect    Disconnect    Observe    Record Value

# Contents

# Section 1 — System Description

## The System

The 990 series of transmitters consists of two systems, the 990 Vibration Transmitter System and the 991 Thrust Transmitter System. Both systems contain three parts - a 3300 NSv™ or 3300 RAM proximity probe and extension cable (If probe is 5 or 7 metres, no extension cable is required), and a transmitter. Both systems provide two types of output signals - a 4 to 20 mA current loop and a voltage signal.

**Note:** The 3300 NSv™ Probe and extension cable replaced and assumed the part numbers of the 3300 RAM Probe and extension cable. The 3300 NSv™ Probe and extension cable have blue coaxial cable with gray shrink at the connectors and the 3300 RAM Probe and extension cable have gray coaxial cable with no shrink at the connectors. These products are identical in form, fit, and function.

The 990 Vibration Transmitter System measures the radial vibration of a shaft or other part of a machine in relation to the location of the probe tip. The following equation represents the relationship between the vibration and the loop current.

$$Vibration = \frac{Current\ (mA - 4\ mA)}{16\ mA}\ x\ Full\ \ Scale\ Mils\ (or\ mm)\ pp$$

The 991 Thrust Transmitter System measures the distance between the target and a reference (zero) point. The following equation represents the relationship between the thrust position and the loop current.

$$Thrust\ \ Postion = \frac{Current\ (mA + 12\ mA)}{8\ mA}\ x\ Full\ \ Scale$$

Where Full Scale is 25 mils for the 25 - 0 - 25 mils thrust range or 0.6 mm for the 0.6 - 0 - 0.6 mm thrust range.

Both transmitters provide a voltage proportional to the distance between the target and the probe tip. This voltage is available at the terminal strip and on the BNC connector for use when gapping the probe and for diagnostic purposes. You may apply this voltage to any battery powered instrumentation with a 1 MΩ or larger input impedance or AC powered equipment when using test adapter part number 122115-01. The phase of the Prox Out signal is inverted from the Bently Nevada standard of a signal going positive when there is motion toward the probe. The Prox Out signal is not isolated and a false alarm may result from connecting it directly to grounded AC powered equipment. The test adapter provides isolation to avoid grounding problems, changes the gap voltage to a negative voltage, and corrects the phase of the signal.

## Receiving, Inspecting, and Handling the System

The probe, extension cable, and transmitter are shipped as separate units and must be interconnected at the installation site by the user. Carefully remove all equipment from the shipping containers and inspect the equipment for shipping damage. If shipping damage is apparent, file a claim with the carrier and submit a copy to Bently Nevada, LLC. Include part numbers and serial numbers on all correspondence. If no damage is apparent and the equipment is not going to be used immediately, return the equipment to the shipping containers and reseal until ready for use.

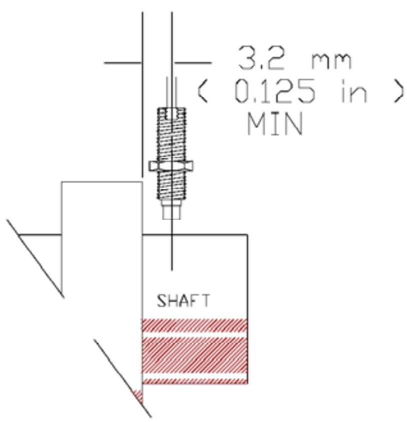
Store the equipment in an environment free from potentially damaging conditions such as high temperature, excessive humidity, or a corrosive atmosphere. See pages 27, 30, and 31 for environmental specifications.

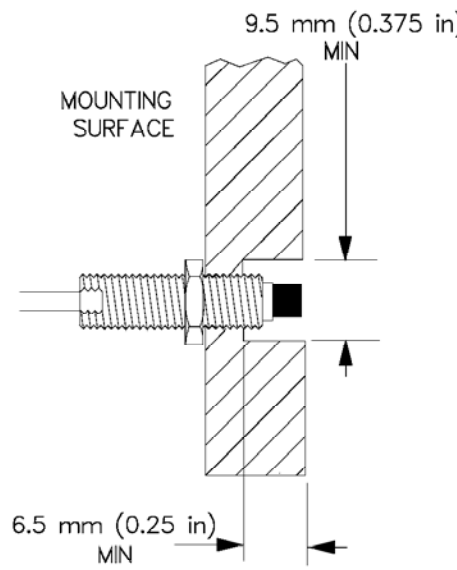
# Section 2 — Installation

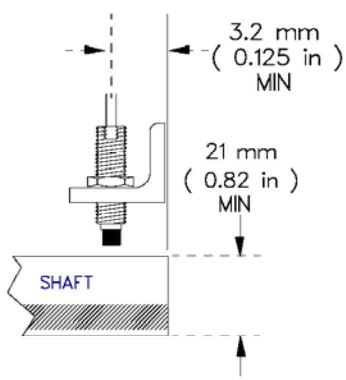
This section contains a checklist of items that you must consider when you install the 990 transmitter system. For detailed information about designing installations for specific applications, refer to document AN013. For more information about the specifications for this transducer, refer to page 27 of this manual or to document 157771.

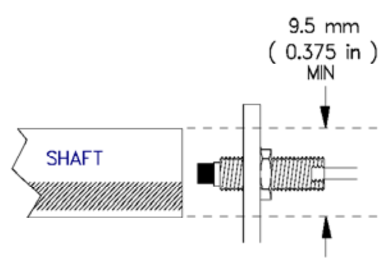
## Installing the Probe

The following figures show the minimum values for side clearance and target size. Refer to Specifications, page 29, for proper torque and the dimensions of the thread.

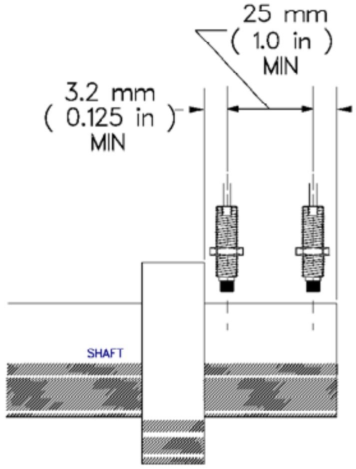


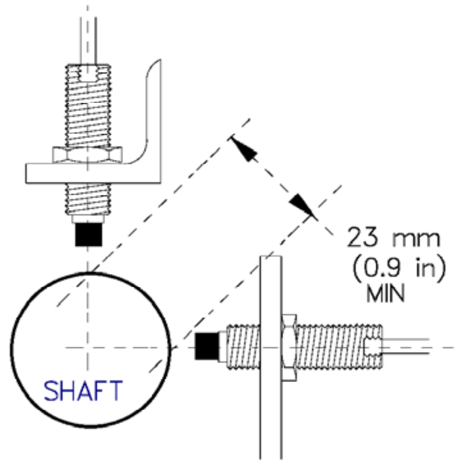



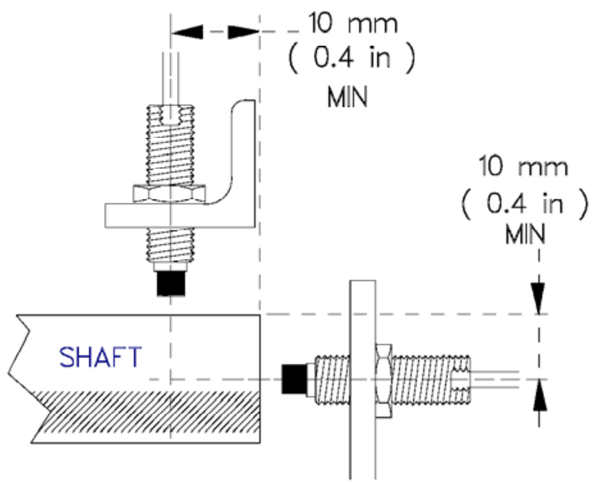



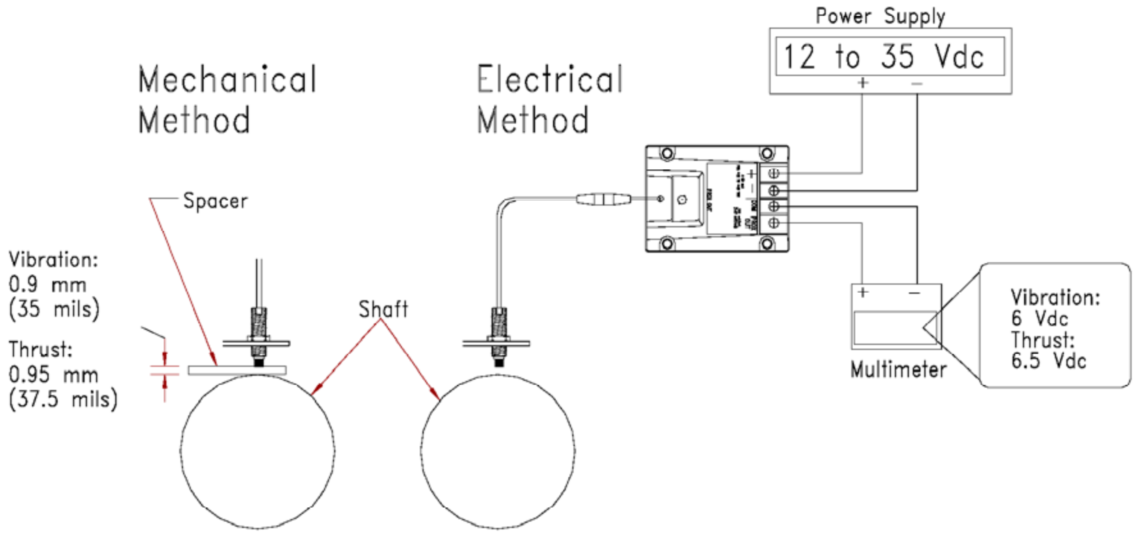
The following figures show the minimum values for probe separation due to crosstalk:



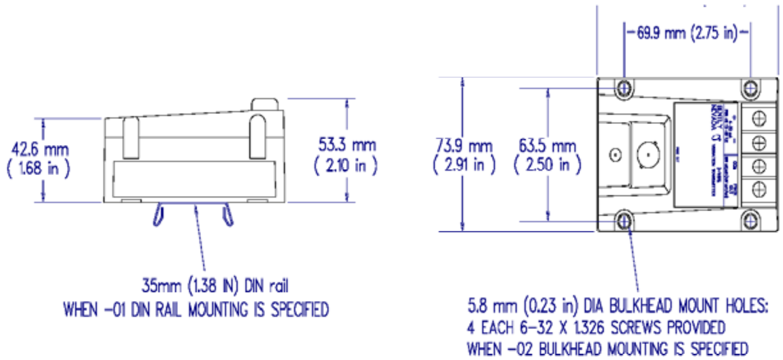



Adjust the distance between the probe tip and the shaft using one of the methods shown in the following figure.



# Mounting the transmitter

Mount the transmitter in a location that is compatible with its environmental specifications. Refer to page 27 for the environmental specifications for the transmitter. The following figure shows the dimensions of the transmitter.




# Routing the Extension Cable and Field Wiring

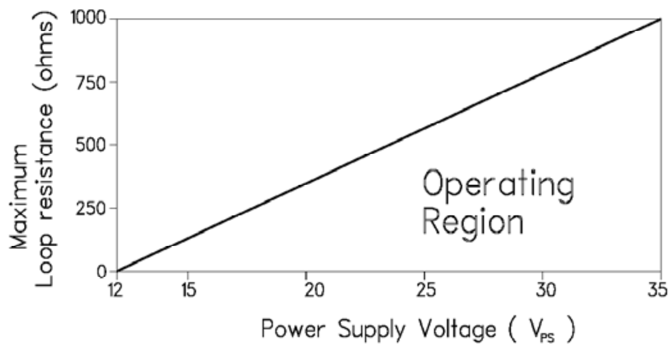
Route the extension cable using the following guidelines.

Check that the Transmitter, extension cable, and probe belong to the same system. The allowable systems are:

| Transmitter | Probe Length | Cable Length |
|---|---|---|
| 5 metre | 5 metre | None |
| 5 metre | 1.0 metre | 4.0 metre |
| 5 metre | 0.5 metre | 4.5 metre |
| 7 metre | 7 metre | None |
| 7 metre | 1.0 metre | 6.0 |
| 7 metre | 0.5 metre | 6.5 |

- Secure the extension cable to supporting surfaces by using mounting clips or similar devices.
- Identify both ends of the extension cable by inserting labels under the clear Teflon sleeves and applying heat to shrink the tubing.
- Secure coaxial connectors between the extension cable and the proximity probe (Refer to Connector-to-Connector Torque Requirements on Page 31).
- Insulate the connection between the probe lead and the extension cable by wrapping the connector with Teflon tape.

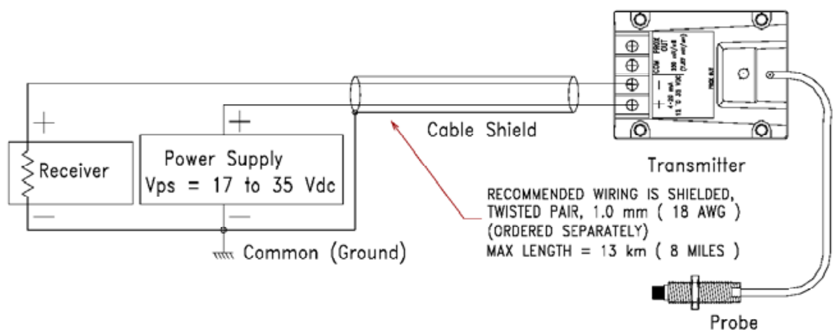
The loop resistance is the total resistance of the power supply output, the receiver, field wiring, and any other devices placed in the loop. Use the following table and equation to determine the maximum loop resistance:

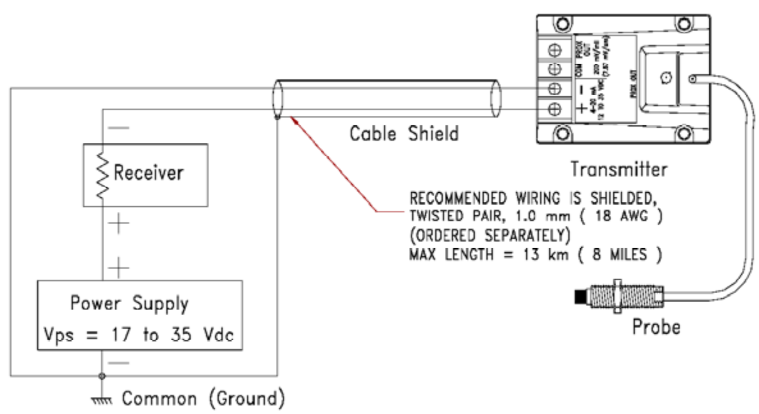


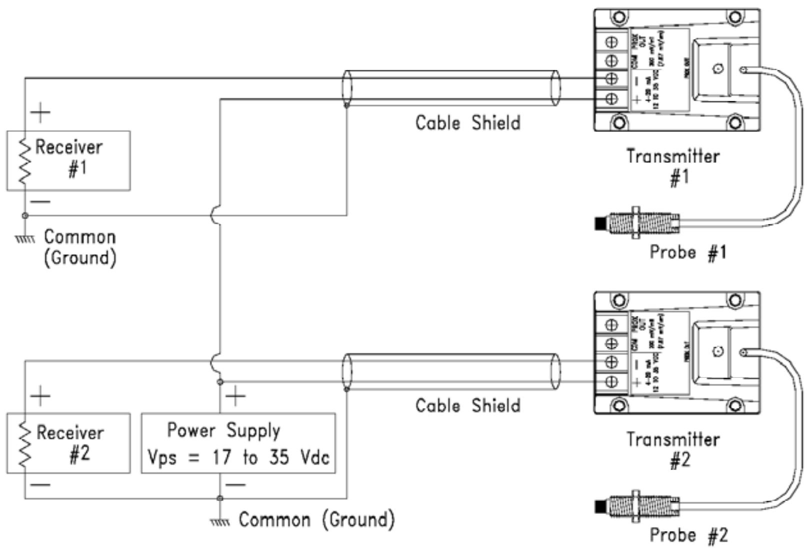

$R_{LOOP} = 43.5 \times ( V_{PS} - 12 )\ \Omega$ maximum

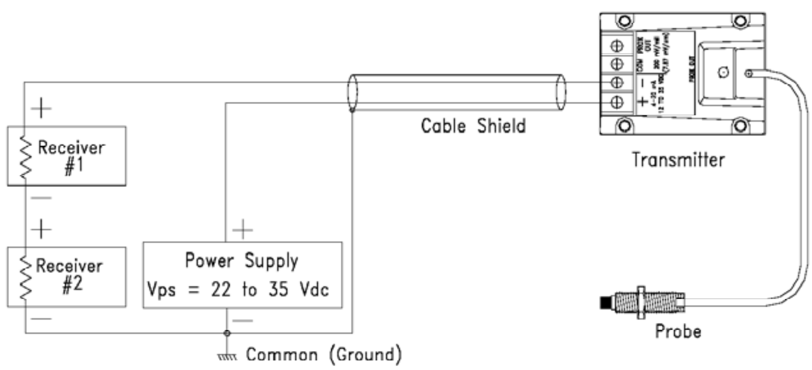
Operation outside of the operating region shown above may result in erratic system behavior.

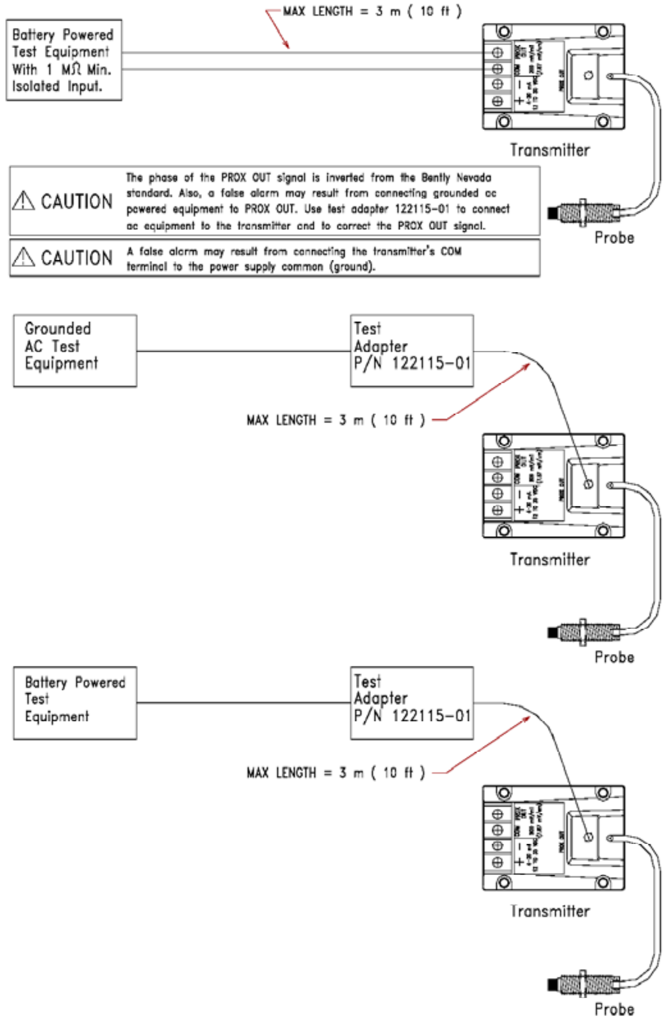
Use the following wiring diagrams to connect the field wiring between the transmitter and the monitoring instruments. Connect the transmitter to an approved source (approved to IEC 1010.1 for example.)




Cable Shield
Receiver #1
Common (Ground)
Transmitter #1
Probe #1
Cable Shield
Receiver #2
Power Supply Vps = 17 to 35 Vdc
Transmitter #2
Common (Ground)
Probe #2


Cable Shield
Receiver #1
Transmitter
Receiver #2
Power Supply Vps = 22 to 35 Vdc
Probe
Common (Ground)


MAX LENGTH = 3 m ( 10 ft )
Battery Powered Test Equipment With 1 MΩ Min. Isolated Input.
Transmitter
Probe
CAUTION
The phase of the PROX OUT signal is inverted from the Bently Nevada standard. Also, a false alarm may result from connecting grounded ac powered equipment to PROX OUT. Use test adapter 122115-01 to connect ac equipment to the transmitter and to correct the PROX OUT signal.
CAUTION
A false alarm may result from connecting the transmitter's COM terminal to the power supply common (ground).
Grounded AC Test Equipment
Test Adapter P/N 122115-01
MAX LENGTH = 3 m ( 10 ft )
Transmitter
Probe
Battery Powered Test Equipment
Test Adapter P/N 122115-01
MAX LENGTH = 3 m ( 10 ft )
Transmitter
Probe

# Section 3 — Maintenance and Troubleshooting

## Maintenance

This section shows how to verify that the system is operating properly, adjust the system, and identify parts of the system that are not working properly.

The transmitter system does not require verification at regular intervals. You should, however, verify operation by using the scale factor verification on page 12 if any of the following conditions occur:

- components of the system are replaced or disturbed
- the performance of the system changes or becomes erratic
- you suspect that the transmitter is not calibrated correctly.

The adjustment procedures on pages 14 thru 17 are included for your information. For target materials other than 4140 steel and for other special applications, contact your local Bently Nevada office.

The scale factor verification procedure, the scale factor adjustment procedure, and the zero/span adjustment procedure require the following instruments:

digital multimeter (2)
spindle micrometer
power supply

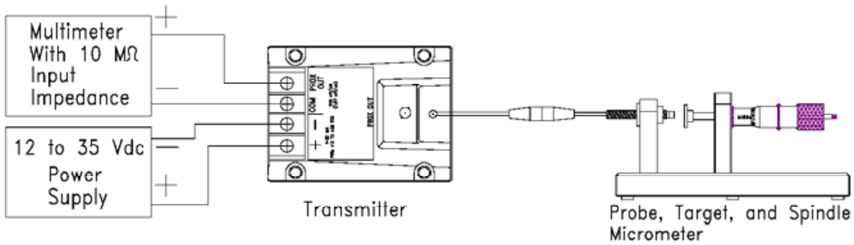
⚠ **CAUTION**

**Electrostatic discharge on the exposed calibration resistor terminals can cause the accuracy of the system to go out of specification, or cause the system to fail. Use appropriate precautions for handling static sensitive devices.**

The adjustment procedure also requires the following items:

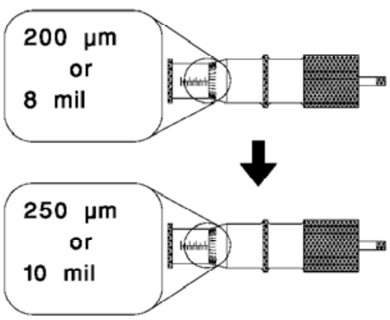
variable resistor, 0 to 100 kΩ
vulcanizing compound (for example, Dow 3110 RTV)
soldering iron (with grounded tip) and soldering supplies

The scale factor verification and the scale factor adjustment procedure both use the test setup as shown in the following figure:



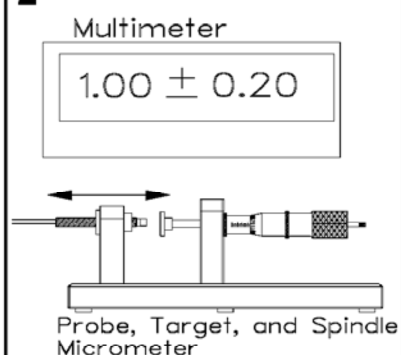

# Scale Factor Verification

**1**



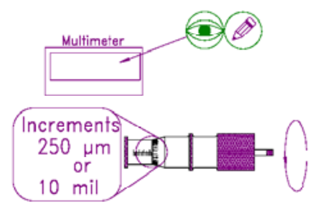

Compensate for mechanical backlash, then adjust the micrometer to the initial gap setting.

**2**




With the micrometer at the initial gap, adjust the probe position so that the voltage is 1.00 Vdc (Electrical Zero).

**3**




Record voltages at each gap increment, and calculate scale factors.

**4**

| n | Adjust Micrometer to… | | Record Voltages | Calculate Scale Factor | |
|---|---|---|---|---|---|
| | mm | Mil | $Vdc_n$ | $ISF_n$ (Incremental Scale Factor) | ASF (Average Scale Factor) |
| 1 | 0.250 | 10 | ________ | | |
| 2 | 0.500 | 20 | ________ | ________ | |
| 3 | 0.750 | 30 | ________ | ________ | |
| 4 | 1.000 | 40 | ________ | ________ | |
| 5 | 1.250 | 50 | ________ | ________ | |
| 6 | 1.500 | 60 | ________ | ________ | |
| 7 | 1.625 | 65 | ________ | ________* | ________ |

* Calculate ISF for the increment between 1.500 and 1.625 mm (60 - 65 mil) ISF by dividing by 0.125 mm (5 mils).

$$ISF_n = \frac{Vdc_{n} - Vdc_{n-1}}{10\ mil\ *} \qquad ASF = \frac{Vdc_{65\,mil} - Vdc_{10\,mil}}{55\ mil}$$

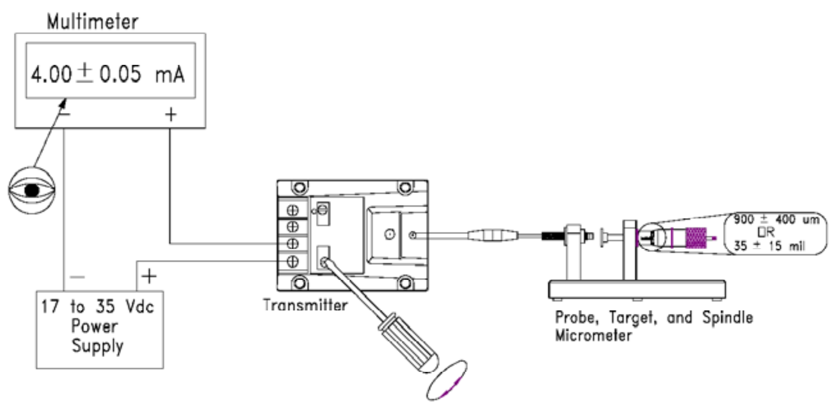
$$ISF_n = \frac{Vdc_{n} - Vdc_{n-1}}{250\ mm\ *} \qquad ASF = \frac{Vdc_{1.625mm} - Vdc_{0.250mm}}{1.375mm}$$

If the incremental scale factor (ISF) or the average scale factor (ASF) of the system is out of tolerance (refer to page 27), contact Bently Nevada, LLC for further information on possible calibration problems or perform the following adjustment.

# Zero/Span Adjustment Procedure - Vibration

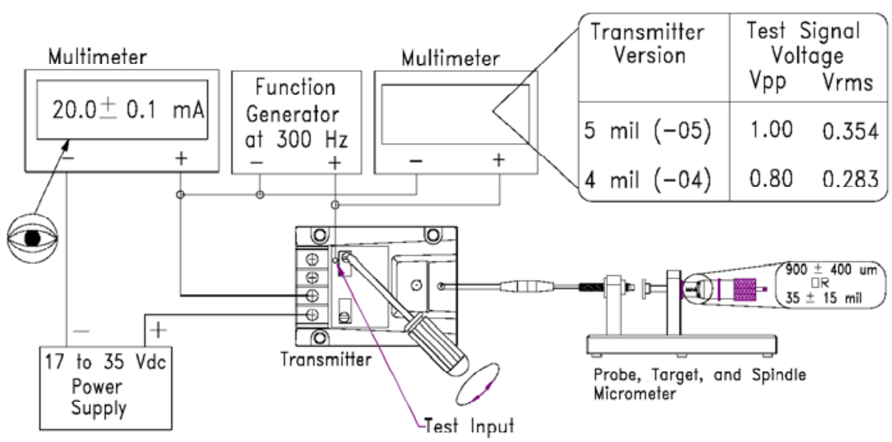
Follow these steps to adjust the zero and span for the 990 vibration transmitter.

**1**




Adjust zero potentiometer with no input signal.

**2**



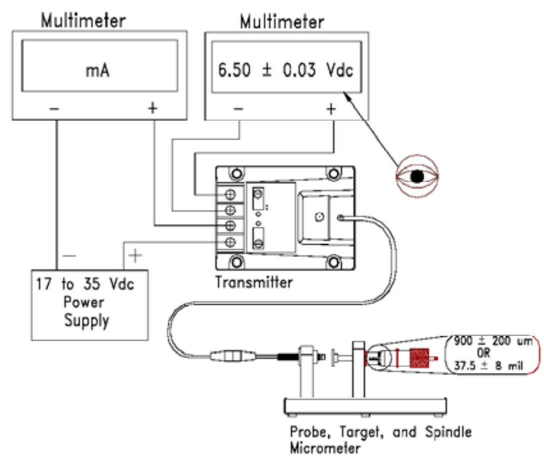

Adjust span potentiometer with full scale input signal.

# Zero/Span Adjustment Procedure - Thrust

You may adjust the 991 thrust transmitter zero and span by using either the probe input (Mechanical method) or an external test signal (Test input method). After you install the system at the machine, you may need to readjust the zero.

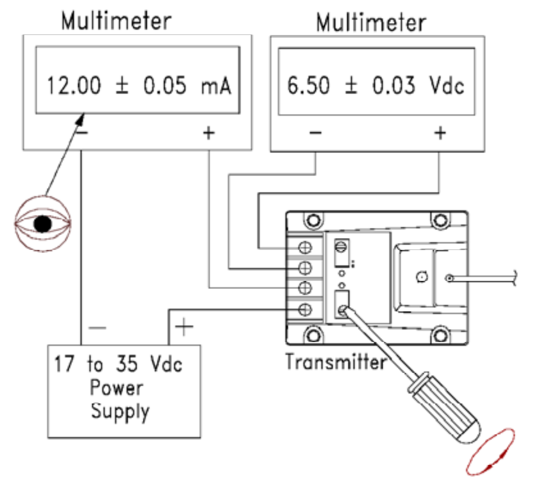
**991 Mechanical Method**

**1**



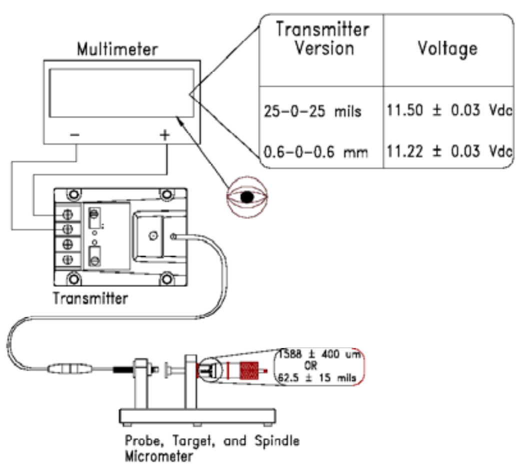

Set probe gap for a 6.5 Vdc signal measured between Prox Out and COM.

**2**



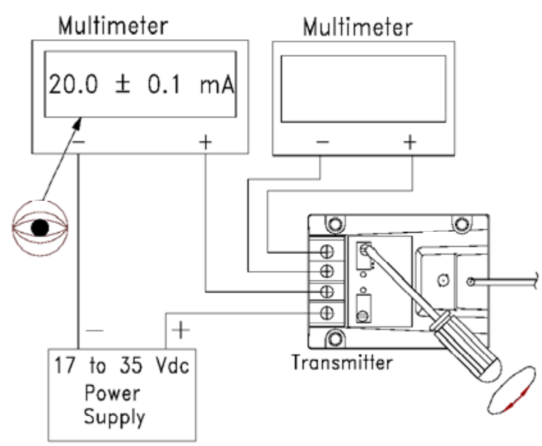

Adjust the zero potentiometer to set the loop current to 12 mA.

**3**




Set the probe gap for a full scale signal measured between Prox Out and COM.

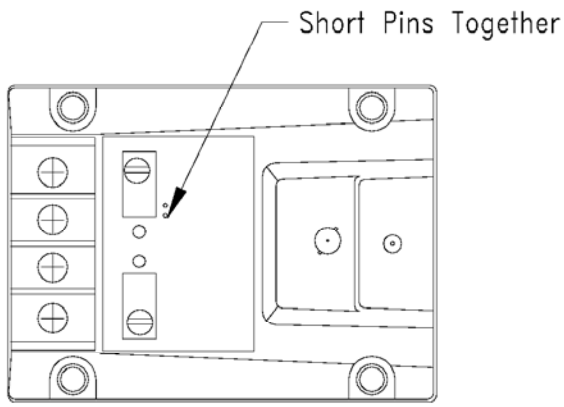
**4**




Adjust the span potentiometer to set the full scale loop current.

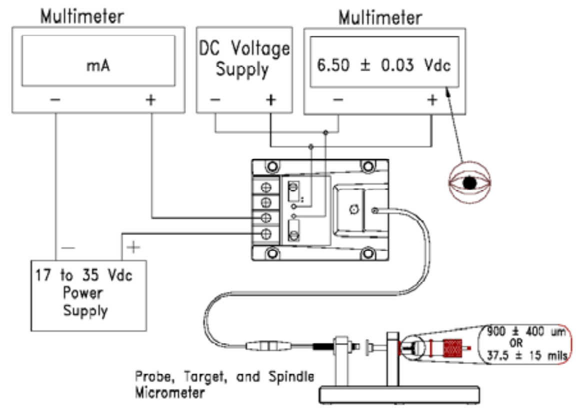
### 991 Test Input Method

**1**



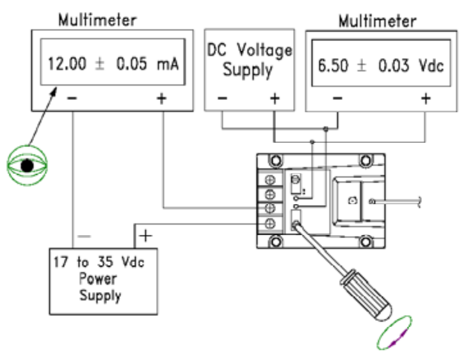

Short the test jumper pins together to enable the test inputs.

**2**



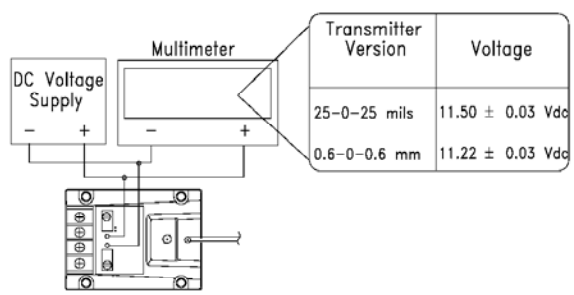

Set the DC test input voltage to 6.5 Vdc.

**3**



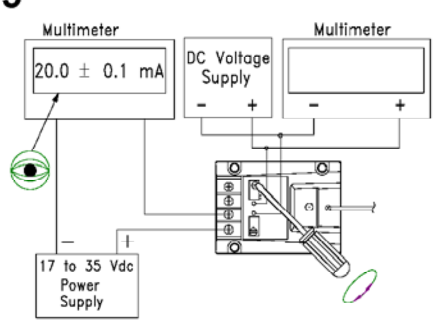

Adjust the zero potentiometer to set the loop current to 12 mA.

**4**



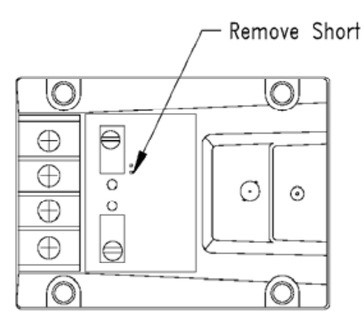

Set the DC test input voltage to the full scale voltage shown.

**5**




Adjust the span potentiometer to set the full scale loop current.

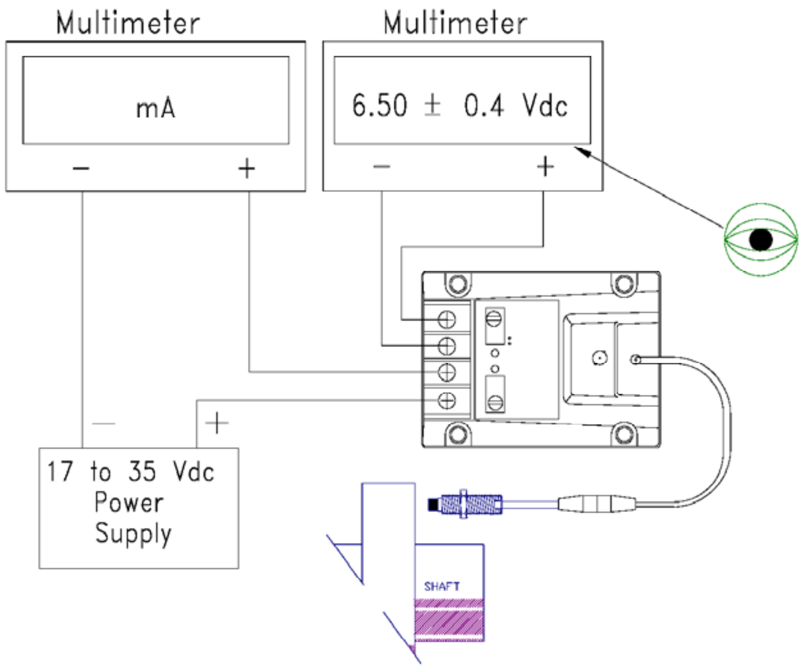
**6**




Remove the short across the test jumper pins.

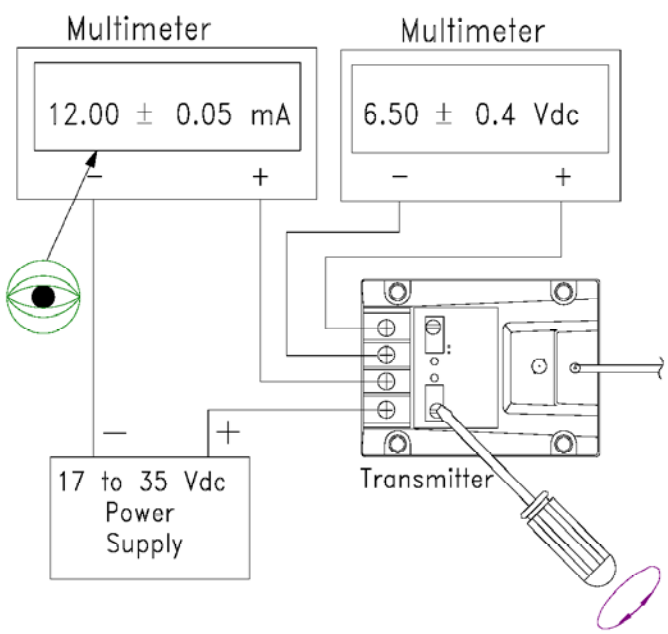
**Adjusting the 991 Zero Potentiometer at the Machine.**

**1**




With the rotor set against the active thrust shoe or in the center of the float (depending on your procedure), gap the probe so that the voltage between Prox Out and COM is 6.5 ± 0.4 Vdc.

**2**



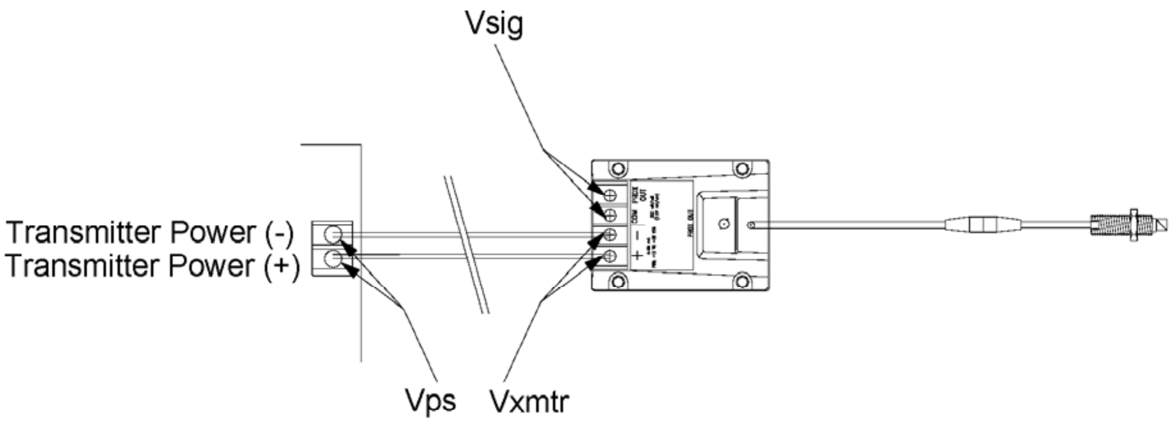

If necessary, adjust the zero potentiometer until the loop current is 12 mA. Do not adjust the span potentiometer.

You may need to readjust the zero after you start the machine.

# Troubleshooting

This section shows how to interpret a fault indication and isolate faults in an installed transducer system. Before beginning this procedure, be sure the system has been installed correctly and all connectors have been secured properly in the correct locations.

When a malfunction occurs, locate the appropriate fault, check the probable causes for the fault indication, and follow the procedure to isolate and correct the fault. Use a digital multimeter to measure voltage and resistance. If you find faulty transducers, please return them to the Product Repair Manager at Bently Nevada, LLC for failure analysis.




The troubleshooting procedures use measured voltages as shown in the following figure and table:

**Symbols for Measured Voltages**

| Symbol | Meaning | Voltage measured between... |
|---|---|---|
| $V_{SIG}$ | Signal voltage from the transducer | Prox OUT and COM |
| $V_{PS}$ | Power supply voltage | Power Source (+) and Power Supply (-) |
| $V_{xmtr}$ | Transmitter supply voltage | Transmitter Power (+) and Transmitter Power (-) |

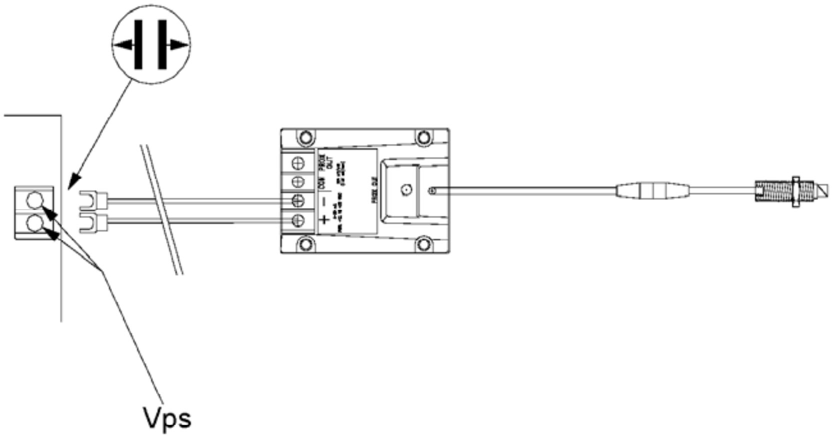
**Definitions**

| Symbol | Definition |
|---|---|
| A > B | "A" value is more positive than "B" |
| A < B | "A" value is more negative than "B" |
| A = B | "A" same value (or very close) to "B" |

# Fault Type 1: Vxmtr < 12 Vdc or Vxmtr > 35 Vdc

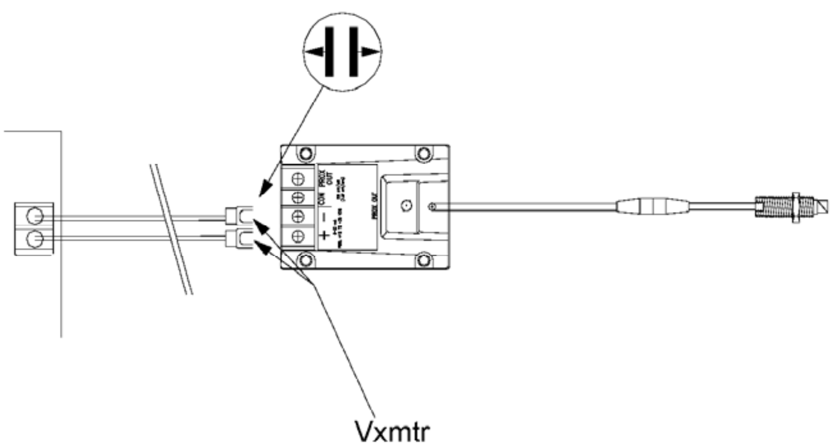
Possible causes:

- Faulty power source
- Faulty field wiring
- Faulty Transmitter




**Measure $V_{PS}$: Is $V_{PS}$ < 12 Vdc or $V_{PS}$ > 35 Vdc?**

**Yes:** Faulty power supply.
**No:** Go to next step.




**Measure Vxmtr: Is Vxmtr < 12 Vdc or Vxmtr > 35 Vdc?**

**Yes:** Faulty Field wiring.
**No:** Faulty Transmitter.

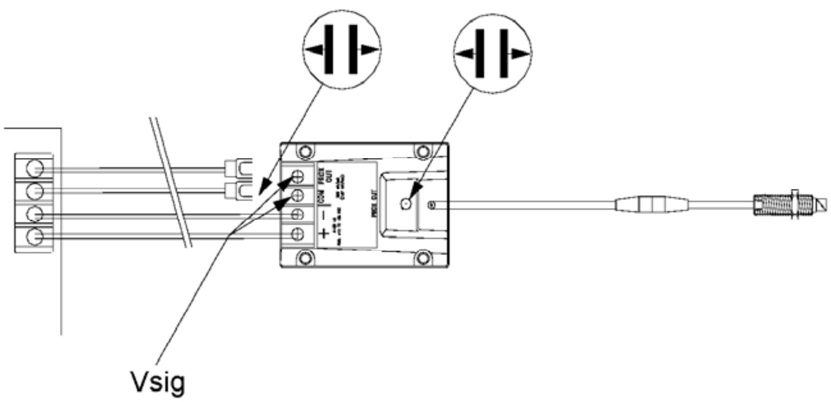
# Fault Type 2: $V_{SIG}$ = 0 Vdc

Possible causes:

- Incorrect power source voltage
- Short circuit in field wiring
- Short circuit at Transmitter terminal connection
- Faulty Transmitter

**Does fault condition type 1 exist?**

**Yes:** Use the procedure for fault type 1
**No:** Go to the next step




**Measure $V_{SIG}$: Is $V_{SIG}$ = 0 Vdc?**

**No:** Short in field wiring.
**Yes:** Test as Fault Type 3.

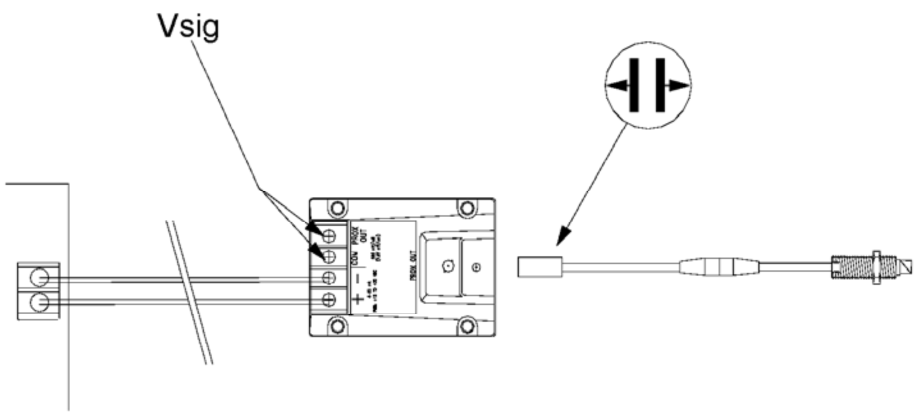
# Fault Type 3: 0 Vdc < $V_{SIG}$ < 1 Vdc

Possible causes:

- Incorrect power source voltage
- Faulty Transmitter
- Short circuit in the probe
- Short circuit in the extension cable
- Short circuit in the connector
- Probe is incorrectly gapped (too close to target).
- Probe is detecting other material than target (counterbore or part of machine case)

**Does fault condition type 1 exist?**

**Yes:** Use the procedure for fault type 1
**No:** Go to the next step




**Measure Vsig: Is 0 Vdc < Vsig < 1 Vdc**

**Yes:** Faulty Transmitter.
**No:** Faulty Probe, cable, or connector
See Fault Type 6.

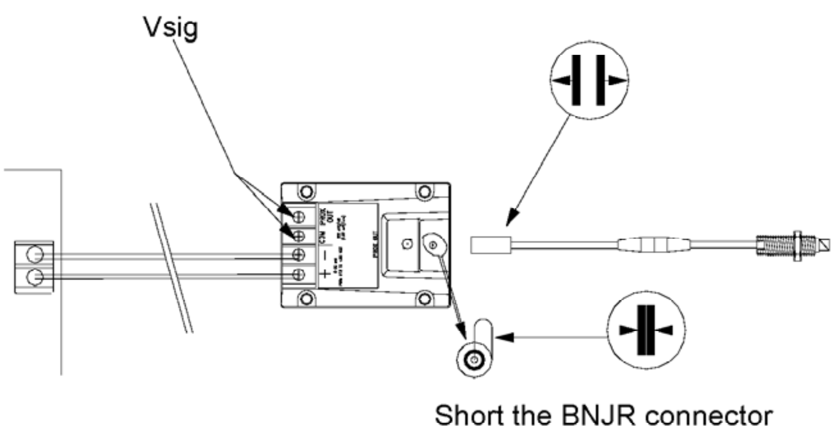
# Fault Type 4: 13 Vdc < Vsig

Possible causes:

- Probe is incorrectly gapped (too far from target)
- Open circuit in the probe.
- Open circuit in the extension cable.
- Open circuit in a connector.
- Faulty Transmitter

**Does fault condition type 1 exist?**

**Yes:** Use the procedure for fault type 1
**No:** Go to the next step




**Measure Vsig: Is 0 Vdc < Vsig < 1 Vdc?**

**No:** Faulty Transmitter
**Yes:** Faulty Probe, cable, or connector
See Fault Type 6.

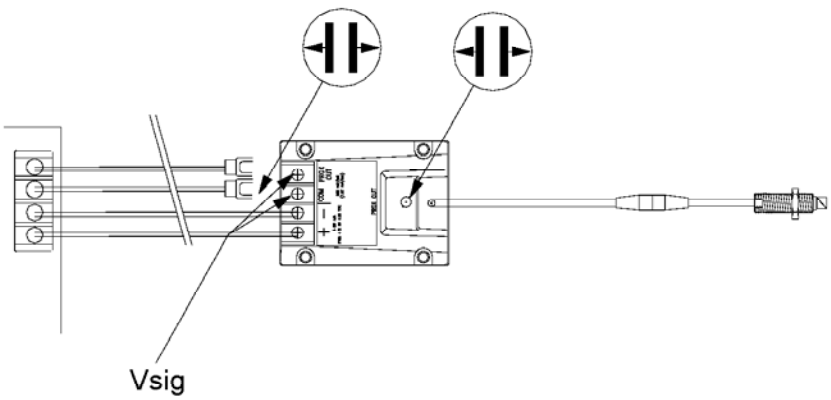
# Fault Type 5: $V_{SIG}$ = Vxmtr

Possible causes:

- Incorrect power source voltage
- Faulty field wiring
- Faulty Transmitter

**Does fault condition type 1 exist?**

**Yes:** Use the procedure for fault type 1
**No:** Go to the next step



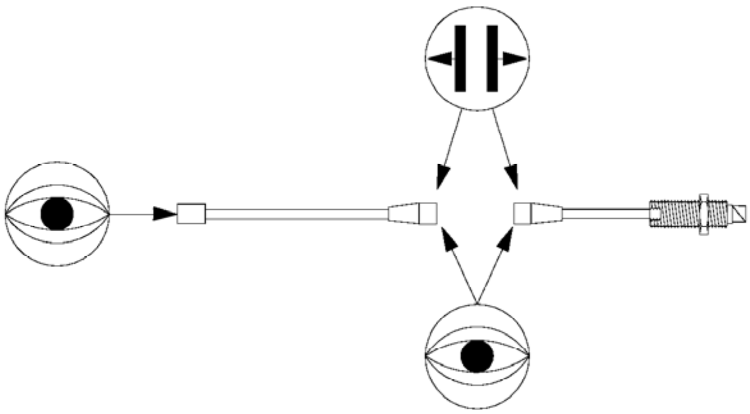

**Measure Vsig: is Vsig = Vxmtr?**

**Yes:** Faulty Transmitter.
**No:** Faulty field wiring.

# Fault Type 6: Faulty probe, cable, or connector

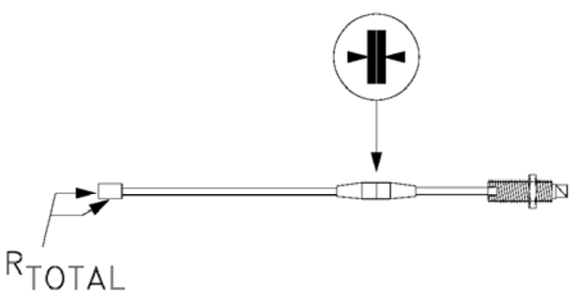
Possible causes:

- Short or open circuit in the probe.
- Short or open circuit in the extension cable
- Short or open circuit in a connector



**Inspect for clean connection: Is the connection dirty, rusty, or a poor connection?**

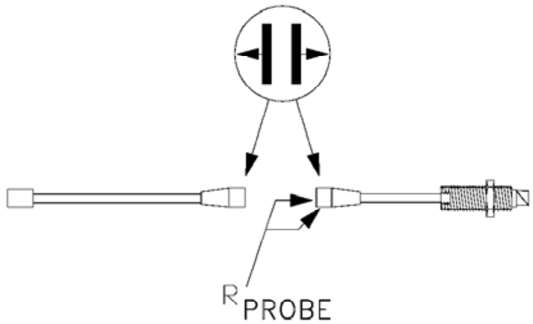
**Yes:** Clean the connector and retest the original system.
**No:** Go to the next step.




**Measure resistance $R_{TOTAL}$: Is $R_{TOTAL}$ within specifications?**

5 m system: 5.3 ± 0.7 Ω
7 m System: 6.5 ± 0.9 Ω

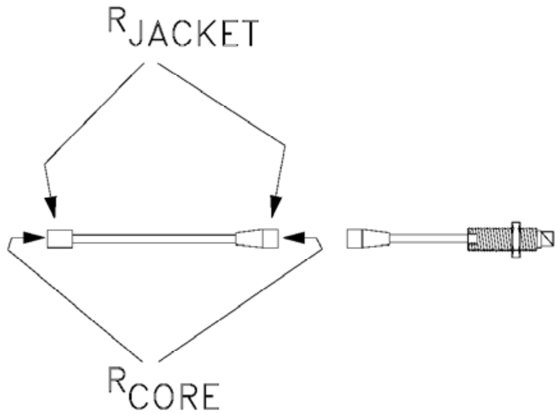
**Yes:** Retest original system
**No:** Go to the next step




**Measure resistance, $R_{PROBE}$: Is $R_{PROBE}$ within specifications?**

0.5 m Probe: 4.0 ± 0.5 Ω
1.0 m Probe: 4.2 ± 0.5 Ω

**No:** Faulty probe.
**Yes:** Go to next step.




**Measure the resistance, $R_{JACKET}$ and $R_{CORE}$: Is the resistance within specifications (see** DC resistance, nominal**, page 30)?**

**No:** Faulty extension cable
**Yes:** Retest the original system

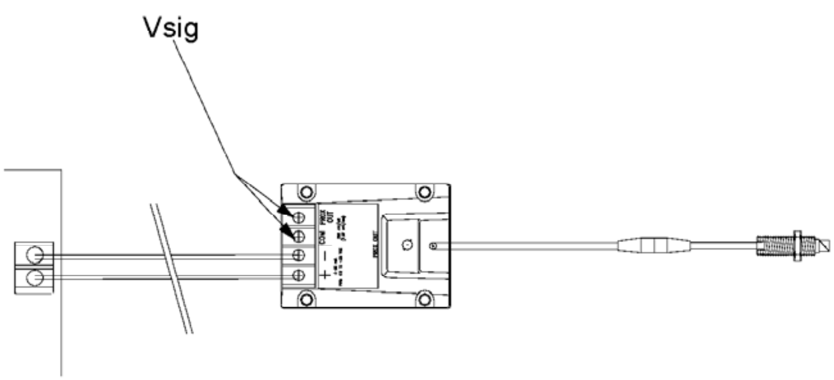
# Fault Type 7: Supply Current < 3.6 mA

Possible causes:

- Incorrect power source voltage
- Faulty transmitter
- Short or open circuit in the probe
- Short or open circuit in the extension cable
- Short or open circuit in a connector
- Probe is incorrectly gapped (too close to target)
- Probe is detecting other material than target such as the couterbore or part of the machine case
- Thrust position is over range in the direction toward the probe (991 thrust transitter only)

**Does fault condition type 1 exist?**

**Yes:** Use the procedure for fault type 1
**No:** Go to the next step




**Measure $V_{SIG}$: Is $V_{SIG}$ < 1 Vdc?**

**Yes:** See Fault Type 3
**No:** Go to next step

**Measure $V_{SIG}$: Is $V_{SIG}$ > 13Vdc?**

**Yes:** See Fault Type 4
**No:** Faulty Transmitter.

# Section 4 — Specifications

Unless otherwise noted, the following specifications are for a 990 and 991 transmitter, extension cable and probe between 18 °C and 27 °C (64 °F and 80 °F) with a -24 Vdc power supply, a 10 kΩ load, a Bently Nevada supplied AISI 4140 steel target that is 31 mm (1.2 in) diameter or larger, and a probe gap of 1.0 mm (40 mils). The system accuracy and interchangeability specifications do not apply when using a transducer system calibrated to any target other than a Bently Nevada AISI 4140 steel target. Typical is defined as 90% of the devices built meeting the specification, and worst case is defined as 99.7% of the devices built meeting the specification. The calibration range is defined as the 1.4 mm (55 mil) range from 1.0 Vdc to 1.4 mm (55 mils) above 1.0 Vdc. This range is approximately equivalent to a calibration range of .25 mm to 1.65 mm (10 to 65 mils).

**Note:** Operation outside the specified limits will result in false readings and/or loss of machine monitoring.

## System

Transducer System specifications refer to the expected performance seen by connecting any cable to any probe and any transmitter unit. The tolerances listed below include interchangeability variations (specified on the following pages).

**Average Scale Factor**

| | |
|---|---|
| Typical | 7.87 ± 0.2 V/mm (200 ± 5.4 mV/mil) |
| Worst Case | 7.87 ± 0.4 V/mm (200 ± 10 mV/mil) |

**Incremental scale factor (ISF)**

7.87 V/mm (200 mV/mil) ±9.5% including interchangeability error when measured in increments of 0.25 mm (10 mils) over the 55 mil linear range

**Deviation from best fit Straight Line (DSL)**
Less than ±0.06 mm (±2.3 mils).

## Transmitter -- General

| | |
|---|---|
| **Weight** | Approximately 0.514 kg (1.1 pounds) |

**Temperature**

| | |
|---|---|
| Storage | -51 °C to +100 °C (-60 °F to +212 °F) |
| Operating | 0 °C to +70 °C (+32 °F to +158 °F) |

The ISF will remain within ±10% of 7.87 V/mm (200 mV/mil) over the calibration range from 0 °C to +70 °C (+32 °F to +158 °F).

| | |
|---|---|
| Relative Humidity | 100% condensing, non-submersible when connector is protected. Tested to IEC 68-2-3 damp heat. |

# Transmitter -- Proximity Signal Output

**Interchangeability Error**

Average scale factor (ASF) change

| | |
|---|---|
| Typical: | Less than 0.09 V/mm (2.3 mV/mil) |
| Worst Case: | Less than 0.33 V/mm (8.4 mV/mil) |

**Apparent Gap Change (maximum)**

| | |
|---|---|
| At 0.90 mm (35 mils) gap: | 0.18 mm (7 mils) |
| At 0.25 mm (10 mils) gap: | 0.13 mm (5 mils) |

| | |
|---|---|
| **Supply Sensitivity** | Less than 2 mV change in output voltage per volt change in input voltage. |
| **Cable Length** | 3 m (10 ft) maximum between transmitter and either test adapter or test equipment. |
| **Output Resistance** | 10 kΩ |
| **Output Load** | Calibrated into a 10 MΩ load (1% error with a 1.0 MΩ load.) |
| **Output Noise** | Less than 50 mV pp. |

# Transmitter -- Current Loop Output

**4-20 mA Loop Accuracy**
Within ±1.5% over specified full scale range (typical).

**Supply Voltage Range**
+17 Vdc to +35 Vdc (The voltage drop across the load resistor will be between 0 and 5 V, so the input voltage at the transmitter is +12 Vdc to +35 Vdc.)

**Maximum Loop Resistance -- including cable resistance**
43.5 X (Supply Voltage - 12) Ω.

**Full Scale Loop Current**
990 Vibration Transmitter:

| | |
|---|---|
| Zero: | 4.0 mA ± 0.1 mA |
| Full Scale: | 20.0 mA ± 0.2 mA |

991 Thrust Transmitter:

| | |
|---|---|
| Zero: | 12.0 mA ± 0.1 mA |
| Upper Full Scale: | 20.0 mA ± 0.4 mA |
| Lower Full Scale: | 4.0 mA ± 0.4 mA |

**Frequency Response**

| | |
|---|---|
| 990 Vibration Transmitter: | Less than 3 db down from 5 Hz to 6 kHz at 0.90 mm (35 mils) gap. |
| 991 Thrust Transmitter: | Greater than 3 dB attenuation above 10 Hz. |

| | |
|---|---|
| **Current Limiting** | 26 mA worst case (23 mA typical). |

**Effect of Shorting BNC "Prox Out" Jack**
Less than 1.0 mA error in loop current.

**Output Noise**
Error less than 0.25% of full scale (10 mV pp with a 250 Ω load resistor) when measured at the output of a low pass RC filter with a 10 Hz corner frequency, and when the power supply ripple is less than 1% of the input voltage when measured at the output of a 120 Hz low pass filter.

**Indication of Faults**
The loop current will go to less than 3.6 mA if the probe is opened, shorted, gapped outside of the linear range (not OK condition) or if the power supply is low. The 990 vibration transmitter loop current will remain below 3.6 mA for 2 to 3 seconds after the fault is removed. The 991 thrust transmitter will resume normal operation within 0.1 seconds after the probe fault is removed.

# 3300 NSv™ or 3300 RAM Probe

**Interchangeability Error**

Average scale factor (ASF) change

| | |
|---|---|
| Typical: | Less than 0.24 V/mm (6 mV/mil) |
| Worst Case: | Less than 0.42 V/mm (11 mV/mil) |

Voltage Difference at Same Physical Gap (Maximum)

| | |
|---|---|
| At 0.90 mm (35 mils) gap | 4.6 Vdc |
| At 0.25 mm (10 mils) gap | 3.6 Vdc |

**Connector-to-Connector Torque Requirement**

| | |
|---|---|
| Two gold ClickLoc™ connectors | Finger tight |
| One stainless steel connector and one gold ClickLoc™ connector | Finger tight plus 1/8 turn using pliers |
| Maximum torque | 0.565 N×m (5 in lb) |

**Case Types and Torque Limits**

| Probe case torque: | Maximum Rated | Recommended |
|---|---|---|
| ¼ -28 or M8x1 probe cases | 7.3 N•m (65 in•lb) | 5.1 N•m (45 in•lb) |
| 3/8-24 or M10x1 probe cases | 33.9 N•m (300 in•lb) | 11.3 N•m (100 in•lb) |
| 3/8-24 or M10x1 probe cases – first three threads | 22.6 N•m (200 in•lb) | 7.5 N•m (66 in•lb) |
| Reverse mount probes | 22.6 N•m (200 in•lb) | 7.5 N•m (66 in•lb) |

**Tensile Strength (Maximum Rated)**

| | |
|---|---|
| Probe case to probe lead | 34 kg (75 lb) |
| Probe case to connector | 27 kg (60 lb) |
| Probe case to armor (if used) | 22 kg (50 lb) |

**Minimum cable bend radius** 25 mm (1.0 inch)

**Weight** Approximately 14 to 150 g (0.5 to 5 oz)

**Temperature**

| | |
|---|---|
| Storage | -51 °C to +177 °C (-60 °F to +350 °F). |
| Operating | -34 °C to +177 °C (-30 °F to +350 °F). |

**Note:** Maximum temp. for sealed ETFE armor is 149 °C (300 °F).

**Note:** Exposing the probe to temperatures below –34 °C (-30 °F) for a sustained period of time may cause premature failure of the probe tip-to-case pressure seal.

The ISF will remain within +14% -19% of 7.87 V/mm (200 mV/mil) at 65 mils gap from –18 °C to +177 °C (0 °F to +350 °F), and the ISF will remain within ±10% of 7.87 V/mm (200 mV/mil) at 35 mils gap from –34 °C to +177 °C (-30 °F to +350 °F).

**Relative Humidity** 100% condensing, non-submersible when connector is protected.

# 3300 NSv™ or 3300 RAM Extension Cable

**Interchangeability Error**

Average scale factor (ASF) change

| | |
|---|---|
| Typical: | Less than 0.09 V/mm (2 mV/mil) |
| Worst Case: | Less than 0.19 V/mm (5 mV/mil) |

Apparent gap change

| | |
|---|---|
| At 0.90 mm (35 mil) gap | 0.145 mm (5.8 mils) |
| At 0.25 mm (10 mil) gap | 0.100 mm (4.0 mils) |

**DC resistance, nominal**

| | |
|---|---|
| Center conductor | 0.220 Ω/m (0.067 Ω/ft) |
| Shield | 0.066 Ω/m (0.020 Ω/ft) |

**Capacitance** 69.9 pF/m (21.3 pF/ft)

**Characteristic Impedance** 65 Ω

**Minimum bend radius** 25 mm (1.0 inch)

**Connector-to-Connector Torque Requirement**

| | |
|---|---|
| Two gold ClickLoc™ connectors | Finger tight |
| One stainless steel connector and one gold ClickLoc™ connector | Finger tight plus 1/8 turn using pliers |
| Maximum torque | 0.565 N×m (5 in lb) |

**Weight**

| | |
|---|---|
| No Armor | 45 g/m (0.5 oz/ft) |
| With Armor | 65 g/m (0.7 oz/ft) |

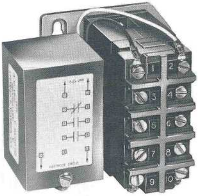
**Temperature**

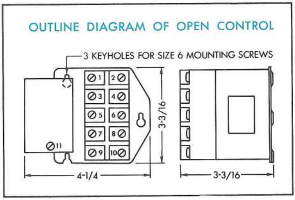
| | |
|---|---|
| Storage | -51 °C to +177 °C (-60 °F to +350 °F) |
| Operating | -51 °C to +177 °C (-60 °F to +350 °F) |

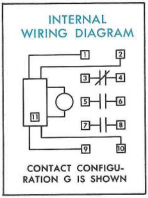
The ISF will remain within +14% -19% of 7.87 V/mm (200 mV/mil) at 65 mils gap from –18 °C to +177 °C (0 °F to +350 °F), and the ISF will remain within ±10% of 7.87 V/mm (200 mV/mil) at 35 mils gap from –34 °C to +177 °C (-30 °F to +350 °F).

| | |
|---|---|
| **Relative Humidity** | 100% condensing, non-submersible when connector is protected. |

# SERIES 2 CONTROLS






## GENERAL

Series 2 controls are UL listed, industrial type, electronically triggered, medium and high sensitivity, two and three pole electromagnetic relays with high contact ratings. They are suitable for use with hard, medium and soft waters including distilled, deionized and demineralized water; beer, wine, whisky and soft drinks; concentrated and dilute acids and alkalis; cleaning and plating solutions; sewage and industrial wastes; starch and concentrated sugar solutions; baby foods, fruit juices, jellies and preserves, milk, soups, raw fruits and vegetables; and any liquid, semisolid or solid granular material of less than 2,000,000 ohm-centimeters specific resistance.

**Series 2 controls are employed when the character of the application makes it desirable to satisfy one or more of the following requirements which cannot be provided by Series 1 controls: (a)** Exposed electrodes dictate a low potential to preclude electric shock hazard to personnel, **(b)** High specific resistance liquids necessitate controls with high sensitivities, **(c)** Critical applications demand controls which can be functioned in the preferred of two possible modes to obtain failsafe operation.

Although described as a liquid level control in this catalog, the device responds to any process variable which may be presented to it as a change of resistance by the use of an appropriate sensor.

Do not use Series 2 controls if the electrodes and/or allied wiring to the control are situated in a potentially explosive atmosphere. Employ Series 7 controls, described on page 17, in such applications.

## SPECIFICATIONS

**Baseplate:** High strength, diecast, aluminum alloy. Three dimpled keyholes for size 6 mounting screws.

**Coils:** Wound on nylon bobbins. Epoxy encapsulated.

**Contact Design:** 2PST and 3PST bridge type double break in all possible combinations of normally open and normally closed. Fully enclosed. Buttons are 1/4 inch diameter silver cadmium oxide.

**Contact Ratings:** (a) **Current:** 16 amperes at 115 volts A.C. and 8 amperes at 230 volts A.C., (b) **Horsepower:** 1 horsepower at 115 and 230 volts A.C., (c) **Pilot duty:** 775 volt-amperes at 115 and 230 volts A.C. and 250 volt-amperes at 460 volts A.C.

**Electronics Module:** Solid state components epoxy encapsulated in nylon shell.

**Identification:** By the use of a component number on a data label affixed to the control. In addition, the electronics module is color coded by a green disc for medium and a blue disc for high sensitivity models.

**Intrinsic Safety:** Series 2 controls are not intrinsically safe. The Series 7 controls described on page 17 have intrinsically safe sensing circuitry.

**Modes of Operation:** Direct and inverse. Easily altered by interchanging two wires on the control.

**Molded Structural Parts:** High mechanical and dielectric strength, dimensionally stable, arc resistant, thermosetting phenolic.

**Primary (A.C. Supply Line):** (a) Voltages: 115, 230, 460 and 575 volts A.C. nominal plus 10% minus 15%, (b) Frequency: 50/60 Hertz, (c) Power: 5 watts maximum with short circuited electrode circuit, (d) Volt-Amperes: 9 volt-amperes maximum.

**Secondary (In Electrode Circuit):** (a) Voltage: 10 volts A.C. RMS with open circuited electrode circuit, (b) Current: 0.0015 plus 10 times the reciprocal of the setpoint resistance amperes, with short circuited electrode circuit. Example: With a 10,000 ohm setpoint resistor the current is 0.0015 plus 10/10,000 ampere, a total of 0.0025 ampere, or 2.5 milliamperes.

**Sensitivity:** A medium sensitivity model accommodates liquids from 0 to 100,000 ohm-cm specific resistance (infinite to 10 micromho/cm specific conductance). A high sensitivity model accommodates liquids from 100,000 to 2,000,000 ohm-cm specific resistance (10 to 0.5 micromho/cm specific conductance). See section titled Sensitivity on page 13.

**Shunt Capacitance Tolerance:** The total maximum allowable distributed capacitance, in microfarads, placed across terminal pair 10-11 by the control-to-electrodes conductors and ground must not exceed 250/R where R is the ohmic value of the setpoint resistor. See section titled Control-To-Tank Distance on page 13.

**Spacings:** For 600 volts. 1/2 inch creepage across surfaces. 1/4 inch through air.

**Temperature:** Minus 20 to plus 150 degrees F. ambient.

**Terminals:** Size 8 pan head screws with captivated wire clamping plate. Numbered 1 to 11 for identification. Located on front of control for accessibility.

# SERIES 2 CONTROLS

| BASIC SERVICE | FUNCTION | MODE OF | ★ NUMBER ELECTRODES REQUIRED | WIRING DIAGRAM | | ■ CONTACTS | | |
|---|---|---|---|---|---|---|---|---|
| | | | | DIA-GRAM | ON PAGE | N.O. | N.C. | ♦ SYM-BOL |
| Single Level | High Level Alarm or Low Level Cutoff | Dir | 1 | C5 | 14 | 2 | 0 | C |
| | | | | F5 | 15 | 3 | 0 | F |
| | | Inv | 1 | E9 | 15 | 0 | 2 | E |
| | | | | J9 | 16 | 0 | 3 | J |
| | High Level Cutoff or Low Level Alarm | Dir | 1 | E5 | 15 | 0 | 2 | E |
| | | | | J5 | 16 | 0 | 3 | J |
| | | Inv | 1 | C9 | 14 | 2 | 0 | C |
| | | | | F9 | 15 | 3 | 0 | F |
| | High or Low Level Cutoff and Alarm | Dir | 1 | D5 | 15 | 1 | 1 | D |
| | | | | G5 | 16 | 2 | 1 | G |
| | | | | H5 | 16 | 1 | 2 | H |
| | | Inv | 1 | D9 | 15 | 1 | 1 | D |
| | | | | G9 | 16 | 2 | 1 | G |
| | | | | H9 | 16 | 1 | 2 | H |
| Differential Level | Pump Down | Dir | 2 | C6 | 14 | ● 2 | 0 | C |
| | | | | F6 | 15 | ● 3 | 0 | F |
| | | Inv | 2 | E10 | 15 | 0 | ▼ 2 | E |
| | | | | J10 | 16 | 0 | ▼ 3 | J |
| | Pump Up | Dir | 2 | D6 | 15 | ● 1 | 1 | D |
| | | | | H6 | 16 | ● 1 | 2 | H |
| | | Inv | 2 | D10 | 15 | 1 | ▼ 1 | D |
| | | | | G10 | 16 | 2 | ▼ 1 | G |
| | Pump Down or Pump Up | Dir | 2 | G6 | 16 | ● 2 | 1 | G |
| | | Inv | 2 | H10 | 16 | 1 | ▼ 2 | H |

★ Terminal 11 of control assumed grounded to metallic vessel. Additional electrode required if vessel is electrical nonconductor.

■ All contacts available for load duty unless otherwise indicated by footnote ● or ▼.

● One normally open contact required to seal electrode circuit. Number of normally open contacts available for load duty therefore one less than figure indicated.

▼ One normally closed contact required to seal electrode circuit. Number of normally closed contacts available for load duty therefore one less than figure indicated.

♦ Letters represent 2nd place symbol in the component number of the control.

**2 X X X X** ← ORDER BY COMPONENT NUMBER

**2ND PLACE SYMBOL**

| ↓ | Contact Configuration | |
|---|---|---|
| | N.O. | N.C. |
| C | 2 | 0 |
| D | 1 | 1 |
| E | 0 | 2 |
| F | 3 | 0 |
| G | 2 | 1 |
| H | 1 | 2 |
| J | 0 | 3 |

**3RD PLACE SYMBOL**

| ↓ | A.C. Line Volts & Freq. |
|---|---|
| 1 | 115 V 50/60 HZ |
| 2 | 230 V 50/60 HZ |
| 4 | 460 V 50/60 HZ |
| 5 | 575 V 50/60 HZ |

See Primary specification paragraph on page 11.

**4TH PLACE SYMBOL**

| ↓ | Maximum Sensitivity Capability In Ohms |
|---|---|
| F | 100,000 |
| G | 2,000,000 |

See footnote ✻ in upper table on page 13.

**5TH PLACE SYMBOL**

| ↓ | Nema Type Enclosure |
|---|---|
| 0 | Open |
| 1 | 1 |
| 4 | 3, 4, 5 |
| 7 | 7, 9, 9A |
| 12 | 12 |

See info on page 18.

### SENSITIVITY

Series 2 controls are provided in two maximum sensitivity capabilities. A medium sensitivity model handles liquids with specific resistances of 100,000 ohm-centimeters or less. This range embraces the majority of electrically conductive liquids. A high sensitivity model accommodates liquids with specific resistances up to 2,000,000 ohm-centimeters. The maximum sensitivity capability of the control is identified by the 4th place symbol in the component number. See the component number formula on page 12.

The controls are seldom functioned at maximum sensitivity. Instead, the actual or working sensitivity is fixed by the use of a setpoint resistor externally connected to the control. **The ohmic value of the setpoint resistor is chosen to approximate the specific resistance of the liquid in ohm-centimeters.** Typical values of setpoint resistors used for various liquids are shown in the upper table to the right. A list of all available setpoint resistors is provided in the lower table. Intermediate values are not required.

Given a conductive liquid, this establishes the ohmic value of the setpoint resistor. Having selected a specific setpoint resistor, this determines whether the medium or high sensitivity control is required. Use the medium sensitivity model if the setpoint resistor is 100,000 ohms or less. Use the high sensitivity model if the setpoint resistor is more than 100,000 ohms.

### CONTROL-TO-TANK DISTANCE

The control places an alternating potential on the electrodes to preclude electrolysis. The capacitance presented to the control by the control-to-electrodes conductors and ground must be limited to impede current flow through that capacitance. Otherwise, the control will be falsely actuated by current resulting from the capacitance instead of current passing through the liquid via the electrodes.

The total capacitance seen by the control is dependent upon the character and length of the control-to-electrodes wiring. Thus, for any given type of wiring, with a particular distributed capacitance to ground, the distance between the control and tank must not exceed a certain figure if the total capacitance is to remain within a specified limit. Since the maximum allowable capacitance is a function of the working sensitivity, which is determined by the setpoint resistance, it is convenient to relate limiting distances to setpoint resistor values. See the lower table at right which tabulates the correlation.

Observe footnote ▲ which qualifies the distances for a specific type of wire installation with a definite distributed capacitance. Other types of wiring installations will have smaller or larger distributed capacitances, allowing longer or shorter limiting distances, respectively. The formula in the Shunt Capacitance Tolerance specification on page 11 can be used to compute limiting distances for other types of wire installations of known distributed capacitances between the control-to-electrodes conductors and ground.

**TYPICAL SETPOINT RESISTORS FOR VARIOUS CLASSES OF LIQUIDS**

| ★ LIQUID | ● ✱ SETPOINT RESISTOR OHMS | SETPOINT RESISTOR PART NO. |
|---|---|---|
| Metallic circuits. | 470 | 2Z1A |
| Concentrated and dilute acids and alkalis. Cleaning and plating solutions. Baby foods, fruit juices, milk, soups and some salad dressings. Sea water. | 1,000 | 2Z1B |
| Beer and wine. | 2,200 | 2Z1C |
| Hard water from wells. | 4,700 | 2Z1D |
| Natural water from lakes, rivers, and storm runoffs. Treated municipal water. Carbonated water and soft drinks. Sewage. | 10,000 | 2Z1E |
| Soft water from wells. Process steam condensate. | 22,000 | 2Z1F |
| Corn syrups. Jellies, jams and preserves. Raw and cooked, whole and diced, fruits and vegetables. | 47,000 | 2Z1G |
| Concentrated sugar solutions. High moisture granular solids. | 100,000 | 2Z1H |
| Bourbon, rye and scotch whisky. | 220,000 | 2Z1J |
| Low moisture granular solids. Extra pure distilled water. | 470,000 | 2Z1K |
| Deion and demineralized water. | 1 Meg | 2Z1L |

★ Inquire for resistor values for unlisted liquids.

● For liquids of known specific resistance use a setpoint resistor with an ohmic value greater than, and closest to, the specific resistance in ohm-centimeters. See list of setpoint resistor values and part numbers in table below.

✱ Use a control with 100,000 ohms maximum sensitivity capability when the setpoint resistor is 100,000 ohms or less. Use a control with 2,000,000 ohms maximum sensitivity capability when the setpoint resistor is greater than 100,000 ohms.

**SETPOINT RESISTOR PART NOS. AND VALUES MAX ALLOWABLE CONTROL-TO-TANK DISTANCES**

| ▼ CFW PART NO. | RESISTOR OHMIC VALUE | ▲ MAX FEET DISTANCE TO TANK | ▼ CFW PART NO. | RESISTOR OHMIC VALUE | ▲ MAX FEET DISTANCE TO TANK |
|---|---|---|---|---|---|
| 2Z1A | 470 | 12,500 | 2Z1G | 47,000 | 125 |
| 2Z1B | 1,000 | 5,000 | 2Z1H | 100,000 | 50 |
| 2Z1C | 2,200 | 2,300 | 2Z1J | 220,000 | 23 |
| 2Z1D | 4,700 | 1,300 | 2Z1K | 470,000 | 13 |
| 2Z1E | 10,000 | 500 | 2Z1L | 1 MEG | 5 |
| 2Z1F | 22,000 | 230 | 2Z1M | 2.2 MEG | 2 |

▼ Order setpoint resistors by specifying part numbers.

▲ Based on thermoplastic insulated conductors in dry metallic conduit. Figures are for differential level service. Double them for single level service.

# SERIES 2 CONTROLS

### MODES OF OPERATION

The principle of operation described on page 6 correlates contact action to liquid level for Series 1 controls. Observe that the relay closes when the electrode circuit closes, and the relay opens when the electrode circuit opens. This is known as direct mode operation. **Series 1 controls function only in the direct mode.**

A converse relationship between the electrode circuit and relay is possible. In this case the relay opens when the electrode circuit closes, and the relay closes when the electrode circuit opens. This is known as inverse mode operation. **Series 2 controls may be functioned in either the direct or inverse mode.** A change, from one mode to the other, is easily performed in the field by reversing two on-chassis wires connected to terminal pair 9-11.

### FAILSAFE OPERATION

The ability to field connect Series 2 controls for operation in either mode permits a safe failure in the event of a power interruption to terminal pair 1-2 or an open circuit in any of the several coils on the device. **Notwithstanding the mode of operation, all contacts assume their normal positions if loss of power or an open circuited coil occurs.** Normally open contacts open. Normally closed contacts close. Thus, by selection of a control with the proper contact configuration, and operating the device in the preferred mode, the contacts handling the electrical loads will open or close, as desired, in the event of a control failure.

There is no universal rule to establish the type of contacts and mode of operation required to provide failsafe operation. **Each specific application will dictate the type of contacts and mode of operation needed to achieve a safe failure for that application.**

Consider the situation where the control is supervising a single alarm circuit. This catalog views an alarm function as closure of a contact if the liquid rises or recedes to an abnormally high or low level. Based on this premise, the control must possess a normally closed contact so the alarm circuit closes if the control fails. The control must then be operated in the inverse mode for high level alarm and in the direct mode for low level alarm.

Notwithstanding the above, some alarm circuits are maintained closed circuited under normal conditions and open if an abnormal condition develops. In such applications the control must have a normally open contact and operate in the inverse mode for high level alarm and in the direct mode for low level alarm.

### SELECTION OF THE CONTACT CONFIGURATION

The following procedure may be used to select the contact configuration after reading Modes Of Operation and Failsafe Operation sections. First, determine the total number of contacts. One contact per load circuit, plus an additional contact to seal the electrode circuit if for a pump down or pump up function, are required.

Second, assuming a control failure, examine each electrical load, insofar as its effect on your specific application is concerned, to determine whether a normally open or normally closed contact is preferred in order to secure failsafe operation.

Third, determine whether direct or inverse mode operation is required to obtain the desired relationship between the load contacts and liquid level during normal operation.

Fourth, if for a pump down or pump up function, determine whether the additional contact required to seal the electrode circuit shall be normally open or normally closed. You fixed the mode in the preceding step. Use a normally open contact for direct mode operation and a normally closed contact for inverse mode operation.

Fifth, check your work by locating and reviewing the appropriate diagram on page 14, 15 or 16 to verify the correctness of the required correlation between contact action and liquid level. The large table on page 12 may be of assistance for this purpose.

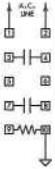
## 2 N.O. CONTACTS
## CONTACT CONFIGURATION C

DIAGRAM C5

DIRECT MODE

SINGLE LEVEL SERVICE

HIGH LEVEL ALARM OR LOW LEVEL CUTOFF



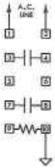

Load contacts 3-4 and 7-8 close when the level rises to the electrode. They open when the level recedes below the electrode.

DIAGRAM C9

INVERSE MODE

SINGLE LEVEL SERVICE

HIGH LEVEL CUTOFF OR LOW LEVEL ALARM



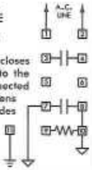

Load contacts 3-4 and 7-8 open when the level rises to the electrode. They close when the level recedes below the electrode.

DIAGRAM C6

DIRECT MODE

DIFFERENTIAL LEVEL SERVICE

PUMP DOWN




Load contact 3-4 closes when the level rises to the short electrode connected to terminal 10. It opens when the level recedes below the long electrode connected to terminal 7.

There is no diagram for inverse mode differential level service for controls with only two normally open contacts because the control does not possess the normally closed contact required to seal the electrode circuit.

# SERIES 2 CONTROLS

## 1 N.C. & 1 N.O. CONTACTS — CONTACT CONFIGURATION D

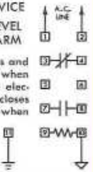
### DIAGRAM D5

DIRECT MODE

SINGLE LEVEL SERVICE

HIGH OR LOW LEVEL CUTOFF AND ALARM

Load contact 3-4 opens and load contact 7-8 closes when the level rises to the electrode. Contact 3-4 closes and contact 7-8 opens when the level recedes below the electrode.



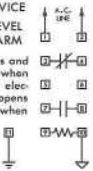

### DIAGRAM D9

INVERSE MODE

SINGLE LEVEL SERVICE

HIGH OR LOW LEVEL CUTOFF AND ALARM

Load contact 3-4 closes and load contact 7-8 opens when the level rises to the electrode. Contact 3-4 opens and contact 7-8 closes when the level recedes below the electrode.



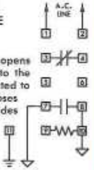

### DIAGRAM D6

DIRECT MODE

DIFFERENTIAL LEVEL SERVICE

PUMP UP

Load contact 3-4 opens when the level rises to the short electrode connected to terminal 10. It closes when the level recedes below the long electrode connected to terminal 7.



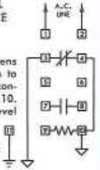

### DIAGRAM D10

INVERSE MODE

DIFFERENTIAL LEVEL SERVICE

PUMP UP

Load contact 7-8 opens when the level rises to the short electrode connected to terminal 10. It closes when the level recedes below the long electrode connected to terminal 3.




## 2 N.C. CONTACTS — CONTACT CONFIGURATION E

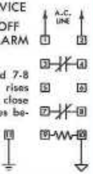
### DIAGRAM E5

DIRECT MODE

SINGLE LEVEL SERVICE

HIGH LEVEL CUTOFF OR LOW LEVEL ALARM

Load contacts 3-4 and 7-8 open when the level rises to the electrode. They close when the level recedes below the electrode.



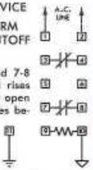

### DIAGRAM E9

INVERSE MODE

SINGLE LEVEL SERVICE

HIGH LEVEL ALARM OR LOW LEVEL CUTOFF

Load contacts 3-4 and 7-8 close when the level rises to the electrode. They open when the level recedes below the electrode.




There is no diagram for direct mode differential level service for controls with only two normally closed contacts because the control does not possess the normally open contact required to seal the electrode circuit.

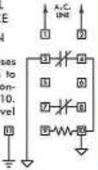
### DIAGRAM E10

INVERSE MODE

DIFFERENTIAL LEVEL SERVICE

PUMP DOWN

Load contact 7-8 closes when the level rises to the short electrode connected to terminal 10. It opens when the level recedes below the long electrode connected to terminal 3.




## 3 N.O. CONTACTS — CONTACT CONFIGURATION F

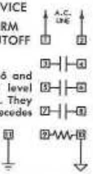
### DIAGRAM F5

DIRECT MODE

SINGLE LEVEL SERVICE

HIGH LEVEL ALARM OR LOW LEVEL CUTOFF

Load contacts 3-4, 5-6 and 7-8 close when the level rises to the electrode. They open when the level recedes below the electrode.



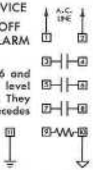

### DIAGRAM F9

INVERSE MODE

SINGLE LEVEL SERVICE

HIGH LEVEL CUTOFF OR LOW LEVEL ALARM

Load contacts 3-4, 5-6 and 7-8 open when the level rises to the electrode. They close when the level recedes below the electrode.



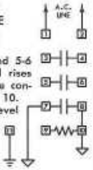

### DIAGRAM F6

DIRECT MODE

DIFFERENTIAL LEVEL SERVICE

PUMP DOWN

Load contacts 3-4 and 5-6 close when the level rises to the short electrode connected to terminal 10. They open when the level recedes below the long electrode connected to terminal 7.




There is no diagram for inverse mode differential level service for controls with only three normally open contacts because the control does not possess the normally closed contact required to seal the electrode circuit.

# SERIES 2 CONTROLS

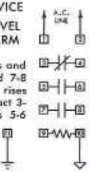
## 1 N.C. & 2 N.O. CONTACTS — CONTACT CONFIGURATION G

### DIAGRAM G5

DIRECT MODE

SINGLE LEVEL SERVICE

HIGH OR LOW LEVEL CUTOFF AND ALARM




Load contact 3-4 opens and load contacts 5-6 and 7-8 close when the level rises to the electrode. Contact 3-4 closes and contacts 5-6 and 7-8 open when the level recedes below the electrode.

## 2 N.C. & 1 N.O. CONTACTS — CONTACT CONFIGURATION H

### DIAGRAM H5

DIRECT MODE

SINGLE LEVEL SERVICE

HIGH OR LOW LEVEL CUTOFF AND ALARM


Load contacts 3-4 and 5-6 open and load contact 7-8 closes when the level rises to the electrode. Contacts 3-4 and 5-6 close and contact 7-8 opens when the level recedes below the electrode.

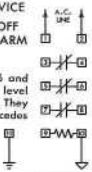
## 3 N.C. CONTACTS — CONTACT CONFIGURATION J

### DIAGRAM J5

DIRECT MODE

SINGLE LEVEL SERVICE

HIGH LEVEL CUTOFF OR LOW LEVEL ALARM



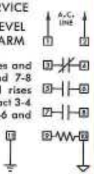

Load contacts 3-4, 5-6 and 7-8 open when the level rises to the electrode. They close when the level recedes below the electrode.

### DIAGRAM G9

INVERSE MODE

SINGLE LEVEL SERVICE

HIGH OR LOW LEVEL CUTOFF AND ALARM



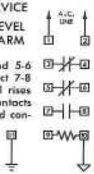

Load contact 3-4 closes and load contacts 5-6 and 7-8 open when the level rises to the electrode. Contact 3-4 opens and contacts 5-6 and 7-8 close when the level recedes below the electrode.

### DIAGRAM H9

INVERSE MODE

SINGLE LEVEL SERVICE

HIGH OR LOW LEVEL CUTOFF AND ALARM



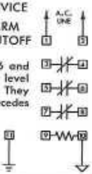

Load contacts 3-4 and 5-6 close and load contact 7-8 opens when the level rises to the electrode. Contacts 3-4 and 5-6 open and contact 7-8 closes when the level recedes below the electrode.

### DIAGRAM J9

INVERSE MODE

SINGLE LEVEL SERVICE

HIGH LEVEL ALARM OR LOW LEVEL CUTOFF



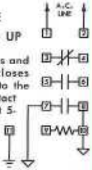

Load contacts 3-4, 5-6 and 7-8 close when the level rises to the electrode. They open when the level recedes below the electrode.

### DIAGRAM G6

DIRECT MODE

DIFFERENTIAL LEVEL SERVICE

PUMP DOWN OR UP



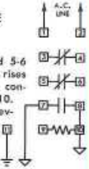

Load contact 3-4 opens and load contact 5-6 closes when the level rises to the short electrode. Contact 3-4 closes and contact 5-6 opens when the level recedes below the long electrode.

### DIAGRAM H6

DIRECT MODE

DIFFERENTIAL LEVEL SERVICE

PUMP UP




Load contacts 3-4 and 5-6 open when the level rises to the short electrode connected to terminal 10. They close when the level recedes below the long electrode connected to terminal 7.

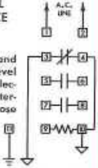
There is no diagram for direct mode differential level service for controls with only three normally closed contacts because the control does not possess the normally open contact required to seal the electrode circuit.

### DIAGRAM G10

INVERSE MODE

DIFFERENTIAL LEVEL SERVICE

PUMP UP



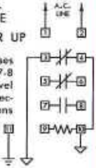

Load contacts 5-6 and 7-8 open when the level rises to the short electrode connected to terminal 10. They close when the level recedes below the long electrode connected to terminal 3.

### DIAGRAM H10

INVERSE MODE

DIFFERENTIAL LEVEL SERVICE

PUMP DOWN OR UP



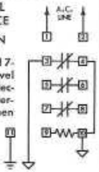

Load contact 5-6 closes and load contact 7-8 opens when the level rises to the short electrode. Contact 5-6 opens and contact 7-8 closes when the level recedes below the long electrode.

### DIAGRAM J10

INVERSE MODE

DIFFERENTIAL LEVEL SERVICE

PUMP DOWN




Load contacts 5-6 and 7-8 close when the level rises to the short electrode connected to terminal 10. They open when the level recedes below the long electrode connected to terminal 3.