LEROY SOMER®

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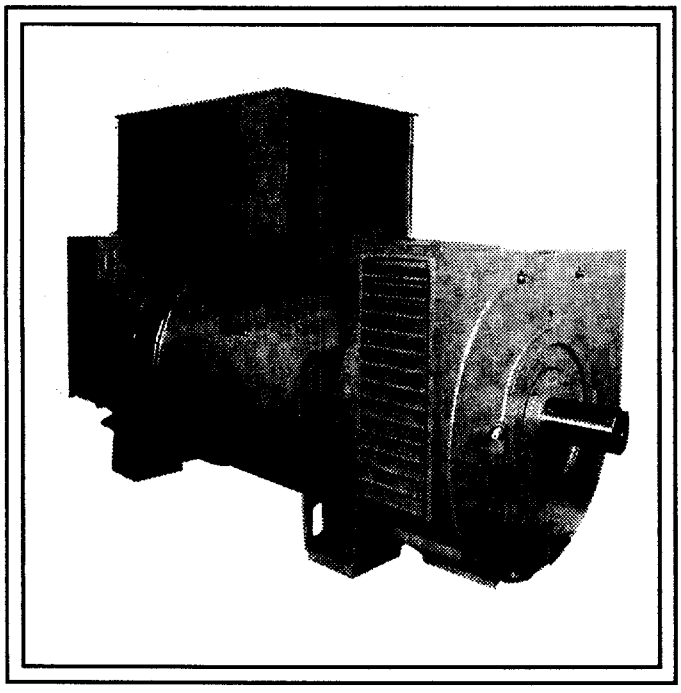

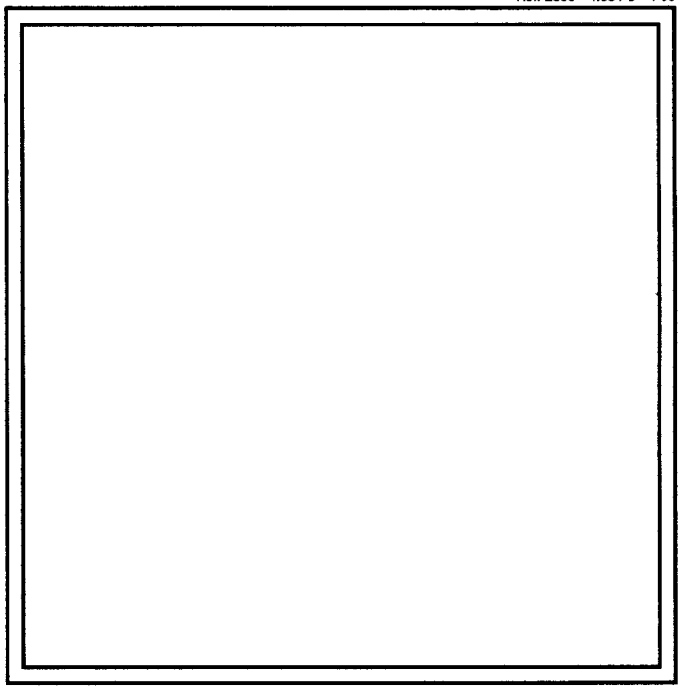

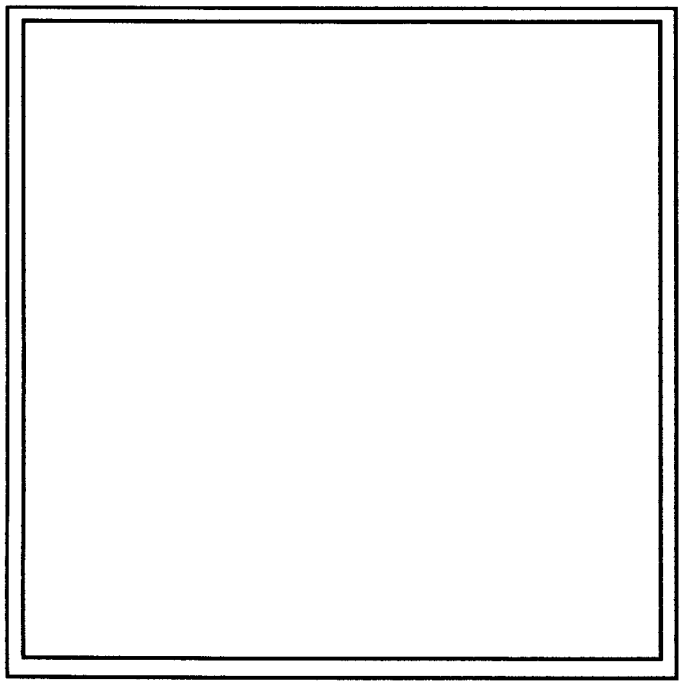

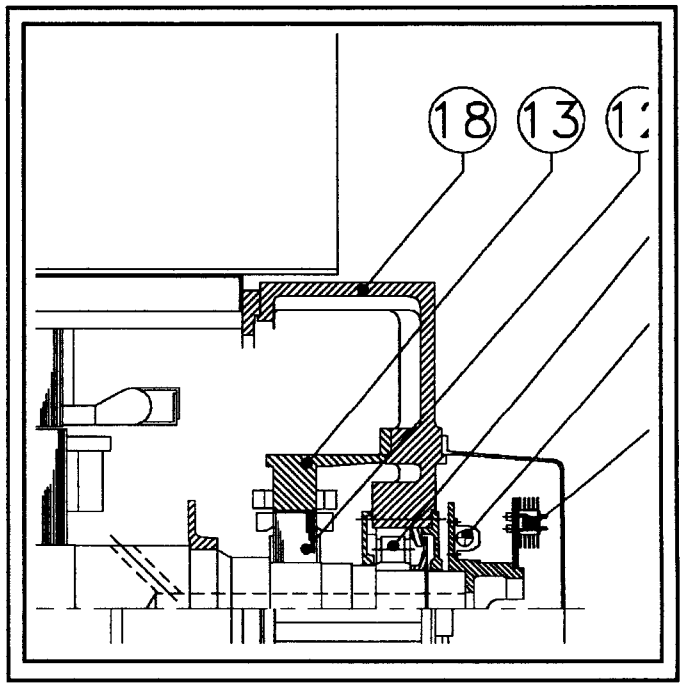

SYNCHRONOUS MOTOR

SERVICE MANUAL

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7.5 DRYING THE WINDING

7.5.0 General points
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1. GENERAL INFORMATION

1.1 INTRODUCTION

1.1.0 General points

This manual provides installation, operating and maintenance instructions for synchronous machines. It also describes the basic construction of these machines. This manual is general ; it applies to an entire group of synchronous motors. Additionally, in order to make information-finding easier, Section 1, « Characteristics and Performance », has been included, describing the machine completely (type of construction, type of bearing, protection index, and so forth...) ; this will enable you to determine exactly the sections which apply to your machine.

This synchronous machine has been designed for a maximum length of service. To achieve this, it is necessary to pay special attention to the section concerning the periodic maintenance schedule for the machines.

1.1.1 Safety notes

The warnings « **DANGER, CAUTION, NOTE** » are used to draw the user's attention to different points :

DANGER :
THIS WARNING IS USED WHEN AN OPERATION, PROCEDURE, OR USE MAY CAUSE PERSONAL INJURY OR LOSS OF LIFE

CAUTION :
THIS WARNING IS USED WHEN AN OPERATION, PROCEDURE, OR USE MAY CAUSE DAMAGE TO OR DESTRUCTION OF EQUIPMENT

NOTE :
This warning is used when an operation, procedure, or delicate installation requires clarification.

1.2 GENERAL DESCRIPTION

1.2.1 Motor

The synchronous Motor is an variable speed alternating-current machine, without rings or brushes. The machine is cooled by the flow of air through the machine.

7.6 RE-VARNISHING

10. FOLDOUT

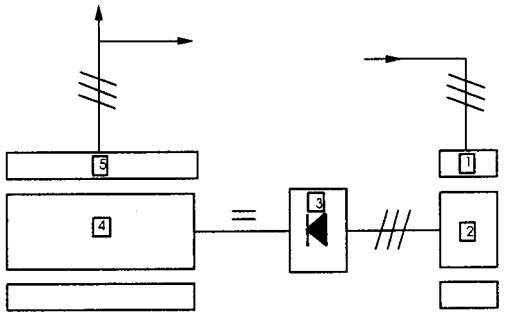
1.2.2 Excitation system

The excitation system is mounted on the side opposite the coupling. The exciter is a rotating transformer

The excitation system comprises two assemblies :

The excitation armature, generating a three-phase current, coupled with the three-phase rectifier bridge (comprised of six diodes) supplies the excitation current to the Motor revolving field. The excitation armature and the rectifier bridge are mounted on the synchronous Motor rotor shaft and are interconnected electrically with the revolving field of the machine.

The excitation field winding (stator) is supplied by the control (three-phase current)



1- Excitation field winding
2- Excitation armature
3- Rotating diode bridge
4- Revolving field
5- Motor stator

2. DESCRIPTION OF SUB-ASSEMBLIES

2.1 STATOR

2.1.1 Electric machine armature

a) Mechanical description

The machine stator comprises low-loss steel laminations, assembled under pressure. The steel laminations are blocked axially by a welded ring. The stator coils are inserted and blocked in the slots, then impregnated with varnish, and polymerised to ensure maximum resistance to mould, excellent dielectric rigidity and perfect mechanical linking.

2.1.2 Excitation field winding

The excitation field winding comprises low-loss steel laminations, assembled under pressure and a winding.

The excitation is flanged on the rear end shield of the machine.

The winding is made of enamelled copper wires.

2.1.3 Stator protection

a) Heating resistor

The heating element avoids internal condensation during the shutdown periods. It is connected to the main terminal box strip. The heating resistor is switched on as soon as the machine is shut down. It is located at the back end of the machine.

The electrical characteristics are provided in Section 1 "Technical Characteristics".

b) Stator winding temperature sensor

The temperature sensors are located in the active part of the stack. They are located in the zone assumed to be the hottest part of the machine. The sensors are connected to a terminal box.

Depending on the temperature rise of the machine, the temperature of the sensors should not exceed a maximum of :

TEMP. RISE class	ALARM	EMERGENCY SHUTDOWN
B	130 °C	135 °C
F	150 °C	155 °C
H	175 °C	180 °C

To improve the machine protection the alarm set point may be reduced following site information :

Alarm temperature (*) = Highest recorded temp + 10 °K

(*) do not pass over the values of the previous chart.

E.g. : a class B machine reached 110°C during a factory heat run test. Set the alarm temperature to 120°C instead of 130°C as indicated in the previous chart

c) Stator air sensor

As an option an RTD or thermostat can measure the stator air inlet temperature (cold air)

Stator air inlet temperature ; Alarm points and shutdown:

- alarm Nominal ambient + 5 K
- shutdown 80°C

NOTE :

Inhibit the stator air sensor safety "alarm" for few seconds during the machine start up;

2.2 ROTOR

2.2.1 Revolving field-coil

The revolving field-coil comprises a stack of steel laminations, stamped and cut to reproduce the indentation of the projecting poles.

The steel lamination stack-up is terminated at each end with high-conductivity electrical plates.

To enable parallel operation between machines, and in order to ensure stability, high electrical conductivity bars are inserted in holes crossing the poles from one side to the other. These bars are welded with the stack end laminations in order to obtain a complete cage winding (or LEBLANC dampening cage).

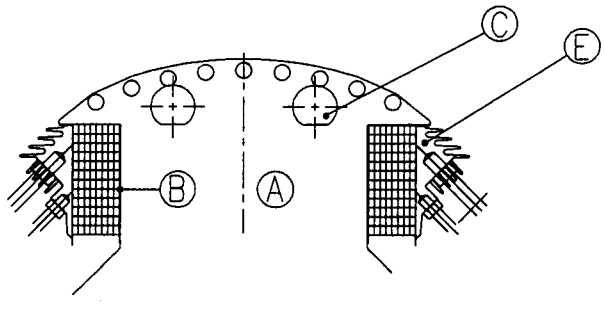
The winding (B) is placed around the pole (A) and is impregnated with epoxy resin (class F machine insulation) or with varnish (class H machine insulation).

The winding is made of insulated flattened copper with high electrical conductivity.

The aluminium plates (E) are pressed against the winding, acting as a heat dissipater and ensure excellent clamping of these coils.

Support bars (C) on each pole protect the end windings against the centrifugal force.

The revolving field-coil is heated and shrunk onto the shaft.



2.2.2 Excitation armature

The excitation armature is constructed by stacking magnetic steel laminations. These steel laminations are held in place by rivets.

The excitation coil is keyed and heat-shrunk onto the shaft.

The windings are enamelled copper wires, class "F" insulation (or "H", depending on the customer's request or size of the machine).

2.2.3 Cooling

a) machines : IC 0 A6

The synchronous machine is characterised by external motor fan. Motor fan (asynchronous motor) with centrifugal fan are installed on the top of the machine.

Air intake is at the rear of the machine and the exhaust on the drive end side.

The cold air intake the synchronous motor through the top of the end shield (motor fan side) and exhaust by the opposite end shield

b) machines : IC 8 A6 W7

The synchronous machine is characterised by external motor fan. Motor fan (asynchronous motor) with centrifugal fan are installed on the top of the machine into the water cooler housing.

Air intake is at the rear of the machine and the exhaust on the drive end side.

The cold air intake the synchronous motor through the top of the end shield (motor fan side) and exhaust by the opposite end shield

Emergency operation :

In case of water cooler defect; the synchronous motor can still operate with a cooling type IC0A6 (as an "open machine") at reduced power.

To operate in this mode: open the flaps labelled "Must be opened in emergency" and block the water cooler air circuit. Slide the blocking plate (delivered with the machine) in the foresee slot, in front of the water cooler.

In emergency mode (as for the normal mode) the stator winding temperature sensors must stay below the allowed values.

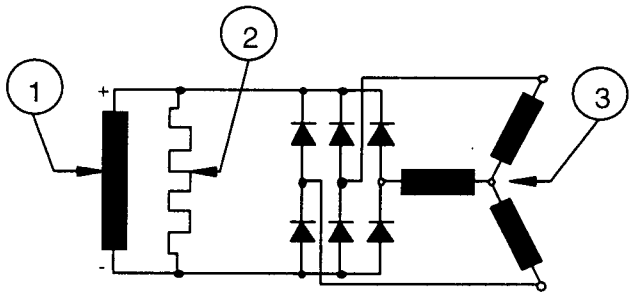
CAUTION :
DO NOT OPERATE IN "OPEN MACHINE" MODE THE COOLER WATER FLOW STILL IN SERVICE.

CAUTION
DO NOT OPERATE WITHOUT MOTORIZED FAN; EVEN MOTOR AT NO LOAD

2.2.4 Rotating diode bridge

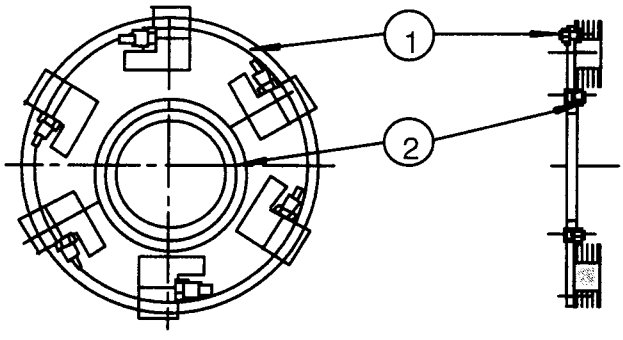
a) General points

The rectifier bridge, comprising six diodes, is placed at the rear of the machine. The rotating bridge is made of glass fibre with a printed circuit to connect the diodes together. This bridge is supplied with alternating current by the excitation armature and supplies direct current to the revolving field-coil. The diodes are protected against over voltage by rotating resistors. These resistors are mounted in parallel with the revolving field-coil.



1 - Field
2 - Rotating resistors
3 - Exciter armature

The inner and outer rings are connected to the revolving field-coil



1 - Outer ring
2 - Inner ring

The diode fastening screws must be tightened to the correct torque.

a) Tightening torque for the rotating diode fastening screws

CAUTION :
THE ROTATING DIODE FASTENING SCREWS MUST BE TIGHTENED USING A TORQUE WRENCH CALIBRATED TO THE RECOMMENDED TORQUE.

Diode	Tightening torque
SKR 100/..	1.5 m.daN
SKR 130/..	1.5 m.daN
SKN 240/..	3 m.daN

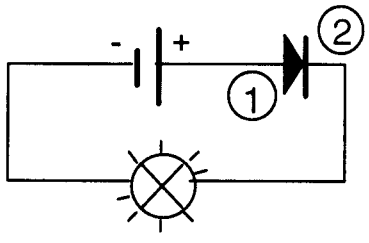
b) Rotating rectifier test

Carry out the test using a D.C. source as indicated below.

A diode in good condition should allow the current to flow **only** in the anode-to-cathode direction.

Disconnect the diodes before the test.

3 ... 48 volts



1 - Anode
2 - Cathode

Diode type	Positive	Negative
SKR	diode housing	diode wire
SKN	diode wire	diode housing

When reassembling ensure that the diodes are be tightened to the correct torque

2.2.5 Balancing

The entire rotor has been balanced according to ISO8221 standard in order to obtain a residual imbalance less than :
: Class G2.5

The balancing is carried out at two levels. The first is that of the fan. It is recommended, when the fan is refitted (after servicing) to respect the initial indexing.

The second is that of the shaft end. The shaft end is cold-stamped to indicate the type of balancing.

H : balancing with **Half-key carried out as standard**
F : balancing with Full key
N : balancing without key (None)

The coupling must be balanced to fit the generator rotor balancing.

2.3 ANTI FRICTION-BEARINGS

2.3.0 Description of antifriction bearings

The bearings are installed at each end of the machine. They can be replaced.

The bearings are protected from external dust by labyrinth seals.

The bearings must be lubricated regularly. The old grease is forced out at the lower part of the bearings by the force of the new grease being injected.

2.3.1 Start-up of antifriction bearings

The bearings are pre-lubricated in the factory, but before they are put into service, it is necessary to complete this lubrication.

CAUTION
UPON START-UP, GREASE THE MACHINE WHILE IT IS RUNNING SO AS TO FILL ALL THE FREE SPACES IN THE GREASING DEVICE

Record the temperature of the bearings during the initial operating hours. Poor lubrication can cause abnormal heating.

If the bearing hisses, lubricate it immediately. Some bearings may make a clattering noise if they do not operate at normal temperature. This may occur if the weather is very cold or when the machine is operating under abnormal temperature conditions (start-up phase, for example). The bearings will become quieter after having reached their normal operating temperature.

2.3.2 Maintenance of antifriction bearings

a) General points

Antifriction bearings or ball bearings do not require special maintenance.

They must be lubricated regularly with the same type of grease as used in the factory. We recommend SHELL ALVANIA G3 type grease (lithium soap). For information concerning the lubrication quantity and interval, refer to Section 1 : « Characteristics and Performance ».

Lubrication should be carried out at least every 6 months.

CAUTION :
DO NOT MIX GREASE OF DIFFERENT SOAPBASES. WHEN CHANGING THE TYPE OF GREASE, CLEAN THE BEARING BEFOREHAND.

b) Lubricant

recommended lubricant : SHELL ALVANIA G3

Following greases may be considered as similar

BP	Energrease LS3
ELF	Rolexa 3
ESSO	Beacon 3
MOBIL	Mobilux EP3
TEXACO	Marsak Multipurpose 3
SKF	SKF65

c) Cleaning bearings

This note is applicable when the type of grease is changed.

Dismantle the machine in order to get to the bearing

Remove the old grease with a palette knife.

Clean the lubricator and the grease removal tube.

For greater cleaning efficiency, use a brush with solvent.

NOTE :
The most widely-used solvent is gasoline : white spirit is acceptable.

DANGER :
THE PROHIBITED SOLVENTS ARE :
CHLORINATED SOLVENT
(TRICHLORETHYLENE,TRICHLOROETHANE) WHICH BECOMES ACID
FUEL-OIL (EVAPORATES TOO SLOWLY)
GASOLINE CONTAINING LEAD
BENZINE (TOXIC)

Blow compressed air onto the bearings to evaporate the excess solvent.

Fill the bearing with the new grease.

Re-assemble the cage bottom and the parts which have been dismantled, filling them with grease. Use a grease pump to complete the bearing lubrication (with machine running)

2.3.3 Servicing the antifriction bearings

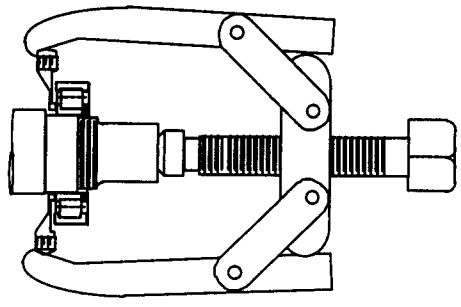
a) General points

CAUTION :
CLEANLINESS IS IMPERATIVE

b) Removing the bearings

The inner bearing race is mounted, shrunk onto the shaft.

The outer bearing race is free, or slightly tightened, on the hub (depending on the type of bearing). To remove the bearing from the shaft, it is necessary to use a hub-puller to avoid damaging the surface of the bearing.



c) Bearing reassembly

A bearing can be refitted if it is known to be in perfect condition

Before refitting a bearing, carefully clean the surface of the bearing and the other parts of the bearing.

To install the bearing on the shaft, it is necessary to heat the bearing. The heat source may be an oven or a space heater (the use of oil baths is strongly discouraged).

CAUTION :
NEVER HEAT A BEARING TO MORE THAN 125°C (257°F)

Push the bearing up to the shaft shoulder, and check after cooling that the inner ring is still in contact with the shoulder. Lubricate using the recommended grease.

2.3.4 Antifriction bearing protection devices

As an option, the bearing may be protected from over-heating by RTD or PTC sensors (customer's choice)..

For special use in warm surroundings where the temperature of the bearings exceeds the authorised limit (for a bearing known to be in good condition), contact us.

Bearing ; Alarm points and shutdown:

• alarm	90°C (194°F)
• shutdown	95°C (203°F)

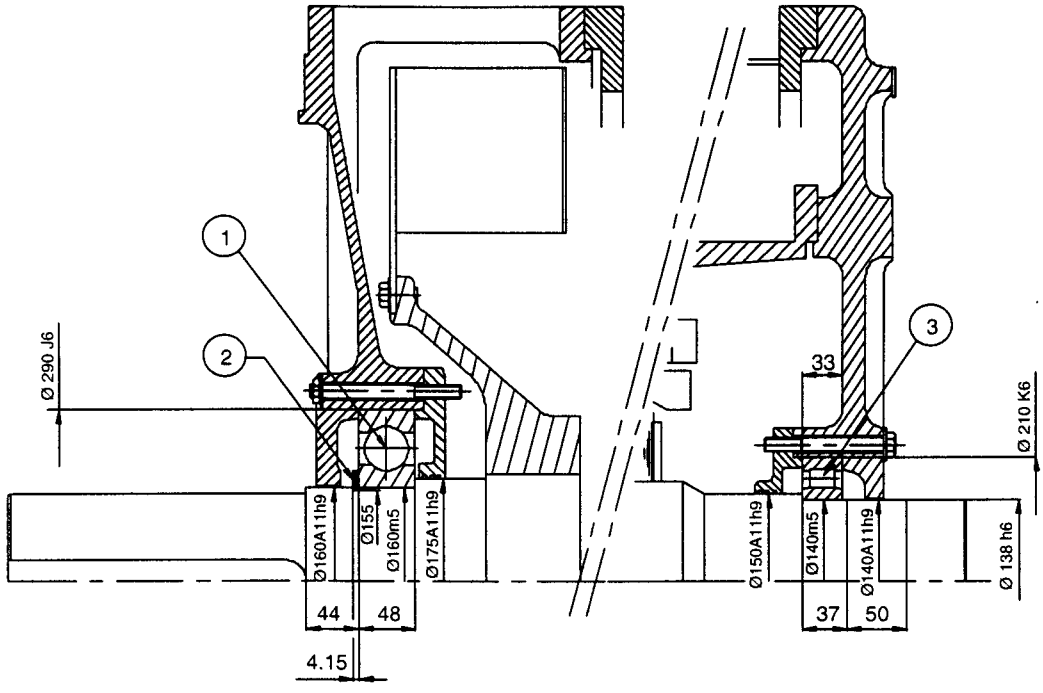
To improve the machine protection the alarm set point may be reduced following site information :

Alarm temperature (*) = Highest recorded temp + 15 °K
(*) do not pass over the values of the previous chart.

E.g. : At site the common bearing temperature is 60°C. Set the alarm temperature to 75°C instead of 90°C as indicated in the previous chart

2.3.9 Anti friction bearing installation drawing

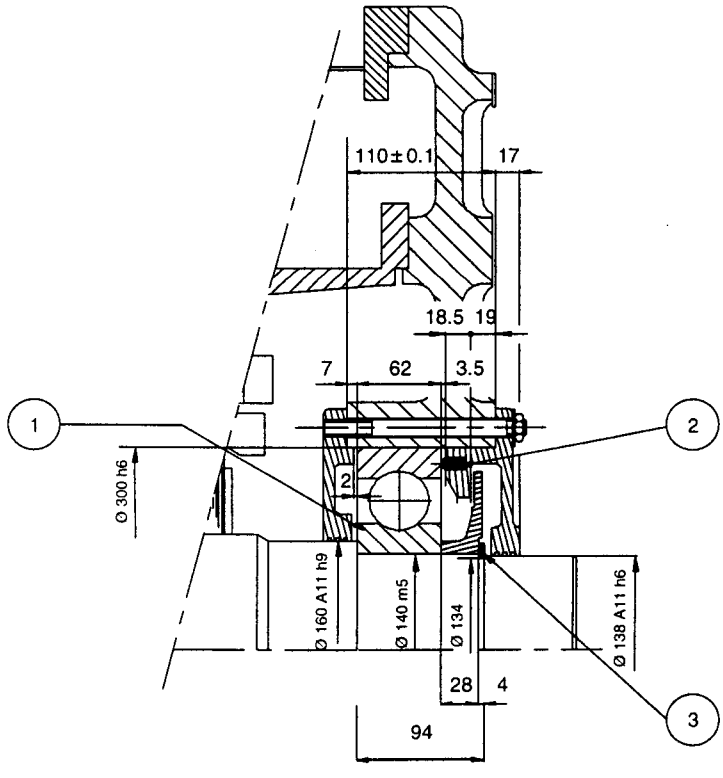
Machine type A52 ; Two bearings; Power plant



1 - Drive end bearing : 6232 MC3 2 - Snap ring 160e 3 - Non drive end bearing : NU1028 MC3

Machine type A52 ; Two bearings ; Marine (non drive end)

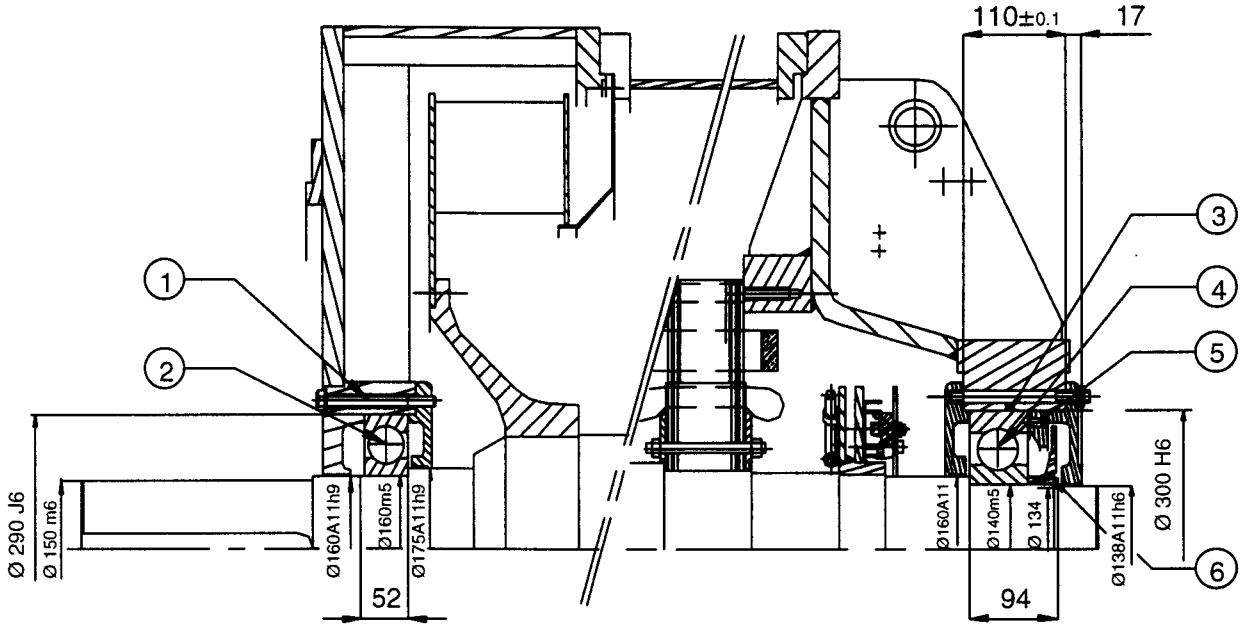
Note ; Drive end bearing Assy identical to the A52 power plant Assy.



1 - Roller bearing : 6328 MC3
2 - Spring
3 - Snap ring 140e

2.3.9 Anti friction bearing installation drawing (following)

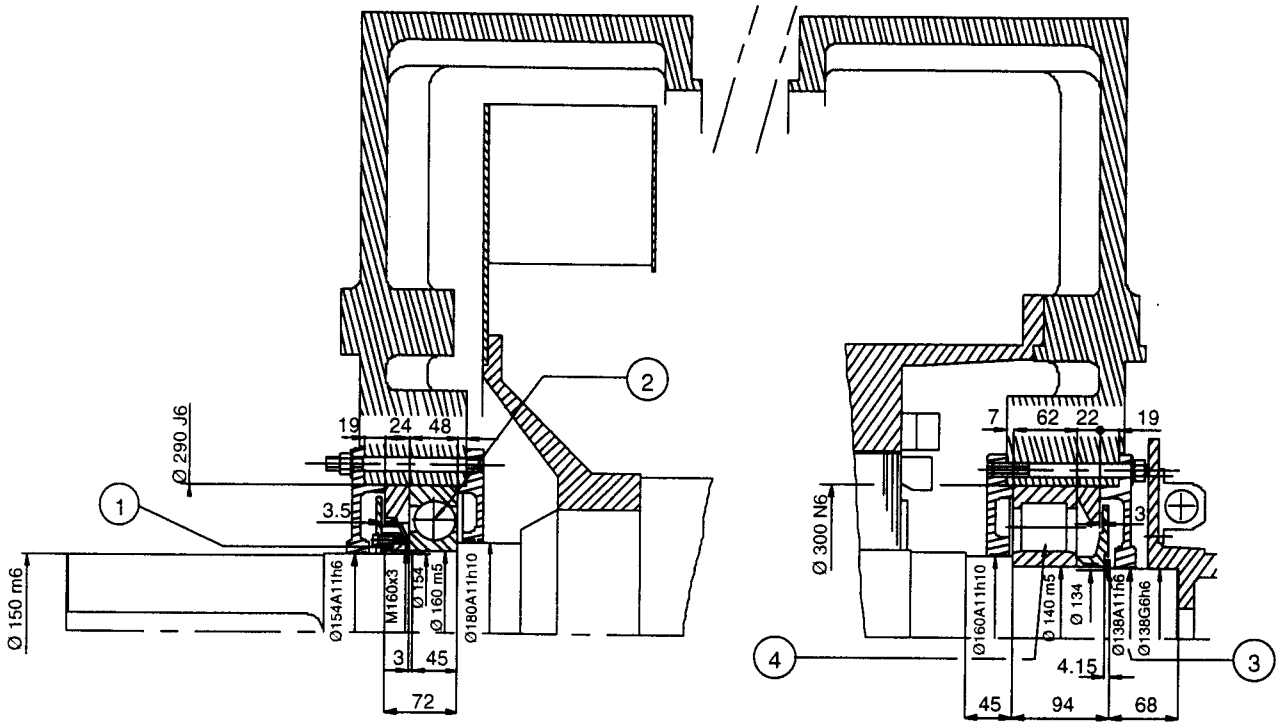
Machine type A53



1 - Screw HM12 120/30
2 - DE bearing : 6232 MC3
3 - O ring Ø extr 297.82 Ø ring 6.99
4 - NDE bearing : 6328 MC3
5 - Spring
6 - Snap ring 140e

2.3.9 Anti friction bearing installation drawing (following)

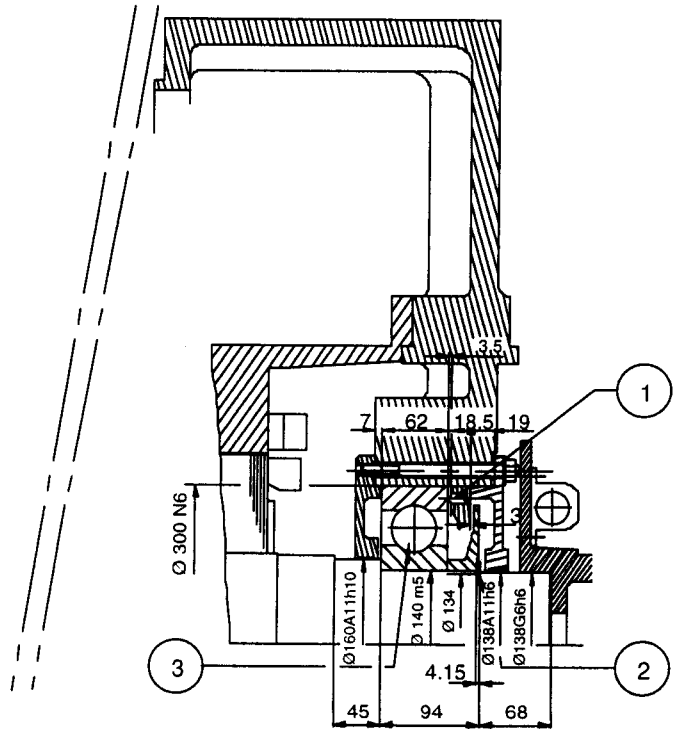
Machine type A54 ; Power plant



1 - Nut+Washer SKF M160 2 - Drive end bearing : 6232 MC3 3 - Snap ring 140e 4 - Non drive end bearing : NU 328

Machine type A54 ; Marine

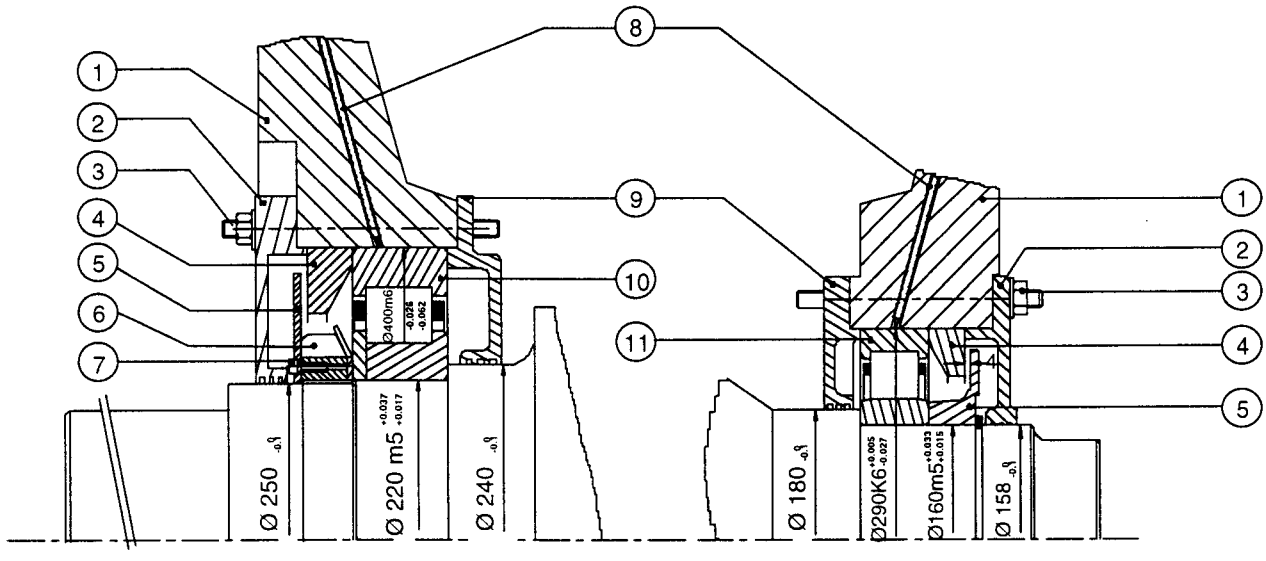
Note : Drive end bearing Assy identical to the A54 power plant Assy.



1 - Spring
2 - Snap ring 140e
3 - Non drive end bearing : 6328 MC3

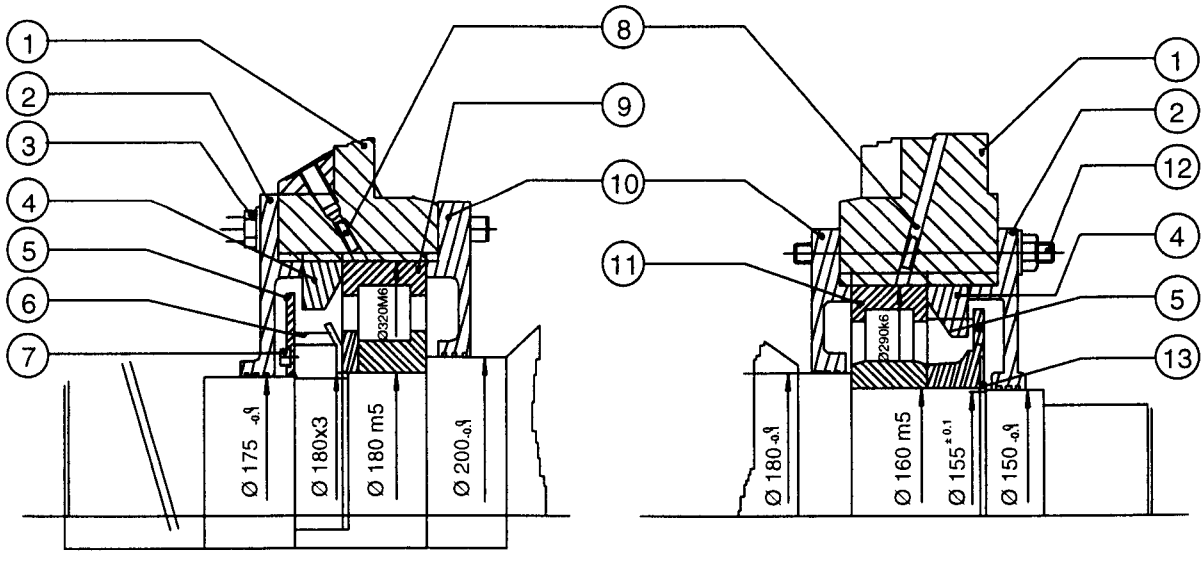
2.3.9 Anti friction bearing installation drawing (following)

Machine type A56 ; Power plant (6 poles and more)



1 - End shield
2 - Outside bearing cover
3 - 4 Goujon m12/150
4 - Fixed deflector
5 - Rotating deflector
6 - Nut
7 - 4 Screw chc M6/16
8 - Bearings sensors
9 - Inside bearing cover
10 - Roller bearing NUP 244
11 - Roller bearing NU 232

Machine type A56 ; Power plant (4 poles only)



1 - End shield
2 - Outside bearing cover
3 - 4 Goujons M16-150-48A
4 - Fixed deflector
5 - Rotating deflector
6 - Nut
7 - 4 Screw chc m6-16
8 - Bearings sensors
9 - Roller bearing NUP 236
10 - Inside bearing cover
11 - Roller bearing NU 232
12 4 Stud bolt M12-126-36
13 Circlips for shafts 160x4

2.4 SLEEVE BEARINGS

Note : For vertical machines refer to the attached specific bearing notice.

2.4.0 Description of horizontal Sleeve bearings

a) Physical description

Rotation of the machine rotor is guided by Sleeve bearings.

The bearing housing is constructed in two ribbed parts providing considerable heat extraction potential.

The sleeve bearing comprises two half-shells with an external spherical shape. This allows self-alignment. The guiding surfaces of the sleeve-bearing are covered with lead-based antifriction metal.

The surface of the housing of the electrically insulated bearings is covered with Teflon. The positioning pin of the sleeve bearing in the housing is also insulated with an insulating bush.

The running surface of the shaft under the sleeve bearing must have a roughness less than 0.63 microns (DIN31699).

The lubrication ring, mounted free on the shaft, is made of brass. In order to simplify dismantling, the ring is cut in two parts, assembled using screws.

A guide for the lubrication ring (synthetic materials) is attached to the upper bearing half-shell (for marine applications only).

The floating labyrinth seals are cut in two parts, held together by an expandable ring. These seals are inserted in a support. A seal-positioning pin rests in the support to block it during rotation.

The upper part of the housing is closed by means of a glass plug allowing observation of the rotation of the lubrication ring. A threaded metal plug allows the bearing to be filled with oil.

Each lower housing may be equipped with an oil-level sight indicator, a thermometer and a temperature sensor.

b) Operating description of Self-lubricating bearing

Upon stopping, the shaft rests on the lower bearing; there is metal-to-metal contact.

During the start-up phase, the shaft rubs against the anti - friction metal of the bearing. Oil lubrication is used.

After having reached its transition speed, the shaft creates its oil film. At this point there is no further contact between the shaft and bearing.

CAUTION :
PROLONGED OPERATION AT EXTREMELY SLOW ROTATION SPEEDS (SEVERAL rpm) WITHOUT LUBRICATION COULD SERIOUSLY DAMAGE THE SERVICE LIFE OF THE BEARING.

c) Operating description of Oil circulation bearing

Proceed as for the self-lubricated bearings.

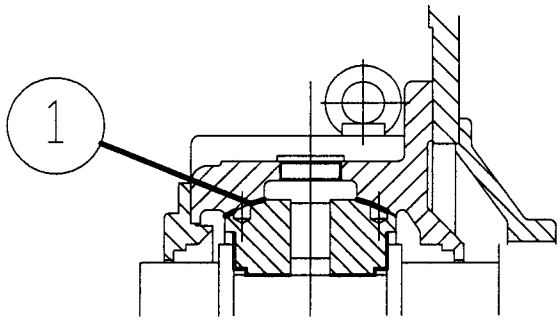
The oil warmed by the bearing losses is externally cooled and is returned directly to the shell. To obtain efficient cooling the oil flow must be correct (refer to section 1).

2.4.1 Electrical insulation of Sleeve bearings

a) Illustration diagram of the insulating film

Following the used technology shaft circulating current may occurs. When necessary, ACEO insulates the Non Drive End bearing to avoid shaft circulating current.

A Teflon film is applied to the bearing housing spherical seat.

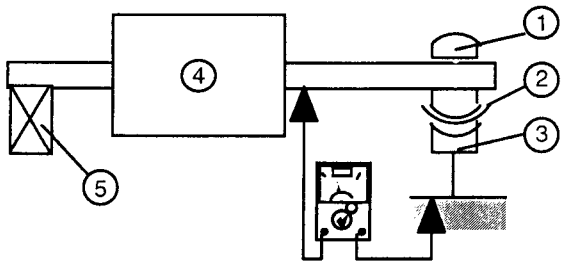


1 - TEFLON insulation

CAUTION :
WHEN INSULATED BEARING IS USED THE ACCESSORIES IN CONTACT WITH THE SHELL MUST BE ELECTRICALLY INSULATED

b) Insulation check

Single bearing machine : Maintain the rotor at the drive end side to insulate it from the earth (disconnect the coupling if not done). Measure the insulating resistance between the shaft and the ground. The insulation should be better than 0.1 MΩ. measured under 500 V DC



1 - Bearing shell
2- Insulating film

3 - Bearing housing
4 - Rotor
5 - Insulating wedging

Double bearing machine : Maintain the rotor at the drive end side to insulate it from the earth (disconnect the coupling; Dismount the drive end bearing if not done). Measure the insulating resistance between the shaft and the ground. The insulation should be better than 0.1 MΩ. measured under 500 V DC

Installed shell accessories (e.g. : RTD) must fit 0.1 MΩ. measured under 500 V DC

2.4.2 Storage of Sleeve bearings machine

When the bearings are not to be used for a long period of time, it is necessary to protect them:

Place an adhesive strip along the parting lines of the housing.

Pour the TECTYL protecting agent through the oil filling hole of the bearing (around 50 cc). Turn the shaft several times in order to spread the product evenly throughout the bearing.

CAUTION :
WE RECOMMEND THE USE OF TECTYL PRODUCTS FROM VALVOLINE GmbH SUCH AS TYPE "511 M"

NOTE :
It is possible to start the machine up without removing the "511.M" protection.

2.4.3 Oil circulation installation

Correct oil flow is obtained by regulating the pressure at the bearing inlet.

The oil circulating bearings are equipped with an oil inlet pressure regulating system.

The delivered oil pressure has to be reduced by the bearing system before entering the bearing (about 0.3 bar up to about 1 bar, refer to start up section).

CAUTION :
REMEMBER THAT THE OIL EXHAUSTED FROM THE BEARING GOES TO THE TANK BY GRAVITY

An inclination of the bearing oil return line (bearing outlet) of around 15° is recommended (a difference of approximately 25 cm for 100 cm in length).

NOTE :
We recommend installation of a downward elbow as close as possible of the bearing oil outlet. This improve s oil outlet flow.

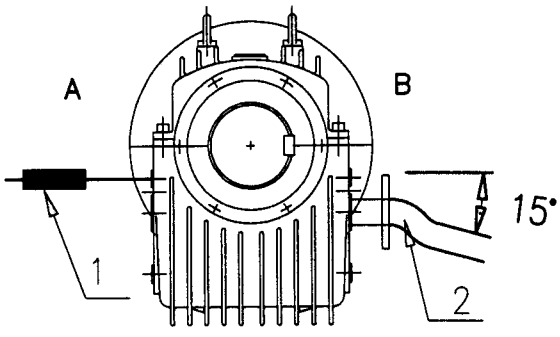
-The oil return lines must not cause back-pressure in the Sleeve bearing housing (this would result in oil leakage). Example : a return line opening into the lower sump of a diesel engine.

A filtering unit must be installed on the supply system. The filtering power must be 25 microns (0.025 mm).

The cross-section of the oil lines must be chosen so that the speed does not exceed 0.15 m/s, a speed based on the full cross-section of the pipes (the required oil flow-rate is given in section 1).

After installation of the oil lines, rinse the entire oil circuit in order to avoid dirt or impurities entering inside the bearing and its connections. Rinse with washing oil. It is important to remove the instrumentation (for example, pressure gauge, flow-meter etc.) during the rinsing operation to avoid any pollution.

NOTE :
Never leave the Sleeve bearing on the rinsing circuit, as insoluble particles could enter the bearing and damage it.



1 - Oil flow regulating system
2 - Output elbow
A - Oil inlet
B - Oil output

2.4.4 Start-up of Sleeve bearings

a) General check before start up

Check that the axial clearance of the front bearing is distributed evenly between the two thrust surfaces of the bearing. To proceed remove the top half housing (refer to service section)

This verification must be carried out upon the first start-up, during periodic inspection of the bearing, or as soon as any part of the bearing alignment is changed (coupling etc.).

After a long shutdown period, check that the shaft has not corroded and fill the bearing oil cavities with oil.

CAUTION :
THE BEARINGS ARE DELIVERED WITHOUT OIL

Clean the external parts of the bearing. Dust and dirt impede the radiation of the heat

Check if the temperature monitoring equipment works.

b) Self-lubricating bearings start up data

Fill the bearing with the recommended oil. The oil must be new, absolutely free of any traces of dust or water.

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

NOTE : It is recommended to filter the oil before filling the bearing.

CAUTION :
NOT ENOUGH LUBRICANT LEADS TO TEMPERATURE RISES AND THUS TO DAMAGE TO THE BEARING.
TOO MUCH LUBRICANT LEADS TO LEAKAGES.

Retighten the split line and flange screws (12), (8), (18) by using the following torque values:

Bearing Size	9	11	14	18	22	28
Torque [Nm] (lightly oiled)	69	69	170	330	570	1150

Check the firm position of the top sight glass (5).

Check the firm position of the oil sight glass (23).

Retighten all screw plugs in the connection holes (4), (22), (24) (27) by using the necessary torque values:

Plugs threads	G 3/8	G 1/2	G 3/4	G 1
Torque [Nm]	30	40	60	110

Plugs threads	G 1 1/4	G 1 1/2	G 2	G 2 1/2
Torque [Nm]	160	230	320	500

Check the operation of the temperature monitoring equipment.

During the start-up period, check the temperature of the bearings. The temperature should stay below 95°C and then drop down to the temperature normally recommended (refer to the technical characteristics for Sleeve bearings in Section 1.)

c) Water cooled bearing (type EFW..) start up data

Proceed as for the self-lubricated bearings and check the operation of the water cooler.

d) Oil circulation bearing (type EFZ..)

The oil circulating bearings are delivered with :
- a breather
- an oil inlet flow regulating system.

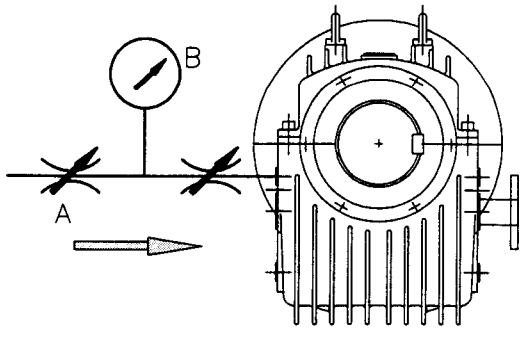
The "oil inlet regulating system" consists of :
- an adjustable pressure reducing valve "A"
- a low pressure manometer "B"
- a diaphragm.

Ensure that the complete oil supply and return lines have been rinsed as instructed in the "oil circulation installation" section.

Ensure that the installation instructions have been followed (refer to "oil circulation installation section) such as filtering unit, return line properly inclined etc.

Proceed as for the self-lubricated bearings and then start the oil supply system (pump etc.), run the motor.

To adjust the oil flow :
Insert an oil flow-meter in the supply line upstream of the "oil inlet regulating system".



Adjust the pressure reducing valve "A" to obtain the correct oil flow (refer to the motor data).

Record the pressure value get on manometer "B".

Stamp (or print with a permanent marker pen) the recorded pressure onto the bearing local nameplate.

During motor operation the oil level in the bearing must comply with the indications in Section 2.4.5.

e) Inspection of Sleeve bearings at the end of start-up

Supervise the bearing during the trial run (5-10 operating hours).

Pay special attention to:
- oil level
- bearing temperature
- sliding noises of the shaft seals
- tightness
- occurrence of vibrations.

CAUTION :
If the bearing temperature exceeds the calculated value of 15 K stop the machine immediately. Inspect the bearing and determine the causes.

Before proceeding to the next stage, it is necessary to dismantle the top of the bearing housing (see Section 2.4.6). After 5 to 10 hours of operation, it is recommended to inspect the bearings to check the appearance of anti - friction metal. Possible scratches or axial pressure marks will have to be carefully scraped off. Replace the oil.

2.4.5 Maintenance of Sleeve bearings

a) Verification of oil-level

Check the oil level at regular intervals.

The oil level limits are as follows:
minimum oil level: bottom of the oil sight glass
maximum oil level: below the top of the oil sight glass

b) Temperature verification

Check the bearing temperature and record it. A bearing temperature which suddenly varies without any obvious reason (change of ambient temperature etc.) indicates abnormal operation. It is then necessary to inspect the bearing.

c) Oil draining

NOTE :
Risk of pollution! Please observe the instructions for the use of the lubricating oil. The manufacturer can provide information on waste oil disposal

It is recommended to drain the oil at intervals of 4000 hours of operation.

Shut down the installation and secure it against unintended operation.

Take all necessary measures to collect all of the lubricating oil.

Release the lubricating oil while it is still warm. Impurities and residues will thus be removed.

Unscrew the oil drain plug (27). Release the lubricating oil and collect it.

NOTE :
If the lubricating oil contains unusual residues or is visibly

changed, eliminate the causes. If necessary, carry out an inspection.

Tighten the oil drain plug (27) using the following torque values:

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

Remove the screw plugs from the oil filler hole (4).

NOTE :
Make sure that no impurities get into the bearing.

Use a lubricant with the viscosity indicated on the bearing type plate. Fill the lubricant through the oil filler hole (4) up to the middle point of the oil sight glass (23).

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

NOTE :
Insufficient lubricant leads to temperature rises and thus to damage to the bearing.
Too much lubricant leads to leakage's. In the case of bearings lubricated by a loose oil ring, too much lubricant could break the oil ring, thus leading to damage to the bearing.

Tighten the screw plug into the oil filler hole (4) using the following torque values:

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

d) Pressure measurement of a Sleeve bearing housing

The external environment of the electric machine may cause pressurising or depressurising of the Sleeve bearing and lead to oil leakage.

Example : The oil return line (of a circulation bearing) opening directly into a diesel motor lower sump and allowing the housing back-pressure to return to the bearing.

Example : A vacuum generated by a coupling located too close the Sleeve bearing and acting as a fan.

The relative depression (or pressure) during operation must remain less than 5 mm of water column. The relative pressure is the pressure difference which exists between the bearing oil sump and the bearing outside (measured close to the seals).

Pe : external pressure close to the seal

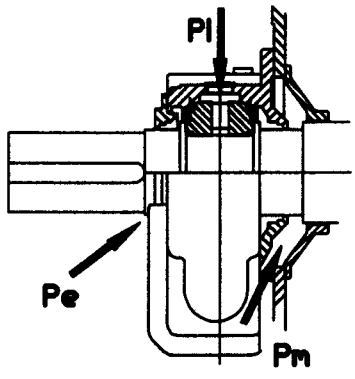
Pi : bearing oil sump pressure

Pm : machine expansion chamber (gain access as indicated by the arrow)

$\Delta(Pe - Pi) < 50Pa$

$\Delta (Pm - Pi) < 50Pa$

Note: 50Pa=5mmWC



Field pressure measure :

Using a transparent tube as water column manometer.

Connect a flexible transparent tube to the upper part of the bearing. Connect a pressure tap corresponding to the flexible tube used.

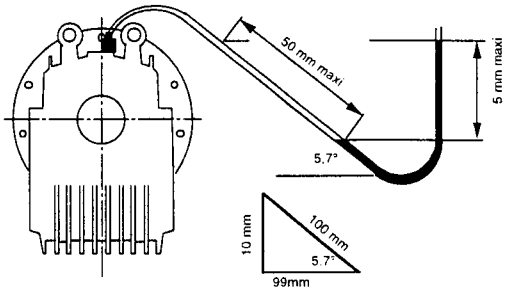
Install the pressure tap in place of the filling plug located on the top of the bearing housing.

Partially fill the pipe with water.

NOTE :
Be careful not to cause water to enter the bearing

Measure the pressure (or depression) in millimetres of water column.

NOTE :
Given the low pressures measured, to make the reading easier it is advised to incline the water column manometer by 5.7° (diagram below). A reading amplification of "10" is thus obtained.



e) Oil for sleeve bearing

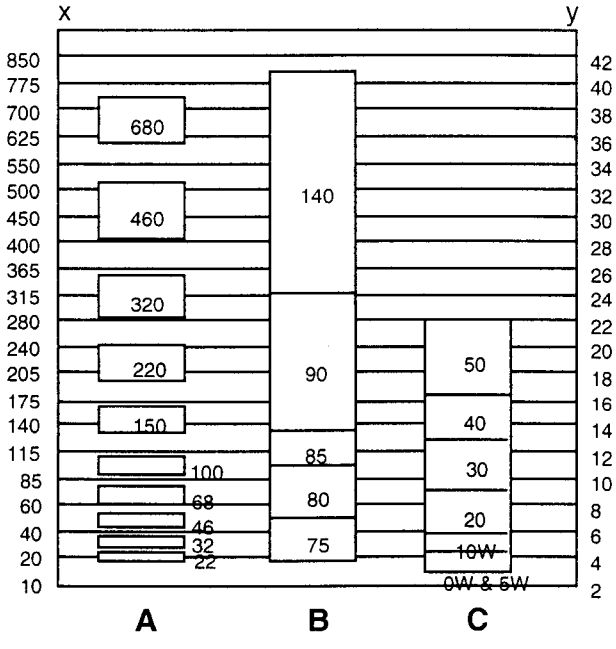
We do not have any special recommendation regarding any oil manufacturer.

The used oil must comply with the requested viscosity (refer to Section 1).

For frequent cold starting (lower than -15°C) without oil sump heater please contact us. A new oil viscosity may be advised.

Use a non-foaming mineral oil, without additives. If an oil containing additives has to be used, make sure that the supplier confirms the chemical compatibility of the oil and the lead antifriction properties.

Viscosity data (for information)



x - cSt at 40°C
y - cSt at 100°C
A ISO (VG)
B - SAE J306c Transmissions
C - SAE J300d Motors

Few examples of suppliers :

	viscosity ISO	viscosity (cSt ; 40°C)	Type
ARAL	VG 32	32	Motanol GM 32
	VG 46	46	Motanol HK46
	VG 68	68	Motanol HK 68
BP	VG 32	31,5	Energol CS 32
	VG 46	46	Energol CS 46
	VG 68	68	Energol CS 68
CHEVRON	VG 32	30,1	OC Turbine Oil 32
	VG 46	43,8	OC Turbine Oil 46
	VG 68	61,9	OC Turbine Oil 68

	viscosity ISO	viscosity (cSt ; 40°C)	Type
ESSO	VG 32	30	TERESSO 32
	VG 46	43	TERESSO 46
	VG 68	64	TERESSO 68
MOBIL	VG 32	29,6	D.T.E. Oil Light
	VG 46	43,4	D.T.E. Oil Medium
	VG 68	63,9	D.T.E. Oil Heavy Medium
SHELL	VG 32	32	Vitrea Oil 32
	VG 46	46	Vitrea Oil 46
	VG 68	68	Vitrea Oil 68
TEXACO	VG 32	30	Rando Oil A
	VG 46	41	Rando Oil B
	VG 68	57	Rando Oil C

f) Oil sump capacity

Bearing size	9	11	14	18	22	28
volume (litter)	1.8	3.8	5.4	9.2	17.5	28.6

2.4.6 Dismantling

a) Tools and equipment

The following tools and equipment are necessary:
- Allan key set
- Wrenching key set
- Open-jaw spanner set
- Feeler gauges (up 0.05mm)
- Calliper gauge
- Emery paper, Sleeve scraper
- Lifting equipment
- Permanent sealing compound (e.g. Curil T)
- Clean cloth
- Oil with the viscosity indicated (see bearing type plate)
- Detergents
- Liquid screw locking compound (e.g. LOCTITE 242)
- Liquid sealing compound and Teflon tape.

DANGER
BEFORE TRANSPORTING OR LIFTING CHECK IF THE EYE BOLTS ARE TIGHT! INSECURE EYE BOLTS COULD RESULT IN THE 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 the lifting equipment.

NOTE :
Make sure that the work place is clean. Contamination and damage to the bearing, especially of the running surfaces, have a negative influence on the operating quality and could lead to premature damage.

Shut down the installation and ensure that any unintended operation is prevented.

Interrupt the cooling water supply (EFW.. bearing only).

Remove all thermo sensors from the connection holes.

Take all necessary measures to collect the lubricating oil.

Unscrew the oil drain plug (27) and collect the lubricating oil (refer to draining section)

b) Lifting equipment

The following steps are to be observed before using the lifting equipment:

To transport the complete bearing unit

Check if the split line screws are tight (12):
Check if the eye bolts are tight (6).
Connect the lifting equipment to the eye bolts (6).

To transport the top half of the housing

Check if the eye bolts are tight (6).

Connect the lifting equipment to the eye bolts (6).

To transport the bottom half of the housing

Screw 2 eye bolts (6) with suitable threads tight into the tap holes (17) marked with a cross.

Bearing size	9	11	14	18	22	28
Tap hole	M 12	M 12	M 16	M 20	M 24	M 30

Connect the lifting equipment to the eye bolts (6).

To transport the Bearing shells

Screw 2 eye bolts or screw hooks with suitable threads tight into the tap holes (9):

Bearing size	14	18	22	28
Tap hole	M 8	M 12	M 12	M 16

Connect the lifting equipment to the screw hooks.

c) Dismantling of the shaft seal type 10 (outboard side)

Loosen all screws (44) and turn them off.

Remove simultaneously in axial direction both top half (37) and bottom half (40) of the seal carrier from the housing.

Shift the top half of the seal (42) a little (about 20 mm). Tilt it over carefully until the hook spring (38) unbends.

DANGER :
DURING DISMANTLING OF THE FLOATING LABYRINTH SEAL HOLD TIGHT THE HOOK SPRING (38). THIS IS UNDER TENSION AND COULD SPRING BACK AND LEAD TO INJURY.

Open the hook spring (38) and remove the bottom half of the seal (41) from the shaft.

d) Dismantling of the shaft seal type 20 (outboard side)

Untighten all seal fixing screws (49) and remove them.

Simultaneously remove in axial direction both top and bottom (48) ,(52) halves of the rigid labyrinth seal.

- Remove the split line screws (50).

- Separate the top half of the rigid labyrinth seal (48) from the bottom half (52).

e) Dismantling of the top half of the housing

Remove the flange screws (8).

Remove the split line screws (12).

Lift the top part of the housing (1) until the top part of the housing can be moved in axial line over the bearing shell, without touching it.

f) Removal of the top half of the shell

Unscrew the split line screws (19) and lift the top half of the shell (11).

CAUTION :
DO NOT DAMAGE THE THRUST AND RADIAL RUNNING SURFACES.

g) Dismantling 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.

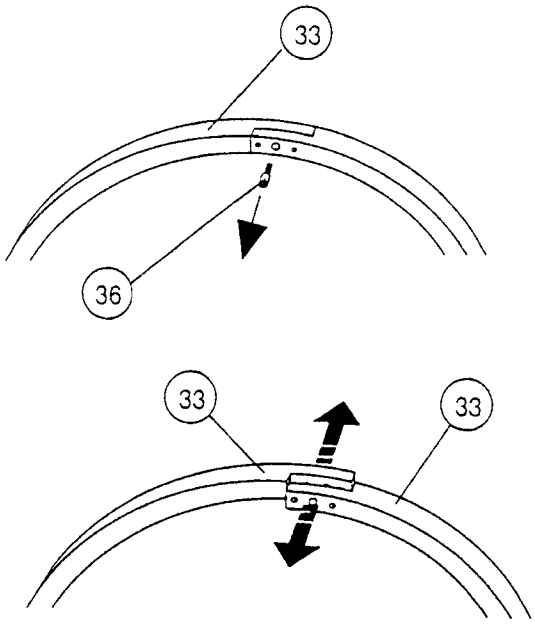


Illustration 1 : Opening of the loose oil ring

To check the geometry of the loose oil ring put it together as follows:

Press the positioning pin (34) into the holes (35).

Adjust both halves of the loose oil ring till the split lines match each other.

Tighten the screws (36).

h) Dismantling the machine side shaft seal

Shift the top half of the seal (42) a little (about 20 mm). Tilt it over carefully until the hook spring (38) unbends.

DANGER :
DURING DISMANTLING OF THE FLOATING LABYRINTH SEAL HOLD TIGHT THE HOOK SPRING (38). THIS IS UNDER TENSION AND COULD SPRING BACK AND LEAD TO INJURY.

Open the hook spring (38) and turn the bottom half of the seal (41) in the opposite direction to the anti-rotation pin out of the integrated seal groove of the bottom half of the housing.

i) Removal of the bottom half of the shell

CAUTION :
MAKE SURE THAT ALL BEARINGS MOUNTED ON A SHAFT LINE ARE OPENED. LOOSEN THE SPLIT LINE SCREWS OF THE HOUSINGS.

CAUTION :
THE LIFTING EQUIPMENT SHOULD NOT COME IN TOUCH WITH THE SEAL AND RUNNING SURFACES OF THE SHAFT.

Lift the shaft up to the point where shaft and bottom half of the shell (13) do not touch each other any more. Protect the shaft against unintended movement.

Turn the bottom half of the shell (13) out of the bottom half of the housing (21) and remove it from the shaft.

j) Dismantling of the machine seal

Usually it is not necessary to dismantle the machine seal (10) if maintenance works are carried out.

If due to certain reasons the split machine seal must be dismantled please observe that this operation can be carried out only from the inner part of the machine. Loosen the split line screws of the machine seal and remove the flange screws (7).

Non-split machine seals can be dismantled only after dismantling the machine shield or the shaft completely.

In the case the machine seal is equipped with a hamp packing, some visible changes can be noticed, such as : tallow excess, black colour of the seal due to temperature development. Even in such cases it is not necessary to renew the hamp packing. Colour changes will appear with a new hamp packing too, until the seal clearance adjusts during operation.

2.4.7 Cleaning and checking

a) Cleaning

CAUTION :
USE ONLY NON-AGGRESSIVE DETERGENTS SUCH AS FOR INSTANCE
· VALVOLINE 150
· ALKALINE CLEANING COMPOUNDS (PH-VALUE 6 TO 9, SHORT REACTION TIME).

DANGER :
PLEASE OBSERVE THE INSTRUCTIONS FOR THE USE OF THE DETERGENTS.

CAUTION :
NEVER USE CLEANING WOOL OR CLOTH. RESIDUES OF SUCH MATERIALS LEFT IN THE BEARING COULD LEAD TO EXCESSIVE TEMPERATURES.

Clean the following parts thoroughly:
top half of the housing (1)
bottom half of the housing (21)

top half of the shell (11)
bottom half of the shell (13)
sealing surfaces of the top half (37) and bottom half (40) of the seal carrier or of the rigid labyrinth seal
loose oil ring (33).

Water cooler cleaning (bearing type EFW.. only)

Check the condition of the oil cooler (26).

In case the oil cooler (26) is encrusted with oil sludge:

Dismantle the oil cooler. Remove the encrustation by using for instance a wire brush.

Install the oil cooler (26) into the bearing.

b) Wear checking

Carry out a visual check of the wear condition of all bearing parts. The following graph provides information on the parts that must be replaced in case of wear. The right evaluation of the wear condition, especially of the running surfaces of the bearing shell, implies a lot of experience. If in doubt, replace the worn part with new ones.

Part	Wear condition	Maintenance proceedings
Shell	Scoring	Bearing temperature before inspection: · not increased no new shells · increased new shells
	White metal lining damaged	New shell
	Bow wave ridges	New shells
Shaft seal	Baffles broken or damaged	New shaft seal
Loose oil ring	Geometrical form (roundness, flatness) visibly changed	New loose oil ring

c) Insulation checking (only for insulated bearing)

Check the insulating layer of the spherical seating (14) of the top half (1) and bottom half (21) of the housing. In case of damage contact ACEO factory.

2.4.8 Assembly of the Bearing

CAUTION :
REMOVE ALL IMPURITIES OR OTHER OBJECTS SUCH AS SCREWS, NUTS, ETC. FROM INSIDE THE BEARING. IF LEFT INSIDE THEY COULD LEAD TO DAMAGE OF THE BEARING. COVER UP THE OPENED BEARING DURING BREAKS.

CAUTION :
CARRY OUT ALL ASSEMBLY OPERATIONS WITHOUT MAKING USE OF FORCE.

CAUTION :
USE A LIQUID SCREW LOCKING COMPOUND (E.G. LOCTITE 242) FOR ALL HOUSING, SPLIT LINE AND FLANGE SCREWS.

a) Fitting in the bottom half of the shell

Apply some lubricant on the spherical seating (14) in the bottom half of the housing (21) and on the running 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 (13) on the running surface of the shaft. Turn the bottom half of the shell (13) 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 does not turn in easily, check the position of the shaft and the alignment of the bearing housing

CAUTION : (ONLY FOR BEARINGS EF..K)
THESE OPERATIONS SHOULD BE CARRIED OUT MOST CAREFULLY. THE THRUST PARTS OF THE BOTTOM SHELL SHOULD NOT BE DAMAGED.

Lower down the shaft till it sits on the bottom half of the shell (13).

b) Assembly of the shaft seal machine-side

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

DANGER :
DURING ASSEMBLY HOLD THE HOOK SPRING ENDS (38) 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 hook 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 hook spring (38) into the spring groove (39).

Turn the floating labyrinth seal on the shaft.

CAUTION :
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 it from the shaft. Remove the worn parts of the seal carefully, by using emery paper or a Sleeve scraper.

Dismantle the floating labyrinth seal.

Apply Curil T on the guide surfaces of the integrated seal groove in the bottom half of the housing.

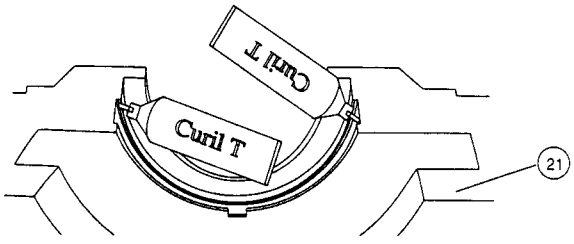


Illustration 2: Coating of Curil T on the integrated seal groove

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

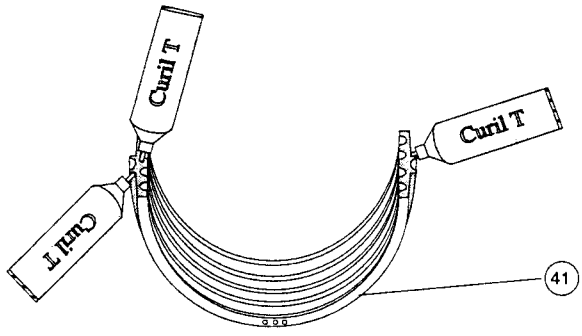


Illustration 3 : Coating of Curil T on the floating labyrinth seal

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 opened.

Turn the seal in the opposite direction to 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 rest of the Curil T.

Push the spring hook 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 hook spring until both ends can be hooked.

c) 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.

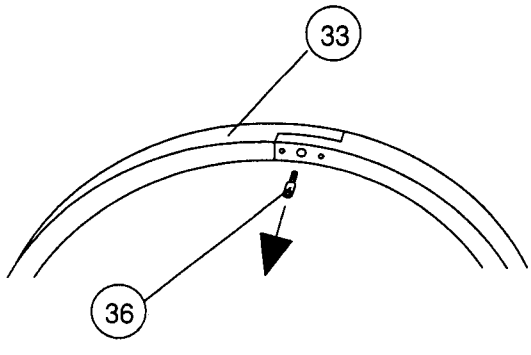


Illustration 4 : Opening of the loose oil ring

Place both halves of the loose oil ring into the shell groove (13) 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 until the split lines match each other.

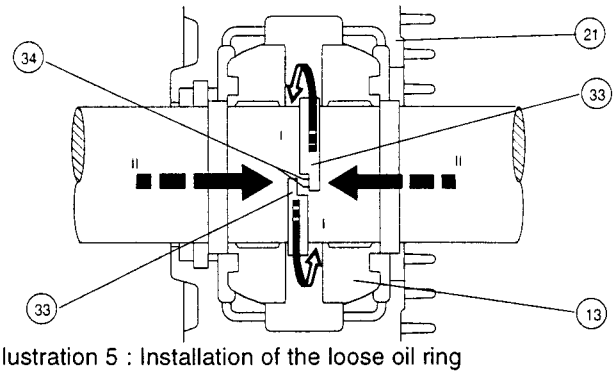


Illustration 5 : Installation of the loose oil ring

Tighten the screws (36) by using the following torque values:

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

d) Fitting in the top half of the shell

Apply some lubricant on the running surfaces of the shaft. Use the same type of lubricant as indicated for bearing operation (see type plate).

Check if the engraved numbers (15) on the bottom and top halves of the shell correspond.

Place the top half of the shell (11) on the shaft; both engraved numbers (15) should be on the same side.

CAUTION :
AN INCORRECTLY PLACED SHELL COULD JAM THE SHAFT THUS LEADING TO THE DAMAGE OF BOTH SHAFT AND BEARING.

CAUTION : (FOR BEARINGS TYPE EF..K ONLY)
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.

Tighten up the split line screws (19) by using the following torque values:

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

Check the split line of the bearing 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 and bottom (11), (13) halves of the shell.

Check the mobility of the loose oil ring (33).

Marine bearing only:
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.

e) Closing of the bearing

Check the true alignment of the shell (11), (13) and bottom half (21) of the housing.

The positioning pin (3) in the top half of the housing fits in the corresponding positioning pin hole (2). The bearing shell is thus placed into its right position.

Check if the engraved numbers (20) on the top and bottom halves of the housing correspond.

Clean the split line surfaces of the top and bottom halves (1), (21) 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 bearing shell.

Lower the top half of the housing (1) vertically on the bottom half of the housing (21). Lower the top half of the housing (1) until 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 split line screws (12). Tighten them hand-tight.

Insert the flange screws (8). Tighten them using the following torque values:

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

Tighten the split line screws (12) of the housing crosswise using the same torque values

f) Assembly of the type 10 Outboard Side Seals

DANGER :
DURING ASSEMBLY HOLD THE HOOK SPRING ENDS (38) 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.

Place the hook spring (38) around the shaft and hook both ends into each other.

Locate both halves of the seal (41), (42) in their place on the shaft.

Locate the hook spring (38) in the spring groove (39).

Turn the floating labyrinth seal on the shaft.

CAUTION :
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 it from the shaft. Remove the worn parts of the seal carefully, by using emery paper or a Sleeve scraper.

Dismantle the floating labyrinth seal.

Apply a uniform layer of Curil T on the seal 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.

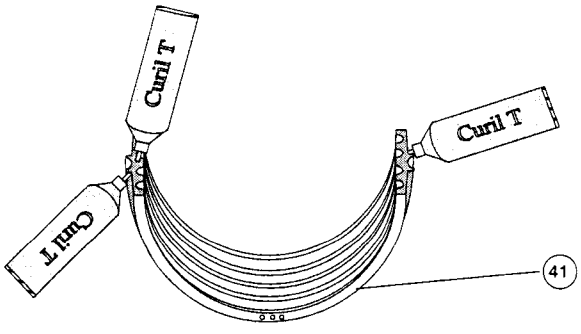


Illustration 6 : Application of Curil T on the floating labyrinth seal

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 hook spring (38) into the spring groove (39) and stretch until both ends can be hooked.

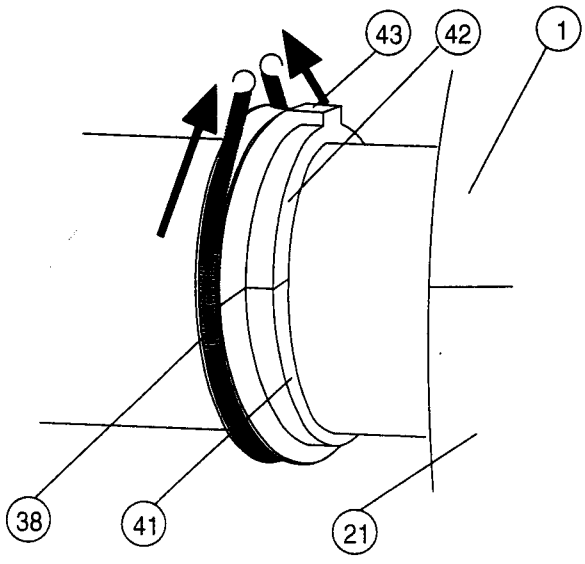


Illustration 7 : Assembly of the floating labyrinth seal

Align 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:
the seal surfaces of the top (37) and bottom (40) half of the seal parts: carrier (the groove of the floating labyrinth seal, the flange surfaces)
the split line surfaces of the top (37) and bottom (40) half of the carrier
the flange surfaces of the housing.
Apply a uniform layer of Curil T on:
the lateral surfaces of the groove at the top (37) and bottom (40) half 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.

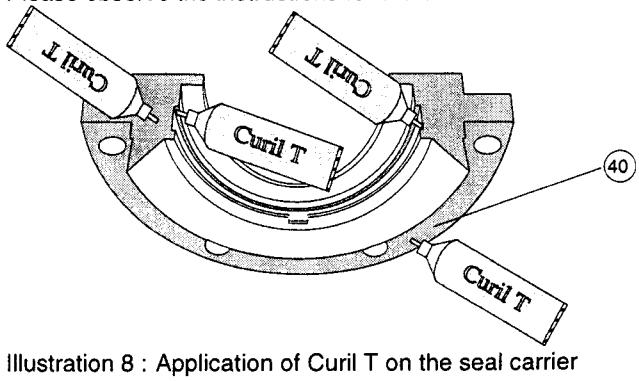


Illustration 8 : Application of Curil T on the seal carrier

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.

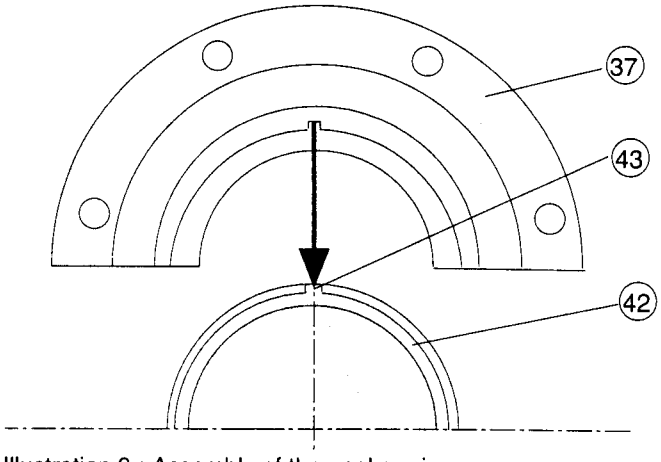


Illustration 9 : Assembly of the seal carrier

Align the split lines of the seal carrier and the housing.

Tighten up the screws (44) by using the torque values:

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

g) Assembly of the type 20 Outboard Side Seals

Check if the engraved numbers on the bottom half (52) and top half (48) of the rigid labyrinth seal correspond.

Clean the flange surfaces of
the top half and bottom half (52) of the rigid labyrinth seal
the split line surfaces of the top half and bottom half (52) of the rigid labyrinth seal
the flange surfaces of the housing.

Apply a uniform layer of Curil T on 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.

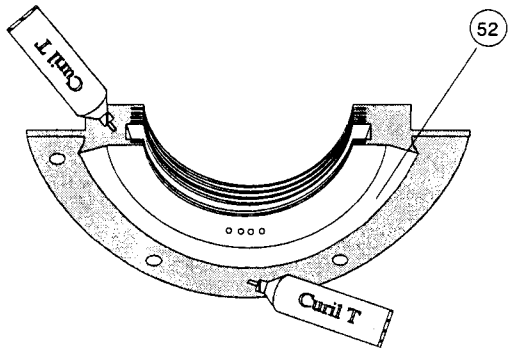


Illustration 10: Application of Curil T on the rigid labyrinth seal

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 split line screws (50).

Place in parallel alignment the split line of the rigid labyrinth seal and the split line of the housing.

CAUTION :
PRESS THE RIGID LABYRINTH SEAL 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.

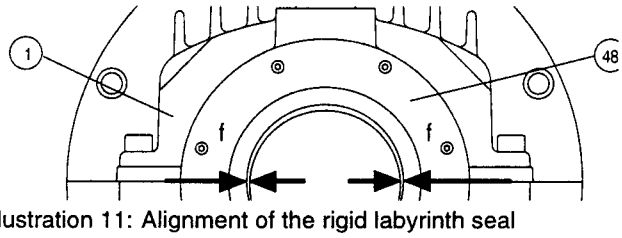


Illustration 11: Alignment of the rigid labyrinth seal

Tighten the screws (49) by using the following torque values:

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

h) Assembly of the RD-thrust pads ; bearing type E...A

Clean both top and bottom halves of the shroud ring and all RD-thrust pads..

Check if the parts show any visible damage.

Carry out the assembly of both thrust parts of the top (6) and bottom (27) half of the shell according to the following instructions:

An RD-thrust pad on both sides of the top half of the shell has a bore for the insertion of a thermo sensor (thrust part temperature measurement).

To mount the RD-thrust pad into the correct position proceed as follows:
- Find the position of the location hole (38) on the top half of the shroud ring (39).Insert the RD-thrust pad (42) with the anti-rotation pin (43) into the corresponding thrust pad location hole (37).

Insert all other RD-thrust pads (42) into the corresponding thrust pad holes (37)
of the top and bottom half of the shell (6),(27).

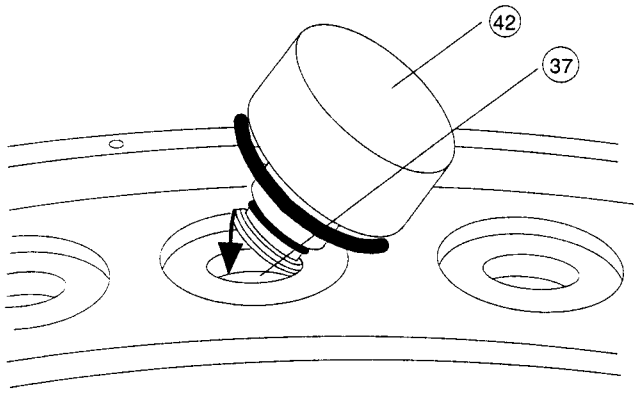


Illustration 1: Assembly of the RD-thrust pads

Place the top half of the shroud ring (39) into the top half of the shell (6) by inserting the anti-rotation pin (43) into the location hole (38). Match the split line of the top half of the shell (6) with the split line of the top half of the shroud ring (39) in true alignment.

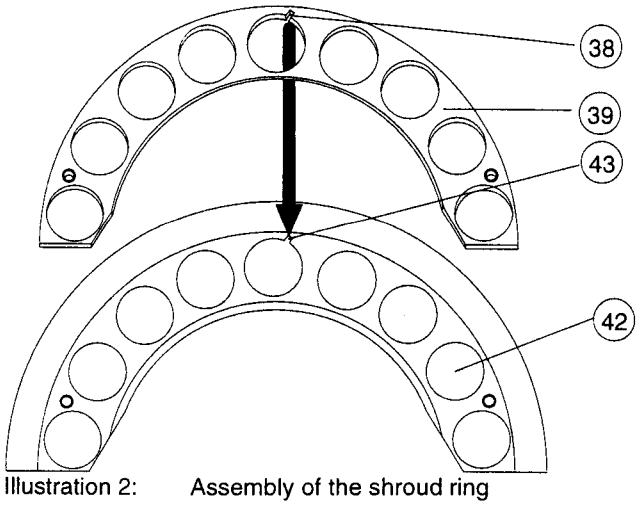


Illustration 2: Assembly of the shroud ring

Tighten the screws (40) by using the following torque values:

Bearing size	9	11	14	18	22	28
Tap hole	M4	M4	M5	M6	M8	M10
Torque [N.m]	1,4	1,4	2,7	8	20	40

Place the bottom half of the shroud ring (41) into the bottom half of the shell (27). Match the corresponding split lines in true alignment. Tighten the screws (40) with the same torque value as valid for the top half of the shell (6).

Check the mobility of all RD-thrust pads (42).
If the RD-thrust pads jam, realign the top (39) and bottom half (41) of the shroud ring.

CAUTION
INSUFFICIENT MOBILITY OF THE RD-THRUST PADS WILL CAUSE DAMAGE OF THE BEARING.

Both top and bottom halves of the shells are prepared for assembly.

2.4.9 Oil-leakage trouble-shooting

Oil leakage can occur in the Sleeve bearings if certain measures are not taken.

a) Self-lubricating bearing

- Is the oil level correct? (see section 2.4.5.a)

- Is the Sleeve bearing in decompression? (see section 2.4.5.d). If the depression level is abnormal, add a protective screen.

- Is the leakage occurring around the parting line? Clean the parting lines carefully with a solvent; apply "CURYL T" upon reassembly (see section 2.4.6)

b) Oil circulation bearing

- All information and instructions concerning the "self-lubricating bearings" apply.

- Is the bearing oil flow correct (for data refer to section 1)? To adjust the oil flow refer to "start up of sleeve bearing" section

-Is the Sleeve bearing under pressure?
To measure refer to section "Maintenance of sleeve bearings" section. This pressure most certainly comes from the oil-return circuit. Check the oil-return circuit (see section 2.4.4.c). The back-pressure can often be eliminated by inserting a siphon-effect on the oil-return line (then make sure that the circuit modification does not disturb the oil-return flow).

2.4.10 Sleeve bearing protection devices

a) Sight-level glass

A sight-level gauge is placed on each bearing housing (on the left or the right). The level control method is described in section 2.4.5

b) Oil thermometer (optional)

The oil thermometer gives the housing oil temperature.

The recorded oil temperature must stay below 90°C

c) Thermostat or sensor (optional)

The sensor gives the temperature of the bearing.

Shell metal ; Alarm points and shutdown:

- alarm 90°C (194°F)
- shutdown 95°C (203°F)

Oil sump ; Alarm points and shutdown:

- alarm 85°C (185°F)
- shutdown 90°C (194°F)

d) Pumping up pump (optional)

A pump takes up the oil from the bearing oil sump and pours it over the bearing shell. This pump ensures bearing lubrication, increasing the greasing effect during operation at very low speed.

Check the electrical connection of the pump motor to be sure of the rotation direction (the rotation direction is indicated on the pump).

2.7 COOLER

2.7.0 Description of the cooler

a) General points

The purpose of the cooler is to remove machine heat losses (mechanical, ohmic etc.). The exchanger is located on the top of the machine.

Normal operation:
The internal air goes through the exchanger, transferring the heat and then goes back to the machine.

b) Description of Air/Air coolers

The internal air flow is moved by a fan fixed on the machine shaft. The internal cooling air circulates through the machine and through the air-cooler in a closed circuit. The external air circulation can be created through natural ventilation (machine class IC 5 A1 A1) or through separate ventilation(machine class IC 5 A1 A7). The manufacture of the air-cooler depends on the type of construction of the machine. The air-cooler comprises tubes, of tube plates and of a hood removable with the fan. The tubes are roll-expanded inside the tube plates. The material constituting the tubes depends on the operating ambient air. Cooler technical data following section 1.

c) Description of Air/Water double tube exchanger

The internal air flow is moved by a fan fixed on the machine shaft. The internal cooling air circulates through the machine and through the air-cooler in a closed circuit. The internal air circulation can be created through natural ventilation (machine class IC 8 A1 W7) or through separate ventilation(machine class IC 8 A6 W7).

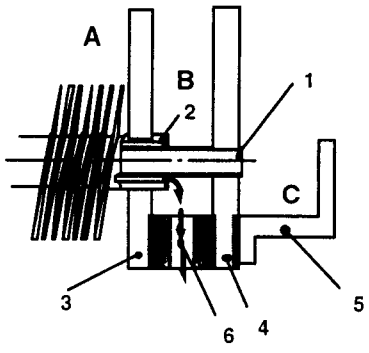
The double-tube technique keeps the cooling circuit from being affected by possible water leakage. The double tube provides a high safety level. In case of leakage, the water goes from the inside of the internal tube to the coaxial space between the two tubes. The water is drained axially to a leakage chamber where it may activate a sensor.

An exchanger comprises a fin-tube block containing :

- a steel frame.
- a fin-tube block crimped mechanically to the tubes.

The tube bundle is roll-expanded in the end plates (parts 3 and 4)

The water distribution in the tubes is provided by two removable water boxes (part 5). A water box is equipped with collars for fitting the inlet and outlet lines. Neoprene seals ensure watertightness between the water boxes and the end plates.



1 - Single internal tube
2 - External tube with internal grooving and with external fins
3 - Internal plate
4 - External plate
5 - Outside wall of the pressure tank
6 - Flow of water or liquid leaks

A - Air
B - Leakage
C - Water

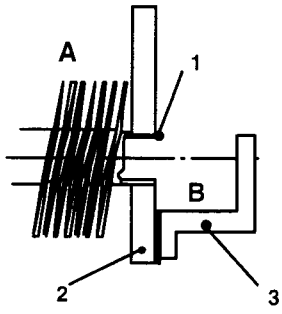
d) Description of Air/Water single tube exchanger

The internal air flow is moved by a fan fixed on the machine shaft. The internal cooling air circulates through the machine and through the air-cooler in a closed circuit. The internal air circulation can be created through natural ventilation (machine class IC 8 A1 W7) or through separate ventilation(machine class IC 8 A6 W7) .

An exchanger comprises a fin-tube block containing
• a steel frame
• a fin-tube block crimped mechanically onto the tubes.

The tube bundle is roll-expanded in the end plates

The water distribution in the tubes is provided by two water boxes. One water box is equipped with collars for fitting the inlet and outlet water lines. Neoprene seals provide watertightness between the water boxes and the end plates.



1 - Tube with fins
2 - End plate
3 - Water box

A - Air
b - Water

2.7.1 Start-up of the cooler

a) General points

Make sure that the safety devices are operating.

Connect the supply and return lines.

Fill with water, whilst carefully draining the circuit.

CAUTION : (machine with motorised fan only)
WE RECOMMEND THAT THE FREE OPERATION OF THE FAN BE CHECKED (NO FRICTION, NO BLOCKING).

CAUTION :
BEFORE START-UP, CHECK THE CLEANLINESS OF THE COOLER FINS.

Start up the installation (if the other sub-assemblies allow this).

Load the machine (kVA); adjust the water flow-rate to obtain the rated flow-rate (refer to Section 1).

Check the watertightness of the lines and of the exchanger.

Check that the temperatures comply with the recommended temperatures.

2.7.2 Maintenance of the water-cooler

a) Cleaning

The frequency of cleaning operations depends essentially on the purity of the water used. We recommend a minimum of one inspection after one complete year of operation and then to determine the further maintenance schedule following the observed durt level.

Stop the machine.

Cut off the power supply by isolating the inlet and outlet lines, and drain the water.

Disconnect the leak sensor (option with double-tube cooler), and make sure that there are no leaks.

Remove the water boxes on each side of the machine.

Rinse and brush each water box.

NOTE :
Do not use a hard wire brush as this will remove the protective oxidation layer which has formed on the surfaces of the water boxes. Clean each tube with a metal scraper. Rinse in soft water.

Keep the leakage chamber dry (double-tube water-cooler only)

b) Leak detection for a double-tube exchanger

If a leak is detected, it is necessary to ascertain its origin immediately and repair it.

Remove the two water boxes, apply a slight positive pressure in the leakage chamber and thus between the two tubes (only concerns double-tube coolers).

If a tube is damaged plug it at BOTH ends. Use a tapered plug. The plug should preferably be made of salt-water resistant aluminium bronze or of a synthetic material.

2.7.3 Servicing the water-cooler

a) Cooler removal

The cooler unit is slid into its housing. It is possible to remove the cooler from the housing without removing the water boxes. The cooler is fastened to the housing via a series of screws on the housing.

Remove the supply and return pipes.

Provide two supports to hold the cooler when it comes out of its housing.

Remove the cooler using slings that can be attached to the connecting flanges.

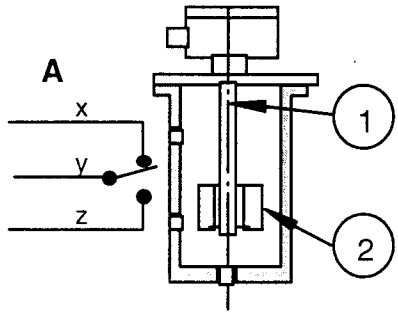
b) Cooler re-assembly

Carry out the operations of the "Cooler Removal" section in the reverse order. Be careful to push the cooler completely into its housing before tightening the fastening screws of the cooler to the casing.

2.7.4 Cooler protection devices

a) Leak detection (float system)

A magnet float activates a switch located in the float guiding rod



A - Dry detector
x - Blue y - Brown z - Black

1 - Guide rod
2 - Magnetique float

2.8 AIR FILTERS

2.8.1. Cleaning

a) Air filter cleaning period

The cleaning period depends of the site conditions and can change

The cleaning of the filter is requested if the record of the stator winding temperature (using the stator winding sensors) indicates an abnormal increas e in temperature.

b) Air filter cleaning procedure

The filter element (flat or cylindrical) is immersed in a tank of cold or warm water (temperature less than 50°C). Use water with detergent added.

Shake the filter gently to ensure that the water flows through the filter in both directions.

When the filter is clean, rinse it with clear water.

Drain the filter properly (there must be no more formation of droplets)

Refit the filter on the machine.

CAUTION :
DO NOT USE WATER WITH A TEMPERATURE HIGHER THAN 50°C, DO NOT USE SOLVENTS.

NOTE :
Do not clean the filter using compressed air. This procedure would reduce filter efficiency.

2.18 TERMINAL BOX

2.18.0 Description

Use the attached Terminal box drawing

The main terminal box of the machine is located on the top of the machine.

The neutral and phase wires are connected to the terminals, one terminal per phase and one terminal per neutral line. See "Terminal Box" diagram.

The openings provide access to the terminals.

The gland plates are made of non-magnetic materials in order to avoid circulating currents.

The connection of accessories is achieved by terminal strips. Use a 5 mm maximum screwdriver to work on the blocking screws. See the "Machine Protection Devices" diagram.

If products have to be added in the terminal box (CT's, VT's, Shunt etc.) refer to the installation section.

2.18.1 Not applicable

2.18.2 Not applicable

2.18.3 Electrical contact tightening

Applicable for brass thread

Thread	M5	M6	M8	M10	M12	M14	M16
Torque [Nm]	2.5	4	8	20	35	57	87

2.19 PROTECTION DEVICES

2.19.1 Stator protection devices

See "Stator protection" in section 2.1.3.

2.19.2 Bearing protection devices

See "Bearing protection" in section 2.3.4 or 2.4.9

2.19.3 Cooler protection devices

See "Cooler safety" in section 2.7.4

2.20 NAMEPLATES

2.20.1. Main nameplate

The main nameplate is fitted to the stator. It gives the manufacturer's electrical characteristics, the type of machine and its serial number.

For machines with antifriction bearings, the quantity of grease, the type and frequency of lubrication are stipulated.

2.20.2. Lubrication nameplate

The machines with Sleeve bearings have a lubrication plate attached to the bearing, giving:

Oil change frequency; Oil capacity of bearing; Oil viscosity.

The machines with antifriction bearings have a lubrication plate fixed on the stator, giving :

Type of bearing; Grease-change frequency; Quantity of grease.

2.20.3. Rotation direction nameplate

An arrow on the drive end bearing indicates the rotation direction.

3. NOT APPLICABLE

4. INSTALLATION

4.1 STORAGE

4.1.1 Storage warehouse

The machine must be stored in clean and dry premises which are not subject to abrupt changes in temperature or to high humidity.

Storage at an ambient temperature of +5 to +45° C is recommended.

The machine must not be subject to vibrations.

4.1.2 Maritime packing

The synchronous machine is carefully packed in a wooden crate, then hermetically sealed.

Breaking the hermetic protective film discharges ACEO of its long-duration storage guarantee.

4.1.3 Unpacking and installation

DANGER :
THE FOUR LIFTING HOOKS MUST BE USED TO LIFT THE MACHINE WITH SLINGS (ONE HOOK AT EACH CORNER OF THE MACHINE)

Rotors of machines with Sleeve bearings and single-bearing machines, are blocked during transportation so as to avoid any movement. Withdraw the retaining bars. The retaining bar is screwed to the end of the shaft and to the front support.

The end of the shaft is protected from corrosion. Clean it before coupling.

4.1.4 Storage measures of a site machine

Before stopping the machine for a long period (several months), it is essential to take several precautionary measures:

The heating resistor must be switched on at all times.

For water-coolers, the water flow must be shut off. If the water is not treated and if there is likelihood of freezing, the exchanger must be drained.

For an open machine, it is recommended that the air inlet and outlet be closed.

Before starting the machine up again, it will be necessary to carry out a start-up inspection.

4.2 INSTALLATION OF THE ELECTRIC MACHINE

4.2.1 Fitting the coupling (double-bearing machine only)

The coupling must be balanced separately before assembly on the machine shaft. Refer to the balancing instructions in section 2.2.5.

4.2.2 Fitting the stator

Four plates on the frame enable the unit to be fitted to a chassis. The machine has been designed to be :

fastened with 4 bolts. The bolts must support the force created by the static and dynamic loads.

positioned by means of 4 dowel pins. The dowel pins make later realignment easier. (The use of pins is optional).

aligned through the use of 4 jacking-screws. These jacking-screws allow the machine to be positioned according to the various axes.

4.3 ELECTRIC MACHINE ALIGNMENT

4.3.1 Alignment general points

a) General points

The alignment consist to obtain the driving shaft and the driven shaft coaxial when operating at the nominal conditions (machine rotating ; at its operating temperature)

The machine must be aligned according to the ACEO standard and adhere to the manufacturer's alignment standard for the drive machine.

When heating the machine has its shaft line which grow up. Between stop and rotation the shaft axis location inside its bearing is different. The total axis height elevation is composed of the thermal elevation and of the bearing elevation.

CAUTION:
THE ALIGNMENT MUST BE DONE TAKING IN CONSIDERATION THE SHAFT MOVEMENT CORRECTION

The correct locating of the parts must be obtained by inserting shims under the machine pads..

The double-bearing machines are mounted with bearings (ball or roller) or Sleeve bearings. The axial clearance of the bearings (if the machine has Sleeve bearings) must be distributed as well as possible, taking into account the axial thermal expansion. The Anti friction-bearing machines with a positioning bearing (standard machine) do not have axial play.

The machines are delivered with the rotor mechanically centred (axially and radially) in relation to the stator.

CAUTION :
THE ALIGNMENT STANDARDS OF MANUFACTURERS OF DRIVE MACHINES ARE FREQUENTLY MORE PRECISE THAN THOSE OF THE A.C.E.O

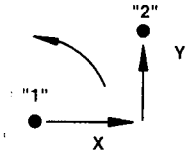
b) Axis height Thermal elevation

$\Delta H\ (mm) = \lambda_{(°K^{-1})} . H_{(m)} . \Delta T_{(°K)}$
H(m) = Height of the machine axis
ΔT= frame temperature elevation = 30°C
λ = Coefficient of steel elongation = 0.012 °K-1

c) Sleeve bearing shaft elevation

For machines with Sleeve bearings, one can consider that the elevation of the shaft axis due to the oil film is more or less of the order of 0.05 mm.

Exact Sleeve bearing elevation due to the oil film :
The machine goes from point "1" to point "2".
The following information corresponds to a counter-clockwise rotation of the machine. Machine running hot or cold:



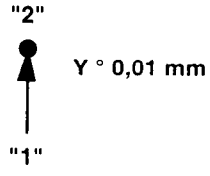
1 - Machine stopped
2 - Machine in rotation

$$X = \left(\frac{\text{Clear.}}{2} - \text{oil film}\right) . \cos(\text{angle of attitude})$$

$$Y = \left(\frac{\text{Clear.}}{2}\right) - \left(\frac{\text{Clear.}}{2} - \text{oil film}\right) . \sin(\text{angle of attitude})$$

d)Antifriction bearing shaft elevation

Caused by thermal growth of the antifriction bearing.



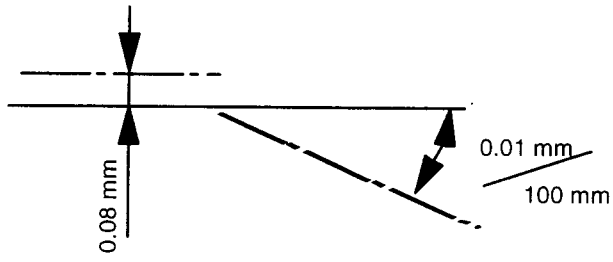
1 - **cold**, in rotation, or stopped
2 - **hot**, in rotation, or stopped

4.3.2 Two bearings machine alignment

a) machines without axial end play (standard)

The alignment must take the tolerances of the coupling into account. A misalignment, acceptable by the coupling, must not create an excess load on the bearing subsequent to the axial and radial stresses outside the tolerances of said bearing.

Shafts alignment limits:



To check the alignment, there are different methods: the "double concentricity" method is described in the "alignment procedure" section.

b) machines with axial end play

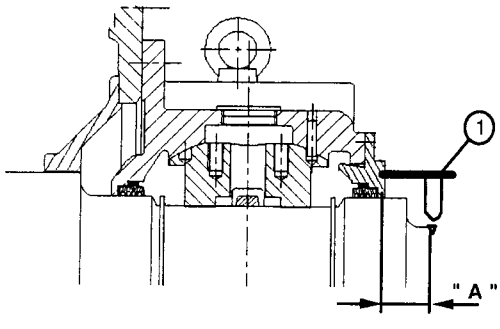
The alignment must be performed using the same method as for a machine having no axial end play.

CAUTION :
THE ROTOR AXIAL LOCATION MUST BE CHECKED TO AVOID ANY MAGNETIC OFFSET

CAUTION :
THE FAN THRUST OF THE ELECTRICAL MACHINE MUST BE HELD THROUGH THE COUPLING.

A needle fitted on the drive end side bearing must face a groove machined on the shaft. If the needle is missing the distance "A" (distance from the groove up to the first bearing part) is stamped on the shaft enabling checking.

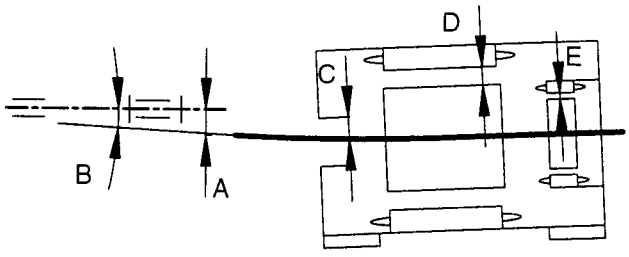
Example for a sleeve bearing machine :



4.3.3 Single bearing machine alignment

a) General points

The alignment consist also to get the rotor of the synchronous machine coaxial to its stator



"A" et "B" give the shaft line alignment

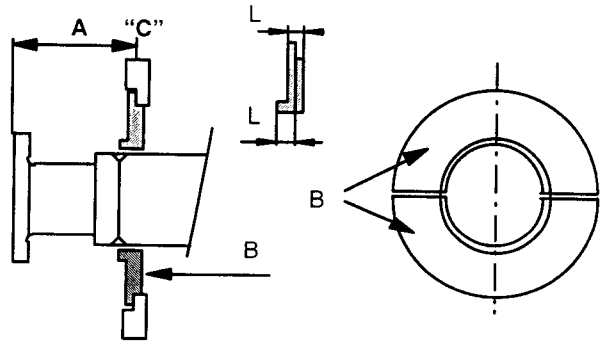
"D" et "E" give the alignment of the stator regarding the rotor. Because of the engineering of the synchronous machine the **only** requested adjustment is "C".

b) Single bearing machine except A56 equipped with antifriction bearing

applicable to all machines; except A56 equipped with anti friction bearing

It is imperative to position the rotor axially in relation to the stator in order to achieve correct magnetic centring of the rotor in the stator.

Single-bearing machines are delivered by the ACEO factory with the rotor centred mechanically (axially and radially) in relation to the stator.



Two half-shells (B parts) mounted on the front flange act as a front bearing for the transportation and installation. The outside of the centring half-shells face a groove machined on the shaft.

The half-shells have "L = L" construction symmetry

The length "A" shown on the diagram is stamped on the shaft end (allowing alignment in case of absence of item "B" rings or in case of absence of groove on the shaft)

The length "L" shown on the diagram is stamped on the shaft end.

The side "C" represents the machined side of the bearing.

Remove the centring upper half-shell (upper "B" part).

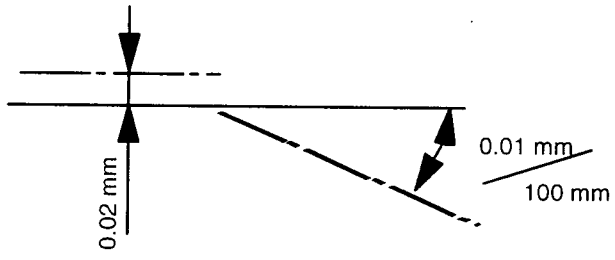
Fit the electric machine to the drive system centring.

Remove the centring lower half-shell (lower "B" part).

Carry out the alignment by moving the machine assembly by means of lifting-screws mounted on the brackets (see alignment procedure below). Use shims in order to obtain proper alignment.

The centring of the rotor in relation to the stator should be checked by measuring the concentricity of the shaft in relation to the bearing. After having tightened the fastening screws completely, the rotor-stator alignment must be better than 0.05 mm axis-to-axis (that is 0.1 mm reading).

Shafts alignment limits:



Check the axial positioning of the rotor in relation to the stator. For this verification, use an upturned half-shell ("B" part) (use of the symmetry of the "L = L" part) as shim. The outside of the shim ("B" part) must be facing the groove machined on the shaft to within +/- 1 mm.

Mount the cover plates by replacing the transportation half-shells (delivered separate with the machine) to avoid foreign matter entering in the machine. Make sure the closing plates are correctly centred in relation to the shaft.

c) Single bearing machine A56 Anti friction-bearing, only

It is imperative to position the rotor axially in relation to the stator in order to have proper magnetic centring of the rotor in the stator.

The single-bearing machines are delivered by the ACEO factory with the rotor centred mechanically (axially and radially) in relation to the stator.

A false front bearing ("Transportation support") keeps the rotor mechanically centred during transportation. The rotor is centred if the groove machined on the shaft coincides with the inside face of the shipping bracket. The inside surface of the shipping bracket is in the same plane as the outside machining of the stator.

The length "A" shown in the diagram is marked by cold stamping on the coupling armature.

Slide the fan screen and the fan onto the shaft.

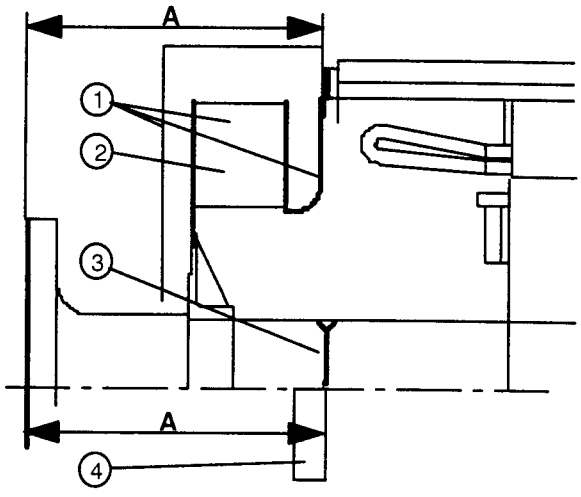
Fit the rotor on the centring of the drive system.

Remove the "Transportation support"

Carry out the alignment by moving the machine assembly by means of lifting-screws mounted on the pads. Use shims to obtain correct alignment.

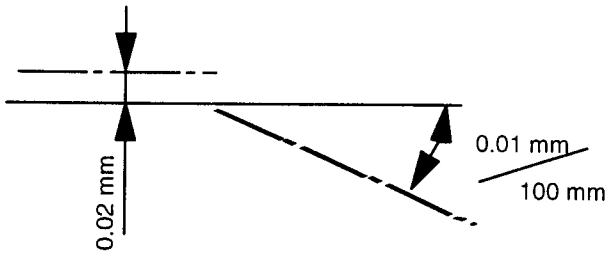
The centring of the rotor in relation to the stator should be checked by measuring the concentricity of the shaft in

relation to the end ring of the stator. After having tightened the fastening screws definitively, the rotor-stator alignment must be better than 0.05 mm from axis to axis (that is 0.1 mm reading).



1 - Delivered dismantled
2 - Fan
3 - Positioning groove
4 Shipping bracket

Shafts alignment limits:



Check that the groove marking machined on the shaft is opposite the outside face of the stator or respects the measurement "A" to within + or - 1 mm.

Mount the fan screen on the stator (delivered with the machine as separate part).

Mount the fan on its hub, whilst respecting the angular marking (balancing respect).

Fit the front housing.

4.3.4 Alignment procedure

a) Checking "Double concentricity" alignment method

This method is not sensitive to axial movements which often cause errors when other methods are used.

It is possible to check the alignment with the coupling installed.

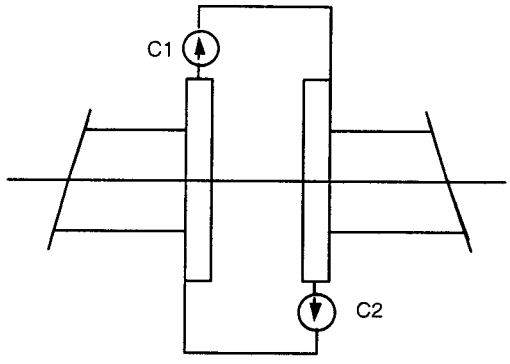
Equipment required :

Two rigid brackets. The rigidity of the two brackets is very important.

Two micrometers

Implementation :

Both shafts must turn simultaneously in the same direction. (For example : the coupling installed with its screws untightened). By turning both shafts simultaneously, the measurement is not affected by the error resulting from circular irregularities of the two shaft ends.



The "C1" and "C2" micrometers are located at an angular difference of 180°.

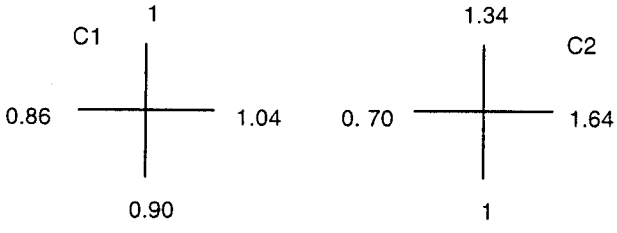
The reading should be performed 4 times for the "C1" and "C2" micrometers : 90°, 180°, 270° and 360°.

It is recommended to record the results and draw the axes for better evaluation, as explained below. Interpretation of measurements by means of an example.

An example may make the interpretation of measurements easier. THE EXAMPLES PROVIDED MUST NOT BE TAKEN AS ACCEPTABLE ALIGNMENT VALUES.

Values given in millimetres. The reading is considered positive (+) when the micrometer stylus is pushed inwards.

MEASUREMENTS



Interpretation of measurements with respect to the vertical plane

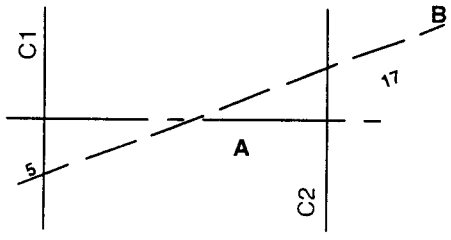
Considering the vertical plane "C1" : The vertical action towards the top of shaft "A" on the micrometer is dominant.

Axis "A" is higher than axis "B" (in the plane "C1")
(100 - 90) / 2 = 5

In the vertical plane "C2", the vertical action towards the top of shaft "B" on the micrometer is greater.

Axis "B" is higher than axis "A" (in the plane "C2")
(134 - 100) / 2 = 17

The respective position of the axes is as follows:



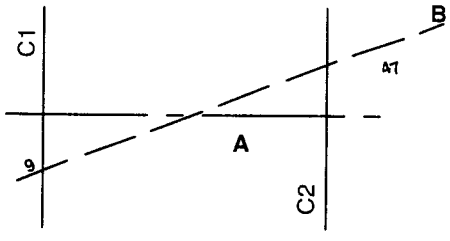
Evaluation of the measurements as regards the horizontal axis

The measurement indicates that :

Shaft "A" is further to the right than shaft "B" in the micrometer plane "C1" (104 - 86) / 2 = 9

Shaft "B" is further to the right than shaft "A" in the micrometer plane "C1" (164 - 70) / 2 = 47

The representation of the shafts is as follows:



4.4 ELECTRICAL CONNECTIONS

4.4.0. General points

The installation must comply with the electrical diagrams. Refer to the attached the electrical diagrams.

Check that all the protection devices are correctly connected and in good working order.

For low-voltage machines, power supply cables must be connected directly to the machine terminals (without adding washers etc.)

For high-voltage machines, power supply cables should be connected to separate terminals or to current transformer terminals.

NOTE :
THE GLAND PLATE IS MADE OF NON MAGNETIC MATERIAL.

CAUTION
DO NOT ADD WASHERS TO THE POWER SUPPLY CABLE TERMINALS OTHER THAN THOSE USED BY THE MANUFACTURER OF THE ELECTRIC MACHINE

Check that the lugs are tightened.

CAUTION
ALL CURRENT TRANSFORMERS MUST BE CONNECTED

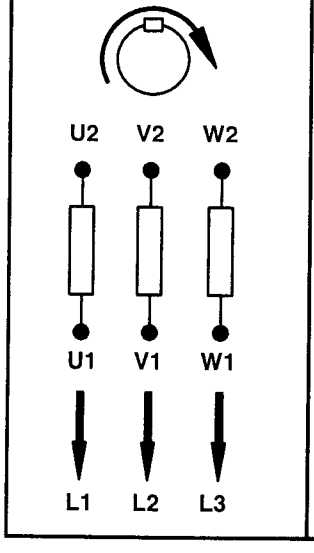
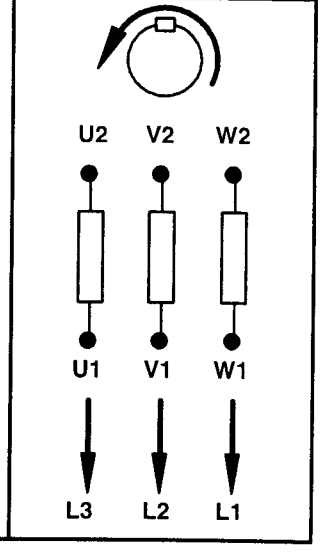
CAUTION
THE INSTALLED POWER CABLES MUST BE FIXED AND SUPPORTED IN SUCH A WAY AS TO BE ABLE TO WITHSTAND THE VIBRATION LEVEL REACHED BY THE SYNCHRONOUS MOTOR IN OPERATION (refer to "Vibration" section)

4.4.1. Phase-sequence

a) Standard units ; IEC 34-8

Except by special request of the customer, the phase-sequence is carried out using the IEC 34-8 standard. An arrow located on the front bearing indicates the direction of rotation.

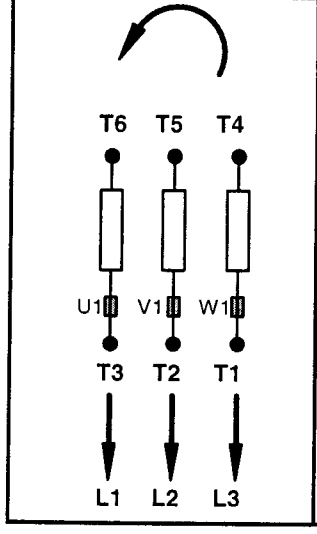
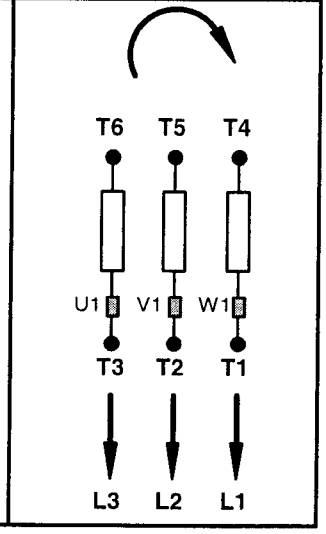
In the terminal box a specific marking plate indicates the specific synchronous motor phase sequence.

Clockwise rotation viewed from the shaft drive end	Counter clockwise rotation viewed from the shaft drive end
The phases are marked: U1, V1, W1.	The phases are marked: U1, V1, W1.
Viewed from the front of the terminal box the terminals are : U1, V1, W1	Viewed from the front of the terminal box the terminals are : U1, V1, W1
The installer connects : L1 --> U1 L2 --> V1 L3 --> W1	The installer connects : L3 --> U1 L2 --> V1 L1 --> W1
	

b) On request ; NEMA

An arrow located on the front bearing indicates the direction of rotation.

In the terminal box a specific marking plate indicates the specific synchronous motor phase sequence.

Counter clockwise rotation viewed from the stator connection (NEMA) (Clockwise rotation viewed from the shaft drive end following IEC)	Clockwise rotation viewed from the stator connection (NEMA) (Counter clockwise rotation viewed from the shaft drive end following IEC)
The cables are marked: U1, V1, W1. The terminals are marked : T3, T2, T1	The cables are marked: U1, V1, W1. The terminals are marked : T3, T2, T1
Viewed from the front of the terminal box the cables are : U1, V1, W1	Viewed from the front of the terminal box the cables are : U1, V1, W1
The installer connects : L1 --> (U1) T3 L2 --> (V1) T2 L3 --> (W1) T1	The installer connects : L3 --> (U1) T3 L2 --> (V1) T2 L1 --> (W1) T1
	

4.4.2 Insulating distances

Products not delivered by ACEO and then installed in the terminal box must meet the electrical insulating distances.

This applies to power cables and lugs, and to added transformers, etc.

Nominal Voltage	500 V	1 kV	2 kV	3 kV
Phase-Phase in the air (mm)	25	30	40	60
Phase-Earth in the air (mm)	25	30	40	60
Phase-Phase Creeping (mm)	25	30	40	70
Phase-Earth Creeping (mm)	25	30	40	70

Nominal Voltage	5 kV	7.5KV	12.5 kV	15 kV
Phase-Phase in the air (mm)	120	180	190	190
Phase-Earth in the air (mm)	90	120	125	125
Phase-Phase Creeping (mm)	120	180	190	190
Phase-Earth Creeping (mm)	120	180	190	190

4.4.3 Added products in the terminal box

This may apply to site added customer CTs ; VTs etc.

ACEO must be informed if some appliances have to be installed in the synchronous motor terminal box.

The products not delivered by ACEO and then installed in the terminal box must meet the electrical insulating distances. Refer to section on Insulating distances.

The installed appliances must be able to withstand vibration.

5. START-UP

5.0 START-UP SEQUENCE

The synchronous motor start up (commissioning) must follow the following sequences:

5.0.1 Static checks

Machine fixing; Alignment; cooling; Bearing lubrication as per chapter 5.2

Electrical connections as per chapter 5.1.0

Winding insulation as per chapter 5.1.1

5.0.2 Rotating checks

a) Rotating checks at no load

Run the synchronous by steps to verify the bearings temperature as per chapter 5.2

At the nominal speed measure the vibrations. Check that the vibration level is in accordance with the synchronous motor (as per chapter 5.21) and duty request.

b) Not applicable

c) Synchronous motor and site safeties

proceed to the site safeties adjustment (overvoltage relay, overcurrent relay;...)

d) Rotating checks at full load

Load the synchronous motor step by step. :
Check the excitation current at 25%of the rated load
Check the excitation current at 100%of the rated load

At the nominal speed (full load) measure the vibrations. Check that the vibration level is in accordance with the synchronous motor (as per chapter 5.21) and duty request.

5.1 ELECTRICAL START-UP INSPECTION

5.1.0 General points

Electrical connections (auxiliaries, safeties and power connections) must comply with the diagrams provided.

Refer to the installation section; chapter 4

DANGER :
CHECK THAT ALL SAFETY EQUIPMENT OPERATES CORRECTLY.

5.1.1 Winding Insulation

The insulation and the polarisation index must be measured on start up.

To measure the insulation refer to the maintenance section.

5.1.2 Electrical connections

The phases must be connected directly to the machine links (with no spacers or washers, etc.).

Make sure that the lugs are sufficiently tightened.

CAUTION :
ALL CURRENT TRANSFORMERS MUST BE CONNECTED

5.2 MECHANICAL START-UP INSPECTION

5.2.0 General points

a) Alignment ; fixing ; prime mover

The installation must comply with the ACEO installation rules and with the driven machine installation rules (alignment, mounting).

The direction of rotation is indicated by an arrow at the front of the bearing.

b) Cooling

The air inlet and exhaust must be unobstructed.

The cooling auxiliaries (water circulation in the cooler, etc.) must be operating.

c) Lubrication

Lubrication must be carried out :

- antifriction bearings, refer to section 2.3
- Sleeve bearings, refer to section 2.4

5.2.1 Vibrations

The machines are engineered to be able to withstand the vibration level indicated by the standard ISO8528-9

Engine speed (RPM)	Power (kVA)	Vibration level (mm/s ; RMS)
		Motor
1300 to 2199	> 250	< 20
721 to 1299	≥ 250	< 20
	> 1250	< 18
≤ 720	> 1250	< 15
		< 10 (*)

(*) Motor on concrete base

The vibration measurement must be taken on each bearing in the three directions. The measured levels must be lower than the specified values indicated in the above chart.

6. PREVENTIVE MAINTENANCE

6.1 MAINTENANCE SCHEDULE

The purpose of the general maintenance schedule below is to help establish the maintenance schedule particular to the installation. The suggestions and recommendations are to be followed as closely as possible in order to maintain the machine efficiency and in order not to reduce the service life of the machine.

The maintenance operations are detailed in the sections relative to the subjects concerned (Example: bearing, see section 2).

LUBRICATION AND PREVENTIVE MAINTENANCE SCHEDULE

Frequency of maintenance

	Days	Hours	Comments
STATOR			
Bolts tightening		8000	
Cleaning air inlet and outlet		1000	refer to 6.2.3
Cleaning coils		40000	refer to 7.4
ROTOR			
Cleaning diodes		8000	refer to 7.4
Diodes tightening		8000	refer to 2.2.4
Cleaning coils		40000	refer to 7.4
TERMINAL BOX			
Cleaning		4000	
SLEEVE BEARINGS (*)			
Oil leak	1		refer to 2.4.9
Oil temperature	1		refer to 2.4.10
Oil level		1000	refer to 2.4.5
Oil change		4000	refer to 2.4.5
Shell visit		8000	refer to 2.4.6
Bolts tightening		8000	refer to 2.4
ANTI FRICTION BEARINGS (*)	See lubrication plate (grease at least every 6 months)		
COOLER (*)			
Leakage level	1		refer to 2.7.4
Water temperature	1		refer to 2.7.4
Cleaning		8000	refer to 2.7.2
FAN-MOTOR (*)	See lubrication plate		
FILTERS (*)		1000	refer to 2.8
PROTECTION DEVICES (*)		8000	(Sensors, detectors, etc.) refer to 2.19 and section 1
CLEANLINESS		1000	refer to 6.2.3

(*) depending on the technical characteristics of the machine and according to section 1.

6.2 MECHANICAL MAINTENANCE

To obtain additional information on the maintenance of sub-assemblies, refer to the sections dealing with the sub-assemblies concerned.

6.2.1 Air gap check

a) Double bearing machine

Verification of the air gap is not necessary. The rotor is mechanically centred by its construction. Even after dismantling and reassembling the machine, the rotor will return to its position without verification of the air gap.

b) Single bearing machine

When the machine is delivered, the rotor is mechanically centred in the stator (see section on alignment). After dismantling the machine, it will be necessary to centre the rotor in the stator, by using the two half-shells (delivered with the machine) as explained in the "alignment" section.

If you do not have 1/2 shells, use a comparator to check the concentricity between the shaft (machined surface) and the front bearing (machined surface).

6.2.2 Bolts tightening

Check the tightening of the sleeve bearing fixing bolts (refer to section 2.4)

Check the tightening of the rotating diodes (refer to section 2.2.4)

Check the tightening of the terminal box accessories (refer to section 2.18)

6.2.3 Cleanliness

The whole machine must be kept clean.

CAUTION :
ALL THE CLEANING PERIODS INDICATED IN THIS MANUAL MAY BE CHANGED (INCREASED OR DECREASED) ACCORDING TO SITE CONDITIONS

The air inlet and air outlet surfaces must be maintained clean (Louvers can be cleaned as per the filters) refer to section 2.8.

CAUTION :
DIRT ENTERING THE MACHINE MAY POLLUTE AND THUS REDUCE THE ELECTRICAL INSULATION

The rotating diodes must be keep clean. The rotating diodes cover has to be clean. Refer to section 7.4

6.3 ELECTRICAL MAINTENANCE

6.3.1 MEASURING INSTRUMENTS

a) Instruments used

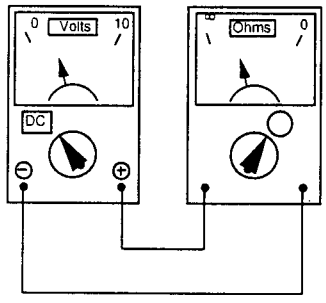
- AC voltmeter 0-600 Volts
- DC voltmeter 0-150 Volts
- Ohmmeter 10E-3 to 10 ohms
- Megohmmeter 1 to 100 Mohms / 500 Volts
- AC Ammeter 0- 4500 A
- DC Ammeter 0-150 A
- Frequency meter 0-80 Hz

Low resistance can be measured by means of an appropriate ohmmeter or by using a Kelvin or Wheatstone bridge.

NOTE :
The identification of the equipment polarity may differ from one ammeter to another.

b) Identification of ohmmeter polarity

In many testing procedures, the ohmmeter polarity is important (diode test, etc.) and must be known. As a second instrument, you must use a voltmeter in the "direct current" position, in order to check the polarity of the ohmmeter connections. Proceed as explained below :



6.3.2 Insulation check of the winding

a) General

The insulation resistance enables the status of the machine insulating to be verified.

The following measurements can be taken at any time without any damage to machine insulating material.

The insulation check must be done :
Before the start up
After a long standstill
As soon as an abnormal operation occurs.

If the measurement indicates a poor result we advise contacting our Service department.

To perform the measurement the synchronous motor must be stopped.

If the resistance is less than that required, it is necessary, if possible, to dry the machine (see "drying" section in the SERVICING section).

b) Armature insulation measure

Disconnect the three phases at the synchronous motor terminals.

The measurement has to be taken between one phase and the earth.

	Machine nominal voltage	
	Un ≤ 2400 V	Un > 2400 V
Applied test voltage (DC)	500 V DC	1000 V DC

The measured value must be over (3. (1+Un)) Meghoms where Un (the nominal voltage) is in Kilovolts. (e.g. : a synchronous motor of 6.6 kV must have an insulation resistance greater than 22.8 MΩ).

If the minimum insulation level is not reached, dry the windings (refer to Servicing section)

c) Field insulation measurement

Disconnect the two ends of the field at the rotating diodes bridge

The measurement should be taken between one end of the field winding and the earth.

The applied test voltage must be of 500 V DC.

The measured value must be over 20 MΩ.

If the minimum insulation level is reached, dry the windings (refer to Servicing section)

d) Exciter insulation measurement

To measure the exciter field insulation disconnect the two ends of the exciter field at the terminals located on the top of the exciter.

To measure the exciter armature insulation disconnect the two ends of the exciter armature at the rotating diodes bridge

The measurement should be taken between one end of the field winding and the earth.

The applied test voltage must be of 500 V DC.

The measured value must be over 20 MΩ.

If the minimum insulation level is reached, dry the windings (refer to Servicing section)

6.3.3 Polarisation index

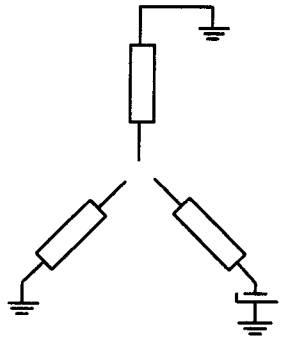
The polarisation index enables the status of the machine insulating to be verified and gives an indication of the pollution of the winding.

The following measurements can be taken at any time without any damage to the machine insulating material.

NOTE :
It must be done using a stable DC source.
Use a specific polarisation index appliance under 500 or 1000 DC volts (refer to » insulation of the winding » section for the correct applied voltage)

Open the winding star point

Disconnect AVR cables from the stator terminals



Apply the requested voltage

After 1 minute record the Insulating resistance

After 10 minutes record the Insulating resistance

$$i_p = \frac{\text{Insulating resistance}_{(t = 10\ \text{minutes})}}{\text{Insulating resistance}_{(t = 1\ \text{minutes})}}$$

The polarisation index must be higher than 2.

Proceed for each phase

7. SERVICING

7.1 GENERAL SERVICING

DANGER :
BEFORE WORKING ON THE SYNCHRONOUS MOTOR, MAKE SURE THAT THE START-UP CANNOT BE ACTIVATED BY ANY MANUAL OR AUTOMATIC SIGNAL

DANGER :
BEFORE WORKING ON THE MACHINE, MAKE SURE THAT YOU HAVE UNDERSTOOD THE OPERATING PRINCIPLES OF THE SYSTEM. IF NECESSARY, REFER TO THE APPROPRIATE SECTIONS IN THIS MANUAL.

CAUTION :
GIVEN THE POWER FACTOR APPLIED TO THE MACHINE, A VOLTMETER OR KILOWATT METER DOES NOT NECESSARILY SHOW THE KVA LOAD OF THE MACHINE.

7.2 TROUBLESHOOTING

7.2.0 General points

When a defective part is replaced with a spare part, make sure that it is in good condition.

7.3 ELECTRICAL TESTS

7.3.1 Stator winding test

See section 6.3

7.3.2 Rotor winding test

See section 6.3

7.3.3 Excitation armature winding test

See section 6.3

7.3.4 Excitation field winding test

See section 6.3

7.3.5 Rotating diode bridge test

See section 2.2

7.4 CLEANING THE WINDINGS

7.4.1 Coil-cleaning product

a) general

CAUTION :
SOLVENTS WHICH ARE HIGHLY CHLORINATED AND SUBJECT TO HYDROLYSIS IN DAMP ATMOSPHERES ARE PROHIBITED. THEY QUICKLY BECOME ACIDIFIED, PRODUCING CORROSIVE AND CONDUCTIVE HYDROCHLORIC ACID.

CAUTION :
DO NOT USE TRICHLORETHYLENE, PERCHLORETHYLENE, OR TRICHLORETHANE

Avoid mixtures sold under various trademarks which often contain white spirit (which evaporates too slowly) or chlorinated products (which are likely to become acidified).

CAUTION :
DO NOT USE ALKALINE PRODUCTS. THEY ARE DIFFICULT TO RINSE AND CAUSE REDUCTION OF INSULATION RESISTANCE BY FIXING THE HUMIDITY

b) Cleaning products

Use pure de-greasing and volatile agents which are well-defined such as :
Gasoline (without additives)
Toluene (slightly toxic) ; inflammable
Benzene or benzine (toxic ; inflammable)
Ciclohexaire (non-toxic; inflammable)
Soft water

7.4.2 Cleaning the stator, rotor, excitation system and diodes

a) using specific chemical product

The insulation and the impregnation system are not damaged by solvents (see the list of authorised products above).

It is essential to avoid entry of cleaning agents into the slots. Apply the product with a brush, sponging frequently in order to avoid accumulation in the housing. Dry the winding with a dry cloth. Allow the traces to evaporate before reassembling the machine.

After cleaning the synchronous motor, drying is imperative to recover the correct winding insulation.

b) Rinsing using soft water

Hot soft water (less than 80°C) used under pressure (less than 20 bars) can be used.

After cleaning the synchronous motor, drying is imperative to recover the correct winding insulation (refer to section on drying the winding).

7.5 DRYING THE WINDING

7.5.0. General points

All electric machines must be stored under dry conditions. If a machine is placed in damp surroundings, it must be dried before it is put into service. Units operating intermittently or placed in areas with high temperature variations, are exposed to dampness and must be dried very thoroughly if necessary.

7.5.1. Drying method

a) General points

During the drying operation measure the winding insulation and the polarisation index each 4 hours.

To survey the insulation progress, record the measured values and plot the obtained progress function of the time.

When the insulation value becomes constant, the machine can be considered as dry.

When the resistance is constant, it may be assumed that the machine is dry. This operation may take up to 24 hours, depending on the size of the machine and on the degree of dampness. This may even take up to 72 hours.

CAUTION :
TAKE FIRE-PREVENTION MEASURES DURING THE DRYING OF THE MACHINE.
ALL THE CONNECTIONS MUST BE TIGHTENED.

b) Drying motor stop

Several thermometers must be positioned onto the winding and the temperature must not exceed 75°C (167° F). If one of the thermometers exceeds this value, immediately reduce the heating effect.

Dry by using an external source of heat, for example, heaters or lamps.

Leave an opening for an exhaust for the damp air.

7.6 RE-VARNISHING

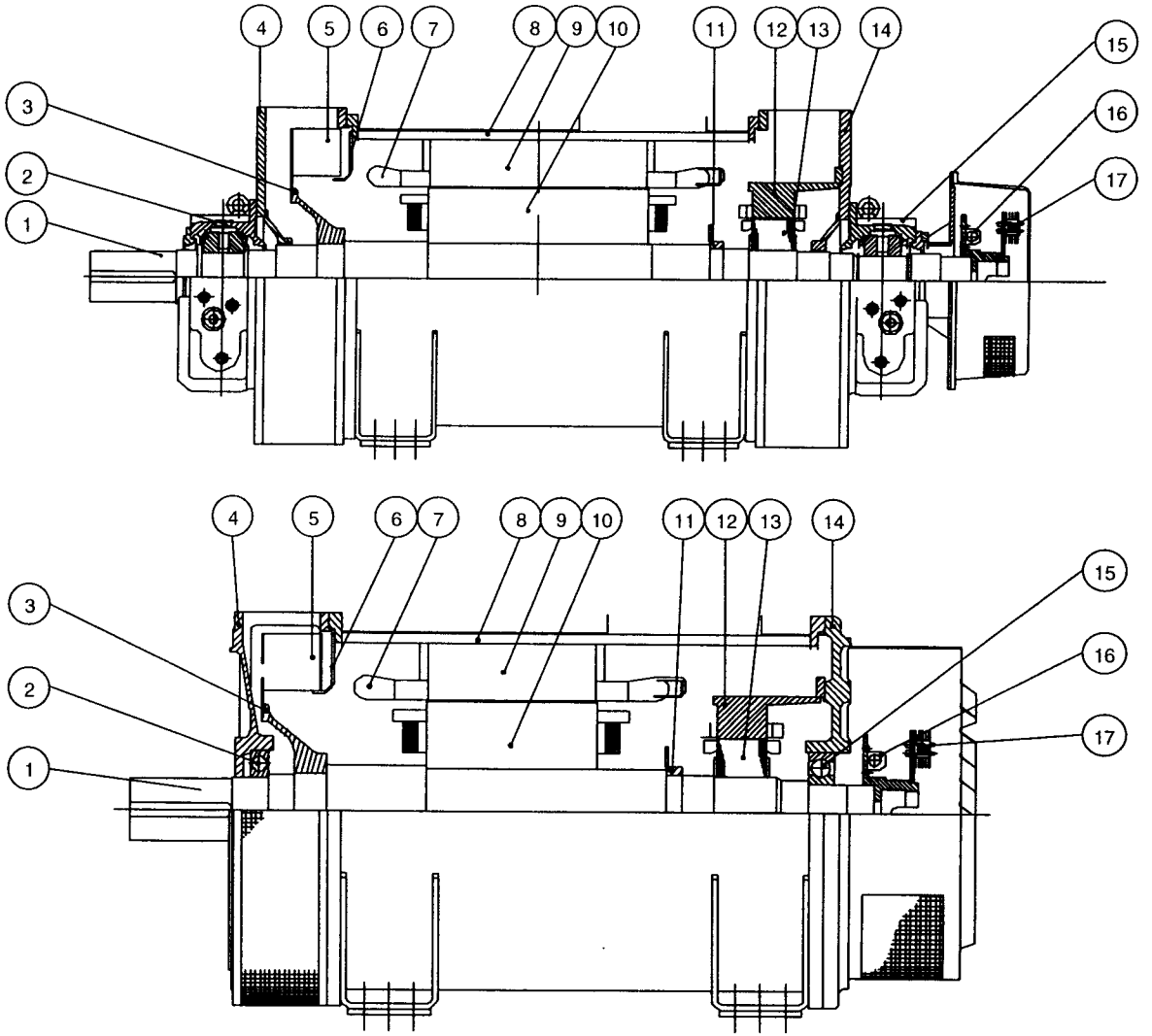
NOTE :
WHATEVER VARNISH IS USED, NEW VARNISHING IS NOT RECOMMENDED, SINCE IT TRAPS AND PERMANENTLY RETAINS THE CONDUCTIVE CARBON PARTICLES. THE ORIGINAL VARNISHES HAVE A LONG SERVICE LIFE AND DO NOT NEED TO BE STRENGTHENED.

10. FOLDOUT (1.)

sheet 1

Typical cut view A52

1 Rotor
2 Bearing (drive end)
3 Fan hub
4 Bearing housing (drive end)
5 Fan
6 Fan screen
7 Stator winding
8 Stator ribs
9 Stator lamination
10 Polar wheel
11 Balancing disc
12 Exciter field
13 Exciter armature
14 Bearing housing (non drive end)
15 Bearing (non drive end)
16 Rotating resistances
17 Rotating diodes

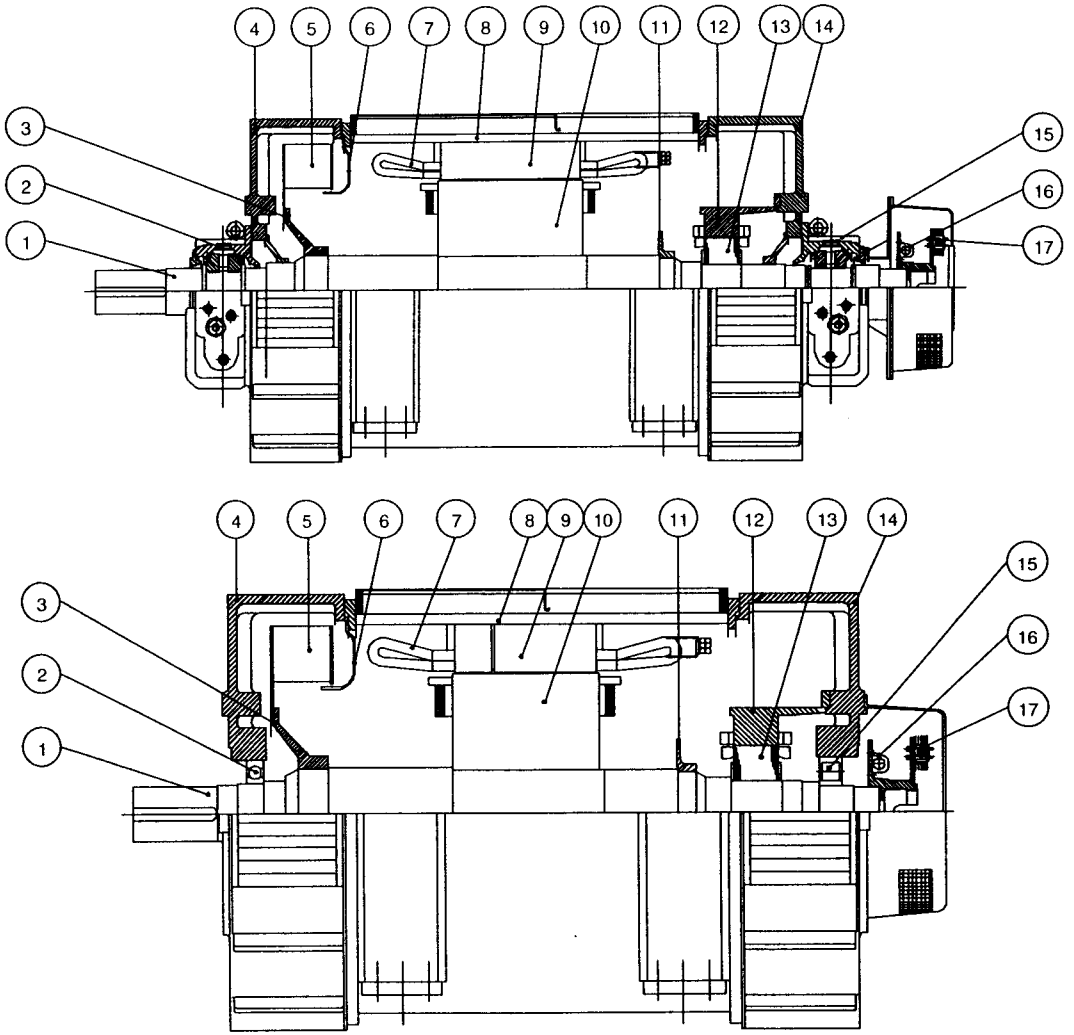


10. FOLDOUT (1.)

sheet 2

Typical cut view A54

1	Rotor
2	Bearing (drive end)
3	Fan hub
4	Bearing housing (drive end)
5	Fan
6	Fan screen
7	Stator winding
8	Stator ribs
9	Stator lamination
10	Polar wheel
11	Balancing disc
12	Exciter field
13	Exciter armature
14	Bearing housing (non drive end)
15	Bearing (non drive end)
16	Rotating resistances
17	Rotating diodes

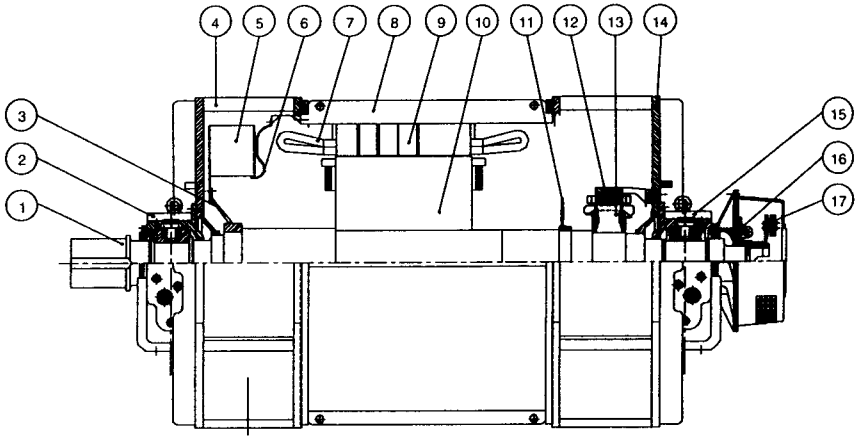


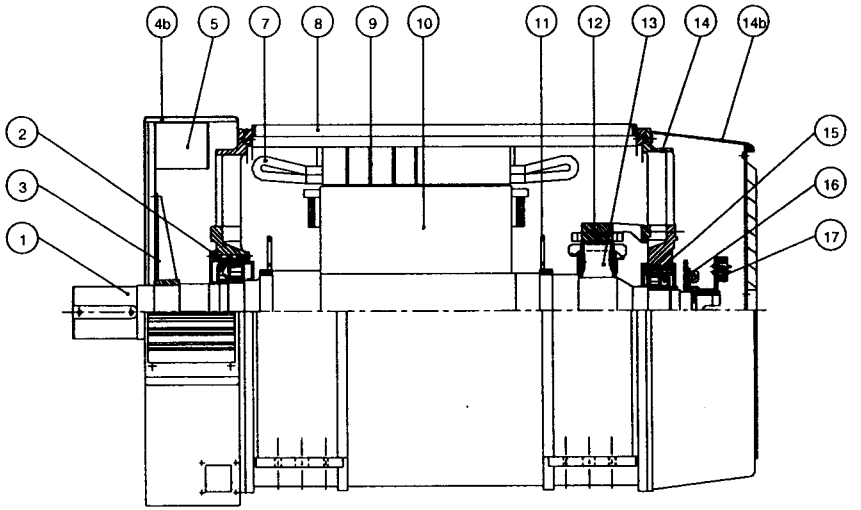
10. FOLDOUT (1.)

sheet 3

Typical cut view A56

1	Rotor
2	Bearing (drive end)
3	Fan hub
4	Bearing housing (drive end)
4b	Drive end cover
5	Fan
6	Fan screen
7	Stator winding
8	Stator ribs
9	Stator lamination
10	Polar wheel
11	Balancing disc
12	Exciter field
13	Exciter armature
14	Bearing housing (non drive end)
14b	Non drive end cover
15	Bearing (non drive end)
16	Rotating resistances
17	Rotating diodes



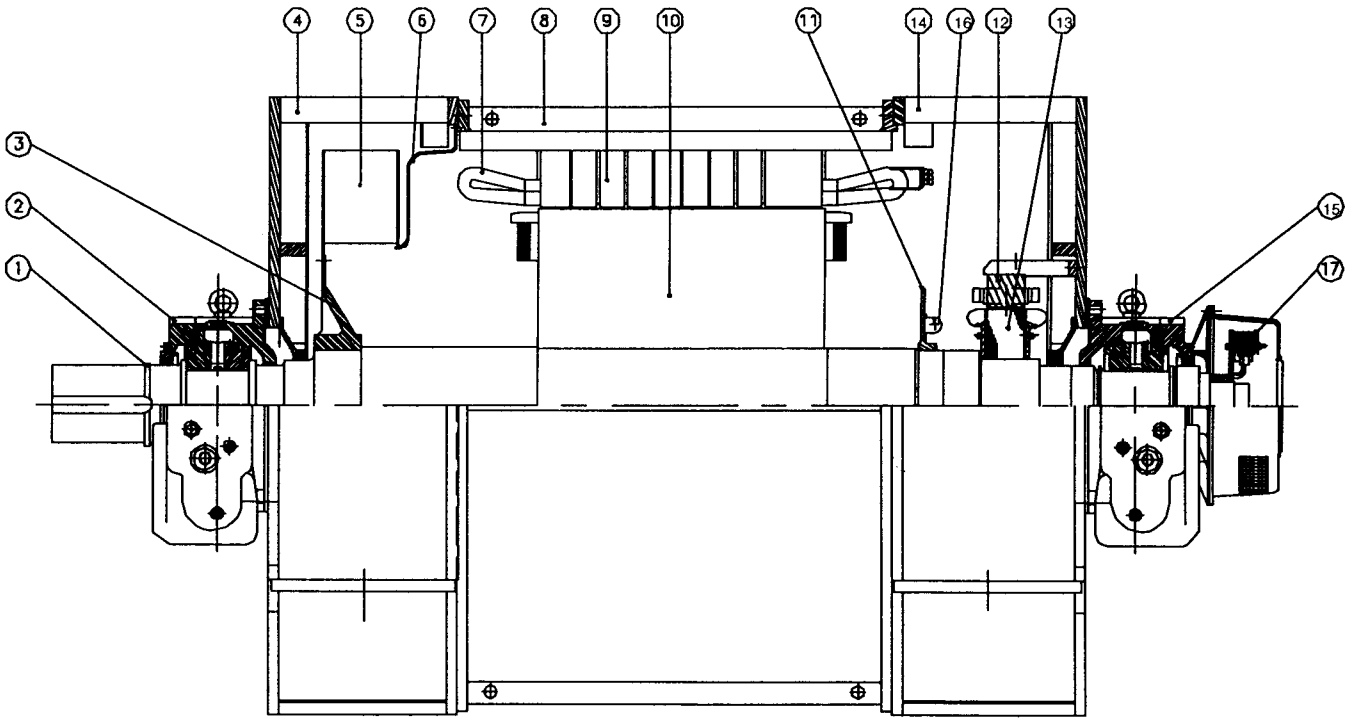


10. FOLDOUT (1.)

sheet 4

Typical cut view A58

1	Rotor
2	Bearing (drive end)
3	Fan hub
4	Bearing housing (drive end)
5	Fan
6	Fan screen
7	Stator winding
8	Stator ribs
9	Stator lamination
10	Polar wheel
11	Balancing disc
12	Exciter field
13	Exciter armature
14	Bearing housing (non drive end)
15	Bearing (non drive end)
16	Rotating resistances
17	Rotating diodes

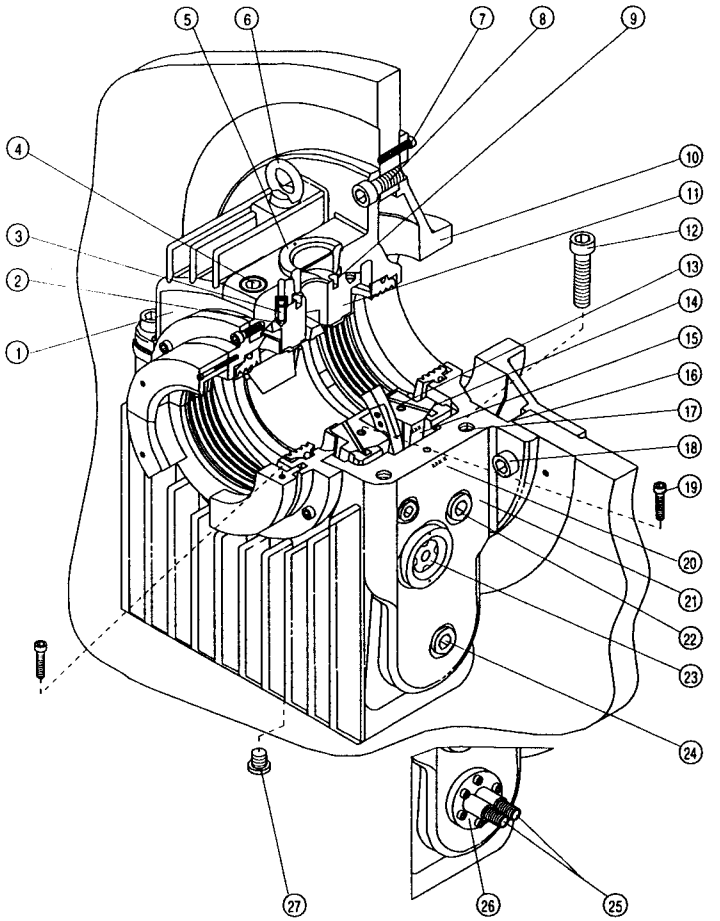


10. FOLDOUT (2.4)

sheet 1

Sleeve Bearing Flange, Self lubricated

1	Top half of the housing
2	Positioning pin hole
3	Positioning pin
4	Oil filler hole
5	Top sight glass
6	Eye bolt
7	Screw
8	Screw
9	Tap hole (in the top and bottom halves of the shell, up size 14)
10	Machine seal
11	Top half of the shell
12	Split line screw - bearing housing
13	Bottom half of the shell
14	Spherical seating
15	Engraved number - bearing shell
16	Recess
17	Tap hole
18	Screw
19	Split line screw - bearing shell
20	Engraved numbers - bearing housing
21	Bottom half of the housing
22	Connection hole for temperature measurement of the journal part
23	Oil sight glass
24	Connection hole for the oil sump temperature measurement
25	Out/Inlet cooling water (Type E.T..)
26	Oil cooler (Type E.T..)
27	Oil drain plug



10. FOLDOUT (2.4)

sheet 2

Sleeve Bearing **Flange, Lubricated by oil circulation**

1	Top half of the housing
2	Positioning pin hole
3	Positioning pin
4	Connection hole for the thrust part oil supply (optional)
5	Top sight glass
6	Eye bolt
7	Screw
8	Screw
9	Tap hole (in the top and bottom halves of the shell, up size 14)
10	Machine seal
11	Top half of the shell
12	Split line screw - bearing housing
13	Bottom half of the shell
14	Spherical seating
15	Engraved number - bearing shell
16	Recess
17	Tap hole
18	Screw
19	Split line screw - bearing shell
20	Engraved numbers - bearing housing
21	Bottom half of the housing
22	Connection hole for temperature measurement of the journal part
23	Oil inlet connection hole
24	Connection hole for the oil sump temperature measurement
25	Out/Inlet cooling water (Type E.T..)
26	Oil cooler (Type E.T..)
27	Oil drain plug
28	Metal tabs (optional for EFZL.)
29	Oil outlet connection hole
30	Oil outlet pipe
31	Marking