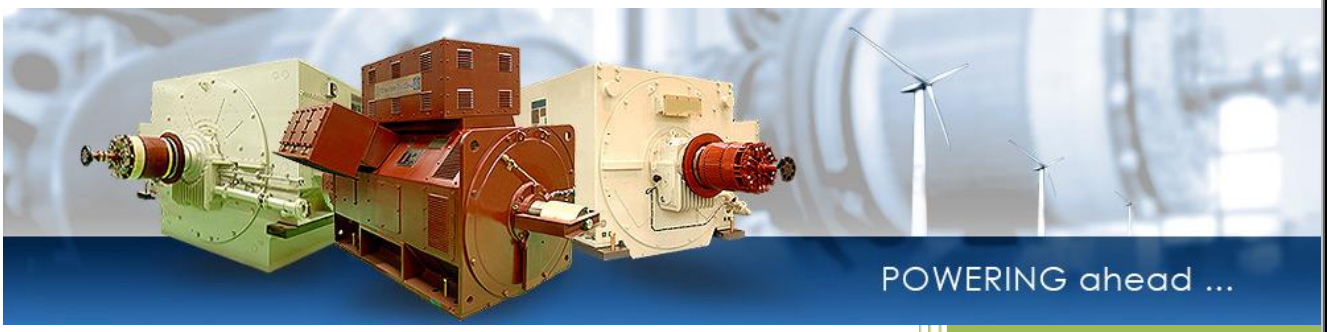
INSTALLATION, COMMISSIONING, OPERATION AND MAINTENANCE MANUAL



Part : 1

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CHAPTER 1

GENERAL

1. GENERAL

1.1. Foreword

Before operating the generating set, read this manual thoroughly. An omission can lead to personnel injury or damage to the generator set.

This manual provides the information & gives the information about installation, commissioning, operation & maintenance of the generator. Specific areas where the lack of care or use of incorrect procedures can cause damage to the equipment and/or personal injury are highlighted, with **Note** and it is important that the contents of this book are read and understood before proceeding to install or use the Generator.

All the information contained in this manual is intended solely for the use of buyer and for the specific as per the application stated by buyer to TDPS, while placing the order. Using this manual for any other purpose is not authorized. TDPS does not accept any such type of unauthorized use.

Note:

Incorrect installation, operation, servicing or replacement of parts can result in severe personal injury or death, and/or equipment damage. Service personnel must be qualified to perform electrical and mechanical service

IMPORTANT

Drawings and photographs are not to scale and do not represent detailed images of the respective product, these are only for reference.

For project specific drawing, refer to the Annexure & project specific drawings.

1.2. Addresses

1.2.1. Manual service

The manual is published by the specialized group for the ***Creation and Improvement of ACG Manual.***

This department is responsible for any improvement and to bring the amendments to the manual. For any feedback with respect manual and for any further information, contact below mentioned address.

TD Power Systems Limited
27, 28 & 29, KIADB Industrial Area,
Dabaspet, Nelamangala Taluk
Bengaluru - 562 111
INDIA.
+91-80-22995700 & 66337700

1.2.2. Product Service

For any information related to generator regarding operation, installation & maintenance, please contact service department group, TDPS.

After Sales Service
H.R.Ravishankar-Head
Phone+91-080-22995700
Cell: +91-9980065091
E-Mail: servicing_acg@tdps.co.in

Manoj Patil
Cell: +919632203413
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Cell: +919686697858
E-Mail: deepak@tdps.co.in

Kamachi Raja
Cell: +919900067806
E-Mail: kamachiraja@tdps.co.in

1.2.3. Returns

When returning any parts to the TDPS use proper address, forwarding mode with proper description for smooth process. Use below address for returning any item.

TD Power Systems Limited
27, 28 & 29, KIADB Industrial Area,
Dabaspet, Nelamangala Taluk
Bengaluru - 562 111
INDIA.
+91-80-22995700 & 66337700

For any clarification regarding address and forwarding mode contact TDPS marketing Team for assistance. Every component which is returned to the TDPS should have name of sender and receiver.

1.3. Safety Precautions

Before operating the generating set, read the generating set operation manual and become familiar with it and the equipment.

SAFE AND EFFICIENT OPERATION CAN ONLY BE ACHIEVED IF THE EQUIPMENT IS CORRECTLY OPERATED AND MAINTAINED.

Many Accidents occur because of failure to follow fundamental rules and precautions.

ELECTRICAL SHOCK CAN CAUSE SEVERE PERSONEL INJURY OR DEATH.

1.3.1. General

This section contains the relevant information necessary for safe operation of a generator.

Although the generator is complied with the applicable safety standards, hazards which could result in personal injury to the user or third parties and damage to the generator or other property cannot be ruled out completely.

Please read this section carefully and make that you comply with the instructions in order to safeguard against personal injury and damage to the generator,

Please not that the safety information in this section is general and applies to different types of generators. Specific instructions are included in the operating instructions provided for the individual components and in the various appendices.

1.3.2. Warnings

The operating instructions use a range of key words and symbols to identify information which is of particular importance. Safety-related information and safety instructions are likewise introduced by key words such as “Danger”, “Caution”, ”Notice”, and “Important” to help identify the significance of the instructions more easily.

Danger: This category is used to warn against potential lethal hazards or serious injury to health if the warning is ignored or not properly heeded.

Caution: This category is used to warn against potential injury to health or major damage to property if the warning is ignored or not properly heeded.

Notice: This category is used when there is no risk to health but potential damage to property if the notice is ignored or not properly heeded.

Important: This category is used to identify any information relevant to ensure maximum generator efficiency.

In order to highlight the above warnings and notices in the text, they are used in conjunction with special signs utilizing pictorial symbols such as the following:

IMPORTANT!	Important refers to hazard or unsafe method or practice which can result in product damage or related equipment damage.

CAUTION	Caution refers to hazard or unsafe method or practice Which can result in product damage or related personal injury.

WARNING	Warning refers to hazard or unsafe method or practice, which CAN result in severe personal injury or possible death.

For safety of generator and working personnel’s in the power plants, Caution nameplates are put on generator and should be followed strictly during installation, commissioning, operation & maintenance.

1.3.3. Normal generator operation

The function of a generator is to convert rotating mechanical energy to electrical energy. Alternatively generators are used as phase shifters. When coupled to gas turbines, generators are used for turbine start up.

To ensure normal and trouble-free operation of the generator it is necessary to comply with the operating instructions as well as the inspection and maintenance intervals specified for the generator.

TDPS does not accept any liability for any damage which may occur as a result of use of the generator for any other purpose or noncompliance with the aforementioned operating instructions or inspection and maintenance intervals

1.3.4. General Organization

The following instructions must be followed to ensure safe and reliable operation:

- The operating instructions must always be kept on hat at the place of installation.
- In addition to the operating instructions, the general legal provisions and other regulations for the prevention of accidents and the protection of the environment must be observed. Note safety data sheet when using hazardous material.
- Place signs in the buildings, at exits and entrances and near the generator. Compliance with these signs must be ensured.
- Any personnel working on the generator and its auxiliary systems must be familiarized with the operating instructions and in particular with the safety instructions and regulations before starting work. This particularly applies to personnel who do not work on the generator on a regular basis.
- Protective apparel and equipment must be used where stipulated or required.
- Compliance with all safety instructions and warnings must be ensured.
- Any irregular events which occur during operation must be reported directly and the generator shut down if necessary.

1.3.5. Personnel

With regard to personnel working on the generator, compliance must be ensured with the following:

- Personnel must be reliable.
- Personnel must be appropriately trained and qualified.
- Activities and associated responsibilities are clearly defined for the personnel.
- Work on the generator and its auxiliary system is performed by authorized personnel only.
- Personnel requiring or undergoing training must only be allowed to perform work on generator or its auxiliary systems under the constant supervision of any appropriately qualified member of staff.
- Work on the electrical systems of the generator may only be performed by electrical engineers or by suitably qualified personnel under the supervision of an electrical engineer in compliance with the relevant electrical engineering standards.

1.3.6. Modifications to Generator

Do not carry out any modifications to the generator or perform any other work on the generator which might impair safety. Any changes must be approved by TDPS prior to their implementation.

1.3.7. Shipment

The following safety instruction applies during generator shipment.

	**WARNING:** **Suspended load. Falling load may cause injure to persons, Keep away**

	**NOTICE:** **Lift the generator only at specified part & in specified method.**

- Please refer to the shipping documents/outline for information about the dimensions and weights of generator components.
- Do not remove packaging or protective covers during shipment.
- Use specified load attachment points. Use suitable or specified lifting equipment. The lifting equipment must be in good condition and have a sufficient load carrying capacity.
- Prevent generator rotor from rope-induced damage by using suitable cushions at load attachment points.
- Only use qualified and experienced staff for attaching loads or instructing crane operators. The person issuing instructions must remain within operator's sight or in voice contact with him.

1.3.8. Erection

The following safety instructions apply during erection.

	**NOTICE:** **Do not remove any blocks, braces, anchors and / or cushions used during shipment until just before final erection or installation of generator.**
	**NOTICE:** **Do not step on generator parts, such as oil inlet & outlet flanges, measuring devices, exciter and so on.**

	**NOTICE:** **If massive pressure oil pipes are connected to the hydrostatic connectors of the generator bearings then:** ▪ **Support them adequately.** ▪ **Measure their natural frequency in the area of the connection, if possible.** ▪ **Check all pipe screw connections for tightness and tighten them according to the manufacturer's instructions.** **The pipes must be adapted and aligned during assembly. The strain on the connection point must be relieved by a suitable device.**

- Before erection, use the layout plans for the buildings to determine set-down areas and installation locations for heavy lifts.
- Before erection remove protective coating and any other materials from components using a suitable cleaning agent. Note environmental regulations.
- Carefully check components for any damage. Notify manufactured in writing for any damage found.
- Take care of the belongings in the pockets; better enter the generator with empty pockets. Record all tools used in a list and check that tools have been completely removed from generator once the work is completely finished.
- Remove any foreign materials from the generator.
- Check efficiency of bearing insulation.
- Check shaft voltage & current.

1.3.9. Generator Start up

The following safety instructions apply during generator start up.

	**WARNING:** **Generator is a Rotating component. These may cause injury to persons.** **Before commencing the generator start up activity ensure that personnel are not exposed to any hazards during the start-up procedure.**

- Involve engineers from TDPS.
- All mechanical and hydraulic components as well as the generator protection system must be checked with regard to function and settings.
- Check insulation resistance of winding.

- Check shaft voltages and currents.
- Before excitation remove any moisture caused by temperature drops below the dew point using suitable methods (eg. Drying).
- Record all operating data after allowing sufficient time for steady-state conditions to be established.
- Prepare startup record.

1.3.10. Operation

The following safety instructions apply during generator operation.

   	**DANGER:** **Electromagnetic fields in the vicinity of the generator.** **Persons with pacemakers must not enter the turbine building.** **Risk of getting burnt, toxic smoke.** **In the event of fire neither the machine hall nor the generator housing must be entered.**

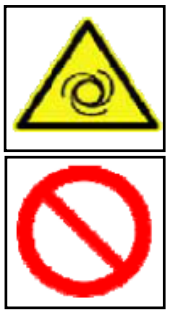
 	**WARNING:** **Hot surface. Parts of generator can be very hot and may cause serious burns.** **Do not touch.**

	**NOTICE:** **Within the bearing, oil mist results from the rotation of the rotor.** **Oil supply system to be provided with vapor extraction system to have negative pressure at outlet pipe, thereby avoiding oil leakage in bearing**

- Check the generator regularly for any visible damage or defects. Any changes (including changes in operating behavior) must be immediately reported to the department and/or person(s) responsible. The generator must be shut down immediately, if necessary.
- Only use lubricants specified by the manufacturer.
- Regular check condition of brushes and slip rings.
- Carry out and record requisite checks during generator operation.
- Only qualified staff with a work order should stay near the running generator.

1.3.11. Maintenance in Operation and Inspection at Generator standstill

The following safety instructions apply during generator maintenance and inspection.

	**WARNING:** **Generator start up may cause severe injury to persons.** **When working on generator or auxiliary equipment ensure that:** ▪ **It is electrically isolated & cannot accidentally be reconnected.** **Do not start turbine generator set if work is being carried out on or near the generator.**

- Work may only be performed by qualified personnel.
- Ensure compliance with the maintenance and inspection intervals and the scope of work set forth in the operating instructions.
- Operating personnel must be notified before starting and maintenance, inspections or repair work. Appoint a suitably qualified supervisor.
- Disable Prime mover-starting circuits before carrying out maintenance.
- Before disassembling the cooler housing first release the plug connection for the leakage water monitoring.
- Establish cause of any deposits, abrasion, fretting corrosion or discoloration and prevent re-occurrence.

1.3.12. Shutdown

The following safety instructions apply during generator shutdown.

	**WARNING:** **Generator is a Rotating component. These may cause injury to persons.** **Ensure that rotor has coasted down.** **Do not remove any guards until generator has come to a full standstill.**

- Perform and record the requisite checks during and following generator shutdown.
- Prepare Shutdown report.
- For long shutdown periods, electrically isolate the generator.
- Take appropriate measures to protect and preserve generator during shutdown.

1.3.13. Waste disposal

Waste products of any kind (eg. Lubricants) must be disposed off in compliance with the applicable waste disposal regulations.

1.3.14. Special Hazards

See below for safety instruction with regard to electric current and noise.

1. Electric current

Ensure compliance with the following instructions.

	**DANGER:** **In the event of loss of control voltage the generator must be shut down immediately.**

- Work on the electrical systems of the generator may only be performed by electrical engineers or by suitably qualified personnel under the supervision of an electrical engineer in compliance with the relevant electrical engineering standards.
- Components which are undergoing maintenance or repairs must be isolated. Check that isolated parts are de-energized, then ground and short-circuit. Isolate adjacent parts which are still energized.
- Regularly check the electrical equipment of the generator and immediately repair any defects.

2. Noise

	**CAUTION:** **If continuously exposed, operating noise of generator may damage hearing.** **Wear ear plugs when staying next to operating generator.**

- The generator may produce high noise level. If continuously exposed, operating noise of generator may damage hearing. Wear ear plugs at the operating generator.

CHAPTER 2

PACKING AND TRANSPORT

2. PACKING AND TRANSPORT

The generators are packed in wooden box and dispatched. The generator is dispatched in partly assembled condition and caution required to be exercised so that intensive shock is not imparted to the generator during transport.

Even though the generator is packed, the packed generator should not be left outdoors and should be protected from moisture, alkali, oil, gas, dust, dirt and other injurious substances and must be stored in an enclosed building.

Generator should be lifted using appropriate capacity of lifting shackle and lugs. In case of temporary resting on ground, lumbers should be placed and the generator should be lowered on them in a horizontal position.

During Transportation & storage of packed generation following symbols to be observed & should be taken care.

WARNING	Incorrect lifting or Inadequate lifting capacity can result in severe personal injury or equipment damage.

- **Acceptance and Protection:**

  Generator is dispatched after conducting thorough inspection, after receiving the generator check the following points:

  - Is there any missing item with reference to packing list? (Especially accessory and spare parts if any)
  - Is there any damage during transport?
  - If any damage is found, the carrier and the relevant TDPS Office / insurance Company must be notified without delay.

2.1. Storage

Below mentioned steps to be followed for proper storage.

1. During the erection work to avoid the lower insulation resistance value due to absorption of moisture in the coils due to rain and water drips, the complete protection measures should be ensured (such as cover the generator with canvas sheet etc,)
2. The generator is provided with space heater, which keeps the temperature several degrees above the ambient. These space heaters must be switched on till the generator is put into operation.
3. With reference to above point the winding temperature should be monitored during shutdown & long storage. Measured temperature should be maintained 10^0C above the ambient temperature & it should not exceed 80^0C.

2.2. Long Storage Method of Generator at Site

2.2.1. Outdoor Storage:

Do not store the shipments outdoors unless the goods concerned are ready assembled for outdoor plants. If outdoor storage is unavoidable, store cases under cover of a weatherproof cover & roof or alternatively cover with adequate (more than one) layer of weatherproof tarpaulins or sheeting which should be tied down. In order to provide the ventilation, proper care should be taken with respect to the tarpaulins which should not lie on the cases.

Protect the cases against ground by placing them on wooden boards or base. Select the storage area to offer maximum protection against flood, dirt, vermin such as rat, mice, termites etc. and tampering.
Avoid stacking heavy goods one on top of the other. Do not overload the goods stored by stacking. **This type of storage is valid for 6 months only. For storage more than 6 months follow below procedure or contact TDPS.**

2.2.2. Indoor Storage:

Indoor storage is most preferred type of storage. The storeroom should be well ventilated and dry, and spacious enough to allow stable and clearly arranged storage. External weather conditions, erection conditions, environmental conditions etc., can affect machine & its accessories. Variations in temperature and humidity can cause condensation throughout the unit, which leads to rust and corrosion on metal parts as well as deterioration of the electrical insulation. The storage facility must provide protection from contact with rain, snow, blowing sand or dust, accumulation of ground water, corrosive fumes and should give protection from insects or worms. Electrical supply for space heater and illumination should be provided. The machine must not be stored where they are liable to accidental damage or exposed to weld spatter, exhaust fumes, fire or dirt. If necessary, erect suitable guards or separating walls to provide adequate protection. Avoid storage in an atmosphere containing corrosive gases, particularly chlorine, sulphur dioxide and nitrous oxides.

The machine in storage must be protected from moisture on the winding and other critical parts. To prevent condensation, energize the space heater to keep the machine temperature above room temp by at least 3 deg C. During the period of extreme cold or rapid temperature decrease, the space heaters may not be sufficient to achieve the required temperature, in that case it is required to use separate heaters or halogen lamps.

2.2.3. Bearing storage care

2.2.3.1. Machine with sleeve bearing: (in which rotor can be rotated manually)

- Generator must be stored in the original operation position and first filling of oil should be carried out.
- During storage, at every 2 months remove the shaft locker, oil to be poured into the bearing from the top sight glass opening.
- If the machine is provided with oil ring then oil to be filled into the bearing to the required level (Half of the side oil sight glass indicator).
- Rotate the shaft at 3 to 5 rpm for 15 to 20 minutes using crane and ropes to circulate the oil and keep the sleeve bearing in good condition.

2.2.3.2. Machine with sleeve bearing: (in which rotor cannot be rotated manually)

2.2.3.2.1. General Points

CAUTION:
We recommend use of TECTYL 511 M from VALVOLINE for Rust Inhibition.

CAUTION:
Before commissioning at site, Oil flushing must be carried out until required filtrate level is achieved.

NOTE:
It is possible to start the machine without removal of Rust Inhibitor (TECTYL 511 M)

2.2.3.2.2. Storage up to 6 months

- Necessary measures will be taken care for all Generators to be stored up to this period at our Works.
- Refer above General points before commissioning.

2.2.3.2.3. Storage above 6 months

- Remove the Top sight Glass of the Bearing.
- Pour about 250cc of fresh rush inhibitor (TECTYL 511 M) through the Sight Glass hole so as to reach the Generator shaft contact surface.
- Close the sight Glass.
- At all exposed shaft external surfaces, clean the surfaces with suitable solvent & coat them with rust preventive coating (TECTYL 506)
- Refer above General points before commissioning.

2.2.3.2.4. Storage above 12 months

- Disassemble the Bearing & clean all the parts.
- Re-assemble the bearing.
- Seal the gaps between the shaft and bearing seals with water proof adhesive tapes.
- Follow the procedure as per 2.2.3.2.3.

2.2.3.2.5. For Storage more than 18 months

- Repeat procedures 2.2.3.2.3 & 2.2.3.2.4 alternatively for corresponding 6 month intervals.

2.2.4. Checks during Storage period:

The generator must be inspected from time to time and records shall be maintained. The following checks to be carried out:

- Physical damages
- Cleaning
- Signs of water condensation
- Paint condition
- Check for any insects or worms
- Check working of space heaters
- Check and apply rust inhibitor or anti corrosive coating on the machined exposed part of the generator / parts
- For long storage follow the below Table 2.2.4-1.

Table – 2.2.4-1

Content of Inspection	Monthly	Every 2 months	Every 6 months	Every 2 years	Before commissioning	Remarks
Storage location						
Inspect the cleaning condition		Δ			Δ	
Inspect moisture condition and the temperature		Δ				
Check for insect/worms infestation signs		Δ				
Packing						
Inspection for physical damages			Δ			
Inspect the relative humidity		Δ				
Change desiccant (silica gel)			Δ			
Space heater (Generator in dismantled condition from package)						
Check for operating condition	Δ					
Complete generator						
Clean external surface of the generator			Δ		Δ	
Check paint condition			Δ			
Check for anti corrosive protection layer on the non painted surfaces			Δ			
Change desiccant (silica gel)			Δ			
Winding						

Content of Inspection	Monthly	Every 2 months	Every 6 months	Every 2 years	Before commissioning	Remarks
Measure insulation resistance		Δ			Δ	
Polarization index					Δ	
Terminal box						
Clean box inside				Δ	Δ	
Antifriction Bearings						
Rotate the shaft		Δ				
Re-lubricate the bearing			Δ		Δ	
Disassemble and clean the bearing				Δ		
Sleeve bearing						
Rotate the shaft		Δ				
Apply rust inhibitor/ anti corrosive protective coating and desiccant (silica gel)			Δ			
Clean and re-lubricate the bearing					Δ	

2.3. Opening of Cases

Open Crates, cases and packing carefully to avoid damage. While doing so, pay attention to markings on case & packing.

Never use crowbars to pierce open cases forcibly. Use a nail puller to remove the nails holding the lid to the top of the sidewalls or the inner frame and the outer bracing. Then lift off the lid or cover boards. Remove enough of the braces and supporting struts to enable the parts to be taken out of the case without their being damaged.

Important! Braces and struts are generally nailed to the outer walls; pull the nails out from the outside.

With packing having an inner frame, all the cover boards are first removed and the inner frame then dismantled methodically into its component parts. After removing the parts securing the machine parts to the bottom of the case or packing, the machine parts themselves can be lifted out without any risk of damaging them.

Note! Remove polythene sheeting carefully. It can be used again later for covering parts while they are waiting to be fitted or to cover other parts which are to be stored for a longer duration.

2.4. Miscellaneous

TECTYL 506:

Application:

Tectyl 506 is an anti-corrosion agent used for protecting machine parts exposed to corrosion, Anti-corrosion protection is particularly important for parts that are to be sent overseas and to tropical regions, and for the storage of parts outdoors.

Directions of use:

Clean and dry the surfaces to be protected, carefully removing fingerprints and grease. Tectyl should not be heated, but be applied at ambient temperature.

2.5. Decommissioning

Once the generator reaches the end of its product lifecycle, it must be decommissioned. To do this, the generator must be switched off, disconnected from the power supply, earthed and secured against switching on again in accordance with the regulations.

Once it has cooled to the ambient temperature, the generator is to be disassembled and disposed of. The entire disposal process must be in line with all relevant and applicable disposal regulations. If there are no suitable disposal options on site, a waste disposal company must be charged with disposing of the equipment.

Reconditioning of used generators:

Because of the high quality of materials and workmanship used in the generator, TDPS offers the option of reconditioning used generators into as-new condition. Depending on their condition, a large number of the components can be reused, which is a more resource-friendly alternative to buying new.

CHAPTER 3

CONSTRUCTIONAL DETAILS OF GENERATOR

3. CONSTRUCTIONAL DETAILS OF GENERATOR

For major dimensions and details refer Outline and Foundation drawings provided in Annexure-1, Part – 2.

The generator design is compliance to standards IEC60034. The generator has indirectly cooled stator & rotor. The insulation system is designed according to class F heat resistance class. The standard design includes closed air circulated through generator. The standard generator is compliance to ingress protection IP54 as per IEC60034-5. (Other degree of protection is offered on customer requirement)

Main assemblies of generator are:

- Stator Frame
- Stator Core
- Stator winding
- Shaft
- Rotor core
- Rotor winding
- Bearings
- Cooler
- Excitation system
- PMG(Optional)
- Oil supply
- Protection & monitoring system

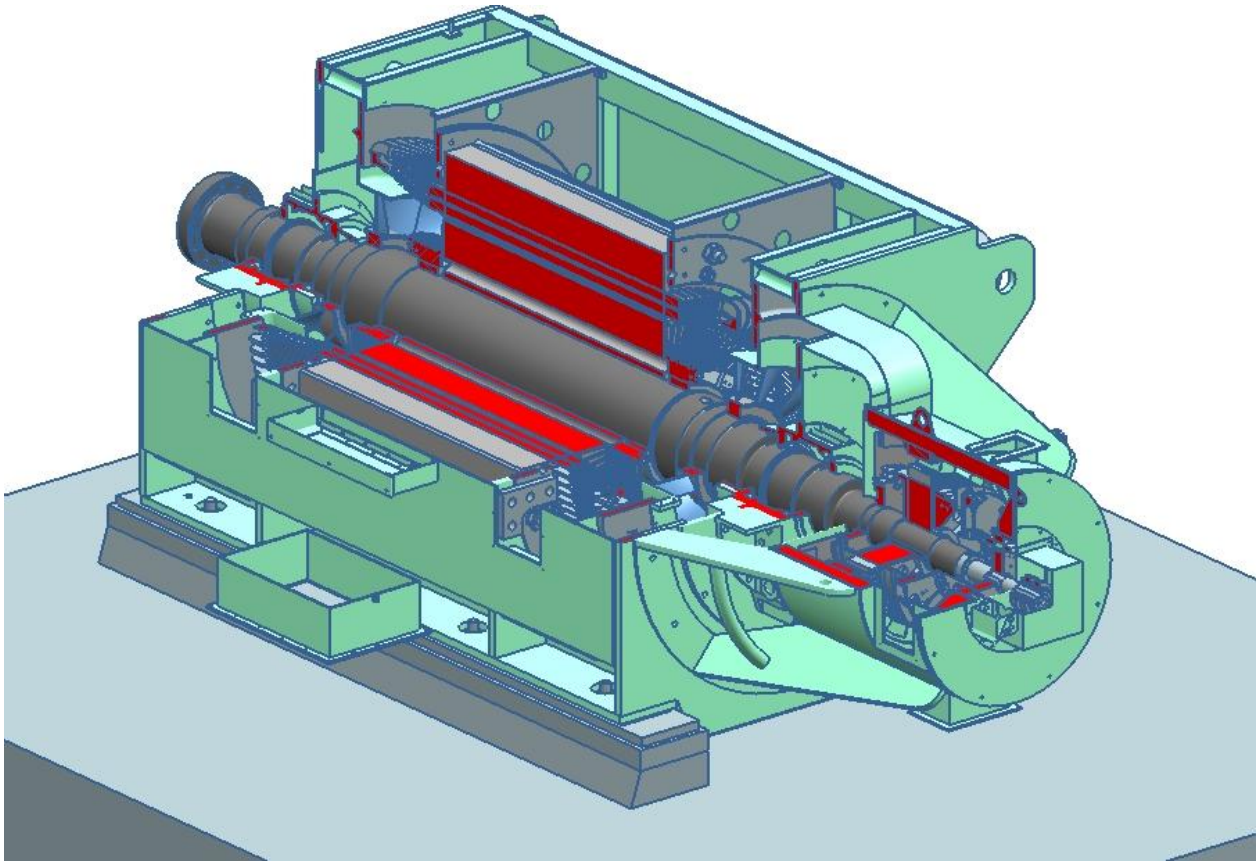


Fig: 3-1: Typical Cross sectional view of Generator

3.1. Construction of Main Stator

Stator consists of following assemblies:

Stator Core assembly
Stator Winding assembly
Stator Frame

3.1.1. Stator Core assembly:

Stator core is built with laminated silicon steel sheets of high quality and low iron loss. At every suitable length in its axial direction, duct pieces are welded forming ventilating ducts to effectively cool the interior. Stator core is tightened and fitted at ample pressure by core clamps and bolt assembly or by core clamps and landing bar assembly as per design requirements.

3.1.2. Stator winding assembly:

The three phase stator winding is designed two layer lap winding. The group of coils formed according to the number of slots per pole per phase.

Stator coils are pulled winding type, insulated with mica tape and coated with special finish coating with property of heat, humidity and oil resistance along with sufficient insulating intensity. End bent part of stator coils are rigidly supported by fiber glass support rings on both ends to protect the winding against mechanical force due to vibration and over current. Harmonic distortions, magnetic noises and vibrations on the lamination core are taken care in the design stage. The stator is vacuum pressure impregnated, which results in high mechanical & electrical strength.

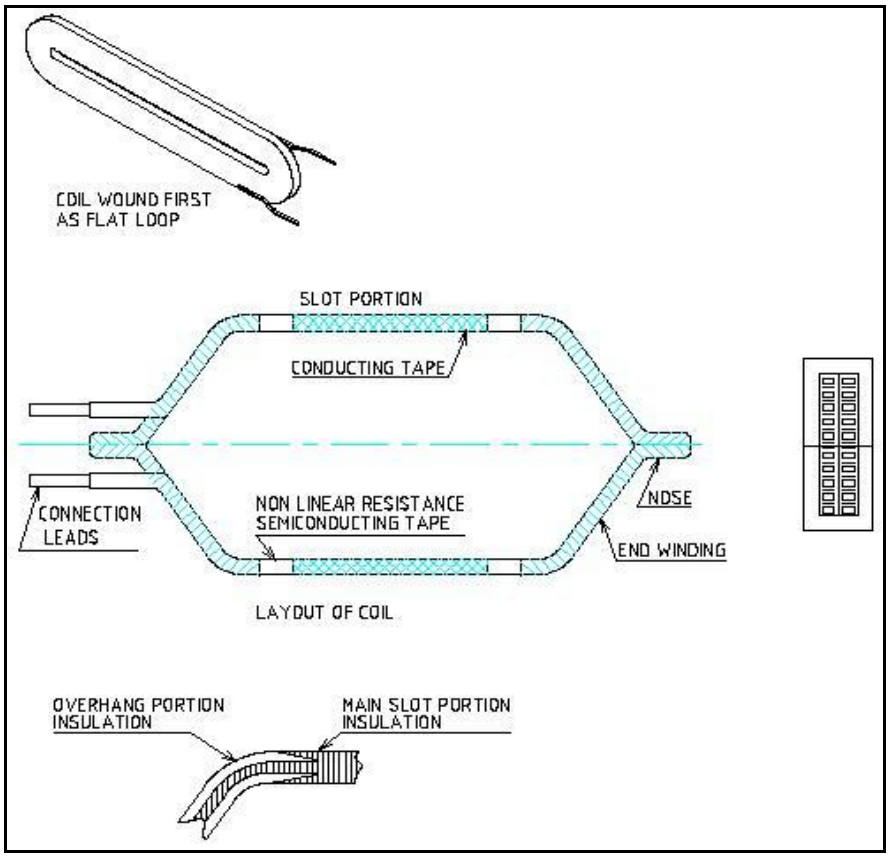


Fig: 3.1.2-1 – Stator coil insulation scheme

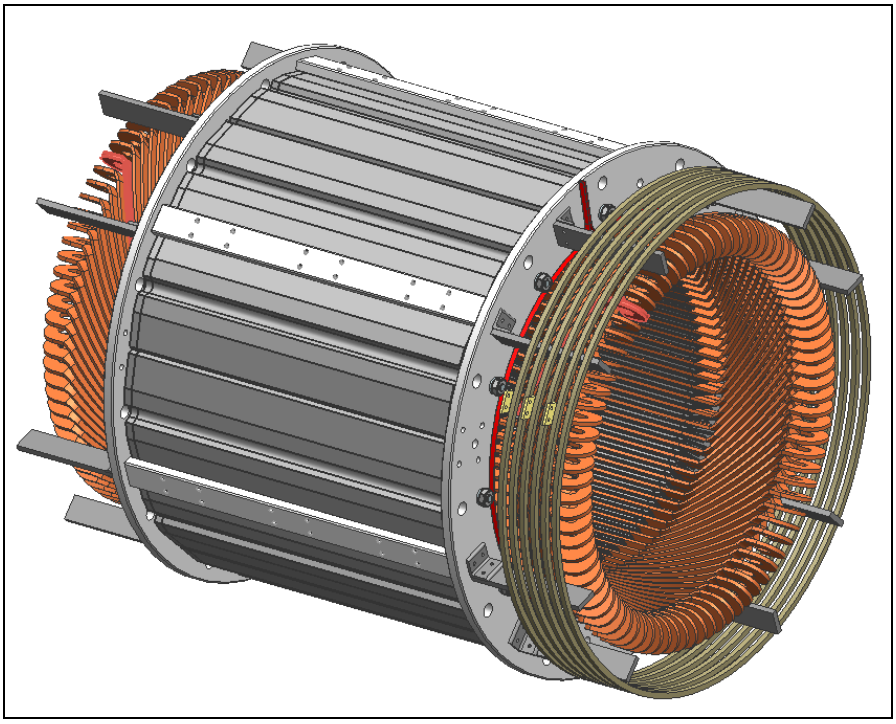
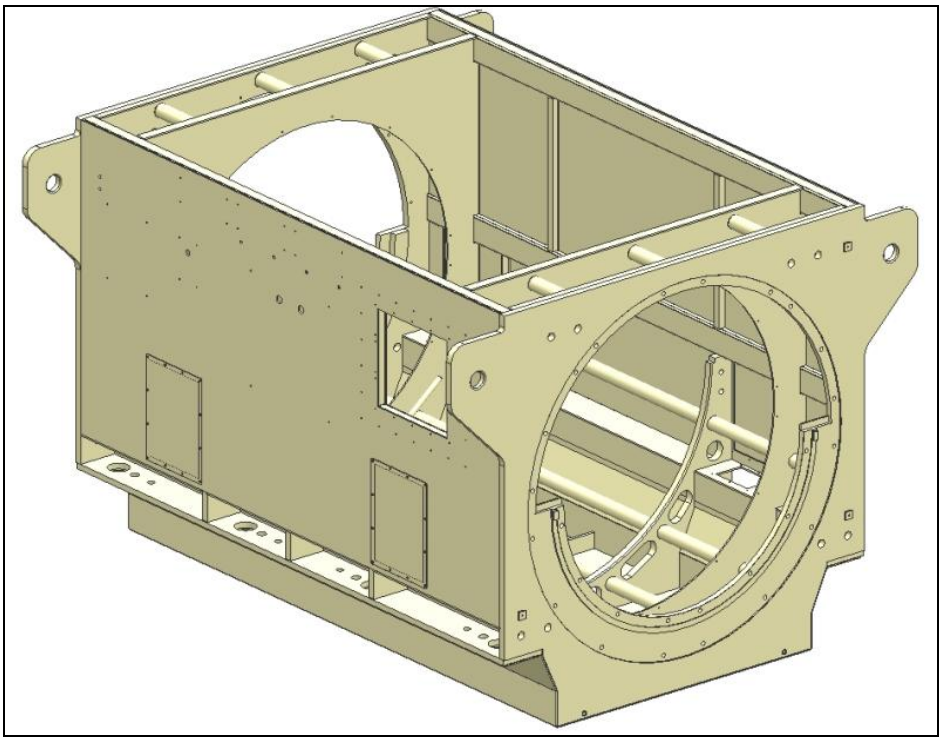


Fig: 3.1.2-2 Typical Wound Stator

3.1.3. Stator Frame:

Outer frame is constructed by fabricated & welded high quality steel to offer high strength and rigid structure. Stator winding forms the main part which is pressed or inserted in the frame. Two rectangular steel plates are bolted to form the generator feet or the complete frame assembly is mounted on base frame. For Diesel generator applications, the complete machine is mounted on Customer's common base frame.



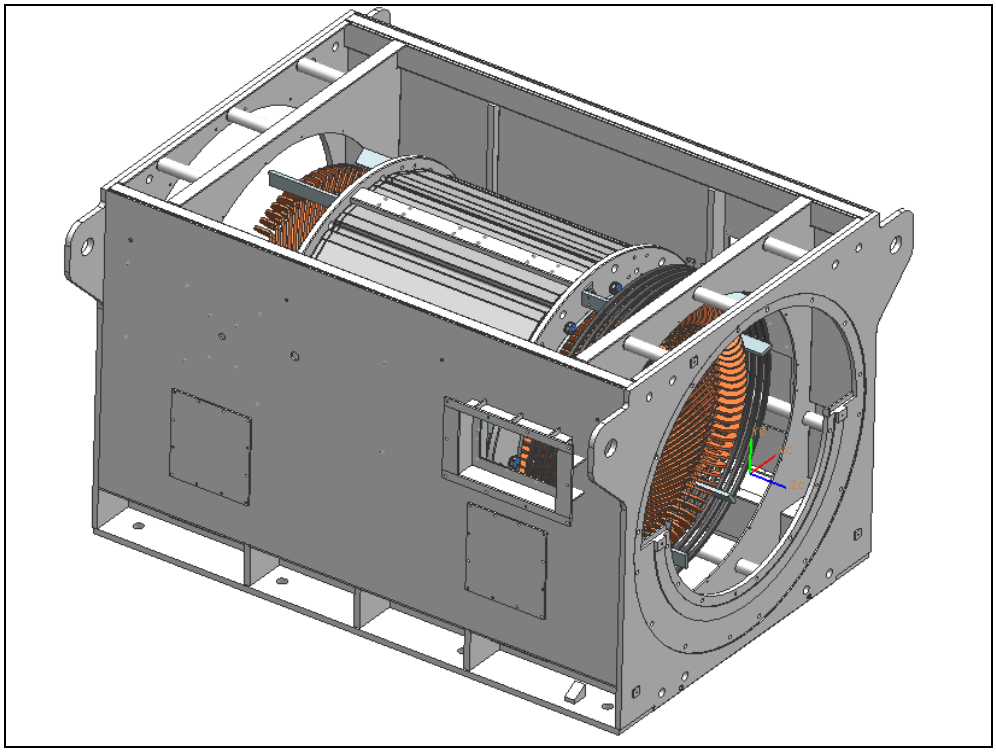


Fig: 3.1.3-1 Typical Stator Frame with wound stator inserted into the frame

3.2. Construction of Rotor

The rotor is of cylindrical pole type.

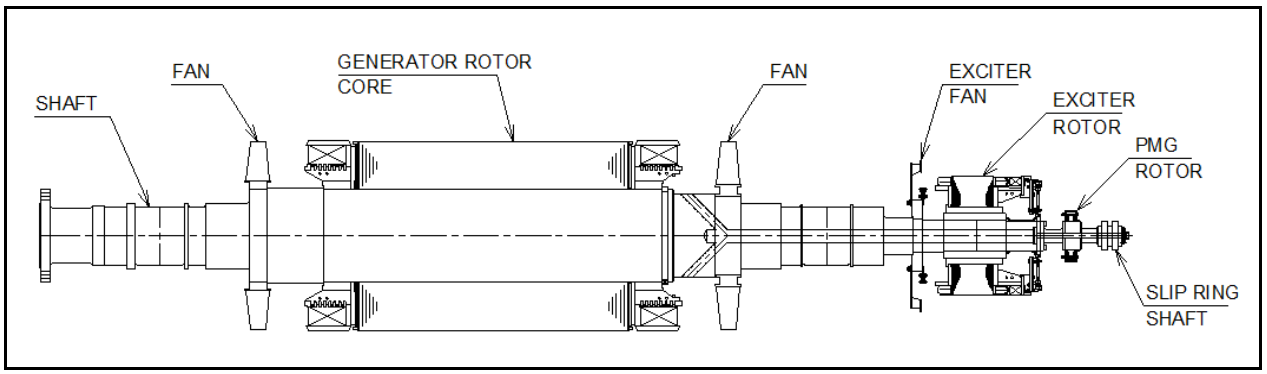
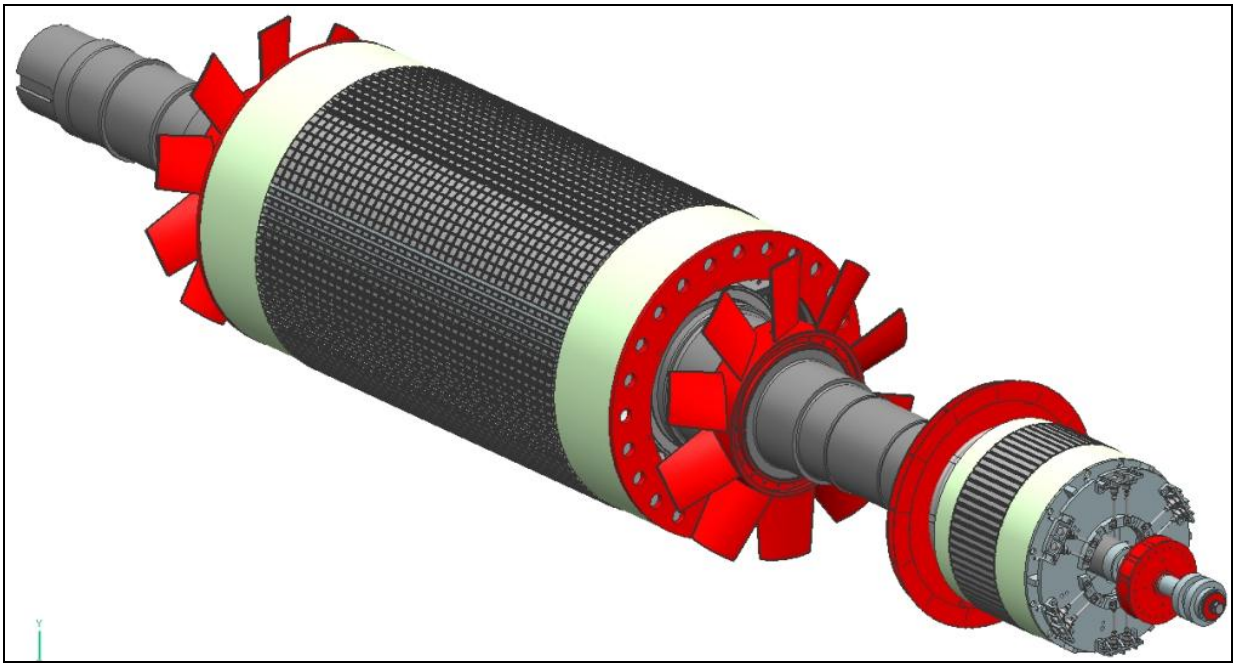
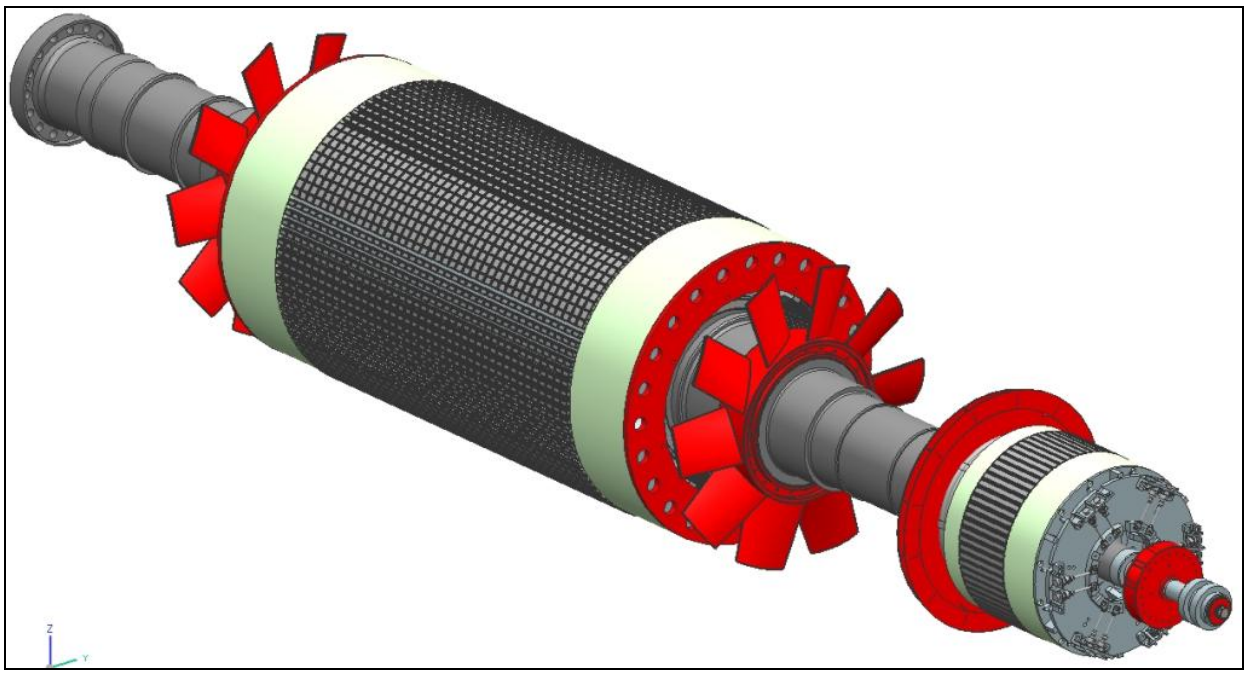


Fig: 3.2-1 Typical Wound Rotor Arrangement (Cylindrical Type)





Cylindrical type construction consists of following assemblies.

Shaft
Rotor Core assembly
Field winding
Fan
Excitation System

3.2.1. **Shaft:** Shaft is made up of forged steel and extension is used to mount coupling or an integral flanged extension is provided as per customer requirement to facilitate the torque transmission during normal operating, overload and short circuit conditions.

3.2.2. **Rotor Core assembly:** Low loss laminated steel sheets forms field core. At every suitable length in its axial direction, duct pieces are welded forming ventilating ducts to effectively cool the interior. Also the outer surface of field core is provided with damper winding that helps to operate with unbalanced loads.

3.2.3. **Field winding:** Field winding is wound as per the rotor slot configuration & connected as per design and is vacuum pressure impregnated, which results in high mechanical & electrical strength. Banding is done on overhang of the rotor winding considering the critical speed as the design criteria. Steel ring is also used in overhang portion of the winding in higher Mega Watt, High sped application. Rotor is manufactured & inspected with due attention given to machining of parts, assembly and balancing.

3.2.4. **Fan:** Fans are assembled on shaft to facilitate air circulation. The fan components are manufactured from rolled-steel plates and welded and stress-relieved and heaved.

3.2.5. Excitation system

TDPS offers Brushless excitation and Static excitation system.

3.2.5.1. **Brushless Excitation:** Brushless excitation consists of Exciter Stator, Rotor and rotating rectifier assembly (RRA).

I. Construction of Exciter Stator

Laminated silicon steel sheets of high quality forms exciter stator core. Exciter stator is wire wound, varnish impregnation process is adapted .The wound exciter stator is pressed into the exciter frame.

Exciter stator houses the field winding to supply the flux to exciter rotor. DC supply is fed to exciter stator from AVR depending.

II. Construction of exciter Rotor

Exciter Rotor core is mounted on the main shaft or on extended shaft tightened and fitted by applying suitable torque and locked. Coils are insulated with nomex insulation, wound exciter rotor is varnish impregnated. The output of the exciter rotor is converted into DC in rotating rectifier assembly, and rectified DC is fed to the main field.

III. Rotating Rectifier Assembly (RRA):

A 3ϕ full wave bridge rectifier is used to convert AC output from exciter armature (Exciter rotor) to DC, which is fed into main field. RRA will be of 6 or 12 diodes (on design requirement) arrangement. Threaded stud-pig tail type Silicon diodes are used which will be fixed to Aluminum heat sinks. Heat sinks are mounted on insulating plate, which is fixed to exciter rotor core clamp through a fitting stand.

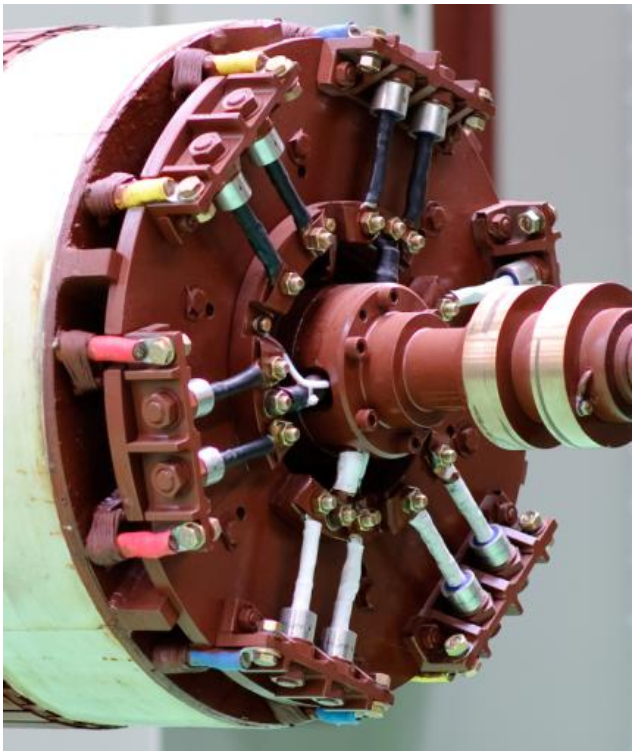


Fig: 3.2.5-1 Typical RRA assembly

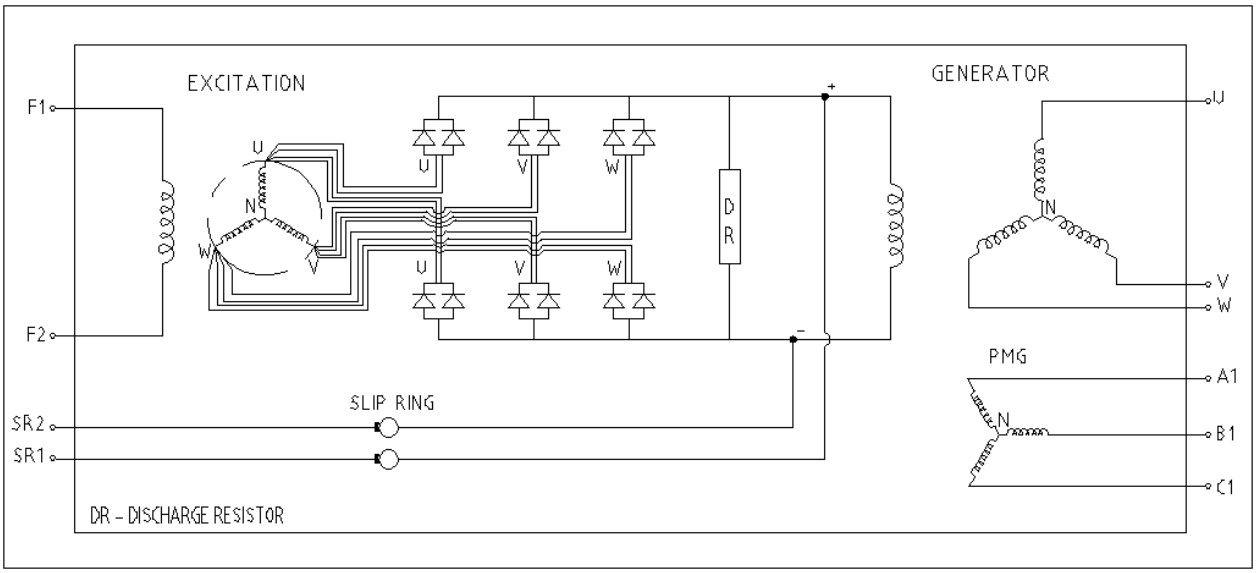


Fig.3.2.5-2 – Typical Generator single line diagram

Above figure shows the connection diagram of generator for reference only. The number of diode & discharge resister depends on the design requirement. PMG & slip rings are provided on customer requirement.

The rectifier assembly is split into two groups namely positive and negative, and the main rotor is connected across these groups. This group is formed through the connection bar shorting between two diodes as shown. Each group carries 3 or 6 diodes, the negative group carrying negative biased diodes and the positive group carrying positive biased diodes. Care must be taken to ensure that the correct polarity diodes are fitted to each respective group. When fitting the diodes to the connecting bar they must be tight enough to ensure a good mechanical and electrical contact, but should not be over tightened. Tightening torque for fixing diodes should be 306 kg-cm.

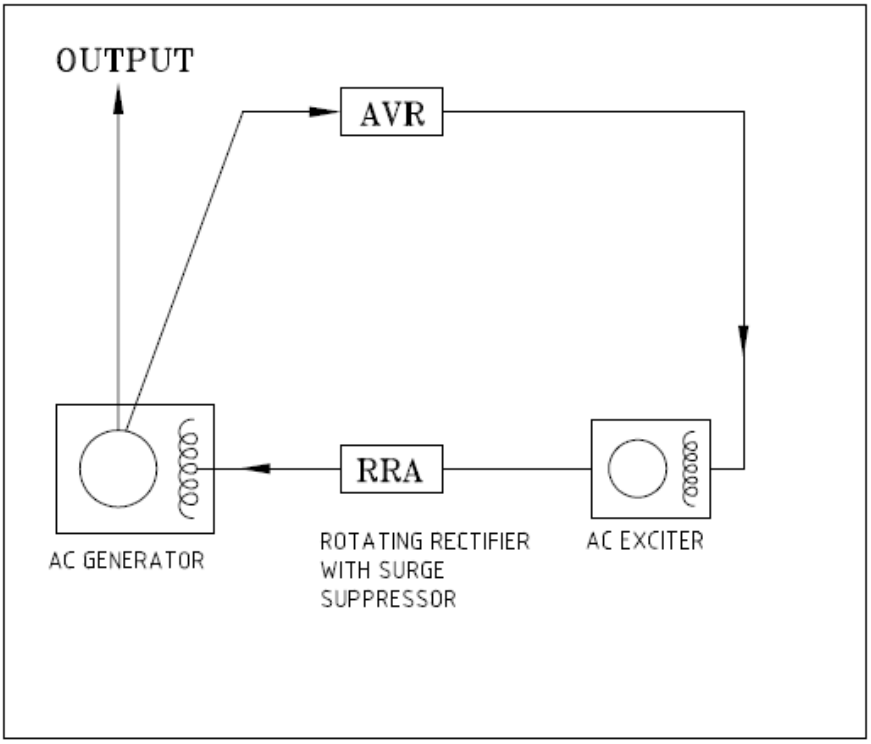


Fig.3.2.5-3 - Brushless generator schematic

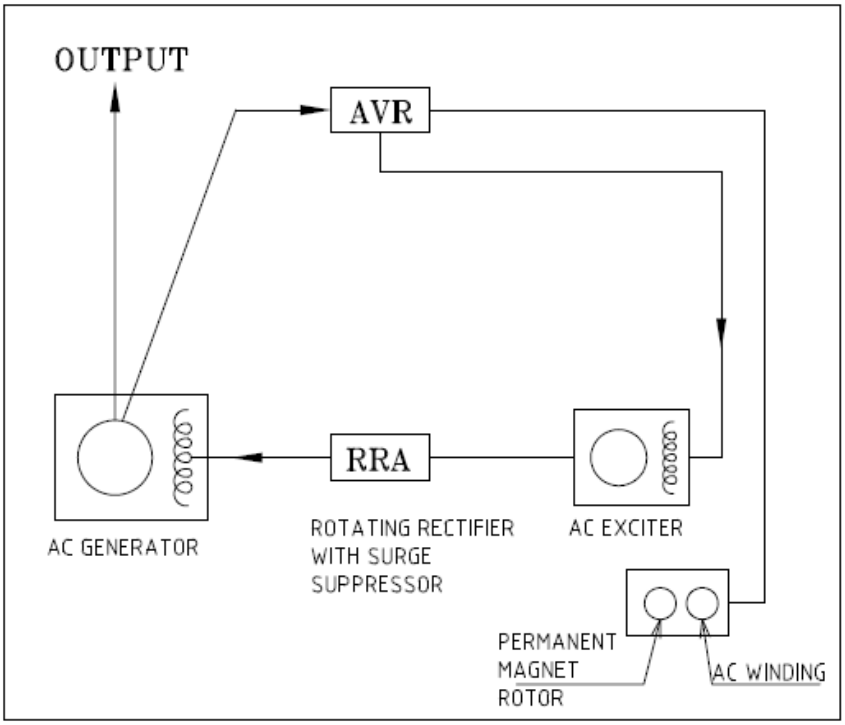


Fig.3.2.5-4 – Brushless generator with PMG schematic

3.2.5.2. Static Excitation: The static excitation system consists of slip ring & brushes. Excitation is fed to the main field using brushes through slip ring assembly.

3.3. Discharge Resistor

The discharge resistor is permanently connected resistor across the rectifier plates to prevent high transient reverse voltages in the field winding from damaging the diodes. The connection configuration can be series or parallel as per design requirements, refer to Part 2 of manual for rating and details.

3.4. Bearings

3.4.1. Sleeve Bearing

3.4.1.1. General Instruction

Generators are usually supplied with two bearing supported at each ends. DE bearing is located & non-insulated (or insulated based on requirement), NDE bearing is non located & insulated type. For DE bearing axial clearance refer respective outline drawing & NDE bearing is a free float. Bearings are not designed to take any axial load coming from coupling, turbine, and gear box.

Coupling has to be selected as per NEMA standard.
Alteration to the bearing may only be carried out with the permission of TDPS, who must also be consulted in the event of load specifications being exceeded. Our qualified team of engineers can carry out repairs and service if required to avoid errors caused by untrained personnel.

3.4.1.2. Construction

Rotation of the generator rotor is guided by Sleeve bearings. The bearing housing is constructed in two ribbed parts providing considerable heat extraction potential.

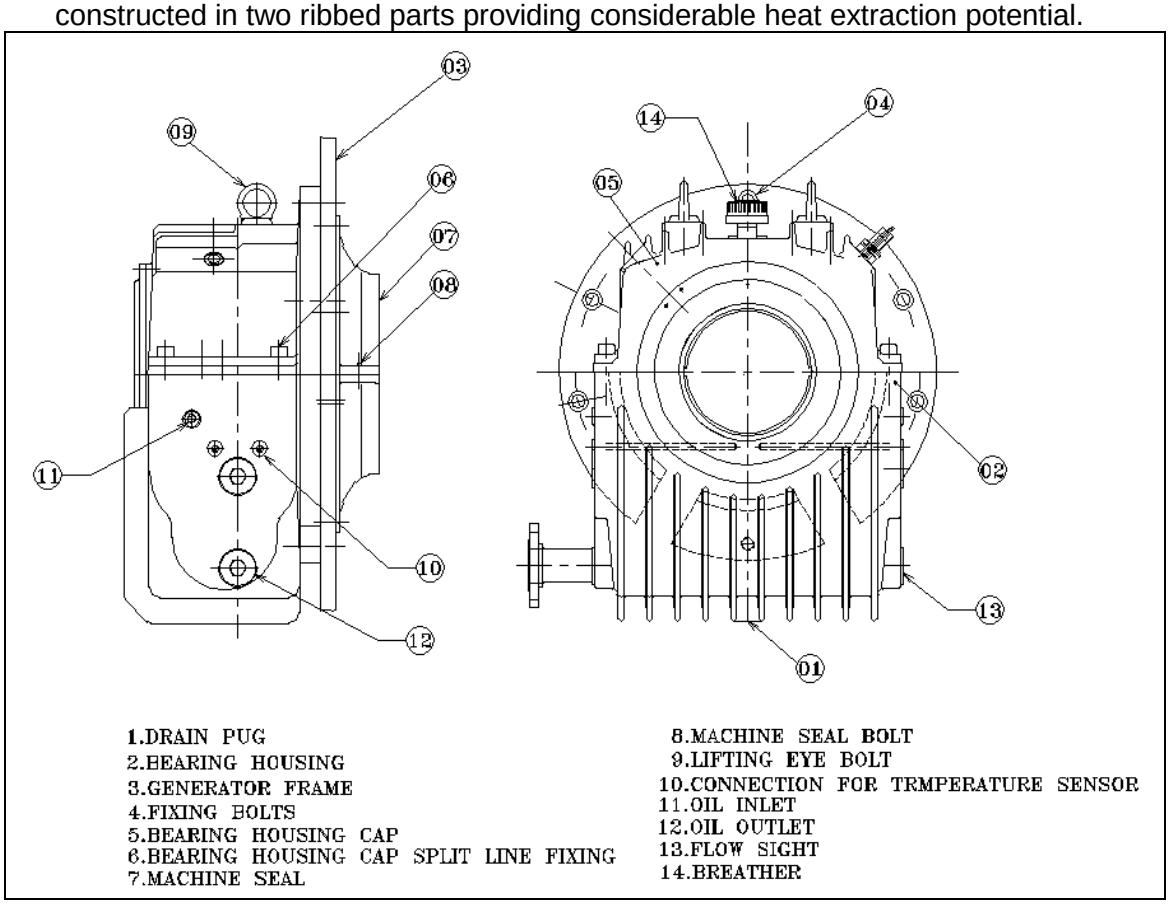


Fig: 3.4.1-1 – Finned, Flanged-Mounted Bearing (Typical)

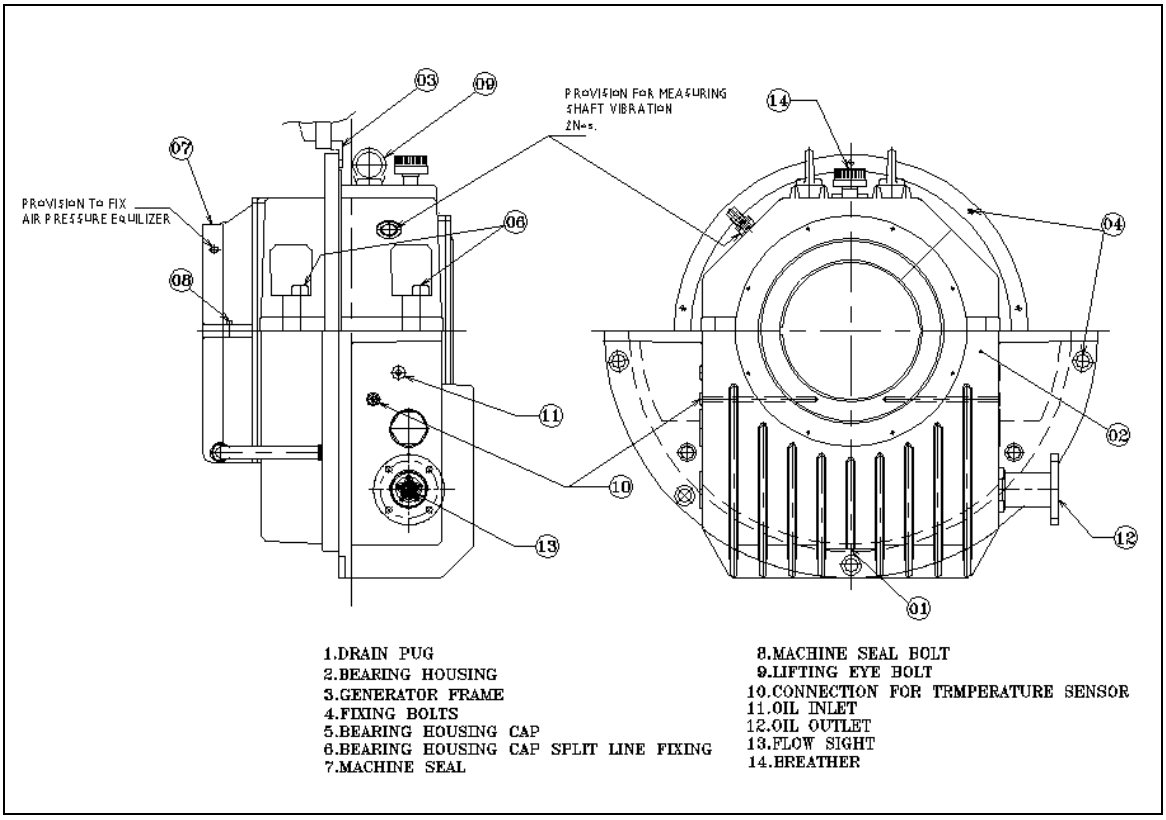


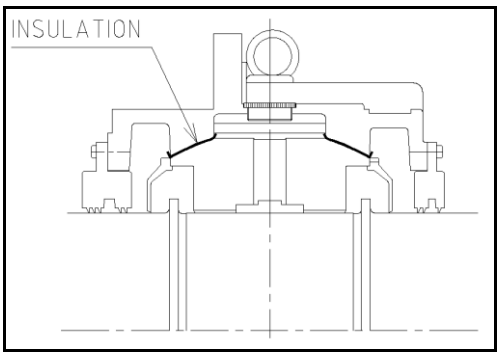
Fig: 3.4.1 - 2 – Finned, Centrally Flanged-Mounted Bearing (Typical)

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 tin based anti-friction metal. The labyrinth seals are split in two half for ease of assembly & Disassembly. An Anti rotation pin is inserted to the top half of bush in order to avoid rotation of bush.

The upper part of the housing is closed by means of a glass plug allowing observation of the rotation of the lubrication ring, if oil ring is provided. Otherwise, a threaded plug is provided where bearing oil is filled.

The lower housing is equipped with an oil-level sight indicator, a thermometer and a temperature sensor. The oil drain plug is located on the bottom of the bearing housing. The spherical seating of NDE bearing is covered with an insulating layer. The anti rotation pin of the NDE bearing in the housing is also insulated.

Temperature monitoring equipment in contact with bearing bush is also insulated.



Generators are supplied in two conditions.

- Assembled
- Disassembled

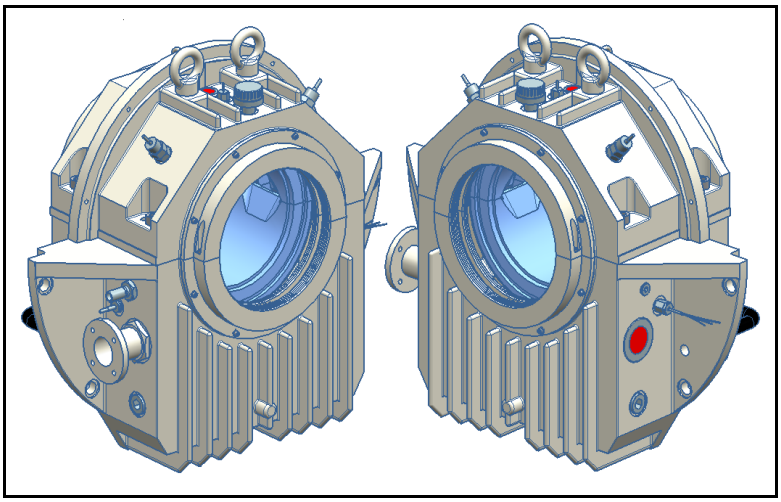
The oil circulating bearings are delivered with:

- Breather.
- An orifice at oil inlet to maintain required pressure, diameter of the same will be punched on the orifice plate.
- Pressure gauge at inlet.
- Temperature gauge at outlet to measure oil temp.
- Flow sight.
- Connection flanges for oil inlet & outlet with mating flanges.
- Temperature sensor (RTD -PT100)

3.4.1.3. Assembled condition:

If generator is supplied in assembled condition, following points to be considered during installation & erection.

- Generator will be transported by draining the oil from bearing sump & shaft will be locked by pushing shaft to the one side, so that bearing bush thrust liner will be in contact with the shaft shoulder.
- Generator bearing are end shield mounted sleeve type. These bearing are located with stator frame by spigot arrangement. Hence top-bearing housing need not to be removed during alignment.
- Leveling & alignment of generator has to be carried out using sprit level gauge of smaller length to get accommodated on the shaft.
- Oil flushing of bearing, this is to be done using inlet & outlet pipe flanges of individual bearings using different mesh size filters without removing top half of bearing housing, till the specified required size particles does not pass through the mesh provided at outlet pipe.
- Prior to cleaning, all measuring instruments, switch fittings (pressure control, flow gauge) and their connections must be removed.



Sleeve Bearing – End shield Mounted type

IMPORTANT!	**After every 20-25 days of storage of generator a manual rotation to the rotor is to be given in order to safeguard the bearings from rusting. Refer section 2.2.3 for details.**

3.5. Space Heaters

Space heaters are fitted in the machine to avoid condensation in the event of long storage, also when machine is not in operation. The space heaters are designed to maintain internal temperature above the ambient temperature. ***Care should be taken to switch on these heaters at site when the machine is not in operation and should be switched off before the machine is commissioned into operation***. When machine is inspected clean the space heaters for dust deposition.

For replacement use same type of space heater. It is advisable to order the space heaters from the TDPS for replacement.

Technical specifications & connection drawing: Refer Manual Part 2, section 1.4

IMPORTANT!	**Care should be taken to switch on these heaters at site when the machine is not in operation and should be switched off before the machine is commissioned into operation**.

3.6. Construction of PMG(Optional)

The permanent magnet Generator is a part of Generator excitation system where the rotor of the PMG is mounted on the main Generator extended stub shaft.

PMG is with rotating permanent magnets mounted on PMG rotor and stationary armature. The output of the PMG is connected to Generator AVR panel.

Using laminated steel sheets, this is firmly held by end clamps forms stationary PMG armature core. Wire wound armature is enclosed by fabricated MS frame.

Terminal output from PMG is terminated in terminal box mounted on the PMG frame. It will further get connected to Generator AVR (from auxiliary terminal box).

WARNING	**Use non magnetic tools and fixtures near PMG rotor in order to avoid personal injury or equipment damage.**

3.7. Cooler

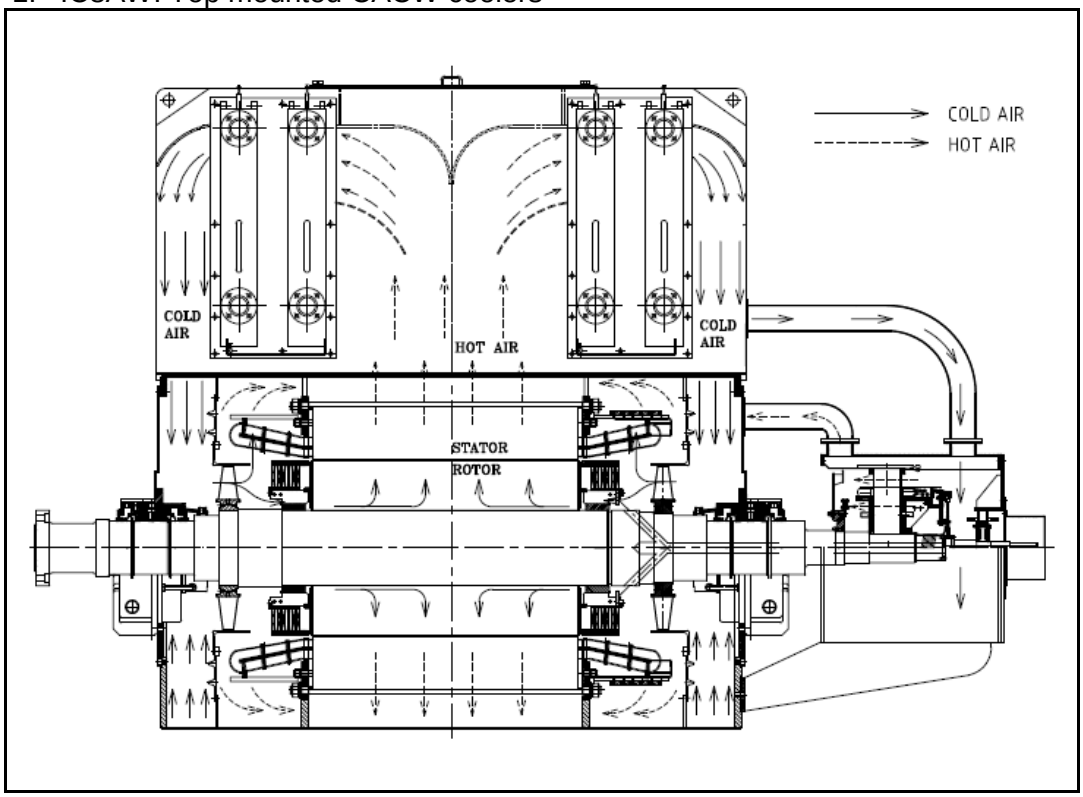
Cooling Method of Generator:

Circulating Air Cooling Water circuit is used for cooling the generator. The cooling method used is indirect cooling method; circulating air is used as the cooling medium. The heat of the winding is dissipated to the cooling medium through winding insulation & laminated core dissipates the heat to the cooling medium. The fans assembled in the shaft facilitate the effective cooling by circulating the air from cold air to hot air & vice versa.

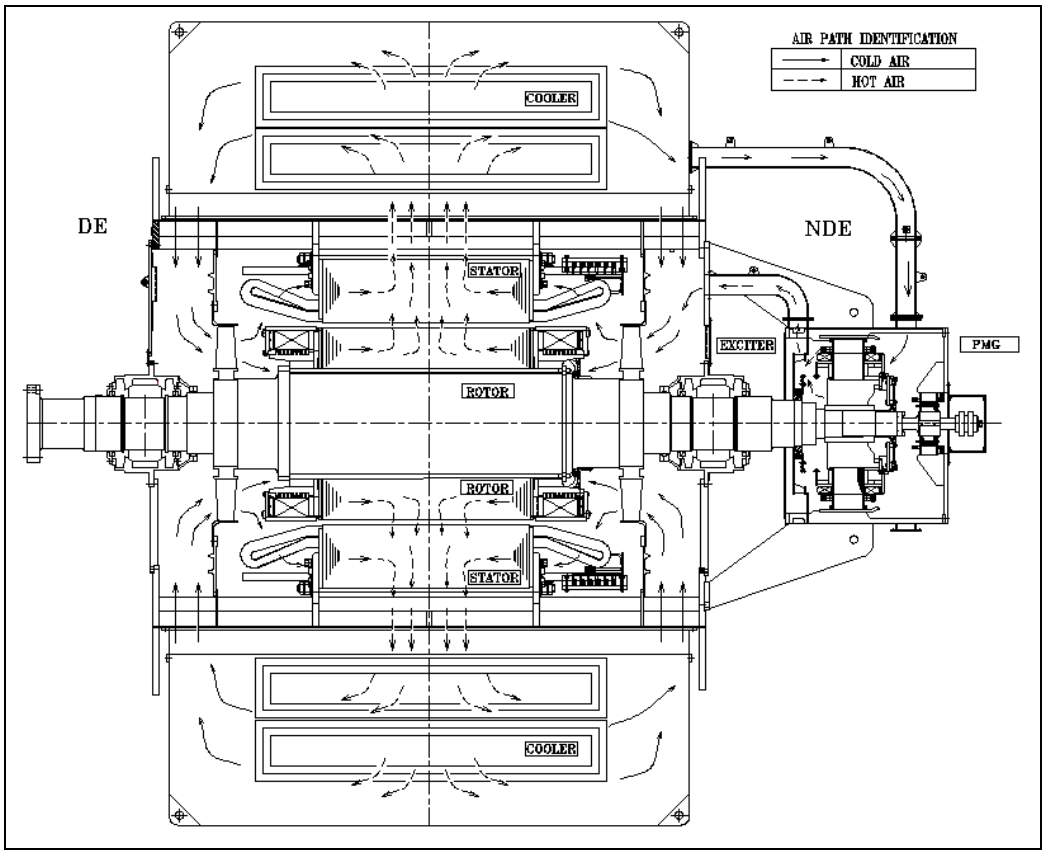
As per the standard IEC60034-6 standard cooling method used is IC81W (top cooler). Depending upon customer requirement following cooler arrangement is offered, i.e. side cooler (IC81W) and IC91W (Bottom cooler) on customer specific requirement.

Below figure shows the different types of cooler arrangement of IC8AW

1. IC8AW: Top mounted CACW coolers



2. IC8AW: Side mounted CACW coolers



Construction of Cooler

Generator is totally enclosed with CACW (closed air and circulating water) cooler .The circulating air absorbs the heat loss of the machine and dissipates it to the cooling water through the heat exchanger/tube bundle. The heat exchanger consists of finned tube bundle .The hot air from the machine is made to flow over the finned tube bundle which is cooled by the cold water flowing through the tubes.

IMPORTANT!	Tubes to be cleaned by using bristle brush or a brush made out of soft brass wire or nylon brush in a direction opposite to the flow of water.

Cleaning interval to be decided by the customer depending on the quality of water.

Refer to cooler manual for construction, operation & maintenance details.

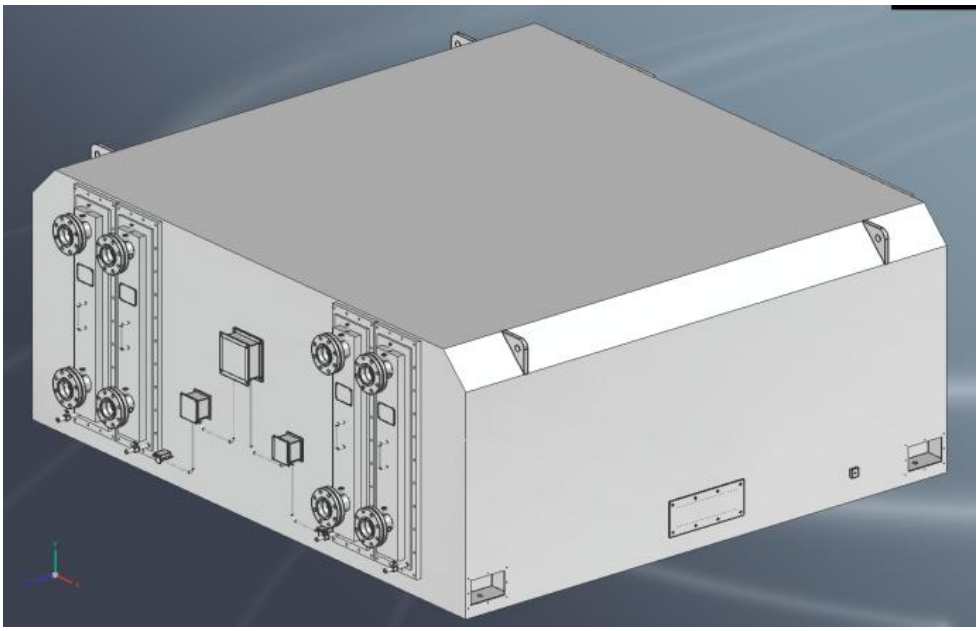


Fig: 3.7-1 – Cooler (image for reference)

Water Leakage Detector:

- Water leakage detector senses the presence of leakage water collected in tray from the cooler. Two probes of the sensing elements are routed to the tray. When there is leakage from the cooler, the two probes of the sensing element electrically connected through water.
- As soon as the water comes in contact with the sensing element, the electromagnetic relay in the control unit gets energized. It results in opening of NC contacts & closes NO contacts. It gives signal to the DCA for alarm & trip.

Block diagram of water leakage detector is shown below.

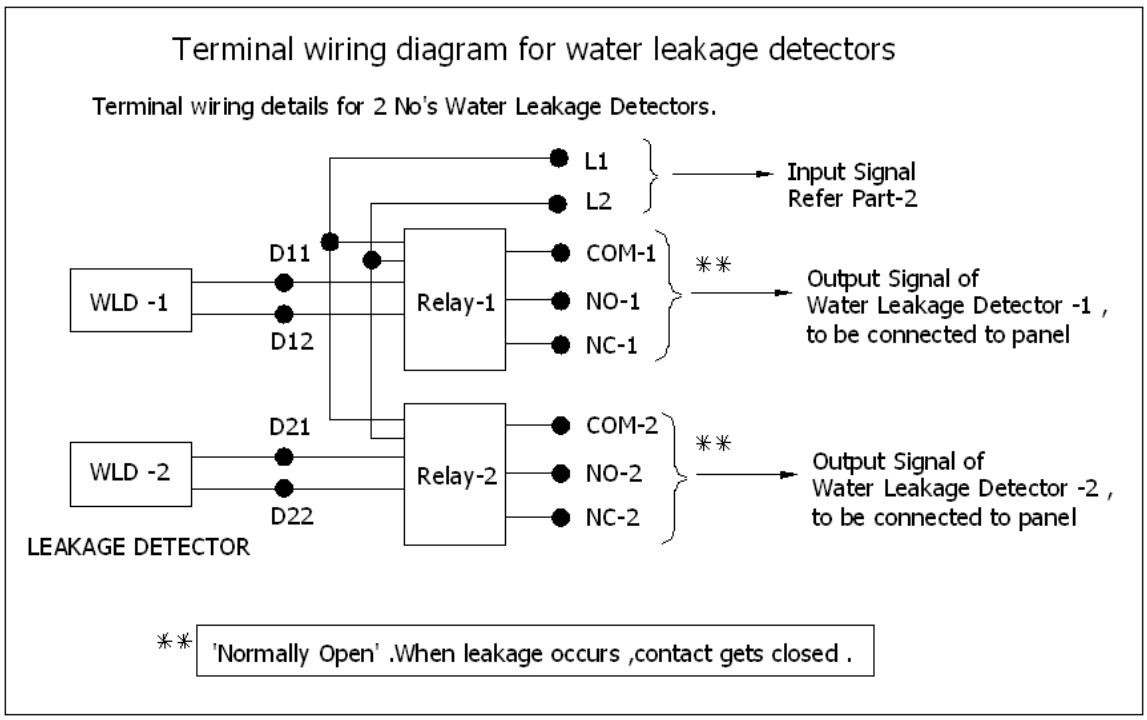


Fig: 3.7-2 – Block Diagram of water leakage detector

3.8. Automatic Voltage Regulator (AVR)

AC supply is given to the AVR from the PMG, AVR rectifies it into DC and the same is supplied to exciter field for excitation and hence to the main filed. The feedback from the generator output is taken to AVR. If there is an increase or decrease in generator output voltage, respectively AVR will increase or decrease the excitation current to the exciter & hence keeps the output terminal voltage of the generator within the limit. During fault condition also AVR maintains the excitation to the exciter.

Typical generator connection diagram with PMG & without PMG is shown in figure 3.2.3-3 & 4.

3.9. Jacking Oil System

For machines having hydrostatic jacking system, during startup and shutdown, rotor lift is to be achieved by external Jack oil system. Following parameters should be ensured.

1. During Start up/Running/Stop
   a. During Starting : From 0 rpm to 200 rpm – **JOP ON**
   b. During Running : above 200 rpm – **JOP OFF**
   c. During Shut down : From 200 rpm till the machine reaches 0 rpm – **JOP ON**
2. Ensure that Shaft lift shall be between **0.06mm to 0.12mm** during start up on each side (DE & NDE).
3. Start up/operational pressure : Refer outline drawing
4. Holding pressure : 50 to 90 bar

3.10.Rotor Grounding System or shaft earthing arrangement

Grounding brushes are fitted to the bearing or labyrinth ring to remove the static charges of the shafts. The typical brush holder arrangement is shown below.

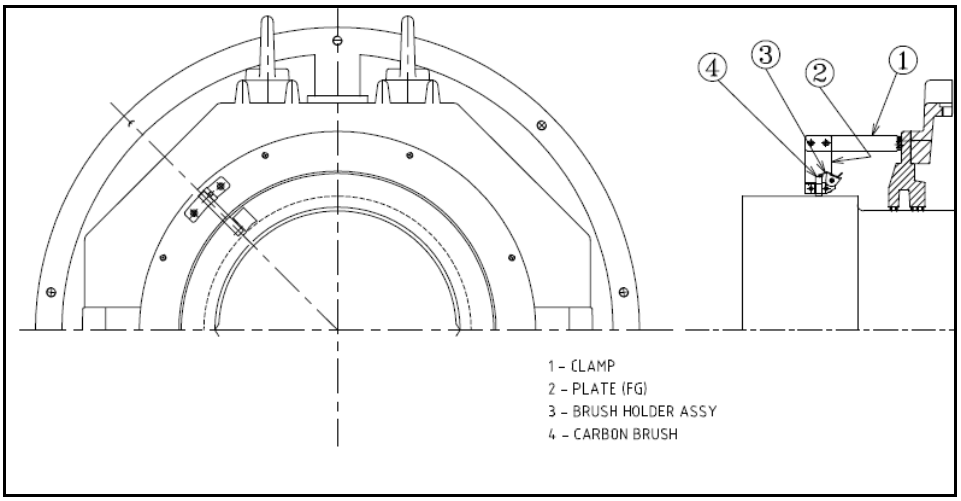


Fig: 3.10-1 – Typical Rotor Grounding System

3.11.Slip Ring

Slip ring is optional assembly provided to facilitate rotor earth fault detection as well as field voltage measurement.

CHAPTER 4

ERECTION OF GENERATOR AT SITE

4. ERECTION OF GENERATOR AT SITE

WARNING	Incorrect installation or replacement of parts can result in severe Personal injury or equipment damage. Service personnel must be qualified to perform electrical and mechanical services.
CAUTION	After installation ensure all protective guards and access covers Are fitted. Failure to do so can result in operator injury.

Installation & Erection of generators requires specific knowledge & great care. These tasks must only be performed by competent installations technicians.

4.1. Pre-Installation Check up

- When the generator arrives at the site, the purchaser should first check the packing list & ensure completeness of the same to avoid installation delays.
- Examine the equipment for transportation damage. File any damage claims with the carrier promptly.
- Check whether all contractual drawings, specifications pertaining to erection are available at site.
- Ensure that proper tools & safety gadgets are available to handle the equipment.
- Clean the machine and the component by jet of dry air & cloth, to remove any dust or dirt accumulated during storage.

The following environmental characteristics must be ensured:

- Clean and well-ventilated place.
- The installation of other equipment or walls should not obstruct generator cooling.
- The space around and above the generator must be sufficient for its maintenance and handling.
- The environment must comply with the generator protection class.

4.2. Foundations Requirements

- The foundation or structure where the generator is to be installed must be stiff enough, level, free of external vibrations and able to withstand to the start-up or in case of generator short-circuits.
- If the foundation dimensions are not executed accurately, serious vibration problems may occur with the generator and drive machine as a whole.
- The dimension of the foundation structure must be executed by considering the foundation drawing of generator and required information about the dynamic forces coming on to the foundation.
- Inherent freq. of generator foundation should not exist within the freq. Range from +20% to -20% of corresponding freq. at rated speed of generator.

4.3. Generator lifting

- It is important to lift the machine / components by the lifting method as specified in the name plate.

IMPORTANT

Drawings and photographs are not to scale and do not represent detailed images of the respective product, these are only for reference.

For project specific drawing, refer to the Annexure & project specific drawings.

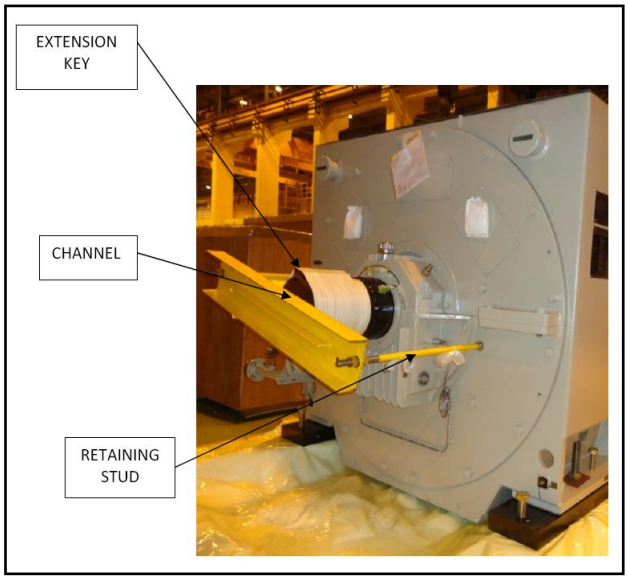
WARNING

The user is responsible for selecting the correct lifting equipment & for using it both properly & safely. Improper or unsafe equipment or its misuse in unsafe configurations could cause a load to shift or drop. Serious injury, death, or equipment damage could result.

DANGER:
The four lifting hooks must be used to lift the machine using slings (one hook at each corner of the machine).

Generator as supplied:

- The generator is supplied with a shaft-locking device to prevent damages to the bearings during the transport. This locking device must be removed before the generator installation.



ATTENTION

The shaft locking device must be used whenever the generator is removed from its base (decoupling from the drive machine) and hence prevent/avoid bearing damages during the transport.

- The shaft extension is protected against corrosion. Clean it before inserting coupling.
- The coupling must be balanced separately before being mounted on the shaft.

CAUTION

Shaft locking device to be removed before proceeding with the installation

CAUTION

All devices painted in yellow color must be removed before installation

4.4. Magnetic Centre Matching

4.4.1. Main machine:

Following procedure to be followed before loading the generator on foundation bed.

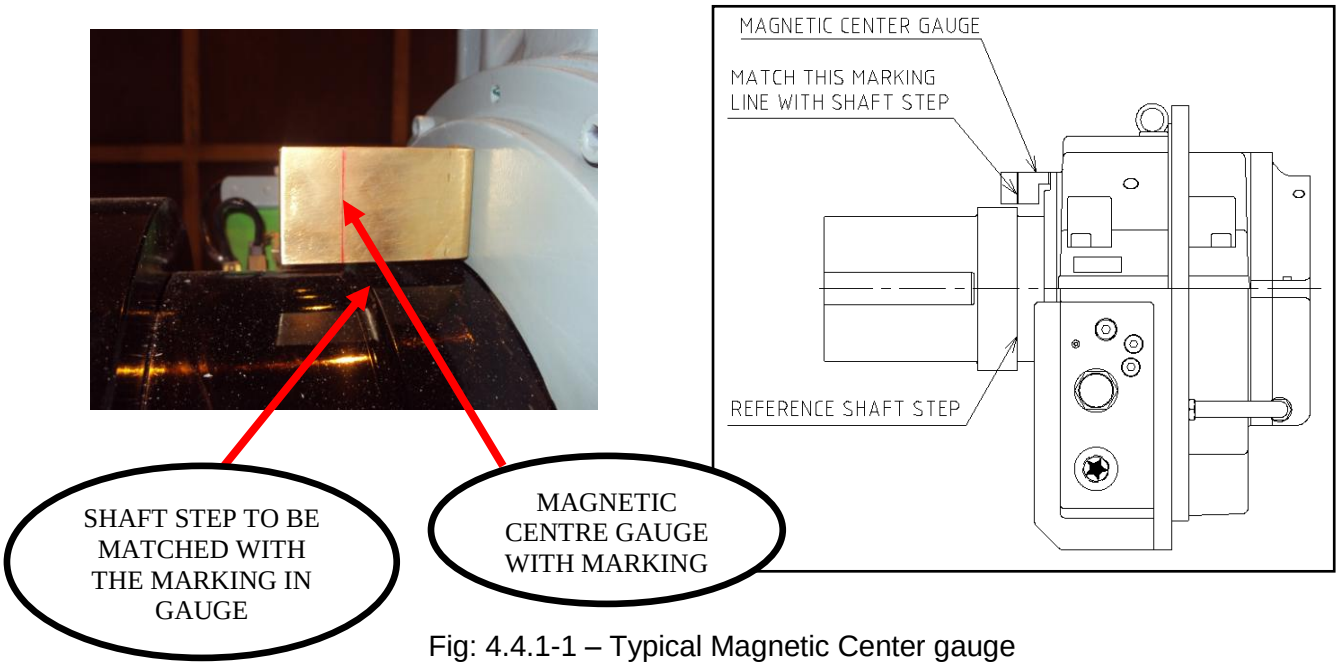


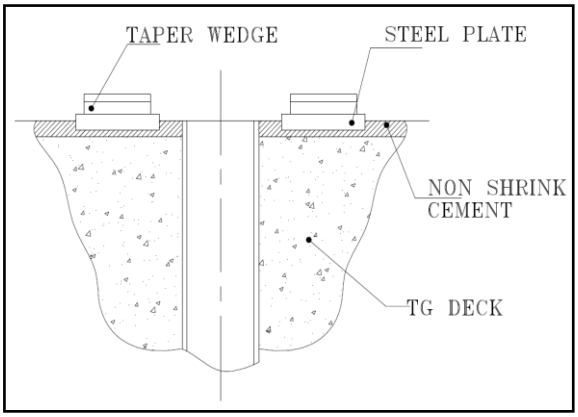
Fig: 4.4.1-1 – Typical Magnetic Center gauge

- After removing shaft locker assembly. Shaft to be axially moved to match the magnetic centre position by matching the marking made in gauge to shaft step as specified in the drawing supplied along the machine. This is important to ensure, running of generator at its magnetic center. It is necessary to take precautions with regard to coupling to avoid undue movement of rotor
- While pulling & pushing the rotor to its magnetic centre position pour the oil from the filler plug provided in the top half of the bearing housing so as to ensure oil film formation between shaft & bearing.

IMPORTANT!	**Magnetic Center gauge instruction is typical representation for reference only. Refer to the Annexure in part – 2 for project specific drawing**

4.5. Foundation Bed Preparation

- Clean the concrete bed where the steel plates (steel wedge) are to be placed, & chip foundation bed to a depth of about 20mm & place the plain steel plates (steel wedge) by the side of the foundation hole & check their levels & height with respect to other by using required instruments, they have to be uniform & grout the steel wedge using non-shrink cement as shown in fig. Allow it to cure.
- Ensure all the steel plates should be of same level



Per one liner
Allowable: 0.2mm/m
Recommended: 0.1mm/m
Between highest & lowest steel wedge
Allowable: 1mm
Recommended: 0.5mm

- Place the taper wedges on the plain wedges. Two taper wedges to be placed one above the other with taper faces mating each other.
- Now place the main generator with sole plates on the Foundation. The sole plate now rests on taper wedges. Check the level of the machine by placing spirit level on the sole plates. Adjust the level if required, by adjusting the taper wedge below the sole plate. It is necessary to jack the sole plate for adjusting the taper wedges.
- Insert the foundation bolt from the bottom of the deck, Tighten the foundation bolt at the bottom & secure the position with lock nut.

4.6. Alignment / Leveling

- The generator must be aligned correctly with the driving machine. It is the correction of relative position of two machines so that Center lines of two rotating shafts form a straight line when the machines are working at normal operating temperature.

4.6.1. Factor to be considered while aligning

- Ensure rotor is in magnetic centre position.
- Displacement of shaft centre due thermal expansion at normal operating temperature.
- Ensure no force is transmitted to the generator rotor.

Misalignment unfailingly results in damage to the coupling, bearings and, if severe, to the shaft as well, beyond repair. Accurate alignment, therefore, is of the UTMOST importance and involves basic operations: axial positioning, paralleling of driven & driving shafts at normal working temperature.

4.6.2. Parallel alignment

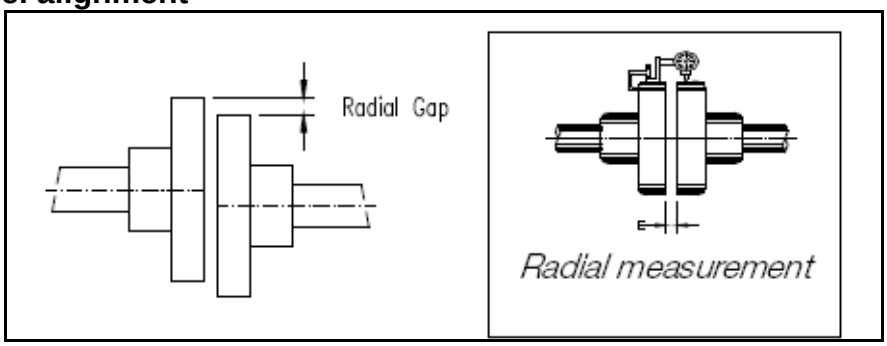


Fig: 4.6.2-1 – Parallel Alignment

The above figure shows the parallel misalignment of the two shaft ends and a practical way for making the measurements is by using proper dial indicators. Allowable offset to be within 0.1mm.

4.6.3. Angular alignment

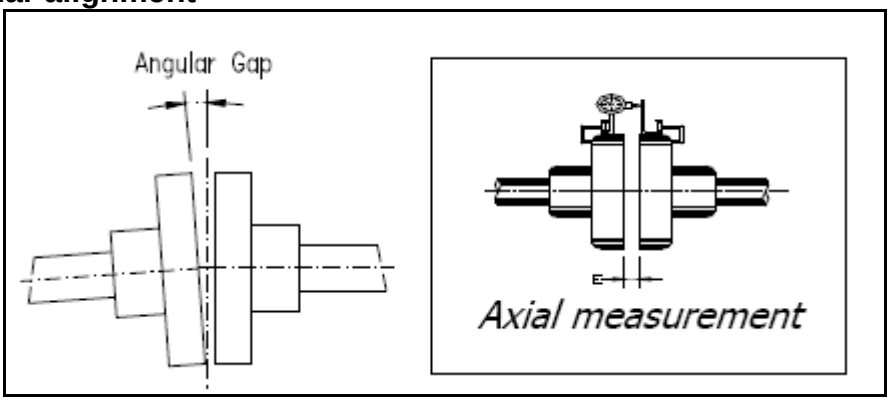


Fig: 4.6.3-1 – Parallel Alignment

Figure shows the angular misalignment and a practical way for making the respective measurement.
Allowable offset to be within 0.03mm/100mm.

CAUTION	**If generator rotor is rotated during alignment, pour the oil from the filler plug, provided in the top half of the bearing housing so as to ensure oil film formation between shaft & bearing.**

- After aligning the generator, fill all the foundation bolt pockets with non-shrink cement. Tighten the generator stator fastening bolts to the specified torque & in proper sequence as shown in below fig. to avoid soft foot error.
- First tighten the two anchor bolts on the DE bearing, then the two bolts on the DE bearing. Then the inner anchor bolts nearest to the DE bearing, then the inner anchor bolts nearest to the NDE bearing, and so on until reaching the anchor bolts in the centre of the generator.

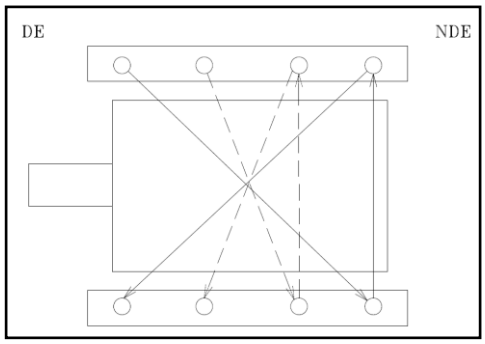


Fig: 4.6.3-2 – Bolt tightening sequence

- After aligning the generator, sole plate must be grouted to the specified level as per foundation drawing.

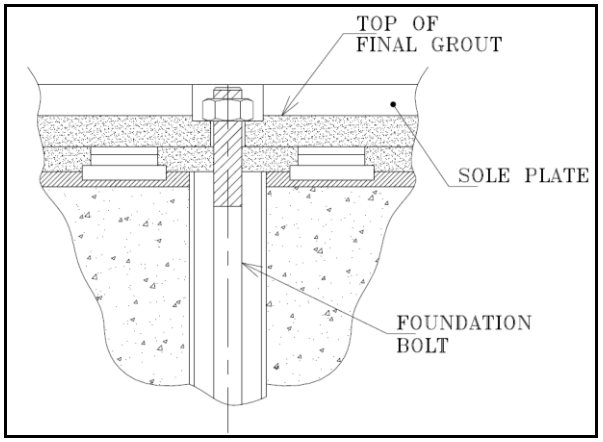


Fig: 4.6.3-3 – Typical grouted foundation

- Allow it to cure.
- Recheck the alignment after curing, if there is a need to adjust. Then shims under the generator feet are to be set. It is necessary to jack the stator frame for this.
- Suitable jacking arrangement is made to each generator foot in order to raise or lower so as to add or remove the liner for alignment.
- The liner used should be straight & free from burr, rust etc.,

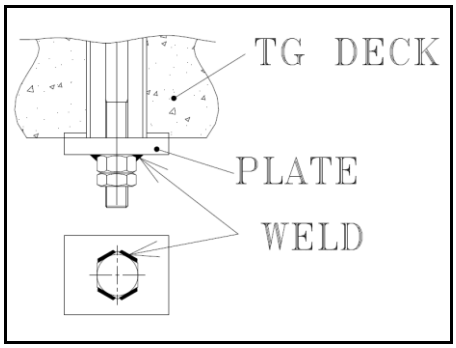
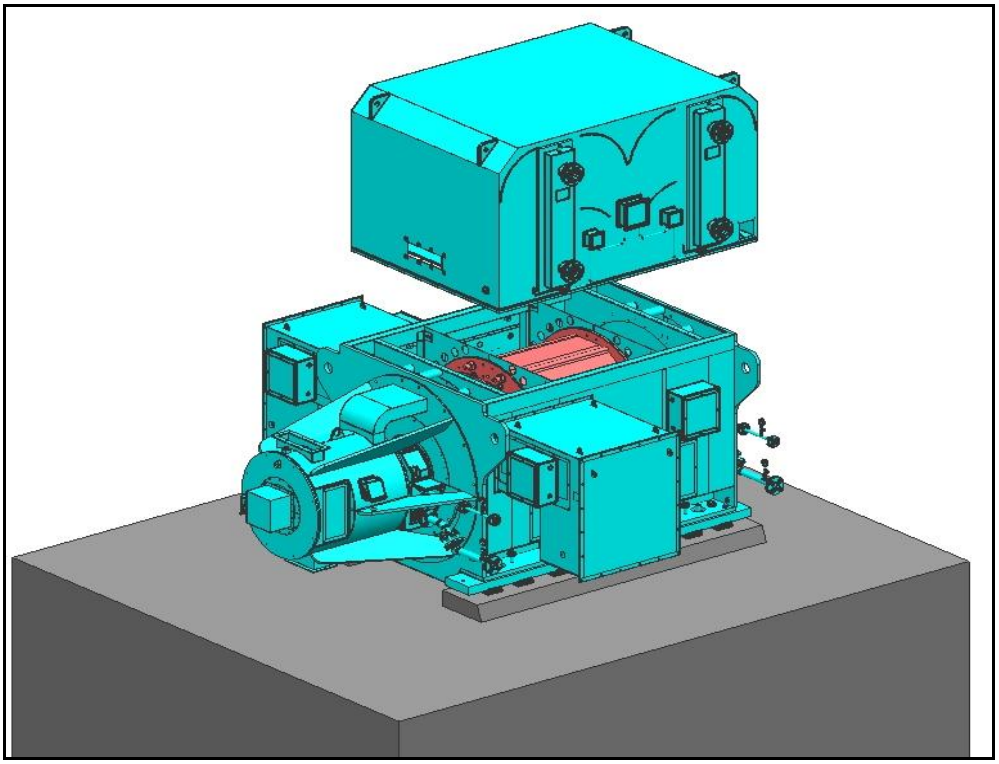


Fig: 4.6.3-4 – Parallel Alignment

- After the machine set has been aligned and checked (in cold and hot operating conditions) the generator foundation bolt must be secured in place by tack welding the bottom nut to foundation plate as shown in the figure above.

4.7. Erection of Cooler

Check and retighten all cooler bundle bolts using a torque wrench and conduct the Hydro pressure test before taking the cooler for installation. For details of hydro pressure test please refer to cooler manual.



Air cooler is mounted on to generator stator frame from top. Direction of assembly is as shown in above fig.

Two parallel pins are provided diagonally opposite on top of generator stator frame to locate cooler position. Remove cover plates in cooler frame which will provide the accessibility to locate cooler on to frame. Cover plates to be assembled after cooler assembly.

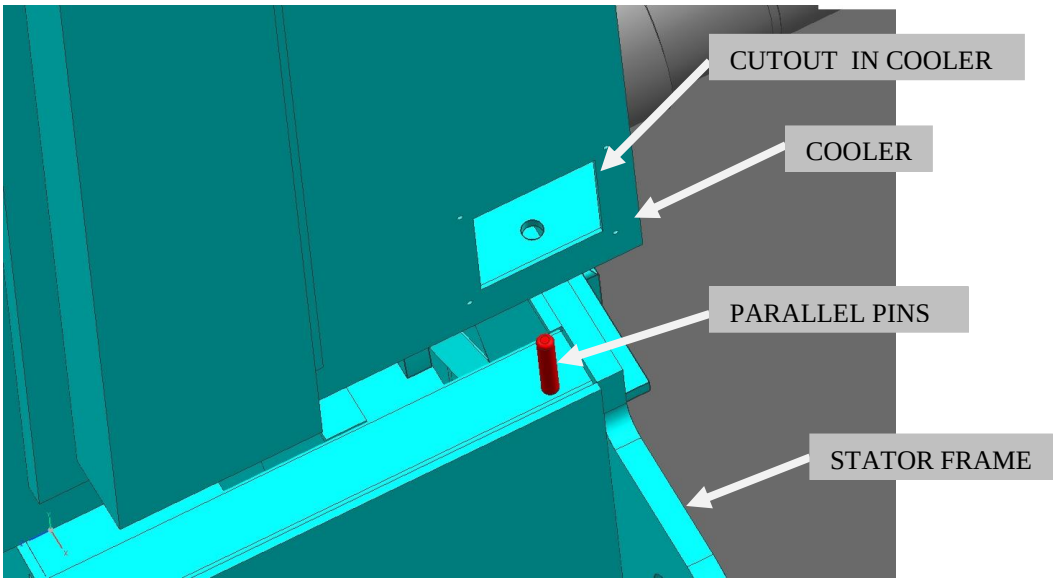


Fig: 4.8.1 – Parallel pin arrangement

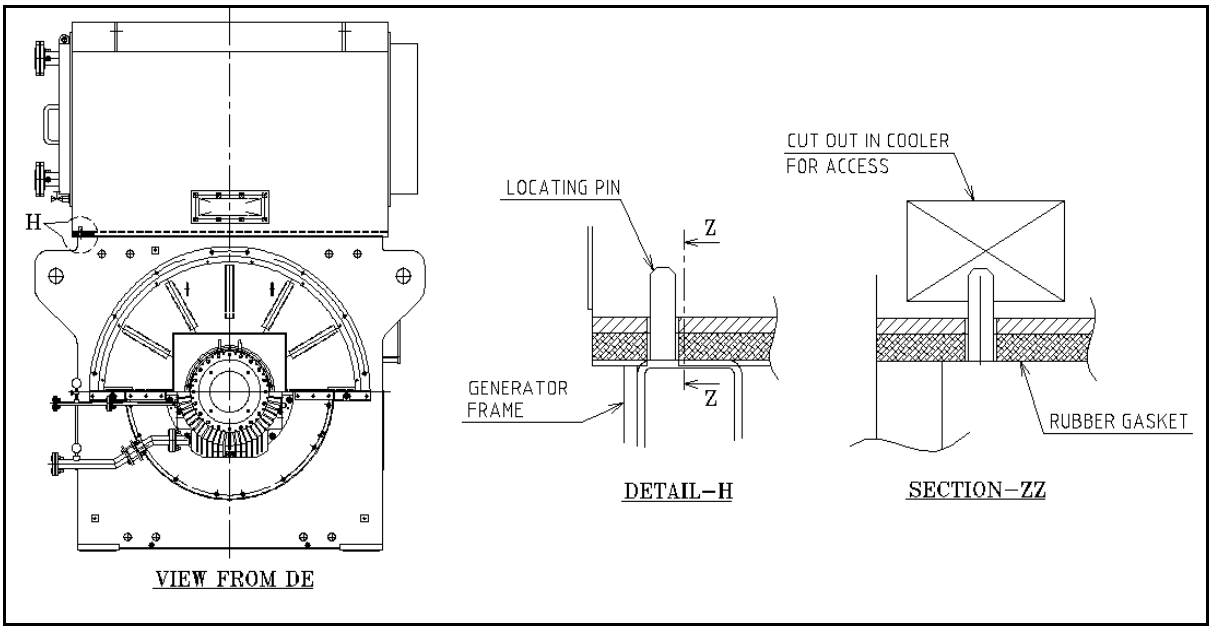
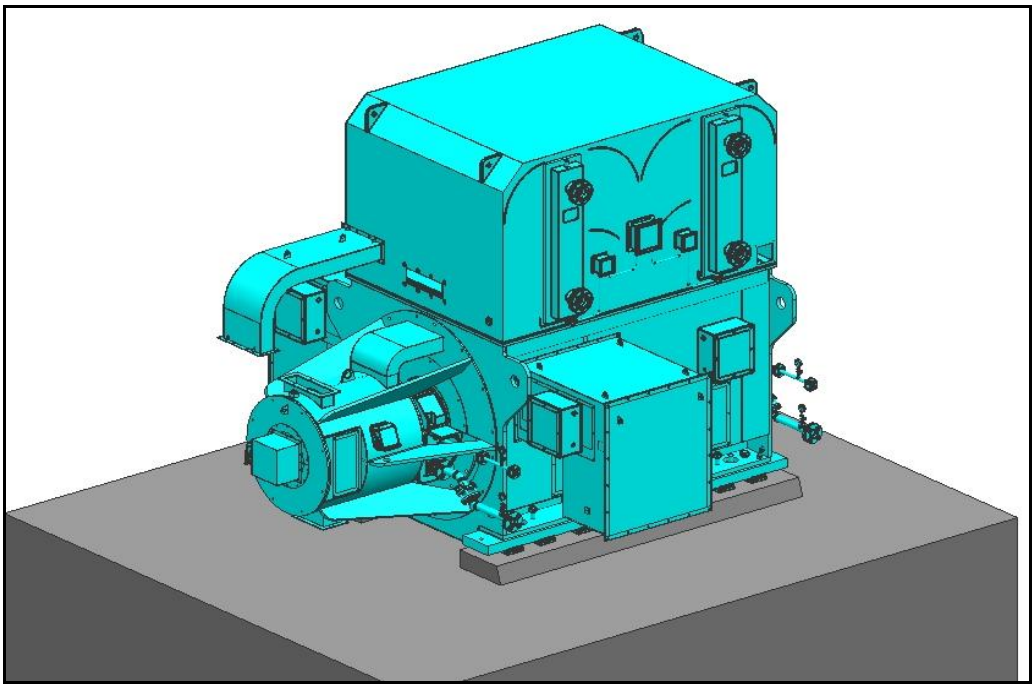
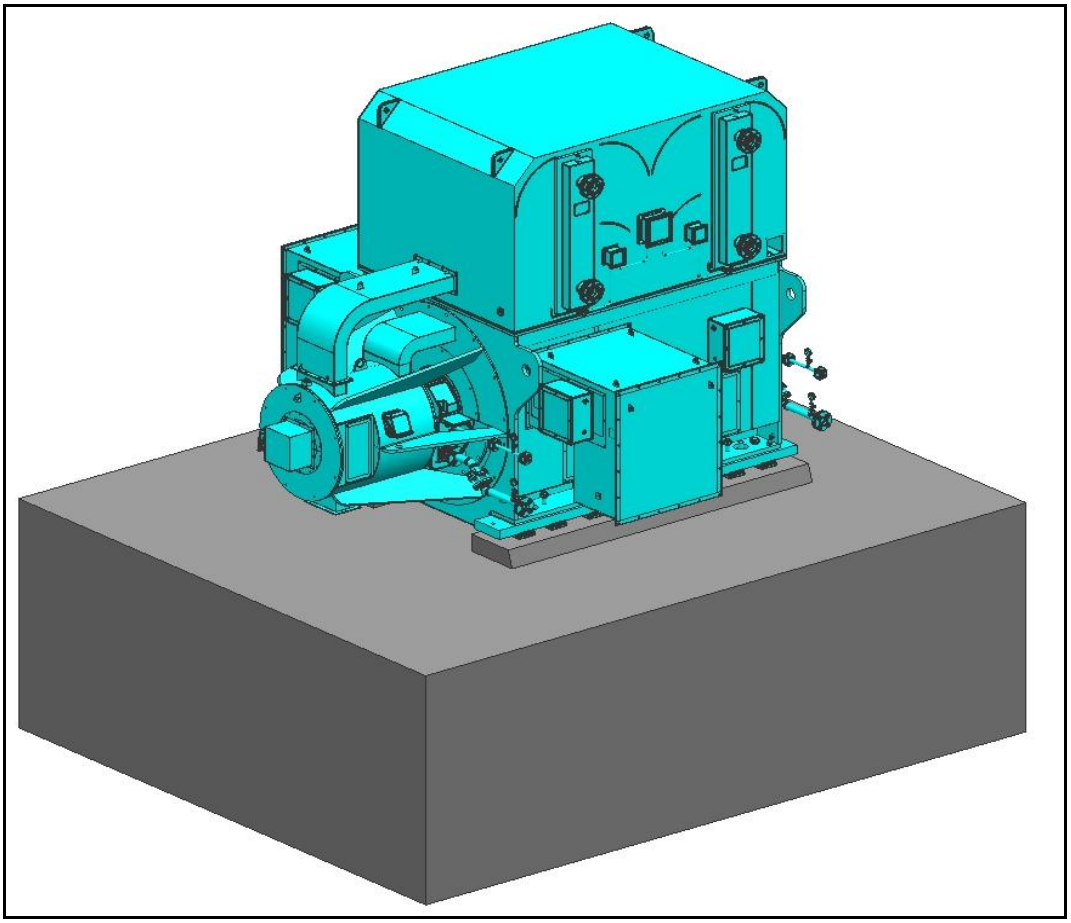


Fig: 4.8.2 – Typical Cooler assembly

Assemble Inlet Duct supplied loose along with generator (Refer packing list) which in turn connects between exciter stator & air cooler as shown below.

After cooler assembly - Connect water leakage detector onto cooler which are left loose routed on stator frame.





4.8. Oil flushing

4.8.1. General

The trouble-free operation of the oil circuits requires the proper and complete assembly of all component parts provided as specified in the drawings furnished by the manufactures of the machine components connected to the oil system. In addition, the entire oil system needs to be cleaned thorough after its completion. This cleaning action is intended to remove any residual contamination which may have entered the pipework during assembly. The assembly and cleaning of the oil systems for the generator and their drive systems requires specialist knowledge and particular care. Observe the applicable rules and regulations for occupational safety, fire protection, and environmental protection during oil flushing and when working with oil or oil-moistened component parts. Before starting oil flushing operations, make certain that operational fire-fighting equipment is readily at hand. Keep access free both in the area around generator and its prime mover, and along all escape and rescue routes. Accordingly, oil flushing should only be performed by instructed expert assembly personnel.

After completing the assembly of the lubricating and lift oil pipeline systems, the circuits should be subjected to a cleaning procedure which, as a general rule, should performed at operating temperature and by using the operating fluid. The cleaning process should cover all tanks, oil coolers, pipes, flexible tubes, fittings, and all other component parts which belong to the system. The corresponding filters should be installed upstream of the bearing connections and upstream of the collecting basin in the return line. Filters should be dimensioned such that there is no major impact on the desired high oil flow speed within the circuit. The filter elements should be replaceable in order to allow the adaptation of the filter stages to the progress of cleaning. Corresponding auxiliary ports, adapted fittings, etc. should

be used to install the filters in the oil circuits. Bypass lines with a corresponding cross-section can be used to keep the flushing process running when the filters are being cleaned. If no bypass lines are available for switching over, the oil pumps should be turned off and protected against unintentional energizing during filter cleaning. It is not allowed to close any stop valves in the oil return system while the pumps are operating. Any flexible tubing or flexible connecting elements used must be capable of withstanding the operating pressures and operating temperatures. Prior to oil flushing, take all precautions needed to prevent any escape of leaking or projected oil. Check all flanges and seals in the oil circuit before the pumps are switched on. The bottom parts of the outer multi-lip sealing rings at the bearing casings should be installed to avoid any escape of projecting oil. The generator's bearings and bearing chambers will be delivered ready for operation and in a clean condition. Cleaning by oil flushing is not necessary. Hence, oil flushing to be carried out by isolating generator bearings.

4.8.2. Flushing oil

Operator and oil supplier are responsible for providing the oil to be used for flushing in accordance with the oil specifications defined by the generator supplier. This should be coordinated with the turbine supplier if necessary.

The following procedures are possible:

Use the same oil grade for flushing and operation. When flushing is complete, an oil examination is carried out to decide whether the flushing oil volume can be used as oil for operation after reprocessing by the oil supplier.

Use oil intended for flushing only right from the outset. The properties of this oil are tuned to this particular application purpose mainly with regard to viscosity. This oil should be removed completely after the flushing process, and be replaced by new operating oil. The properties of operating oil and flushing oil must be matched.

4.8.3. Flushing process

The oil flow speed should be as high as possible, and the maximum temperature should be limited to 80 °C in the oil circuit pipelines during the flushing process.

The flushing process can be carried out along the whole line system and simultaneously in the entire bearing oil pipe work, and in all pressure-oil pipelines belonging to the hydraulic shaft lift-oil system. If the oil flow speed drops excessively in the whole line system, parallel branches may be flushed locally one after the other by installing isolating valves.

The oil temperature should not be increased during the first few hours. The heavier particles will be entrained by the higher oil density and by the higher oil speed brought about as coarser filters are used. Oil temperature should be increased to a maximum of 80 °C after the installation of finer filters.

During the flushing process, the oil lines should be tapped continuously to remove the dirt particles stuck at the inside pipe walls.

The feed pumps should be switched on and off repeatedly in order to generate a surging flow.

Filters should be cleaned more often, and be replaced by finer filters, depending on the dirt volume and on the grain sizes found. Do not finish the flushing process unless no dirt has been found even in the finest filters and screens during an extended period of time. All filters and screens should be removed and cleaned as a general rule after the completion of every flushing process. The filters and screens removed before the flushing process should either be reinstalled or be replaced by the filters and screens belonging to the original line

equipment. Remove all bypass lines, orifice plates, blind flanges and any filters installed in addition. Connect the ports of the shaft lifting devices to the bearing blocks, and check for leakage if applicable. Check the proper fitting of the bearing ports. Finally, assemble all bearing parts and flanges such that they are ready for operation. Proceed with care when completing work on the oil system and on the bearings and take the corresponding precautions to prevent any new contamination.

After completing work on the oil system, clear all pipes, flanges, and ports externally, and then carry out a system pressure and leak test.

NOTE:

The user is responsible for the generator installation & Alignment.

TDPS shall not be responsible for damages to the generator, associated equipment and installation occurred as a result of:

Excessive transmitted vibrations;

Precarious installations;

Alignment failures;

Improper storage conditions;

Noncompliance with the pre-operation instructions

Incorrect electrical connections.

4.9. Recommended torque values for bolts and screws

Table-4.9-1: Recommended torque values for bolts and screws with ISO metric coarse threads.

Note: For foundation bolt, refer respective outline drawing.

TORQUE VALUES FOR HARDWARE ON EPOXY PARTS			
BOLT SIZE	Recommended torque in N-m		
	Property class of bolts and screws		
	8.8	**10.9**	**12.9**
M6	4	6	7
M8	10	14	16
M10	19	27	32
M12	33	47	55
M16	80	118	138

TORQUE VALUES FOR HARDWARE ON STATIONARY PARTS			
BOLT SIZE	Recommended torque in N-m		
	Property class of bolts and screws		
	8.8	**10.9**	**12.9**
M6	8	11	13
M8	19	27	32
M10	38	54	63
M12	66	94	110
M16	166	235	276
M20	331	458	536
M24	574	789	922
M30	1137	1573	1832
M36	1987	2743	3206

TORQUE VALUES FOR HARDWARE ON ROTATING PARTS			
BOLT SIZE	Recommended torque in N-m		
	Property class of bolts and screws		
	8.8	**10.9**	**12.9**
M6	10	15	18
M8	26	36	43
M10	51	73	84
M12	88	126	147
M16	221	314	368
M20	441	611	714
M24	765	1053	1229
M30	1516	2097	2443
M36	2649	3657	4275

TORQUE VALUES FOR HARDWARE ON SHAFT LOCKER	
BOLT SIZE	Recommended torque in N-m
	Property class of bolts and screws
M16	70
M20	125
M24	220
M36	500

CHAPTER 5

INSTALLATION

5. INSTALLATION

5.1. Terminal box Installation

Check whether the terminal box is assembled in the generator or removed for the ease of packing and transportation. Assemble the terminal box, if it is disassembled. Connect cable or bus bar to the generator output terminals as per main and neutral terminal arrangement drawings.

5.2. Auxiliary terminals installation

All the winding temperature detectors, core temperature detectors (if applicable), exciter winding temperature detectors, inlet & outlet air temperature detectors, Bearing temperature detectors, water leakage detectors & shaft & bearing vibration detectors are terminated to the respective terminal boxes.
Connect all the auxiliaries to the control circuit and monitor the corresponding parameter during operation & storage as applicable.

5.3. Space heater installation

Connect the space heater to the suitable supply as per space heater specification in manual part: 2. When the generator is in standby condition, switch on the space heater to avoid IR drop.

5.4. CT Installation (Optional)

CT's are mounted in neutral terminal box as per project requirement & terminated to in auxiliary terminal box. Ensure that CT secondary terminals are shorted or connected to relevant protection or measurement devices before the machine is put into operation. Check the equipotential shield is connected to the primary conductor.
Refer Auxiliary termination drawing for details of PT / CT connection (Part-2, Annexure)

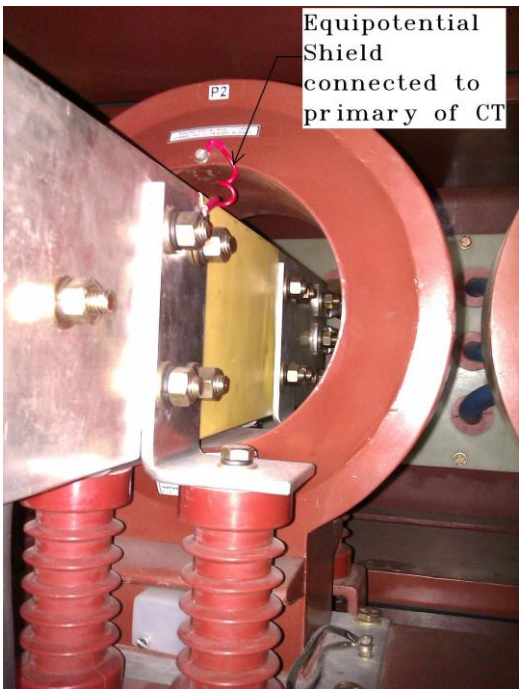


Fig: 5.4-1 – Typical CT installation in Terminal Box

5.5. PT Installation (Optional)

If PT's are provided in the terminal box then the PT secondary terminals are terminated to the auxiliary terminal box. Connect the PT secondary terminals to the control circuit. Check the PT secondary common earthed properly or not.
Refer Auxiliary termination drawing for details of PT / CT connection.

5.6. Earthing

Earthing pads are provided in main generator, exciter, main & neutral terminal boxes, and all the auxiliary terminal boxes. All these earthing pads should be earthed properly during system erection.

Fig: 5.6-1 – Earthing (Typical Image for reference)

CHAPTER 6

PROTECTIVE DEVICES, ITS APPLICATION AND IMPORTANCE

6. PROTECTIVE DEVICES, ITS APPLICATION AND IMPORTANCE

Generator is designed taking care of possible fault condition & necessary actions are taken to withstand the consequences of faults. In addition to this, automatic protective system is very important to minimize the effect on machine. It is necessary to design an effective protective system so that, the effect of serious fault will result in immediate disconnection & de-excitation of generator, if necessary, also to trip the turbine.

The operating staff must be experienced and well knowledgeable about the type of fault & its consequences on generator. If the fault is not so serious, it may not be necessary to shut down the generator, in such cases operator should be aware of enabling the generator to operate in safe operate mode or shutdown if required.

Generator may be endangered by short circuit fault, ground faults, overvoltage, under excitation & excessive thermal stresses. So the relevant protection system should be installed to take necessary action.

For safe operation of generator, during manufacturing some of measuring and monitoring devices are incorporated in the generator. The number of devices fitted depends on the customer requirement. The details of measuring devices are provided in auxiliary terminal arrangement drawing. The most important measuring and monitoring parameters in generator are temperature and vibration.

6.1. Temperature Monitoring

Temperature monitoring includes

1. Winding Temperature Monitoring
2. Stator core Temperature Monitoring
3. Cold and Hot air Temperature Monitoring
4. Bearing Temperature Monitoring

1. Winding Temperature Monitoring

Resistance Temperature Detectors (RTD's) in the shape of long thin strips are used for measuring the winding temperature. The platinum measuring wire is embedded in an insulating molding to relieve it against stress. PT100 double element 6 wire type RTD is used (PT100 single element 3 wire type RTD is used on case to case basis). RTD's are positioned in between top and bottom coil in the slots, and is distributed evenly between all the three phases. The winding temperature is the important parameter to decide the healthiness of the winding. The periodic monitoring of the winding temperature is required. Alarm and trip setting values are given in GA drawing, same to be ensured during operation.

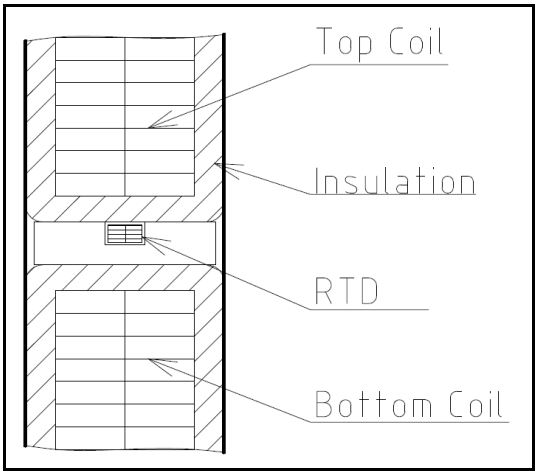


Fig 6.1-1 – Typical RTD Fixing in the Slot

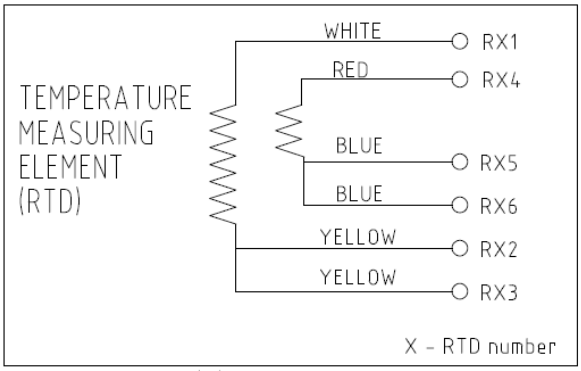


Fig: 6.1-2(a) - RTD terminal wiring representation (Duplex)

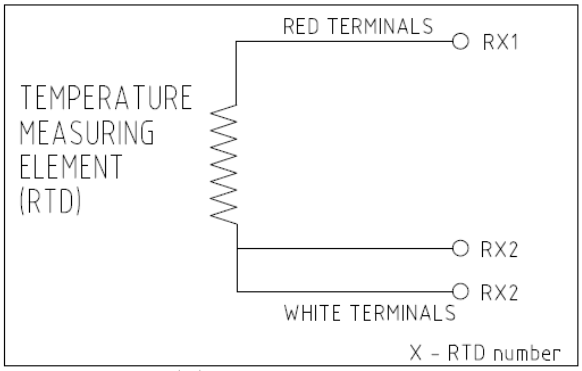


Fig: 61-2(b) - RTD terminal wiring representation (Simplex)

2. Stator Core Temperature Monitoring (Optional)

PT100 double element 6 wire type RTD's are used for measurement and monitoring of stator core temperature. The alarm and trip values are for the temperature to be monitored as per Manual Part 2 section 1.10.

3. Cold and Hot Air Temperature Monitoring

Cold and hot air temperature is monitored using RTD's. PT100 double element 6 wire type RTD are provided (PT100 single element 3 wire type RTD is used on case to case basis).

Periodic monitoring of cold and hot temperature is necessary to study the cooler and its healthiness, this also provides information to access and decide on proper cooling activity.

4. Bearing Temperature Monitoring

- Provision for measuring bearing temperature is provided at both side of the bearing housing.
- NDE Bearing temp RTD'S are insulated type, same to ensure while removal & assembly.

- The bearing housing must be kept clean as heat transfer can be hindered by dirt and dust leading to bearing overheating and subsequent damage leading to failure.
- During normal machine operation, the recorded bearing temperature must stay below 85°C.

Bearing temperature Alarm and shutdown levels:

- Alarm - 85°C
- Shutdown -90°C

To improve the machine protection, the alarm and shutdown set points may be reduced in accordance with actual site conditions:

Alarm temperature (*) = Max. site temp(stabilized temp.) +10 °C
Shutdown temperature (*) = Max. Alarm temp +15 °C
(*) Max. site temp: Temperature of bearing sensors
Measured on site in the least favorable conditions.

Eg: A bearing reaches 60°C in the least favorable site conditions.

Set the alarm level to70°C as indicated.
Set the shutdown level to 85°C as indicated.

IMPORTANT!	During operation if the bearing temperature exceed the specified or set value for no obvious reason like change of ambient temperature, etc..., this indicates some abnormal operation, the machine should be stopped and the causes to be investigated.

6.2. Vibration Monitoring

Vibration includes, monitoring of bearing pedestal / housing vibration & shaft vibration

1. Bearing Housing Vibration

The absolute bearing housing vibration is measured by sensor.

2. Shaft Vibration

Provision in bearing housing is provided for mounting the Vibration sensors to detect relative shaft vibrations. The measurement of the shaft vibration gives information about the running characteristics like bearing play, imbalance etc.., of the shaft.

6.3. Humidity sensor

Humidity sensor is optional instrumentation provided based on customer requirement.

Humidity sensor is compact two wire transmitter with its capacitive sensor and electronic circuitry housed in a protective enclosure. The transmitter is loop powered and controls the loop current at 4-20mA according to the calibrated range.

The connection drawing is shown below. 4-20mA is equivalent to 0-95% of RH (Relative Humidity). These terminals to be taken to control panel for indication or setting.

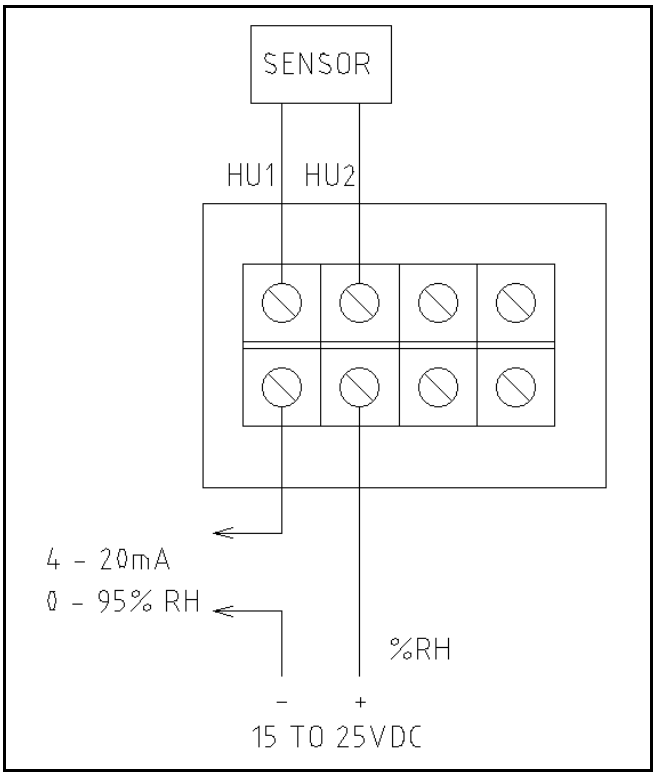


Fig 6.3-1 – Humidity Sensor connection detail

To be connected to a current loop, with power supply between 15 to 25VDC.

4 – 20mA corresponds to 0 to 100%RH.

Working range = 10% to 95%RH

Cleaning:

Clean the filter cap regularly without removing filter cap. In case of a highly polluted environment filter cap shall be opened and cleaned or exchanged.

In consultation with the manufactures when the cap is removed, clean the sensor element by using isopropyl alcohol in an ultrasonic cleaner. Do not touch or rub the sensor surface. After cleaning with isopropyl alcohol, use distilled water to rinse and let it dry before putting into service.

Calibration:

Send the sensor for re-calibration at least once a year.

For high accuracy requirements under extreme humidity and temperature working conditions, re-calibration period shall be once in 6 months.

CHAPTER 7

COMMISSIONING

7. COMMISSIONING

7.1. Drying prior to starting and running

In case of running the generator after stopping it over a long period of time, there is need of drying the interior of generator by energizing space heater. And the drying must be performed until the insulation resistance rises as per table 7.3.1-1.

IMPORTANT!	**While re-running the generator, pay attention not to forget to cut off the electric source of space heater.**

7.2. Inspection prior to test running

Prior to test running below mentioned checks to be followed.

IMPORTANT!

INSPECTION ITEM	CONTENT OF INSPECTION
Condition of erection	• Check whether the foundation is cured? • Check whether any clearance found between the base plate and foundation? • Check whether the tightening bolts of respective parts fully tightened? • Check whether any pieces of paper and cloth lying on the surroundings? Remove them, if any.
Inspection of interior and exterior of the generator	• Check whether any foreign matters such as concrete pieces, tools, etc., remaining in the main body? Remove them, if any. • Are all the bolts and nuts intact and tightened? (No missing bolts and nuts) • Check for any erroneous connection of wiring. • Check for any flaw or crack on covering of lead wire and insulation?
Terminations	• Check for all connections made as per the generator connection diagram? • Check for extension cables or bus bars connected properly? • Check for the clearance maintained in the terminal box?
Insulation resistance	• Check the insulation resistance of stator, rotor and discharge resistor.
Bearing parts	• In the case of forced lubrication, is the gradient of oil discharge pipe sufficient? Gradient must be over 5/100. • In the case of forced lubrication, check whether the oil is flowing? Is the drain plug fully tightened?

7.3. Tests at site before commissioning

Following measurement should be carried out before commissioning the machine into the continuous operation.

7.3.1. Measurement Stator Insulation Resistance: Follow below table to select the megger.

Table7.3.1-1 – IR limit value.

Type of Winding	Rating of Megger Meter	IR value in MΩ
For Low voltage stator winding and the field winding	0.5kV	> 1
For 3.3kV and 6.6kV stator windings.	2.5kV	> 10
For 11kV and more stator windings.	5.0kV	> 100

a. IR measurement of Total winding

- Make the test setup as per below schematic.
- Note down the temperature.
- Apply the voltage as per Table: 7.3.1-1.
- Note down the applied voltage.
- Note down the IR value at different time interval.
- Calculate the PI value.
- Repeat the same procedure for other terminal also.

b. IR measurement of individual winding:

- Make the test setup as per below schematic.
- Note down the temperature.
- Apply the voltage as per Table: 7.3.1-1.
- Note down the applied voltage.
- Note down the IR value at different time interval.
- Calculate the PI value.
- Repeat the same procedure for other terminal also.

Stator winding temperature: _____^{0}C Applied Voltage: _____kV

Testing Interval	Insulation Resistance in MΩ						
	Total winding	U Phase	V Phase	W Phase	U – V Phase	U – W Phase	V – W Phase
30 sec							
1 min							
3 min							
5 min							
7 min							
10 min							
Measuring Instrument:							

Measurement of Total winding

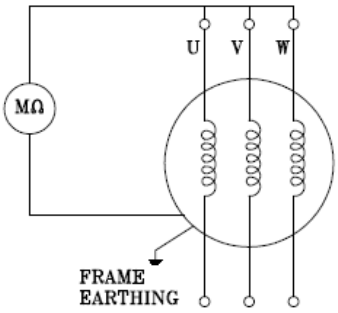
Corrected to 40^{0}C : R1,40 = _____MΩ
Corrected to 40^{0}C : R10,40 = _____MΩ

Measurement of U Phase
Corrected to 40^{0}C : R1,40 = _____MΩ
Corrected to 40^{0}C : R10,40 = _____MΩ

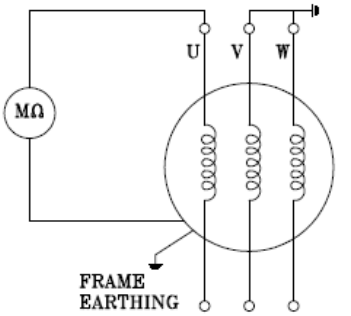
Measurement of V Phase
Corrected to 40^{0}C : R1,40 = _____MΩ
Corrected to 40^{0}C : R10,40 = _____MΩ

Measurement of W Phase
Corrected to 40^{0}C : R1,40 = _____MΩ
Corrected to 40^{0}C : R10,40 = _____MΩ

IR MEASUREMENT OF TOTAL WINDING



IR MEASUREMENT OF PHASE U

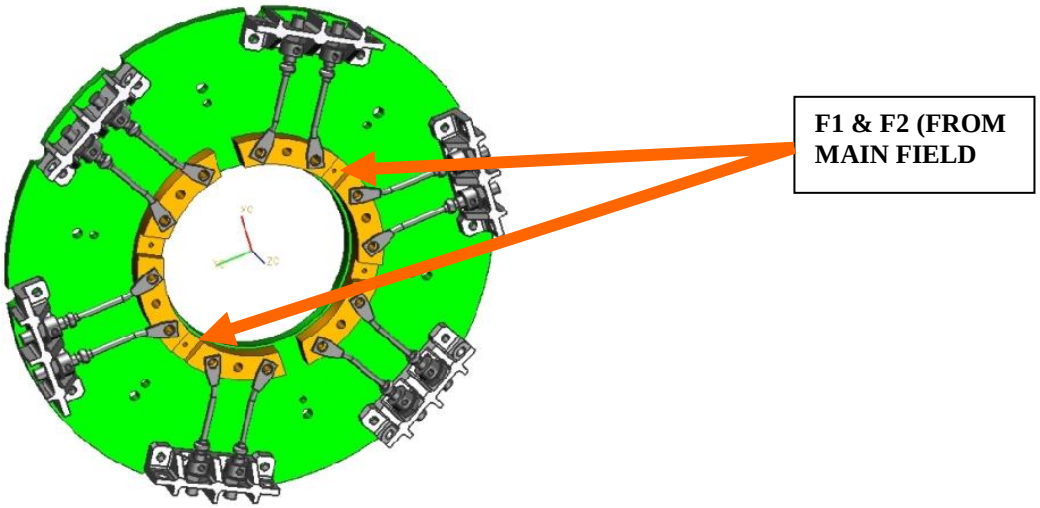


PI Calculation	Total winding	U Phase	V Phase	W Phase
PI= R10/R1				

Date:	Tested By:	Reviewed By:

7.3.2. Measurement Rotor Insulation Resistance

- Remove the F1 & F2 connections.
- Note down the temperature.
- Apply the voltage as per Table: 7.3.1-1 to F1 to earth or F2 to earth.
- Note down the applied voltage.
- Measure the IR value & note down.



NOTE: Disconnect the Main field (F1 & F2) terminals then connect a DC source across F1 to earth or F2 to earth and measure the insulation resistance.

Measurement of Rotor IR during running condition without excitation:

- If slip rings are provided, then SR1 & SR2 terminals are connected to rotor earth fault relay.
- Disconnect SR1 & SR2 terminals from rotor earth fault relay & connect 500V megger terminals across SR1 to earth or SR2 to earth and measure the insulation resistance.

Rotor winding temperature: _____^{0}C Applied Voltage: _____kV

Insulation Resistance 2 min: _____ MΩ

Corrected 40^{0}C : _____ MΩ

Measuring Instrument:
Time: Tested By: Reviewed By:

IMPORTANT!

NOTE: - At the time of measuring insulation resistance, attention should be paid to the following points:

- If rotating type megger is used, keep rotating it for at least one-minute before the measurement.
- If battery driven megger is used, error increases as the battery voltage drops.
- Prior to measurement, residual electric charge of winding should be removed.
- To exclude the effect of connected auxiliary devices, other circuits should be disconnected at an easy convenient part and then measurement should be done.
- After the measurement the residual charges should be discharged.

CAUTION	After the measurement of Insulation resistance, electrical parts should be grounded to avoid the electric shock caused by the electric loading.

7.3.3. Stator winding temperature measurement

Temperature in ^{0}C = (Resistance – 100) / 0.385

WTD Number	Phase	Terminal number	Resistance in Ω	Temperature in ^{0}C
1	U	R11 – R12		
		R11 – R13		
		R14 – R15		
		R14 – R16		
2	V	R21 – R22		
		R21 – R23		
		R24 – R25		
		R24 – R26		
3	W	R31 – R32		
		R31 – R33		
		R34 – R35		
		R34 – R36		
4	U	R41 – R42		
		R41 – R43		
		R44 – R45		
		R44 – R46		
5	V	R51 – R52		
		R51 – R53		
		R54 – R55		
		R54 – R56		
6	W	R61 – R62		
		R61 – R63		
		R64 – R65		
		R64 – R66		
Measuring Instrument:				
Date	Tested By:		Reviewed By:	

7.3.4. Stator Core temperature measurement (If provided)

CTD Number	Terminal number	Resistance in Ω	Temperature in ^{0}C
1	C11 – C12		
	C11 – C13		
	C14 – C15		
	C14 – C16		
2	C21 – C22		
	C21 – C23		
	C24 – C25		
	C24 – C26		
3	C31 – C32		
	C31 – C33		
	C34 – C35		

CTD Number	Terminal number	Resistance in Ω	Temperature in ^{0}C
	C34 – C36		
4	C41 – C42		
	C41 – C43		
	C44 – C45		
	C44 – C46		
5	C51 – C52		
	C51 – C53		
	C54 – C55		
	C54 – C56		
6	C61 – C62		
	C61 – C63		
	C64 – C65		
	C64 – C66		
Measuring Instrument:			
Date	Tested By:	Reviewed By:	

7.3.5. Bearing temperature measurement

BTD Number	Side	Terminal number	Resistance in Ω	Temperature in ^{0}C
1	DE	B11 – B12		
		B11 – B13		
		B14 – B15		
		B14 – B16		
2	NDE	B21 – B22		
		B21 – B23		
		B24 – B25		
		B24 – B26		
Measuring Instrument:				
Date	Tested By:		Reviewed By:	

7.3.6. Inlet Air temperature measurement

ATD Number	Terminal number	Resistance in Ω	Temperature in ^{0}C
1	A11 – A12		
	A11 – A13		
	A14 – A15		
	A14 – A16		
2	A21 – A22		
	A21 – A23		
	A24 – A25		
	A24 – A26		
Measuring Instrument:			
Date	Tested By:		Reviewed By:

7.3.7. Outlet Air temperature measurement

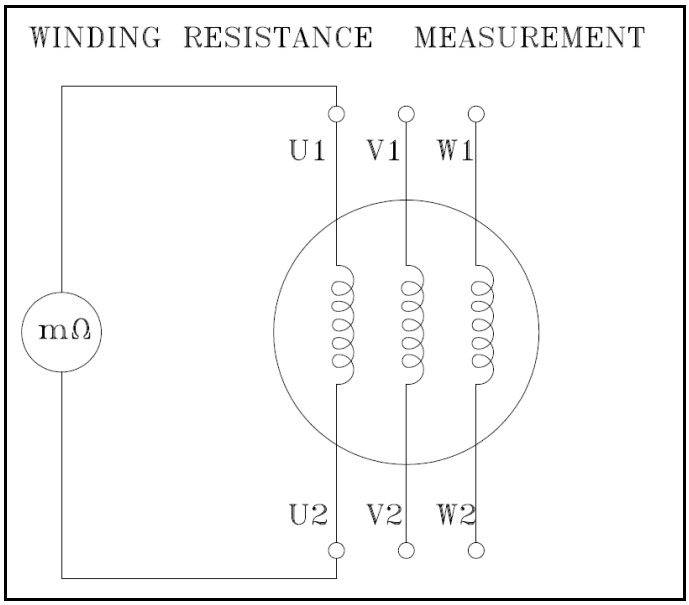
ATD Number	Terminal number	Resistance in Ω	Temperature in ^{0}C
1	A31 – A32		
	A31 – A33		
	A34 – A35		
	A34 – A36		
2	A41 – A42		
	A41 – A43		
	A44 – A45		
	A44 – A46		
Measuring Instrument			
Date	Tested By:	Reviewed By:	

7.3.8. Measurement of winding resistance

Measure the main stator, rotor, exciter & rotor resistance. Use the instruments mentioned in below table to get the correct results.

Sl. No.	Winding	Instruments to be used
1	Main Stator	Kelvin double Bridge
2	Main Rotor	Kelvin double Bridge
3	Exciter Stator	Kelvin double Bridge
4	Exciter Rotor	Kelvin double Bridge

Main Stator:
Measure the winding resistance start and finish of the winding as shown below. Repeat the same for all the phases.



Phase	Resistance in Ω	Slot temperature
U1/U – U2/X		
V1/V – V2/Y		
W1/W – W2/Z		
Measuring Instrument		
Date	Tested By:	Reviewed By:

Main Rotor:
Measure the winding resistance between F1 & F2

Terminals	Resistance in Ω	Temperature
F1 – F2		
Measuring Instrument:		
Date:	Tested By:	Reviewed By:

Exciter Stator:
Measure the winding resistance of exciter stator terminated in auxiliary terminal box.

Terminals	Resistance in Ω	Temperature
F1 – F2		
Measuring Instrument:		
Date:	Tested By:	Reviewed By:

Exciter Rotor:
Measure the winding resistance of Exciter Rotor.

Phase	Resistance in Ω	Temperature
U – V		
V – W		
U – W		
Measuring Instrument		
Date	Tested By:	Reviewed By:

7.4. Inspection prior to load running

In case of running, after test running or shutdown for a long period of time, no load running should be done for about 30 minutes. Then conduct the inspection in accordance with the following table and confirm the absence of any abnormality. Thereafter start the load running.

IMPORTANT!

INSPECTION ITEM	CONTENT OF INSPECTION
Bearing parts	• Is the lubricating oil flowing? (In the case of forced lubrication) • Is there any oil leakage? • Is there any abnormal noise and vibration? • Is the temperature abnormally high? • Is the current flowing from bearing housing to earth?
Generator and Exciter	• Is there any abnormal odor and smoke coming out? • Is there any abnormal vibration? • (Caution is required because the vibration from prime mover is high). • Are there any parts where temperature is abnormally high?

7.5. Tests at site during test running

Following measurement should be carried out during continuous operation of the machine.

7.6.1. Bearing Inspection

Bearing temperature & oil pressure to be checked as a part of bearing inspection

Time Interval	Before Running	5 min	10 min	15 min	30 min	60 min	120 min	180 min
DE side Temperature in ^{0}C								
NDE side Temperature in ^{0}C								
Date			Tested By:			Reviewed By:		

Time Interval		10 min	15 min	30 min	60 min	120 min	180 min
Shaft lift oil Pressure	DE						
	NDE						
Bearing oil film Pressure	DE						
	NDE						
Date		Tested By:			Reviewed By:		

7.6.2. Temperature Measurement

a. Winding Temperature in ^{0}C

Phase	WTD number	Before Running	5 min	10 min	15 min	30 min	60 min	120 min	180 min
U	1								
V	2								
W	3								
U	4								
V	5								
W	6								
U	7								
V	8								
W	9								
U	10								
V	11								
W	12								
U	13								
V	14								
W	15								
Date		Tested By:				Reviewed By:			

b. Air Temperature in ^{0}C

Time Interval	ATD number	Before Running	5 min	10 min	15 min	30 min	60 min	120 min	180 min
Cold Air	1								
	2								
	3								

Cold Air	1								
	2								
	3								
Hot Air	1								
	2								
Date		Tested By:				Reviewed By:			

c. Stator Core Temperature in ^{0}C

Phase	CTD number	Before Running	5 min	10 min	15 min	30 min	60 min	120 min	180 min
U	1								
V	2								
W	3								
U	4								
V	5								
W	6								
Date		Tested By:				Reviewed By:			

7.6.3. Relative Shaft Vibration

Condition	r/min	DE		NDE		Criteria
		X	Y	X	Y	
Un excited						
Rated V						<90 µm
Over speed						

7.6.4. Bearing Housing Vibration

Time	DE		NDE		Voltage (kV)	I (A)	Power (MW)	Vf (V)	If(A)
	Microns	mm/sec(pk)	Microns	mm/sec(pk)					
Date			Tested By			Reviewed By:			

CHAPTER 8
MAINTENANCE AND INSPECTION

8. MAINTENANCE AND INSPECTION

8.1. Maintenance

WARNING	Ensure prime mover starting circuits are disabled before commencing Maintenance procedures. Isolate anti-condensation heater supply.

WARNING	Generator is embedded with HV terminals, which should be discharged for any stray voltage before undertaking any work.

To supply stabilized power, generator must always be set at the condition of fully enabling the exhibition of its performance. In case of handling and maintaining the generator, its performance must be fully understood and the unexpected fault must be avoided by taking proper means of maintenance. The following points that need to be paid consistent attention: -

- ♦ Is there any abnormality of the respective parts of generator itself?
- ♦ Is there any harmful matter in the surrounding atmosphere?

When abundant dust is presence in the wind passage, such dust will stick to coil and that leads to the cause of short-circuit failure and grounding failure. It is necessary to keep the generator free from dust. When the generator is started after a long time, since there may be chances of lowering the insulation resistance of coil, hence perform the drying thoroughly using space heater.

Follow the below mentioned maintenance to avoid machine breakdown

8.1.1. Winding Temperature monitoring

Winding RTD's are positioned in between top and bottom coil of stator winding and is distributed evenly between all the three phases. The winding temperature should be monitored, if any deviation in winding temperature the cause must be traced. Necessary correction action should be taken. The RTD's should measure identical values in all phases for identical current. If different temperature is measured with equal current in all the three phases, then check the RTD's for calibration.

8.1.2. Air Temperature Monitoring

RTD's provided for cold and hot air temperature measurement. The cold and hot air temperature should be monitored to confirm proper cooling of the machine with proper water inlet temperature.

8.1.3. Shaft Vibration Monitoring

Shaft vibration should be monitored, if any deviation, the root cause for should be determined. If the problem serious then the generator must be shutdown & perform necessary checks and action needs to be taken.

8.1.4. Maintenance of Bearing

During bearing operation, assembly, maintenance and repair, accidents and injuries must be avoided at all costs. The following points require special attention:

- During maintenance and repair ensure that rotating machinery is at a standstill, isolated from electrical supply with interlocks such the supply cannot be resumed unintentionally.
- Loads and speeds must not exceed those that specified in data sheets, drawings or calculation sheets.
- Rotating parts must be fixed so that accidental movement is not possible.
- BEWARE: After stand still bearings will be hot, there is a danger from burning during repairs and maintenance if the bearing is not allowed to cool.
- The bearing screws / bolts to be tightened to the specified torque.
- Ensure that lubrication oil system is switched on prior to start of the machine.

IMPORTANT!	**Never use wool or cloth for cleaning any residues, These materials left in the bearing could lead to overheating.**

Eyebolts are fastened to the upper part of the bearing to assist handling of the complete and assembled bearing. It is important to remember that they are not suitable for the handling of the assembled machine and that the eyebolts are only to be used for lifting bearings only.

Following points to be given special attention

- The oil level
- The bearing temperature
- Sliding noises from the shaft seals
- Tightening
- Occurrence of vibrations

OIL LEVEL:

- Proper maintenance of sleeve bearings includes a periodical checking of the level and actual condition of the lubricant. Oil grade, Quantity & pressure at the inlet of bearing should be as given in the data sheet.
- It is advisable to filter the oil before filling the bearing.
- When the supply oil pressure is too high, oil quantity increases, and oil cannot be fully discharged and thereby causes oil leakage. Please make sure to keep the specified oil pressure and permit the flow of prescribed oil quantity.

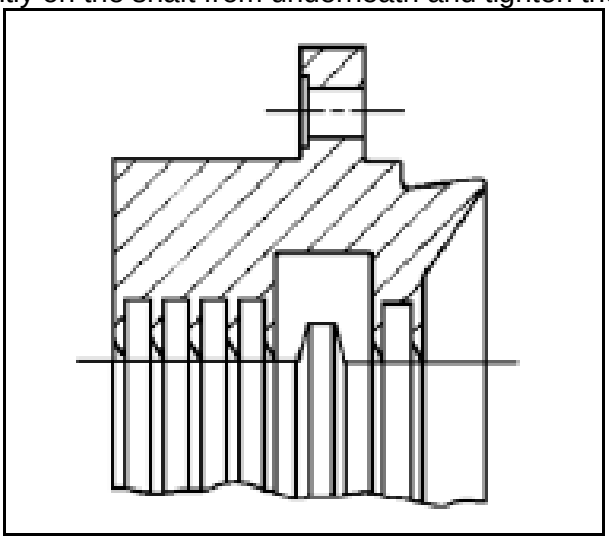
CAUTION	Insufficient oil level will lead to ineffective lubrication, bearing overheating and subsequent damage leading to failure. Too high a level of oil will not hinder the operation of the bearing, but could lead to leakage at the seals. Prior to commissioning of the bearing it must be checked for leaks. All oil port plugs and securing screws are correctly fitted and tightened.

- Bearings require a special emergency oil supply in case of failure in oil supply line.
- For systems with prolonged running time and those installed in plants which require to be in continuous operation and which have no oil rings/discs to keep the lubrication going, a second pump is provided as standby.
- The main pump unit which ensures the oil supply during normal operation is supplied with electrical power from the mains. The second pump (and, where applicable, the third), as standby, must be driven by a source of energy which is independent of the mains (emergency 3 phase current, DC, accumulator, overhead tank oil supply).
- If, during operation, the oil supply is assured by a shaft driven pump, care must be taken that the motor driven startup pump does not switch off until the shaft driven pump delivers an adequate quantity of oil at required pressure.
- For plants operated solely on circulating oil must be assured that the lubricating oil pumps do not cut the supply off until the rotating masses come finally to a stop (this particularly applies to great mass inertia moments with prolonged slowdown times).

CAUTION	Check oil flow & Level prior to start. Supply oil until machine stops.

Bearing seals:
All sleeve bearing are fitted with **Rigid seals**. For proper sealing sealant to be applied between housing & seal.

Seals are directly mounted on the bearing housing with interposed sealing compound. When fitting, push lightly on the shaft from underneath and tighten the bolts.

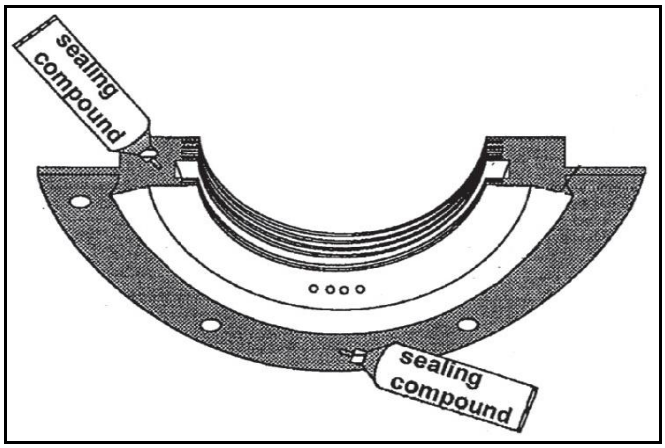


Clean the following surfaces

- Flange surfaces of the top half and bottom half of the rigid labyrinth seal
- The split line surfaces of the top half and bottom half of the rigid labyrinth seal.
- Flange surfaces of the housing.

Apply a uniform layer of sealing compound to the following parts:

- Flange surfaces of the top and bottom half of the rigid labyrinth seal
- Split lines of the bottom half (63) of the rigid labyrinth seal.



OIL CHANGE INTERVALS

- For forced oil lubricated bearings we recommend an interval of 15000 hours. Shorter intervals are necessary where there is frequent starting or where oil temperatures are high or where there is an excessively dirty environment. To change the oil, take out the oil drain port which is positioned at the centre beneath the bearing (allow the oil to drain whilst hot). Should unusual oil discoloration or smell be apparent the causes must be investigated. Should any chemical cleaning compounds be used these must be thoroughly flushed away prior to further operation.
- The oil is refilled through the oil sight glass or plug. Use only the recommended oil grade as shown by the manufacturer's plate. The oil is at the correct level when it reaches the middle of the oil level glass. There is always a possibility of overfilling - too high a level of oil will hinder the operation of the bearing.

OIL SUPPLY SYSTEM

The pipe bends, T-pieces etc. in the piping must be measured and added to make the total pipe length. The viscosity of the oil must be noted in the calculation of pipeline resistances. The oil quantities must also be delivered in the case of a cold start.

Oil supply system to be provided with vapor extraction system to have negative pressure at outlet pipe, thereby avoiding oil leakage in bearing.

If the oil supply system is placed out door, it must be protected against atmospheric influences (heat, frost, rain, wind) in order to avoid fluctuations in temperature which could lead to failure of the equipment.

Pipelines:

For inlet pipelines use seamless steel tubes and for connection use suitable fittings. The pipelines may be bent and tig welded, the cross section should be such that the flow speed does not exceed 1,5 m/s.

For the return lines piping, instead of pipe fittings use pipe bends of larger possible radii in order to reduce pipeline resistance. Junctions in return lines are to be tangential to the flow. The cross sections should be selected in such a way that the flow speeds do not exceed 0.15 m/s, based on the full pipe cross section.

Piping of return line should be with a gradient of at least 3 deg. so that the oil flows out smoothly. Confirm by looking at the flow-sight that the condition of flow does not change from that at normal times. In case the oil in the flow-sight becomes full in winter season when the viscosity of oil increases, the oil may spill out. In such cases close the oil supply valve a little. When the oil temperature increases and its viscosity drops open the valve slowly and carryout the adjustment. In this case, an identification line should be marked at the original position of the valve for the sake of convenience.

CAUTION	Check that the oil exits the bearing and goes to the lubrication unit simply through the effect of gravity

Bearing insulation checking:

This requires disassemble of Drive end bearing.

Hold the rotor at the drive end to insulate it from the earth (disconnect, then remove the drive end bearing, if not already done).

Measure the insulation resistance between shaft and earth. The insulation resistance should be more than 0.1 MΩ measured at 500 V DC.

Accessories installed in the bearing liner (eg: Pt100 sensor) should have minimum insulation of 0.1 MΩ measured at 500 V DC.

Provision for measuring shaft vibration (Eddy current probe) is provided in the bearing 45 deg apart from the vertical.

Setting of which to be referred to respective catalogue.

MACHINE WITH OUTDOOR APPLICATION:

Bearing housing is sealed against influences of the weather. In order to achieve this, special measures are necessary which vary according to the type of bearing and also the speed of the shaft. However, due to fluctuations in temperature, these measures cannot prevent the formation of condensation inside the bearing. After some time, especially with self-lubricated bearings, this may cause the oil to emulsify, for example, the bearing is exposed to solar irradiation during the day and cools down considerably at night. As result of which loading capacity of the oil film will get reduced.

Bright parts (shaft) may rust during down times.

Therefore, slide bearings which are operated outdoor should at least have a protective roof.

Generator supplied in Disassembled condition:

Rotor in disassembled condition, Complete rotor supplied in separate package, in which all the bearing steps will be covered, at any point of time rotor should not be lifted using these steps.

NOTE: IMPORTANT!

WHEN THE SUPPLY OIL PRESSURES IS TOO HIGH, OIL QUANTITY INCREASES, AND OIL CANNOT BE FULLY DISCHARGED AND THEREBY CAUSES OIL LEAKAGE TO THE INTERIOR. PLEASE MAKE SURE TO KEEP THE SPECIFIED OIL PRESSURE AND PERMIT THE FLOW OF PRESCRIBED OIL QUANTITY.

Causes of bearing over-heating and corrective actions:

The causes of over heat and impairment by overheat of bearing and their corrective actions are as described below,

SL.NO.	CAUSE	CORRECTIVE ACTIONS
1	Defective lubricating oil	Change the lubricating oil.
2	Shortage of oil	Feed the prescribed quantity of oil up to the required level on the oil level gauge.
3	Peeling-off of white metal Due to Abnormal Vibration	Repair or replace (investigate the cause of abnormal vibration and carryout the repair).
4	Roughness of white metal surface due to shaft current.	Replace bearing insulation for eliminating shaft current. Repair or replace the white metal.
5	Deformation or damage of oil ring/oil disc	Modify and repair oil ring/disc. Replace the same.
6	Shortage of oil (supply interruption of oil or oil leakage)	Inspect and repair piping. Adjust for the required quantity of oil.
7	Contamination of cooling oil	Change the oil.
8	Mixing of foreign matter in cooling oil.	Remove the foreign matter by flushing.
9	Defective contact between bearing and journal.	Repair or replace the white metal.

8.1.5. Maintenance of brushes

The length of brush can be determined by visual inspection. The carbon brushes must be changed when the length remaining falls below 3 mm from brush holder. The carbon brushes should be replaced with new ones having contact faces matching the rotor shaft contour.

⚠ CAUTION	Carbon brushes should be changed while the machine is stationary.

Changing the worn out carbon brushes

Carbon brushes should be changed while the machine is stationary. First the cable lug is unclamped. Only loosen the fixing screw enough to enable the cable lug to be pulled out. Swing the finger plate on the brush holder upwards, and carefully pull the carbon brush out of its holder by its cable.
The new carbon brushes are then inserted, ensuring that they are fitted with the correct orientation (see fig. 3.10-1). Clamp in the cable lug, and lower the insulated plate slowly onto the brush.

8.2. Inspection

To avoid failure in advance, it is indispensable to watch and inspect the generator at all times.

By preparing checklist, please perform the inspection periodically. Below points that need to be paid attention especially date of inspection and methods of inspection are given.

In other words, please pay due attention by comparing the temperature rise and vibration through the feeling obtained by touching your hand on the generator, and by sensing abnormal noise or odor. As for the confirmation of abnormal odor, please confirm it by opening the covers once in a while.

8.2.1. Re-tightening of bolts and connecting location

Inspection and maintenance within the extent considered possible must be performed once in a year without taking out the rotor. In particular, inspection of stator winding and re tightening of respective bolts and nuts must be carried out. Tightening of set bolts must be done once after half a month from the date of commencing running and furthermore inspection and re tightening of these bolts must be done at the rate over 3 times within one year thereafter.

8.2.2. Bearing

Prior to starting, always confirm the flow of lubricating oil by observing flow sight. After the starting if bearing is overheated considerably within a short time or if abnormality of noise or odor is detected, there is the need of dismantling and inspection. The root causes for bearing over heating are as below.

- Lubricating oil does not flow
- Use of filthy oil
- Deficient erection and coupling
- Defect of oil supply pipe is in presence and shortage of lubricating oil arises.
- Generation of rust or presence of scar on the journal part during the time generator is laid off.

8.2.3. Inspection of Insulation Resistance

Note:

Insulation tests should be carried out before running the generator set, both after assembly and after installation on site. The windings have been H.V. tested during manufacture; further H.V. test may degrade the insulation with consequent reduction in operating life. Should it be necessary to demonstrate H.V. testing, for customer acceptance, the tests must be carried out at reduced voltage levels i.e. Test Voltage= 0.8 (2 X Rated Voltage + 1000)

Insulation resistance is the resistance against leakage current that flows in the interior and on the surface of insulation when certain value of D.C. voltage is imposed. In case of the generator is installed at a place where high humidity exists or when the generator is kept idle for a long period of time, generally the insulation resistance drops due to deposit of moisture on the insulation surface. Therefore insulation resistance should be measured prior to running the generator.

- Measurement of IR is the easiest way to check the healthiness of insulation of the equipment. However, the value of insulation resistance measured indicates the condition of insulation deterioration.
- Measurement is essential before running the generator. Although the measured value indicates the absolute value corresponding to the condition of insulation at the instant of measurement, a comparative value has more significance. It is essential to measure periodically and to make a comparison with reference to previous measured values.
- Although the insulation resistance increases with time after the imposition of D.C. voltage the value that settles down to a constant should be noted. In case the insulation resistance increases gradually, then insulation resistance value to be taken for 30 seconds value or 1-minute value.
- Since the insulation resistance has a close relationship with the temperature, so while measuring IR, it is always necessary to note down the temperature of insulation. It serves convenient for maintenance purposes if the relationship between the insulation resistance value and winding temperature at clean and dry condition of winding is available. Generally, the insulation resistance value drops rapidly together with the rise of temperature and the relationship between the logarithm of insulation resistance value and temperature changes as straight line approximately in the temperature range of usage.
- Insulation resistance value differs from the process by the insulation composition of equipment and the temperature rise. There are generally three types of classification as given below.

1. Initially the insulation resistance drops at once and then starts rising as the drying effect progresses. This is most generally seen.
2. In case the absorbed moisture on the surface is significant first the insulation resistance rises by the drying effect and thereafter follows the same process as (1).
3. In the case of drying on site the equipment that has absorbed moisture excessively and/or large size machines, this type of characteristic is frequently experienced. In the case of equipment that has absorbed moisture excessively, since the amount of moisture absorbed is large, the insulation characteristic is to be absorbed before the drying effect appears. In the case of large size machines a long time is required for

the temperature rise of equipment and the drop portion due to insulation characteristic offsets the rise portion due to drying effect. In both the above cases, a fairly low value for the measured insulation resistance by megger should continue without change. About 3 full days (days and nights) may be required to reach the rising point.

8.2.3.1. Minimum Insulation resistance (IR) values required (without any accessory connections)

The minimum permissible insulation resistance value changes extensively by the type, rating, dimension and insulation method of generator. A general value cannot be determined. However, the following guideline can be approximately used when the windings are at normal temperature, for permitting normal running.

Table: 8.2.3.3-1 – IR value.

Type of Winding	Rating of Megger Meter	IR value in MΩ
For Low voltage stator winding and the field winding	0.5kV	> 1
For 3.3kV and 6.6kV stator windings.	2.5kV	> 10
For 11kV and more stator windings	5.0kV	> 100

Alternatively, the following formula may be used for the minimum insulation resistance value.

- $\dfrac{\text{Rated Voltage (V)}}{\text{Rated Output (kW or KVA + 1000)}}$

- $\dfrac{\text{Rated Voltage (V)+1/3(rpm)}}{\text{Rated Output (kW or KVA)+2000+0.5M-ohm}}$

8.2.3.2. Prevention of IR drop

It is desirable to run the generator with its winding condition always set clean and dry. Dust deposited on the winding surface prevents heat dissipation and becomes the cause of deterioration dependent on its kind. Also the intrusion of moisture into the interior forms the cracks on insulation, leads to the drop in insulation resistance. Therefore daily attention to cleaning and prevention against moisture absorption leads to prevention of IR drop. Although generator's interior presents dry condition during running, there may be moisture absorption during shutdown of generator at times of high humidity such as rainy season. To prevent such situations, it is required to put-on the space heater immediately after the generator shutdown to raise the interior temperature of generator to higher than the ambient temperature.

Following safety measures to be taken care to keep the IR value within the limit so that to keep the insulation healthy.

1. Cleaning method of Winding

Dust accumulated on the insulation reduces the ventilation area and the cooling effect. This may result in over-heating of the generator. Even though the accumulated dust is not conductive by itself, it absorbs moisture and becomes conductive over a period, thereby causing short circuit of winding or ground fault. Therefore, it is essential to keep the winding always in a clean condition.

The particular points that need to be paid consistent attention are as below:

- Is there any abnormality of the respective parts of generator itself?
- Is there any harmful matter in the surrounding atmosphere?

When abundant dust is present in the wind passage, which may enter inside the generator accumulate on coil, which leads to short-circuit or grounding. When the generator is reused after a long period of shutdown, there may be chances of low insulation resistance of winding. Before starting the generator switch on the space heater & recheck the insulation resistance.

2. Wiping with cloth

This method is especially effective for cleaning the local parts where the contamination is severe. Dry and clean cloth from which thread pieces do not come out should be used. Attention should be given as not to impair the insulation by rubbing strongly

As part of routine maintenance procedures, periodic attention to winding condition (particularly when generators have been idle for a long period) and bearings is recommended.

3. Rotor/Stator Heating Procedure:

The following procedures have to be carried if the IR value of the rotor/stator is lower than the specified standard value.

A. When machine is stored for a longer duration the bearings has to be disassembled, cleaned for rust formation & protected against water.

B. If deep corrosion appears & pitting of shaft is observed, then it is necessary to perform machining / grinding the affected surfaces. Sometimes it may need replacement of bearings / seals to suit the machined dimensions.

C. Switch on the space heater & hot air has to be blown for removal of moisture. Along with the space heaters adequate number of halogen lamps can be used to get temperature around 90 to 100°C.

Check the insulation resistance of rotor and stator.

For older generators, the minimum value recommended in IEEE standard 43 could be used. The value in mega ohms, when corrected to **40^0C**, is equal to the generator rated voltage plus 1. Fox example: For a generator with rated voltage of 3.3 kV, the limit value would be: 3.3+1 = 4.3 (mega ohms)

D. If the machine is completely submerged in water, then the machine has to be completely disassembled, cleaned with pressure of warm water for removal of dirt / silt particles. The machine has to be carried out for drying insulation as mentioned in drying insulation procedure.

E. Drying of winding: If the insulation resistance is less than satisfactory value & the reason for low IR is excessive moisture in the winding. Dry the winding by any of the below mentioned method:

I. Warm air oven.
II. Electric strip heater.
III. Circulating currents through the coils.

The heat should be applied slowly so that the desired temperature will not be obtained in less than 6 hours.

Insulation drying temperature*		
Class "B"	Class "F"	Class "H"
90°C	115°C	130°C
* Class "F" & "H" insulated generators should be baked to 70% specified temperature (to avoid the steam inside the winding) for about 6 hrs, before temperature is raised to drying temperature.		

Insulation resistance should be measured before the heat is applied & every 6 to 8 hours thereafter.

NOTE: Insulation resistance will decrease as the motor warms up, but will begin to increase as the drying process continues.

1. Stator winding drying:

I. Warm air oven drying:

a. Remove the bearings

b. Remove the rotor from the generator.

Bake in the oven at temperatures specified in insulation drying temperature table and follow procedures described for drying insulation

II. Electric Strip heater drying:

a. Remove the bearings

b. Remove the rotor from the generator.

c. Direct a fan on stator to carry away the moisture

d. Attach temperature indicators to winding & apply heat as specified in the insulation drying temperature table & follow procedures described for drying insulation.

e. Radiant type heaters are not recommended because some parts may become scorched before remote parts reach desired temperature.

III. Circulating current drying:

a. Remove the bearings

b. Remove the rotor from the generator.

c. Direct a fan on stator to blow away excessive moisture.

d. Attach temperature indicators to winding & apply heat as specified in the insulation drying temperature table & follow procedures described for drying insulation.

e. An external source of current can be used to circulate DC current through the winding. A portable low voltage motor-generator set such as is used for welding.

When this method is used on the stator, the stator phase may be connected in series or in parallel to suit the available power supply if both ends of all phases are

accessible. If three leads are brought out from the generator then current may be circulated between one terminal & the other two connected together. If this is done, the temperature of the single lead connection must be checked frequently, and it is desirable to shift the leads occasionally. Usually 50 to 70% of full load & correspondingly check the insulation drying temperature limit as per the chart.

2. Drying of rotor:
   - The rotor has to be cleaned with pressure of warm water for removal of dirt & silt if required.
   - For cylindrical / salient pole type of rotors the main rotor has to be circulated with an external source of DC current through the winding. A portable low voltage motor-generator set, such as is used for welding can be used.
   - At regular intervals check the IR values & continue heating till desired IR is obtained.
   - Along with the above system use halogen lamps for heating purpose. Temperature should not be exceeded at any point of time as per the insulation drying temperature.

3. In case of salient pole rotor if the IR value is not obtained to desired level then partial or total disassembly of poles may have to be carried out due to several reasons listed below
   a. When the poles are fixed to the rotor by steel wedges, it is then necessary to remove the onset of rust from the wedges and to clean and dry the appropriate surfaces otherwise future disassembly of the poles could be extremely difficult.
   b. There are number of slits / cavities where the in the poles where water could remain resulting insufficient IR value
   c. Cleaning & drying is easier when the poles are dismantled.

F. When the machine put into operation, it is recommended first to run the machine without excitation in order remove the moisture content. As a second step the machine should be dried for some time running the machine in under excitation condition with stator winding short circuited. The stator current & winding temperature has to be controlled.

⚠ CAUTION	High temperatures may cause damage to insulation. Avoid hot spots & radiant type heat.

G. If the insulation resistance is not improved even after following the above-mentioned points then the whole machine is to be sent to manufacturer works for rectification.

8.2.4. Inspection of Winding resistance

Inspect the winding resistance of main stator, main rotor, exciter stator, exciter rotor & PMG stator on regular interval. Before measuring the winding resistance, remove all the external connections for accurate results.

8.2.5. Inspection and cleaning of Rotating Rectifier Assembly (RRA)

Investigate whether the bolts and nuts around the rotating rectifiers are loose or not. Unless otherwise there is a problem, inspection of individual diodes is not required. In case, the voltage is not built-up or generated voltage is low, failure of diodes is to be considered as one of the probable cause. Therefore, remove the lead wires and check the diode healthiness using multimeter using below procedure.

- While testing using multimeter, keep the multimeter in Diode testing mode.
- During forward bias the voltage should be 0.3 - 0.4V DC.
- During reverse bias the voltage will not be displayed.

The above said condition shows the healthiness of diode. In case any diode is found to be damage, replace that with an identical one.

Note: please note the following points while replacing the diodes.

a. During diode replacement remove the end cover from exciter side, so that the diode is accessible to replace.

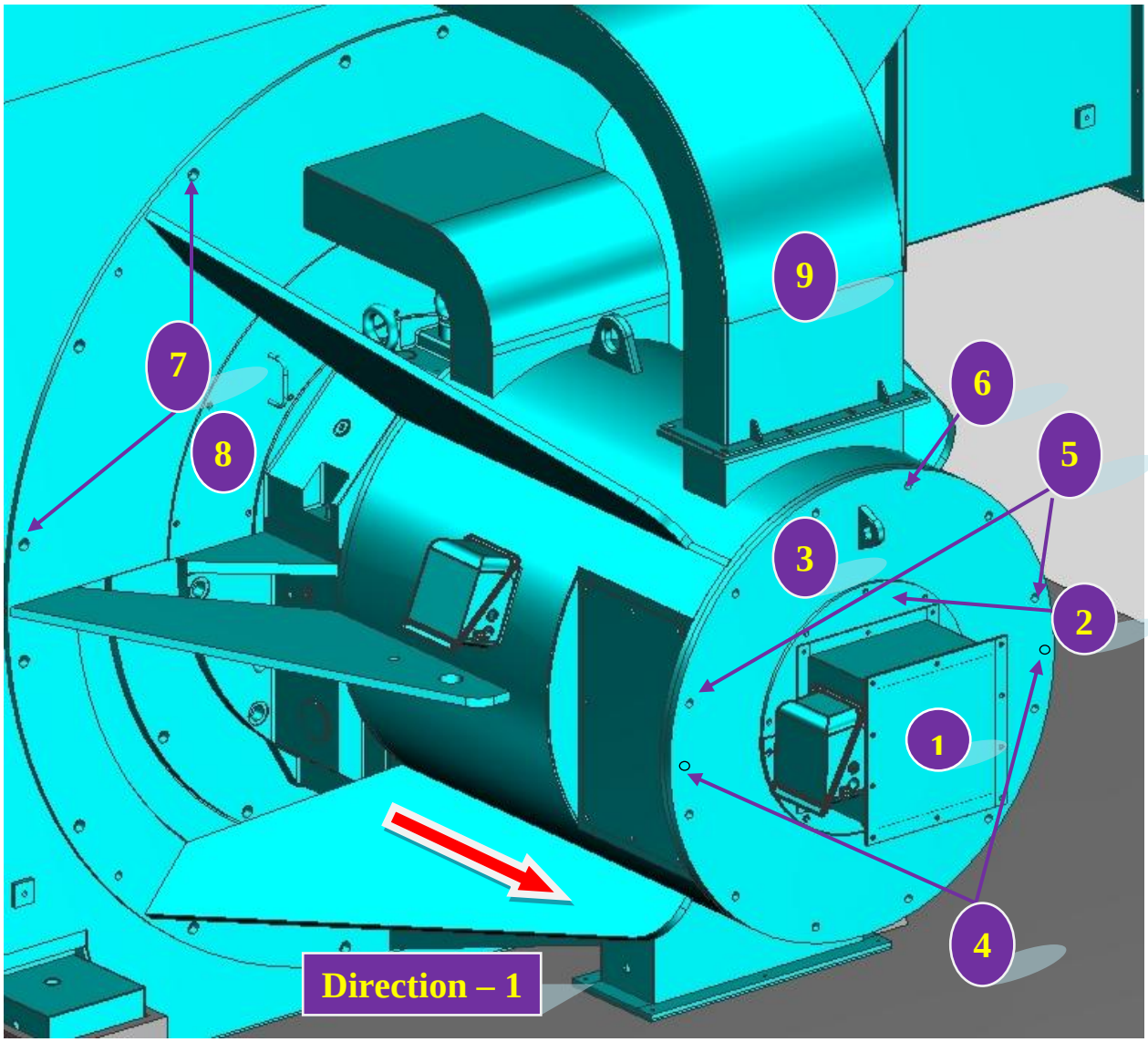
b. Since 2 types of diodes (forward polarity and reverse polarity are used, confirm the polarity of the diode to be replaced).

c. Clean the tightening thread part of diode and coat conducting grease to prevent electrical corrosion of this part.

d. Tighten the diode using torque wrench.

8.3. Assembly and Disassembly of Exciter & PMG(Optional)

The machine is dispatched in assembled condition with factory set air gap. During maintenance, if required to disassemble the exciter & PMG contact TDPS for assistance & guidance.



1 – Slip Ring Cover
2 – Cover Plate
3 – PMG Stator
4 – PMG Dovelling
5 – Stud to guide the PMG Stator
6 – PMG Fixing
7 – Exciter Fixing
8 – Exciter Cover
9 – Inlet Duct

Fig 8.3.1 - Assembly and Disassembly of Exciter & PMG

Disassembly of exciter & PMG:

Follow the below steps to disassemble the exciter & PMG:

- Remove the Exciter field, Exciter space heater, PMG & Slip ring connections.
- Remove the inlet duct (**9**).
- Remove the slip ring brush assembly, slip ring cover & Cover Plate (**1 & 2**).

- Remove the 2 nuts (provided on other sides of dowelling pin (**4**)) opposite to each other of PMG Stator
- Use M16x500mm stud to guide the PMG stator (**3**) outside.
- Cover the PMG rotor with non-magnetic sheet to avoid the damage.
- Remove the dowel pin (**4**).
- Remove all the PMG stator fixing bolts (**6**).
- Pull the PMG stator outside by guiding on studs
- Remove the Exciter cover (**8**)
- Remove the Exciter fixing bolts (**7**).
- Remove the exciter in the direction – 1 as shown in above fig 8.3.1.

Assembly of Exciter & PMG:

To assemble the exciter stator follow the below steps.

- Assemble the Exciter Stator with the Main stator frame.
- Cover the PMG rotor with non-magnetic sheet
- Assemble the PMG Stator using the same stud & guide the stator
- Dowel the PMG Stator with dowel pin.
- Fix all the PMG fixing bolts.
- Assemble Cover Plate & slip ring brush assembly.
- Ensure proper brush bedding & assemble slip ring cover
- Terminate all the removed connections.
- Assemble the inlet duct with gaskets.

WARNING	**Use non magnetic tools and fixtures near PMG rotor in order to avoid personal injury or equipment damage.**

8.4. Periodical Inspection

Refer document **TYM011** for periodical inspection of generator.

CHAPTER 9

FAULT TRACING AND CORRECTIVE ACTION

9. FAULT TRACING AND CORRECTIVE ACTION

The faults listed here under are the possible fault condition that may come across in the continuous operation. There may some other faults come across in the generator set, which has to be sorted on case to case basis. In most of the cases operator has to analyze the fault and there need to take the corrective action.
If the operator fails to find the remedy for the fault, the turbo generator should be shut down. If the fault cannot be traceable, then discuss the fault with manufacturer to find the corrective action.
The possible faults and corrective actions are listed below.

9.1. Abnormal winding temperature

Root Cause	Corrective Action
Malfunction of RTD's	With balanced load current between phases, RTD's to be checked when different temperature observed in the slots. Check RTD resistance values & RTD leads without any excitation. While measuring the RTD resistance care should be taken that RTD's are not heated, this leads to false results.
High warm or cold air temperature or cooler circuit failure.	Check the cooler circuit as per problem clause 2.
Unbalance loading or over loading	If the generator is operated with unbalanced load due to particular system condition. The unbalanced load should be within the limit. The unbalanced load is defined as ratio of negative sequence current to rated current. The permissible rated stator current should not exceed in any phase during unbalance condition. When there is unbalanced load, steps to be taken to bring the system into uniform condition. If it is not possible to distribute the load, then generator should be shut down. If the generator is overloaded it will also leads to rise in winding temperature.

9.2. High warm or cold air temperature or cooler circuit failure

High temperature may cause because of over loading the generator. The load should be reduced immediately within the limit.

a. Direct Air cooling:

Root Cause	Corrective Action
Filter contaminated	Air passage filter to be checked frequently, cleaned if necessary.
Drawn-in cold air too warm	If the cold air temperature downstream of the cooler cannot be required to the permissible operating value, the generator load should be reduced.

b. Totally Enclosed water / air cooling:

Root Cause	Corrective Action
Insufficient cooler capacity	In the design stage the cooler is designed adequately considering redundancy & overload condition. The cooler system has to be checked & the cooler to be cleaned during a generator standstill situation.
Insufficient cooling water volumetric flow or high cooling water temperature	Rise in temperature requires high cooling water flow. The cooling water volumetric flow should be increased.
Loss of cooling water flow	Restore the adequate cooling water flow or else shutdown the generator.
Water quality	Cooling water ph value should be within the limit, if not it will degrade the material.
Leakage of cooler water or cooler system.	Identify the faulty cooler section, take out for service & reduce the lad accordingly.

9.3. No output voltage in Generator

Root Cause	Corrective Action
Excitation system failure	Check the excitation system & adjust it properly.
Field open circuit	Check all the switches & power supplies circuits.
Speed too low	Check the prime mover speed & increase accordingly.
Excitation system failure	Check the function of excitation system

9.4. Rated voltage not achieved when Generator is loaded

Root Cause	Corrective Action
Overload	Load has to be reduced within the permissible value
Inter turn short in field winding	High temperature rise & discolored varnish can indicate the inter turn short circuit. If there is inter turn, contact the manufacturer for further action.

9.5. Generator draws inductive reactive power

Root Cause	Corrective Action
Field open circuit	Check all the switches & power supplies circuits.
Excitation system failure	Check the function of excitation system
Inter turn short in field winding	High temperature rise & discolored varnish can indicate the inter turn short circuit. If there is inter turn, contact the manufacturer for further action.

9.6. Unequal phase voltage

Root Cause	Corrective Action
One supply phase connected	Check the switchgears & supply circuits
Stator winding incorrectly connected	Check the connection & rectify it.
Inter turn phase short circuit in stator winding	High temperature rise & discolored varnish can indicate the inter turn short circuit. If there is inter turn, contact the manufacturer for further action.

9.7. Sudden deterioration in Rotor running

Root Cause	Corrective Action
• Inter turn short in field winding • Rotor unbalance • Unequal air gap over poles due to rotor shaft distorted • Misalignment • Unbalance or shocks from prime mover or turbine. • Uneven running because of gearing • Resonance with foundation • Changes in foundation	Check the reason for fault is whether it is turbine or damaged in bearings. If there is deterioration in rotor running shut down the generator immediately, & locate the root cause. If at all it is possible or not possible to sort out the issue, it is a serious problem hence it is advised all the time to contact the manufacturer for further action.

9.8. Rise in bearing temperature

If there is a sudden change in bearing temperature monitor the temperature. If it exceeds the limiting value shutdown the generator.

Root Cause	Corrective Action
Oil inlet temperature too high or bearing pressure too low.	Check the bearing oil temperature & pressure correct it if necessary.
Oil contaminated or aged	Clean the bearing housing & renew the bearing oil.
Low oil level	Check the oil level; fill the oil if it calls far.
Oil ring not in position (if applicable)	Oil ring have to be realigned, straightened or replaced if it calls far.
Oil viscosity too high	Change the oil
Forced lubrication fails	The oil supply system has to be inspected.

Root Cause	Corrective Action
Residual oil pressure of bearings with oil jacking drops during operation with jacking oil pump inoperative	The jacking oil piping and the no return valve have to be checked. Check for the concerning bearing shell skewed
Excessive axial thrust resp. radial load	Check the magnetic center & alignment. In case of deviations, then the bearing or the machine has to be realigned.
Inadequate radial clearance	The concerned bearing shell has to be adapted by scraping or reaching
Damage to bearing lining. Defective bond between supporting lining and supporting block of bearing shell	If the bond is in poor condition, the lining has to be replaced. In this connection the correct shape of oil pockets and oil grooves has to be ensured.
Oil pockets too small, transition to bearing surface not smooth enough	The oil pockets to be refinished accordingly.
Bearing currents	The bearing insulation has to be checked: if necessary clean or replace.

CHAPTER 10 LIST OF ABBREVIATIONS

1.	Ω	:	Ohm.
2.	A	:	Ampere.
3.	AC	:	Alternating Current.
4.	ACG	:	Alternating Current Generator.
5.	ACW	:	Anti-Clock Wise.
6.	ATD	:	Air Temperature Detector.
7.	AVR	:	Automatic Voltage Regulator.
8.	BTD	:	Bearing Temperature Detector.
9.	CACW	:	Closed Air Circulating Water.
10.	CT	:	Current Transformer.
11.	CTD	:	Core Temperature Detector.
12.	CW	:	Clock Wise.
13.	DC	:	Direct Current.
14.	DE	:	Driven End.
15.	emf	:	Electro motive force.
16.	HV	:	High Voltage.
17.	Hz	:	Hertz.
18.	IC	:	International Cooling.
19.	IEC	:	International Electrotechnical Commission.
20.	IP	:	Ingress Protection or International Protection.
21.	IS	:	Indian Standards.
22.	kΩ	:	kilo Ohm.
23.	kA	:	kilo Ampere.
24.	kV	:	kilo Volt.
25.	kVA	:	kilo Volt Ampere.
26.	kW	:	kilo Watt
27.	MΩ	:	Mega Ohm.
28.	MW	:	Mega Watt.
29.	NDE	:	Non-Driven End.
30.	Ph	:	Phase.
31.	PMG	:	Permanent Magnet Generator.
32.	PT	:	Potential Transformer.
33.	RPM	:	Rotation per Minute.

34.	RRA	:	Rotating Rectifier Assembly.
35.	RTD	:	Resistance Temperature Detector.
36.	STG	:	Steam Turbine Generator.
37.	V	:	Volt.
38.	VPI	:	Vacuum Pressure Impregnation.
39.	W	:	Watt.
40.	WLD	:	Water Leakage Detector.
41.	WTD	:	Winding Temperature Detector.

IMPORTANT

TDPS Reserves the right to carry out modifications on its machines, in order to improve them, without prior notice.

NOTES:

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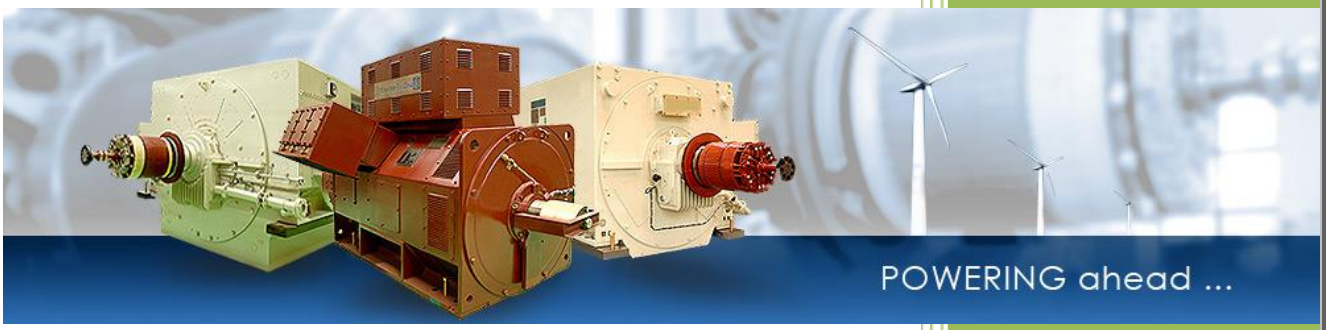
INSTALLATION, COMMISSIONING, OPERATION AND MAINTENANCE MANUAL



Part : 2

RATING : **8750kVA, 13.8kV, 60Hz, 4P**

TYPE : **TC150**

PROJECT : **AIR CLEAN -COLUMBIA**

MACHINE No. : **T-04420**

TABLE OF CONTENTS

Chapter 1

TECHNICAL SPECIFICATIONS

1. TECHNICAL SPECIFICATIONS

1.1. SPECIFICATION OF GENERATOR:

This generator is a Brush less AC generator with an AC exciter and rotating rectifier mounted on a common shaft. The specification of the generator is as follows:

Sl. No.	AC GENERATOR	DETAILS
1.	Type	Cylindrical Rotor type
2.	Conforming standards.	NEMA MG-1
3.	Type of excitation system	Brushless
4.	Continuous rated output kW / kVA	7000 / 8750
5.	Speed in (rpm)	1800
6.	Voltage (Volts)	13800
7.	Full load current (Amps)	366
8.	Frequency (Hz)	60 Hz
9.	No. Of phases / No of terminals	3 ph / 6
10.	Power factor	0.8 (Lag)
11.	No. Of poles	4
12.	Insulation Class	Stator: Class F Rotor: Class F
13.	Temperature rise class limited to	Class B
14.	Enclosure	Main: IP 54
15.	Cooling System	Main: IC 81W
16.	Bearings	Two nos. sleeve Bearings
17.	Bearing oil feed system	Forced Lubrication

1.2. SPECIFICATION OF A.C. EXCITER:

The rotating silicon rectifier rectifies AC supply to DC, which comes from three-phase exciter. The DC electric source excites the Main field of generator.

1.	Type of exciter	GZA84
2.	Output(kW)	67
3.	Voltage (V)	108
4.	Current (A)	620
5.	Frequency (Hz)	180
6.	Revolutions (rpm)	1800
7.	Excitation Voltage (V)	63
8.	Excitation current (A)	10.3
9.	No. of phases	3
10.	No. of poles	12
11.	Power factor	0.95 (lag)
12.	Insulation class	F
13.	Rating	Continuous
14.	Type of outer housing	IP 54
15.	Cooling System	IC 31
16.	Armature	Revolving-armature type
17.	Exciting system	Self-excitation

1.3. ROTATING RECTIFIER (DIODE) SPECIFICATION:

SKN 240 / 16	**SKR 240 / 16**
I_{FAvg} = 240A	I_{FAvg} = 240A
Reverse Voltage up to 1600V	Reverse Voltage up to 1600V
Anode to Stud	Cathode to Stud
3 Nos.	3 Nos.

1.4. SPACE HEATER SPECIFICATION:

	Main Generator	Exciter
Capacity(Watts)	1000	200
Voltage(Volts)	120	120
Frequency(Hz)	60	60
Phase	1 φ	1 φ
Quantity	2 Nos.	1 No.

1.5. LUBRICATION OIL REQUIREMENTS:

OIL QUANTITY (lpm)	DE	NDE
	6 ±10%	6 ±10%
Pressure At Inlet (Mpa)	0.1~0.2	
Temp. At Inlet (°C)	45 to 49	
Grade Of Oil	ISO VG46	

1.6. DISCHARGE RESISTOR SPECIFICATION:

	Resistor-1	Resistor-2
Resistance (Ω) @ 25°C	16	14.3
Applied Voltage (Volts) DC	160	160
Capacity (Wattage)	1600	1800
IR Value required MΩ @ 25°C	> 100	> 100

1.7. PMG SPECIFICATION:

Output (KVA)	5
Line Voltage (V)	200 ±10%
Current (A)	14.4
Frequency (Hz)	180
Speed (rpm)	1800
Power factor	0.85(lag)
Rotator Structure	Permanent magnet type
Excitation System	Brushless with AVR
Connection	3Ph, 3 wire
Insulation Class	Class F

1.8. COOLING WATER REQUIREMENTS OF AIR COOLER:

Fresh Water at inlet	PH7
Temperature (inlet) -°C	32
Volume (lpm)	900
Working Pressure (Mpa)	0.1 ~ 0.2

1.9. RTD/BTD/ATD LIMIT SETTING:

SL. NO	NAME	SPECIFICATION	SET VALUE	
			For Alarm	For Trip
1.	Stator Coil	3 Wire RTD	For class-B temp.rise machines.	
			125°C	130°C
2.	Bearing	6 Wire RTD	85°C or Max. Site temp (stabilized temp.) +10 °C	90°C or Max. Alarm temp +15 °C
3.	Air Temp.(Inlet)	3 Wire RTD	50°C	55°C
4.	Air Temp.(Outlet)	3 Wire RTD	80°C	85°C
5.	Space Heater (Main machines)	Refer section 1.4	SET AT 120°C	
6.	Space Heater (Exciter)	Refer section 1.4	---	---
7.	Water Leakage Detector	120V, 1Φ, 60Hz	---	---

Refer to test report for technical parameters apart from above table.