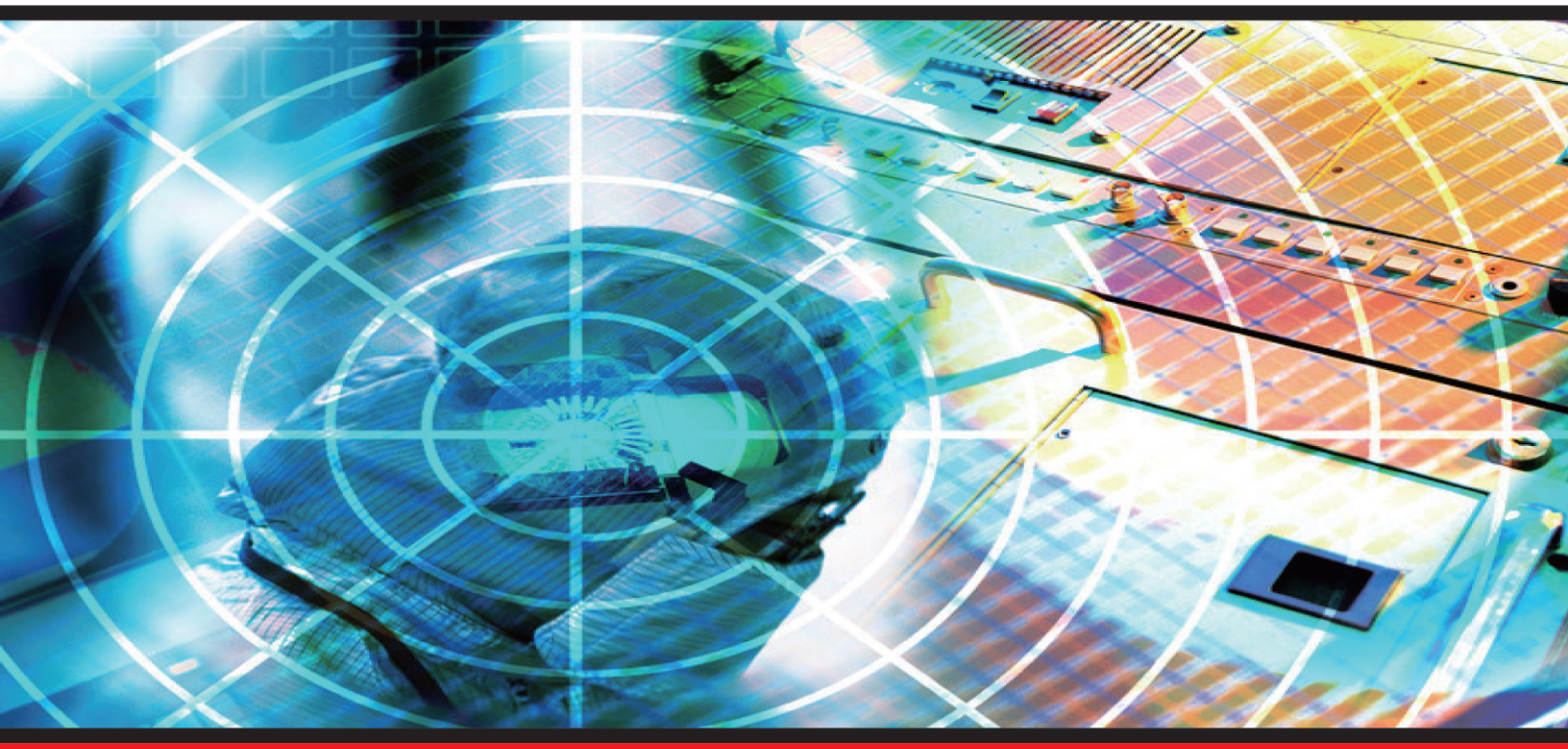
GENERATOR INSTALLATION, MAINTENANCE & MAINTENANCE MANUAL



SAFETY PRECAUTIONS

Before operating the generating set, read the generating set operation manual and this generator 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 PERSONAL INJURY OR DEATH.

- Ensure installation meets all applicable safety and local electrical codes. Have all installations performed by a qualified electrician.
- Do not operate the generator with protective covers, access covers or terminal box covers removed.
- Disable engine start circuits before carrying out maintenance.
- Disable closing circuits and/or place warning notices on any circuit breakers normally used for connection to the mains or other generators, to avoid accidental closure.

Observe all IMPORTANT, CAUTION, WARNING, and DANGER notices, defined as:

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 injury to personnel.**

 **Warning !**	**Warning refers to a hazard or unsafe method or practice that can result severe injury to personnel, possibly death.**

 **Danger !**	**Danger, refers to immediate hazards which will result in severe injury or death to personnel.**

Due to our policy of continuous improvement, details in this manual which were correct at time of printing, may now be due for amendment. Information included must therefore not be regarded as binding.

Photograph
The Front Cover photograph is representative only.

CONTENTS

CONTENTS

SECTION 1
INTRODUCTION

1.1 INTRODUCTION

The generator is of brushless rotating field design, available up to 660V at 50 Hz or 60 Hz.

The design, build and test procedures meet a range of British, European and International standards including, BS 5000, BS EN 60034 and ISO 60034, where applicable.

The generators are fitted with the PMG pilot exciter system and an 'automatic voltage regulator' (AVR). The MX 341 or the MX 321 can be fitted.

1.2 SERIAL NUMBER LOCATION

Each generator has its unique serial number stamped in to the upper section of the drive end frame end-ring.

Inside the terminal box two adhesive rectangular labels have been fixed, each carrying the generator's unique identity number. One label has been fixed to the inside of the terminal box sheet metal-work, and the second label fixed to the main frame of the generator.

1.3 DESIGNATION

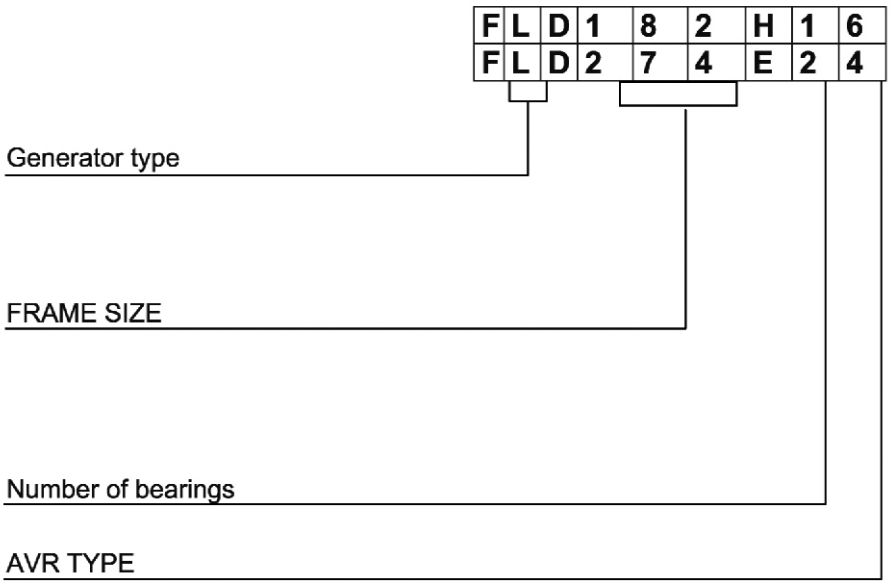
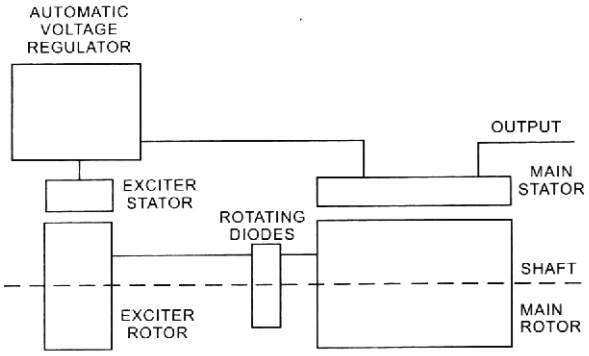


Fig 1

SECTION 2
PRINCIPLE OF OPERATION

2.1 SELF-EXCITED AVR CONTROLLED GENERATORS

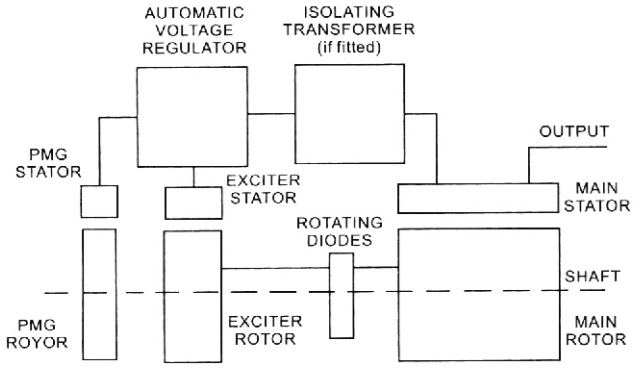


The main stator provides power for excitation of the exciter field via the SX440 AVR which is the controlling device governing the level of excitation provided to the exciter field.
The AVR responds to a voltage sensing signal derived from the main stator winding. By controlling the low power of the exciter field, control of the high power requirement of the main field is achieved through the rectified output of the exciter armature.

The SX440 AVR senses average voltage on two phases ensuring close regulation. In addition it detects engine speed and provides voltage fall off with speed, below a pre-selected speed (Hz) setting, preventing over-excitation at low engine speeds and softening the effect of load switching to relieve the burden on the engine.

The SX421 AVR in addition to the SX440 features has three phase rms sensing and also provides for over voltage protection when used in conjunction with an external circuit breaker (switchboard mounted)

2.2 PERMANENT MAGNET GENERATOR(PMG) EXCITED - AVR CONTROLLED GENERATORS



The permanent magnet generator (PMG) provides power for excitation of the exciter field via the AVR MX341 (or MX321) which is the controlling device governing the level of excitation provided to the exciter field. The AVR responds to a voltage sensing signal derived ,via an isolating transformer in the case of MX321 AVR from the main stator winding By controlling the low power of the exciter field, control of the high power requirement of the main field is achieved through the rectified output of the exciter armature.

The PMG system provides a constant source of excitation power irrespective of main stator loading and provides high motor starting capability as well as immunity to waveform distortion on the main stator output created by non linear loads,e.g. thyristor controlled dc motor.

The MX341 AVR senses average voltage on two phases ensuring close regulation. In addition it detects engine speed and provodes an adjustable voltage fall off with speed, below a pre-selected speed (Hz) setting, preventing over-excitation at low engine speeds and softening the effect of load switching to relieve the burden on the engine. It also provides over-excitation protection which acts following a time delay, to de-excite the generator in the event of excessive exciter field voltage.

The MX321 provides the protection and engine relief features of the MX341 and additionall incorporates 3 phase rms sensing and over-voltage protection.

The detailed function of all the AVR circuits is covered in the load testing section (subsection 4.7).

2.3 AVR ACCESSORIES

The SX440,MX341 and MX321 AVRs incorporate circuits which, when used in coniunction with accessories, can provide for parallel operation either with 'droop' or 'astatic' control, VAR/PF control and in the case of the MX321 AVR, short circuit current limiting.

Function and adjustment of the accessories which can be fitted inside the generator terminal box are covered in the accessories section of this book.

Separate instructions are provided with other accessories available for control panel mounting.

SECTION 3
APPLICATION OF THE GENERATOR

The generator is supplied as a component part for installation in a generating set. It is not, therefore, practicable to fit all the necessary warning/hazard labels during generator manufacture. The additional labels required are packaged with this Manual, together with a drawing identifying their locations. (see below).

It is the responsibility of the generating set manufacturer to ensure that the correct labels are fitted, and are clearly visible.

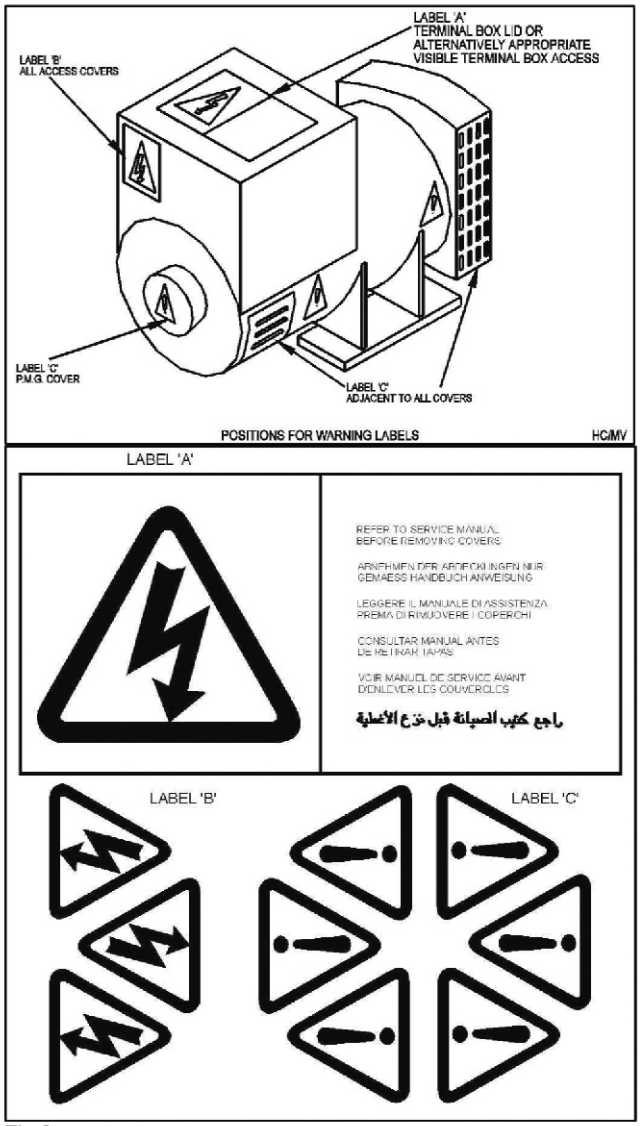


Fig 3

The generators have been designed for use in a maximum ambient temperature of 40℃, and altitude less than 1000 metres above sea level in accordance with BS5000.
Ambients in excess of 40℃, and altitudes above 100 0 metres can be tolerated with reduced ratings – refer to the factory.

The generators are of air-ventilated screen protected drip-proof design and are not suitable for mounting outdoors unless adequately protected by the use of canopies. Anti-condensation heaters are recommended during storage and for standby duty to ensure winding insulation is maintained in good condition.

When installed in a closed canopy it must be ensured that the ambient temperature of the cooling air to the generator does not exceed that for which the generator has been rated. The canopy should be designed such that the engine air intake to the canopy is separated from the generator intake, particularly where the radiator cooling fan is required to draw air into the canopy. In addition the generator air intake to the canopy should be designed such that the ingress of moisture is prohibited, preferably by use of a two stage filter.

The air intake/outlet must be suitable for the air flow given in the following table with additional pressure drops less than or equal to those given in table 1 below:

Frame	Air Flow		Additional (intake/outlet) Pressure Drop
	50Hz 1500 Rev/Min	60Hz 1800 Rev/Min	
	2.18m^3/sec	2.63m^3/sec	6 mm water gauge
	4619cfm	5573cfm	(0.25")

Table 1

The generators may be fitted with air filters. These are oil charged wire gauze filters and require charging during installation.

IMPORTANT !	**Reduction in cooling airflow or inadequate protection to the generator can result in damage and/or failure of windings.**

Dynamic balancing of the generator rotor assembly has been carried out during manufacture in accordance with BS 6861 Part 1 Grade 2.5 to ensure vibration limits of the generator are in accordance with BS 4999 Part 142.

The main vibration frequencies produced by the component generator are as follows:

	1500 rpm	1800 rpm
4 pole	25 Hz	30 Hz

Table 2

The standard terminal box is arranged for cable entry on the right hand side looking from the end of the generator. If specified at the time of order cable entry may be arranged on the opposite side.

The terminal box is constructed with removable panels for easy adaptation to suit specific glanding requirements. Within the terminal box there are insulated terminals for line and neutral connections and provision for earthing. Additional earthing points are provided on the generator feet.

The neutral, as supplied from the factory, is NOT connected to the frame.

 Warning!	**No earth connections are made on the generator and reference to site regulations for earthing must be made. Incorrect earthing or protection arrangements can result in personal injury or death.**

Fault current curves (decrement curves), together with generator reactance data, are available on request to assist the system designer to select circuit breakers,
calculate fault currents and ensure discrimination within the load network.

3.1 VIBRATION

Vibrations generated by the engine are complex and contain harmonics of 1.5, 3, 5 or more times the fundamental frequency of vibration. The generator will be subjected to this vibration, which will result in the generator being subjected to vibration levels higher than those derived from the generator itself.
The generators are designed to withstand the vibration levels encountered on generating sets built to meet the requirements of ISO 8528-9 and BS5000-3. (Where ISO 8528 is taken to be broad band measurements and BS5000 refers to the predominant frequency of any vibrations on the generating set.)

Definition of BS5000 - 3
Generators shall be capable of continuously withstanding linear vibration levels with amplitudes of 0.25mm between 5Hz and 8Hz and velocities of 9.0 mm/s rms between 8 Hz and 200 Hz when measured at any point directly on the carcass or main frame of the machine. These limits refer only to the predominant frequency of vibration of any complex waveform.

Definition of ISO 8528 - 9
ISO 8528-9 refers to a broad band of frequencies, the broad band is taken to be between 2 Hertz and 300 Hertz. The table below is an example from ISO 8528 - 9 (value1). This simplified table lists the vibration limits by kVA range and speed for acceptable genset operation.

VIBRATION LEVELS AS MEASURED ON THE GENERATOR				
Engine Speed Min -1	**Set Output kVA**	**Vibration Displacement**	**Vibration Velocity**	**Vibration Acceleration**
4 POLE 1500 rpm 50Hz 1800 rpm 60Hz	>30 kVA	0.32	20	13
The 'Broad band' is taken as 2 Hz – 300 Hz				Table 2

It is the responsibility of the generating set designer to ensure the alignment of the genset, stiffness of the bed-frame and mountings are such that the vibration limits as defined above are met.

If the vibration levels of the generating set are not within the parameters quoted above: -

1. Consult the genset builder. The genset builder should address the genset design to reduce the vibration levels as much as possible.

2. Discuss, with

3. the impact of not meeting the above levels on both bearing and generator life expectancy.

IMPORTANT !	**Important, refers to hazard or unsafe method or practice which can result in product damage or related equipment damage.**
IMPORTANT !	**Exceeding either of the above specifications will have a detrimental effect on the generating set and in particular on the life of the bearings. (See section on bearings). This will invalidate the generator warranty. If you are in any doubt, contact Dingol.**

In standby applications where the running time is limited and reduced life expectancy is accepted, higher levels than specified in BS5000 can be tolerated, up to a maximum of 18mm/sec.

Two bearing generators require a substantial bedplate with engine/generator mounting pads to ensure a good base for accurate alignment. Close coupling of engine to generator can increase the overall rigidity of the set. A flexible coupling, designed to suit the specific engine/generator combination, is recommended to minimise torsional effects.

Alignment of single bearing generators is critical and vibration can occur due to the flexing of the flanges between the engine and generator. A substantial bedplate with engine/generator mounting pads is required.

The maximum bending moment of the engine flange must be checked with the engine manufacturer.

Torsional vibrations occur in all engine-driven shaft systems and may be of a magnitude to cause damage at certain critical speeds. It is therefore necessary to consider the torsional vibration effect on the generator shaft and couplings.

It is the responsibility of the generator set manufacturer to ensure compatibility, and for this purpose drawings showing the shaft dimensions and rotor inertia are available for customers to forward to the engine supplier. In the case of single bearing generators coupling details are included.

IMPORTANT !	**Torsional incompatibility and/or excessive vibration levels can cause damage or failure of generator and/or engine components**

SECTION 4
INSTALLATION - PART 1

4.1 LIFTING

Warning!	**Incorrect lifting or inadequate lifting capacity can result in severe personal injury or equipment damage. MINIMUM LIFTING CAPACITY REQUIRED IS AS INDICATED ON THE LIFTING LABEL. Generator lifting lugs should not be used for lifting the complete**

Two lifting lugs are provided for use with a shackle and pin type lifting aid. A spreader with chains, to ensure that the lift is vertical, of suitable length and lifting capacity must be used. Lifting points are designed to position the craneage point as close to the centre of gravity of the generator as possible, but due to design restrictions it is not possible to guarantee that the generator frame will remain horizontal while lifting. Care is therefore needed to avoid personal injury or equipment damage. The correct lifting arrangement is shown on the label attached to the lifting lug. (See sample below).

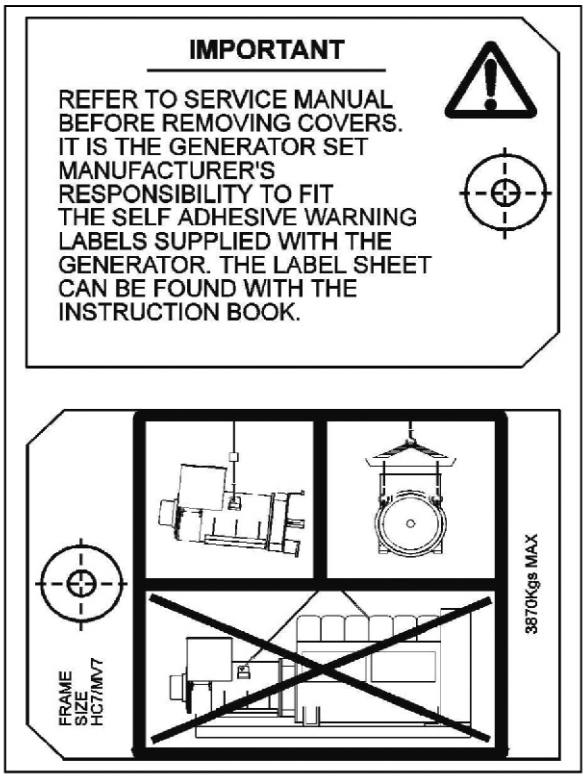


Fig. 4

Single bearing generators are supplied fitted with a rotor retaining bar at the drive end of the shaft. Single bearing generators are also fitted with wooden wedges supporting the fan for transit purposes.

Once the bar is removed to couple the rotor to engine, the rotor is free to move in the frame, and care is needed during coupling and alignment to ensure the frame is kept in the horizontal plane.

4.2 ENGINE TO GENERATOR COUPLING ASSEMBLY

During the assembly of the Generator to the Engine it will be necessary to firstly carefully align, then rotate, the combined Generator rotor - Engine crankshaft assembly, as part of the construction process, to allow location, insertion and tightening of the coupling bolts. This requirement to rotate the combined assemblies exists for both single and two bearing units.

During the construction of single bearing units it is necessary to align the generator's coupling holes with the engine flywheel holes. It is suggested that two diametrically opposite

location dowel pins are fitted to the engine flywheel. The coupling can then slide into final location on the engine flywheel recess. The dowels must be removed and replaced by coupling bolts before the final bolt tightening sequence.

While fitting and tightening the coupling bolts it will be necessary to rotate the Engine crankshaft - Generator rotor assembly. Care should be taken to ensure that rotation is carried out in an approved manner that ensures safe working practice when reaching inside the machine to insert or tighten coupling bolts, and that no component of the assembly is damaged by non-approved methods of assembly rotation.

Engine Manufacturers have available a proprietary tool designed to enable manual rotation of the crankshaft assembly. This tool must always be used, having been engineered as an approved method of assembly rotation, by engaging the manually driven pinion with the engine flywheel starter ring-gear.

Danger !	**Before working inside the generator, during the aligning and fitting of coupling bolts, care should be taken to lock the assembly to ensure there is no possibility of assembly rotational movement.**

4.2.1 TWO BEARING GENERATORS

A flexible coupling should be fitted and aligned in accordance with the coupling manufacturer's instruction.

If a close coupling adaptor is used the alignment of machined faces must be checked by offering the generator up to the engine. Shim the generator feet if necessary. Ensure adaptor guards are fitted after generator/engine assembly is complete.

Open coupled sets require a suitable guard, to be provided by the set builder.

Axial loading of the generator bearings should be avoided. Should it be unavoidable contact the factory for advice.

CAUTION!	**Incorrect guarding and/or generator alignment can result in personal injury and/or equipment damage.**

4.2.2 SINGLE BEARING GENERATORS

For transit and storage purposes the generator frame spigot and rotor coupling plates have been coated with a rust preventative. This MUST BE removed before assembly to engine.
A practical method for removal of this coating is to clean the mating surface areas with a de-greasing agent based on a petroleum solvent.

CAUTION!	**Care should be taken not to allow any cleaning agent to come into prolonged contact with skin.**

Alignment of single bearing generators is critical. If necessary shim the generator feet to ensure alignment of the machined surfaces.

The sequence of assembly to the engine should generally be as follows :

1. On the engine check the distance from the coupling mating face on the flywheel to the flywheel housing mating face. This should be within 0.5mm of nominal dimension. This is necessary to ensure that a thrust is not applied to the ac generator bearing or engine bearing.

2. Check that the bolts securing the flexible plates to the coupling hub are tight and locked into position. Refer to Section 7, subsection 7.5.3.4 for tightening torques.

3. Remove covers from the drive end of the generator to gain access to coupling and adaptor bolts. Check coupling joint interfaces are clean and lubricant free.

4. Check that coupling discs are concentric with adaptor spigot. This can be adjusted by the use of tapered wooden wedges between the fan and adaptor. Alternatively the rotor can be suspended by means of a rope sling through the adaptor opening. Offer the generator to engine and engage both coupling discs and housing spigots at same time, pushing generator towards engine until coupling discs are against flywheel face, and housing spigots located.

5. Fit housing and coupling bolts taking care to use heavy gauge washers between coupling bolt head and coupling disc. Tighten bolts evenly around assembly sufficiently to ensure correct alignment.

6. Tighten housing bolts.

7. Tighten coupling disc to flywheel bolts. Refer to engine manufacturers manual for correct tightening torque.

8. Remove rotor-aligning aids, either wooden wedges, or the two M10 set screws and sheet metal wear plates.

Incorrect guarding and/or generator alignment can result in personal injury and/or equipment damage.

4.3 EARTHING

The generator frame should be solidly bonded to the generating set bed-plate. If anti-vibration mounts are fitted between the generator frame and its bed-plate a suitably rated earth conductor (normally one half of the cross sectional area of the main line cables) should bridge across the anti-vibration mount.

Refer to local regulations to ensure that the correct earthing procedure has been followed.

4.4 PRE-RUNNING CHECKS

4.4.1 INSULATION CHECK

Insulation tests should be carried out before running the generating set, both after assembly and after installation on site. (see Section 7.1).

IMPORTANT!	**The windings have been H.V. tested during manufacture and further H.V. testing 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)**

4.4.2 DIRECTION OF ROTATION

The standard direction of rotation is clockwise, as viewed from the drive end. This matches the predominant direction of rotation used by diesel engine manufacturers. The generator can be driven in the opposite direction with a small reduction in efficiency and an increased noise level. The phase rotation will also be effected.

4.4.2.1 PHASE ROTATION

Phase rotation is fixed for the standard direction of rotation, clockwise as viewed from the drive end. If the generator is to be rotated in the counter-clockwise direction it will be necessary to connect the customer output cables accordingly. Refer to the factory for 'reverse rotation wiring diagram'.

4.4.3 VOLTAGE AND FREQUENCY

Check that the voltage and frequency that are required for the generating set application is as indicated on the generator nameplate. If it is necessary to reconnect the stator for the voltage required, refer to diagrams in the back of this manual.

4.4.4 AVR SETTINGS

To make AVR selections and adjustments remove the AVR cover and refer to depending upon type of AVR fitted. Reference to the generator nameplate will indicate AVR type.

Most of the AVR adjustments are factory set in positions that will give satisfactory performance during initial running tests. Subsequent adjustment may be required to achieve

optimum performance of the set under site operating conditions. Refer to 'Load Testing' section for details.

4.4.4.1 TYPE MX341 AVR

The following 'jumper' connections on the AVR should be checked to ensure they are correctly set for the generating set application.

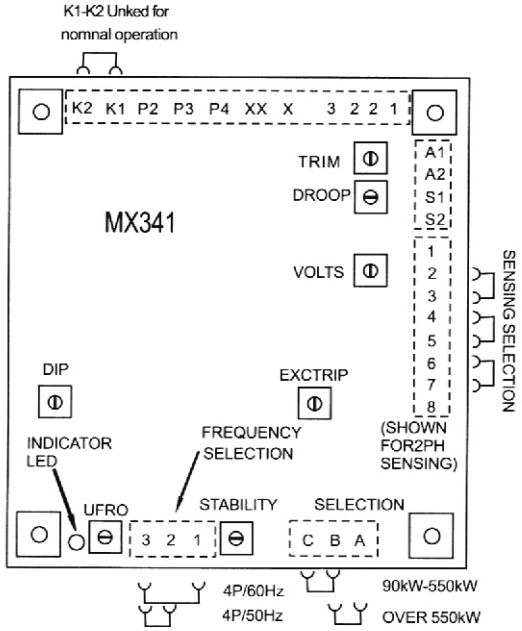
Refer to Fig. 5a for location of selection links.

4 pole	50Hz operation	LINK 2-3
4 pole	60Hz operation	LINK 1-3
6 pole	50Hz operation	NO LINK
6 pole	60Hz operation	LINK 1-2

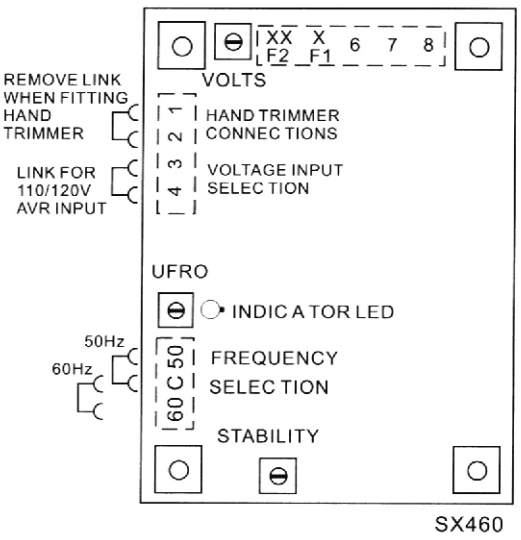
2. Stability selection terminals LINK A-B

3. Sensing selection terminals LINK 2-3
LINK 4-5
LINK 6-7

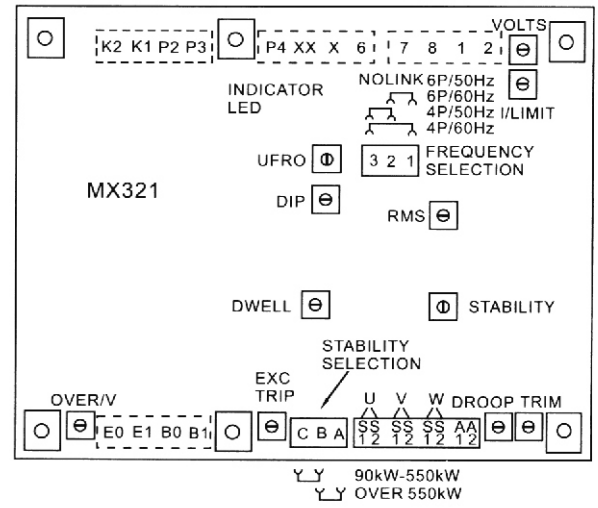
4. Excitation Interruption Link LINK K1-K2

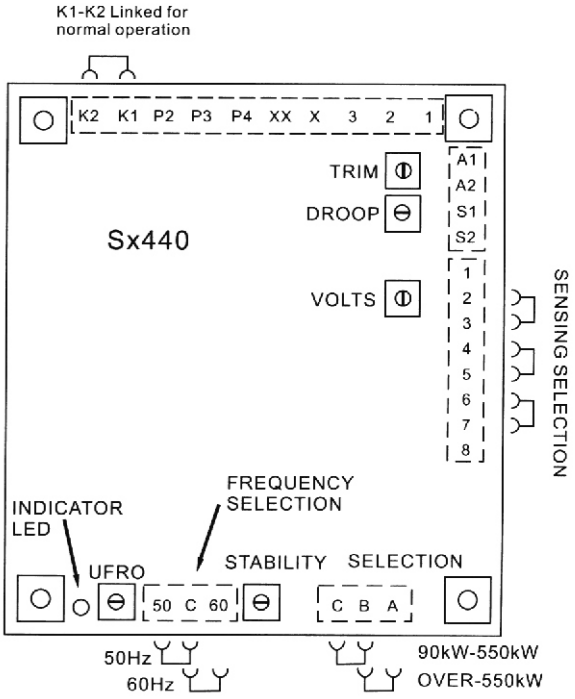


AUTOMATIC VOLTAGE REGULATOR
LINKING AND ADJUSTMENTS.

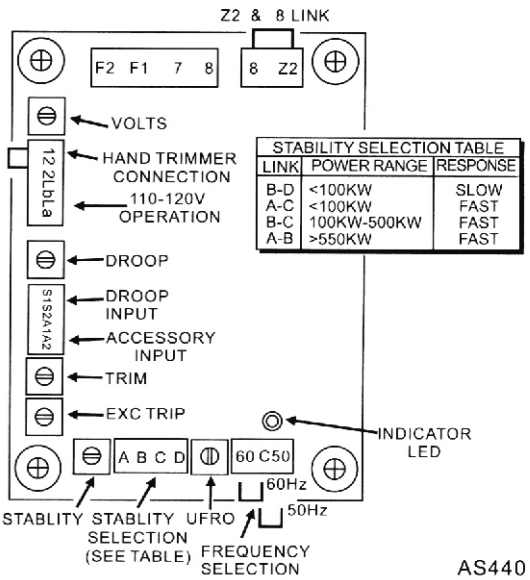


SX460





AUTOMATIC VOLTAGE REGULATOR
LINKING AND ADJUSTMENTS



AS440

4.5 GENERATOR SET TESTING

 Warning!	**During testing it may be necessary to remove covers to adjust controls exposing 'live' terminals or components. Only personnel qualified to perform electrical service should carry out testing**

4.5.1 TEST METERING/CABLING

Connect any instrument wiring and cabling required for initial test purposes with permanent or spring-clip type connectors. Minimum instrumentation for testing should be line to line or line to neutral voltmeter, Hz meter, load current metering and kW meter. If reactive load is used a power factor meter is desirable.

IMPORTANT !	**When fitting power cables for load testing purposes, ensure cable voltage rating is at least equal to the generator rated voltage. The load cable termination should be placed on top of the winding lead termination and clamped between the two nuts provided.**
CAUTION!	**Check that all wiring terminations for internal or external wiring are secure, and fit all terminal box covers and guards. Failure to secure wiring and/or covers may result in personal injury and/or equipment failure.**

4.6 INITIAL START-UP

 Warning!	**During testing it may be necessary to remove covers to adjust controls exposing 'live' terminals or components. Only personnel qualified to perform electrical service should carry out testing and/or adjustments. Replace all access covers after adjustments are completed.**

On completion of generating set assembly and before starting the generating set ensure that all engine manufacturer's pre-running procedures have been completed, and that adjustment of the engine governor is such that the generator will not be subjected to speeds in excess of 125% of the rated speed.

IMPORTANT !	**Over-speeding of the generator is never advisable as this can result in damage to the generator rotating components. Special care is necessary during initial setting of the speed governor.**

In addition remove the AVR access cover and turn VOLTS control fully anti-clockwise. Start the generating set and run on no-load at nominal frequency. Slowly turn VOLTS control potentiometer clockwise until rated voltage is reached. Refer to Fig. 5 for control potentiometer location.

IMPORTANT !	**Do not increase the voltage above the rated generator voltage shown on the generator nameplate.**

The STABILITY control potentiometer will have been pre-set and should normally not require adjustment, but should this be required, usually identified by oscillation of the voltmeter, refer to Fig. 5 for control potentiometer location and proceed as follows: -

1. Run the generating set on no-load and check that speed is correct and stable.

2. Turn the STABILITY control potentiometer clockwise, then turn slowly anti-clockwise until the generator voltage starts to become unstable.

The correct setting is slightly clockwise from this position (i.e. where the machine volts are stable but close to the unstable region).

4.7 LOAD TESTING

 Warning!	**During testing it may be necessary to remove covers to adjust controls exposing 'live' terminals or components. Only personnel qualified to perform electrical service should carry out testing and/or adjustments. Refit all access covers after adjustments are completed.**

4.7.1 AVR ADJUSTMENTS

Refer to Fig. 5 for control potentiometer locations. Having adjusted VOLTS and STABILITY during the initial start-up procedure, other AVR control functions should not normally need adjustment. If instability on load is experienced, recheck stability setting. Refer to subsection 4.6.

If however, poor voltage regulation on-load or voltage collapse is experienced, refer to the following paragraphs on each function to

a) Check that the symptoms observed do indicate adjustment is necessary.
b) Make the adjustment correctly.

4.7.1.1 UFRO (UNDER FREQUENCY ROLL OFF)

The AVR incorporates an underspeed protection circuit that gives a voltage/speed (Hz) characteristic as shown:

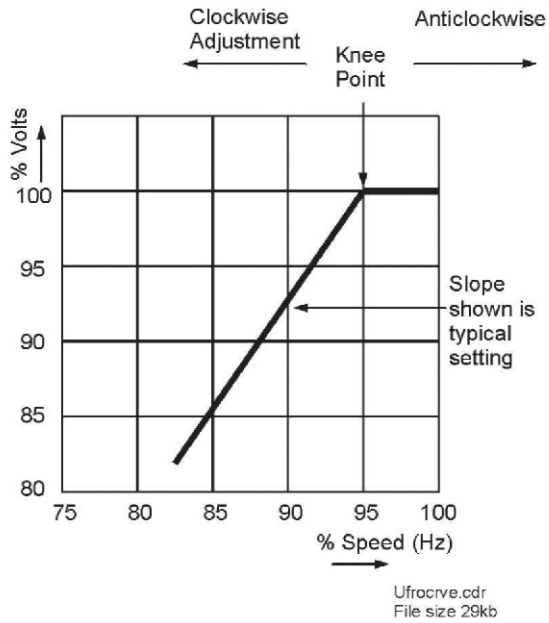


Fig 6

The UFRO control potentiometer sets the "knee point". Symptoms of incorrect setting are a) the light emitting diode (LED) indicator, just above the UFRO Control potentiometer, being permanently lit when the generator is on load, and b) poor voltage regulation on load, i.e. operation on the sloping part of the characteristic.

Clockwise adjustment lowers the frequency (speed) setting of the "knee point" and extinguishes the LED. For Optimum setting the LED should illuminate as the frequency falls just below nominal frequency, i.e. 47Hz on a 50Hz generator or 57Hz on a 60Hz generator.

IMPORTANT !	**If the LED is illuminated and no output voltage is present, refer to EXC TRIP and/or OVER/V sections below.**

4.8 ACCESSORIES

Refer to the "ACCESSORIES" Section of this Manual for setting up procedures related to generator mounted accessories.
If there are accessories for control panel mounting supplied with the generator refer to the specific accessory fitting procedures inserted inside the back cover of this book.
Replace AVR access cover after all adjustments are completed.

Warning!	**Failure to refit covers can result in personal injury or death.**

SECTION 5
INSTALLATION - PART 2

5.1 GENERAL

The extent of site installation will depend upon the generating set build, e.g. if the generator is installed in a canopied set with integral switchboards and circuit breaker, on site installation will be limited to connecting up the site load to the generating set output terminals. In this case reference should be made to the generating set manufacturer's instruction book and any pertinent local regulations.
If the generator has been installed on a set without switchboard or circuit breaker the following points relating to connecting up the generator should be noted.

5.2 GLANDING

IMPORTANT !	**To avoid the possibility of swarf entering any electrical components in the terminal box, panels must be removed for drilling.**

The terminal box is arranged for glanding on the right hand side (or if specifically ordered on the left-hand side) viewed from the end. Both panels are removable for drilling / punching to suit glands/or glanding boxes. If single core cables are taken through the terminal box side panel an insulated or non-magnetic gland plate should be fitted.

At entry to the terminal box incoming cables should be supported by a recognised glanding method such that minimum unsupported weight, and no axial force, is transferred to the terminal assembly.

Incoming cables external to the terminal box, should be supported. The supports should allow for an adequate radius at each bend, and allow for the vibration of the generating set without putting excessive stress on the cables.
Before making final connections, test the insulation resistance of the windings. The AVR should be disconnected during this test and RTD leads grounded.

A 500V Megger or similar instrument should be used. Should the insulation resistance be less than 5MΩ the windings must be dried out as detailed in the Service and Maintenance section of this manual.

5.3 TORQUE SETTINGS FOR TERMINAL CONNECTIONS

Pre treatment: Clean plated surfaces with a degreasing agent, then lightly abrade them to remove any tarnish. Don't score the surface.

The generator torque settings for all generator connections, links, CT's, accessories, cables, etc. is 45 Nm.

The **customer output cables** should be connected to the terminals using 8.8 grade steel bolts and associated anti-vibration hardware. The following table is for your guidance when connecting the customer output cables.

Carry out **periodic checks** to ensure that the torque settings are correct.

5.4 EARTHING

The neutral of the generator is not bonded to the generator frame as supplied from the factory. An earth terminal is provided inside the terminal box adjacent to the main terminals. Should it be required to operate with the neutral earthed a substantial earth conductor (normally equivalent to one half of the section of the line conductors) must be connected between the neutral and the earth terminal inside the terminal box. It is the responsibility of the generating set builder to ensure the generating set bedplate and generator frame are all bonded to the main earth terminal in the terminal box.

CAUTION!	**Reference to local electricity regulations or safety rules should be made to ensure correct earthing procedures have been followed.**

5.5 PROTECTION

It is the responsibility of the end user and his contractors/subcontractors to ensure that the overall system protection meets the needs of any inspectorate, local electricity authority or safety rules, pertaining to the site and it's location. To enable the system designer to achieve the necessary protection and/or discrimination, fault current curves are available on request from the factory, together with generator reactance values to enable fault current calculations to be made.

 **Warning!**	**Incorrect installation and/or protective systems can result in personal injury and/or equipment damage. Installers must be qualified to perform electrical installation work.**

5.6 COMMISSIONING

Ensure that all external cabling is correct and that all of the generating set manufacturer's pre-running checks have been carried out before starting the set.

Generators fitted with air filters should have the filters charged with oil prior to commissioning. Refer to Service Section for charging procedure (subsection 7.3.2).

The generator AVR controls will have been adjusted during the generating set manufacturer's tests and should normally not require further adjustment.

Should malfunction occur during commissioning refer to Service and Maintenance section 'Fault Finding' procedure (subsection 7.4).

SECTION 6
ACCESSORIES

Generator control accessories may be fitted, as an option, in the generator terminal box. If fitted at the time of supply, the wiring diagram(s) in the back of this book shows the connections. When the options are supplied separately, fitting instructions are provided with the accessory.

6.1 REMOTE VOLTAGE ADJUST

A remote voltage adjust (hand trimmer) can be fitted.

The remote voltage adjustment potentiometer is connected across AVR terminals 1&2.

These terminals are normally linked.

When the remote voltage adjust potentiometer is used the link across terminals 1&2 must be removed.

On WSR31 the link 1&2 is on an adjacent terminal block.

6.2 PARALLEL OPERATION

IMPORTANT !	**Failure to meet conditions 1, 2, and 3 when closing the circuit breaker, will generate excessive mechanical and electrical stresses, resulting in equipment damage.**

Understanding of the following notes on parallel operation is useful before attempting the fitting or setting of the droop kit accessory. When operating in parallel with other generators or the mains, it is essential that the phase sequence of the incoming generator matches that of the busbar and also that all of the following conditions are met before the circuit breaker of the incoming generator is closed on to the busbar (or operational generator).

1. Frequency must match within close limits.
2. Voltages must match within close limits.
3. Phase angle of voltages must match within close limits.

A variety of techniques, varying from simple synchronising lamps to fully automatic synchronisers, can be used to ensure these conditions are met.

Once connected in parallel a minimum instrumentation level per generator of voltmeter, ammeter, wattmeter (measuring total power per generator), and frequency meter is required in order to adjust the engine and generator controls to share kW in relation to engine ratings and kVAr in relation to generator ratings.
It is important to recognise that :-

1. kW are derived from the engine, and speed governor characteristics determine the kW sharing between sets

and

2. kVAr are derived from the generator, and excitation control characteristics determine the kVAr sharing.

Reference should be made to the generating set manufacturer's instructions for setting the governor controls.

6.2.1 DROOP

The most commonly used method of kVAr sharing is to create a generator voltage characteristic that falls with a decreasing power factor (increasing kVAr). This is achieved with a current transformer (C.T.) that provides a signal dependent on current phase angle (i.e. power factor) to the AVR.
The current transformer has a burden resistor on the AVR board, and a percentage of the burden resistor voltage is summed into the AVR circuit. Increasing droop is obtained by turning the DROOP control potentiometer clockwise.

The diagrams below indicate the effect of droop in a simple two generator system :-

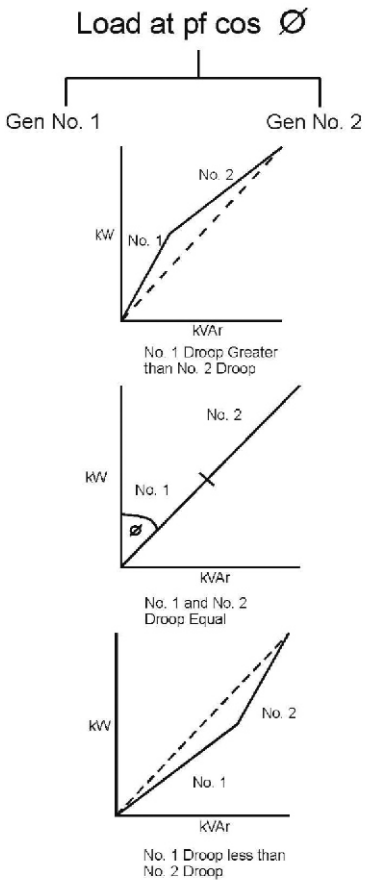


Fig 9

Generally 5% droop at full load current zero power factor is sufficient to ensure kVAr sharing.

If the droop accessory has been supplied with the generator it will have been tested to ensure correct polarity and set to a nominal level of droop. The final level of droop will be set during generating set commissioning.

Although nominal droop setting may be factory set it is advisable to go through the setting procedure below.

6.2.1.1 SETTING PROCEDURE

Depending upon available load the following settings should be used, all are based on rated current level.

0.8 P.F. load (at full load current) set droop to 3%
zero P.F. load (at full load current) set droop to 5%

Setting the droop with low power factor load is the most accurate.

Run each generator as a single unit at rated frequency or rated frequency + 4% depending upon type of governor and nominal voltage. Apply available load to rated current of the generator. Adjust 'DROOP' control potentiometer to give droop in line with above table. Clockwise rotation increases amount of droop. Refer to Fig. 5a or 5b for potentiometer locations.

Note 1)
Reverse polarity of the C.T. will raise the generator voltage with load. The polarities S1 & S2 shown on the wiring diagrams are correct for clockwise rotation of the generator looking at the drive end. Reversed rotation requires S1 & S2 to be reversed.

Note 2)
The most important aspect is to set all generators equal. The precise level of droop is less critical.

Note 3)
A generator operated as a single unit with a droop circuit set at rated load 0.8 power factor is unable to maintain the usual 0.5% regulation. A shorting switch can be connected across S1 & S2 to restore regulation for single running.

IMPORTANT !	**LOSS OF FUEL to an engine can cause its generator to motor with consequent damage to the generator windings. Reverse power relays should be fitted to trip main circuit breaker.**
IMPORTANT !	**LOSS OF EXCITATION to the generator can result in large current oscillations with consequent damage to generator windings. Excitation loss detection equipment should be fitted to trip main circuit breaker.**

IMPORTANT !	**When using this connection arrangement a shorting switch is required across each C.T. burden (terminals S1 and S2.) The switch must be closed a) when a generating set is not running and b) when a generating set is selected for single running.**

Should 'Asiatic' control of the generator be required, request the diagrams from the factory.

The setting procedure is exactly the same as for DROOP. (Subsection 6.2.1.1)

SECTION 7
SERVICE AND MAINTENANCE

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. (Refer to subsections 7.1 and 7.2 respectively).

When generators are fitted with air filters regular inspection and filter maintenance is required. (Refer to subsection 7.3).

7.1 WINDING CONDITION

 Danger !	**Service and fault finding procedures present hazards that can result in severe personal injury or death. Only personnel qualified to perform electrical and mechanical service should carry out these procedures. Ensure engine start circuits are disabled before commencing service or maintenance procedures. Isolate any anti-condensation heater supply.**

Guidance of Typical Insulation Resistance [IR] Values
The following is offered as general information about IR values. The aim is to provide guidance about the typical IR values for generators from new through to the point of refurbishment.

New Machines
The generators Insulation Resistance, along with many other critical factors, will have been measured during the alternator manufacturing process. The generator will have been transported with an appropriate packaging suitable for the method of delivery to the Generating Set assemblers works, where we expect it to be stored in a suitable location protected from adverse conditions.

However, absolute assurance that the generator will arrive at the Gen-set production line with IR values still at the factory test levels of above 100 MΩ cannot be guaranteed.

At Generating Set Manufacturers Works
The generator should have been transported and stored such that it will be delivered to the assembly area in a clean dry condition. If held in appropriate storage conditions the generator IR value should typically be 25 MΩ.

If the unused/new generator's IR values fall below 10 MΩ then a drying out procedure should be implemented by one of the processes outlined below before being despatched to the end customer's site. Some investigation should be undertaken into the storage conditions of the generator while on site.

Generators in Service
Whilst It is known that a generator will give reliable service with an IR value of just 1.0 MΩ. For a relatively new generator to be so low it must have been subjected to inappropriate operating or storage conditions.

Any temporary reduction in IR values can be restored to expected values by following one of the drying out procedures.

7.1.1 WINDING CONDITION ASSESSMENT

CAUTION!	**The AVR should be disconnected and the Resistance Temperature Detector (R.T.D.) leads grounded during this test.**

The condition of the windings can be assessed by measurement of insulation resistance [IR] between phase to phase, and phase to earth. Measurement of winding insulation should be carried out: -

1. As part of a periodic maintenance plan.
2. After prolonged periods of shutdown.
3. When low insulation is suspected, e.g. damp or wet windings.

Care should be taken when dealing with windings that are suspected of being excessively damp or dirty. The initial measurement of the [IR] Insulation Resistance should be established using a low voltage (500V) megger type instrument. If manually powered the handle should initially be turned slowly so that the full test voltage will not be applied, and only applied for long enough to very quickly assess the situation if low values are suspected or immediately indicated.

Full megger tests or any other form of high voltage test should not be applied until the windings have been dried out and if necessary cleaned.

Procedure for Insulation Testing
Disconnect all electronic components, AVR, electronic protection equipment etc. Ground the [RTD's] Resistance Temperature Detection devices if fitted. Short out the diodes on the rotating diode assembly. Be aware of all components connected to the system under test that could cause false readings or be damaged by the test voltage.

Carry out the insulation test in accordance with the 'operating instructions' for the test equipment.

The measured value of insulation resistance for all windings to earth and phase to phase should be compared with the guidance given above for the various 'life stages' of a generator. The minimum acceptable value is 1.0 MΩ.

If low winding insulation is confirmed, one or more of the methods, given below, for drying the windings should be carried out.

7.1.2 METHODS OF DRYING OUT GENERATORS

Cold Run
Providing a generator in good condition but has not been run for some time. It is possible that simply running the genset, without excitation, will raise the IR sufficiently (greater than 1.0 MΩ) to allow the unit to be put into service. Run the generator for approximately 10 minutes

with AVR terminals K1 and K2 open. Visually check that the windings appear dry and carry out an insulation resistance test to prove that the minimum (1.0 MΩ) insulation value has been achieved. If this method fails, use one of the traditional methods outlined below.

Blown Air Drying
Remove the covers from all apertures to allow the escape of the water-laden air. During drying, air must be able to flow freely through the generator in order to carry off the moisture.

Direct hot air from two electrical fan heaters of around 1 – 3 kW into the generator air inlet apertures. Ensure the heat source is at least 300mm away from the windings to avoid over heating and damage to the insulation.

Apply the heat and plot the insulation value at half hourly intervals. The process is complete when the parameters covered in the section entitled, 'Typical Drying Out Curve', are met.

Remove the heaters, replace all covers and re-commission as appropriate.

If the set is not to be run immediately ensure that the anti-condensation heaters are energised, and retest prior to running.

Short Circuit Method
NOTE: This process should only be performed by a competent engineer familiar with safe operating practices within and around generator sets of the type in question. Ensure the generator is safe to work on, initiate all mechanical and electrical safety procedures pertaining to the genset and the site.

Bolt a short circuit of adequate current carrying capacity, across the main terminals of the generator. The shorting link should be capable of taking full load current.

Disconnect the cables from terminals "X" and "XX" of the AVR.

Connect a variable dc supply to the "X" (positive) and "XX" (negative) field cables. The dc supply must be able to provide a current up to 2.0 Amp at 0 - 24 Volts.

Position a suitable ac ammeter to measure the shorting link current.

Set the dc supply voltage to zero and start the generating set. Slowly increase the dc voltage to pass current through the exciter field winding. As the excitation current increases, so the stator current in the shorting link will increase. This stator output current level must be monitored, and not allowed to exceed 80% of the generators rated output current.

After every 30 minutes of this exercise: Stop the generator and switch off the separate excitation supply, and measure and record the stator winding IR values, and plot the results. The resulting graph should be compared with the classic shaped graph. This drying out procedure is complete when the parameters covered in the section entitled 'Typical Drying Out Curve' are met.

Once the Insulation Resistance is raised to an acceptable level - minimum value 1.0 MΩ – the dc supply may be removed and the exciter field leads "X" and "XX" re-connected to their terminals on the AVR.

Rebuild the genset, replace all covers and re-commission as appropriate.

If the set is not to be run immediately ensure that the anti-condensation heaters are energised, and retest the generator prior to running.

Typical Drying Out Curve
Whichever method is used to dry out the generator the resistance should be measured every half-hour and a curve plotted as shown. (Fig 9.)

Fig 10

The illustration shows a typical curve for a machine that has absorbed a considerable amount of moisture. The curve indicates a temporary increase in resistance, a fall and then a gradual rise to a steady state. Point 'A', the steady state, must be greater than 1.0 MΩ. (If the windings are only slightly damp the dotted portion of the curve may not appear).

For general guidance expect that the typical time to reach point 'A' will be approximately 3 hours for a LV6 generator.

Drying should be continued after point "A" has been reached for at least one hour.

It should be noted that as winding temperature increases, values of insulation resistance may significantly reduce. Therefore, the reference values for insulation resistance can only be established with windings at a temperature of approximately 20℃.

After drying out, the insulation resistances should be rechecked to verify minimum resistances quoted above are achieved. On re-testing it is recommended that the main stator insulation resistance is checked as follows: -
Separate the neutral leads

Ground V and W phase and megger U phase to ground
Ground U and W phase and megger V phase to ground
Ground U and V phase and megger W phase to ground
If the minimum value of 1.0 MΩ is not obtained, drying out must be continued and the test repeated.

If the minimum value of 1.0 MΩ for all components cannot be achieved rewinding or refurbishment of the generator will be necessary.

The generator must not be put into service until the minimum value, of 1.0 MΩ for all components, can be achieved.

7.2 BEARINGS

All bearings are supplied from the factory pre-packed with Kluber Asonic GHY 72 grease.
Do not mix Kluber Asonic GHY 72 with any grease of different specifications. Mixing grease of differing specifications will reduce bearing life.
The specification for Kluber Asonic GHY 72 is available on request from the factory.

Sealed for life bearings are fitted with integral seals and are not re-greasable.

BEARING LIFE

IMPORTANT !	**The life of a bearing in service is subject to the working conditions and the environment.**
IMPORTANT !	**High levels of vibration from the engine or misalignment of the set will stress the bearing and reduce its service life. If the vibration limits set out in BS 5000-3 and ISO 8528-9 are exceeded bearing life will be reduced. Refer to 'Vibration' below.**
IMPORTANT !	**Long stationary periods in an environment where the generator is subject to vibration can cause false brinnelling, which puts flats on the ball and grooves on the races, leading to premature failure.**
IMPORTANT !	**Very humid atmospheric or wet conditions can emulsify the grease causing corrosion and deterioration of the grease, leading to premature failure of the bearings.**

HEALTH MONITORING OF THE BEARINGS

It recommends that the user check the bearing condition, using monitoring equipment, to determine the state of the bearings. The 'best practice' is to take initial readings as a base line and periodically monitor the bearings to detect a deteriorating trend. It will then be possible to plan a bearing change at an appropriate generating set or engine service interval.

VIBRATION

The generators are designed to withstand the vibration levels encountered on generating sets built to meet the requirements of ISO 8528-9 and BS5000-3. (Where ISO 8528 is taken to be broad band measurements and BS5000 refers to the predominant frequency of any vibrations on the generating set.)
Definition of BS5000 – 3
Generators shall be capable of continuously withstanding linear vibration levels with amplitudes of 0.25mm between 5Hz and 8Hz and velocities of 9.0mm/s rms. between 8 Hz and 200 Hz when measured at any point directly on the carcass or main frame of the machine. These limits refer only to the predominant frequency of vibration of any complex waveform.

Definition of ISO 8528 - 9
ISO 8528-9 refers to a broad band of frequencies, the broad band is taken to be between 2 Hertz and 300 Hertz. The table below is an example from ISO 8528 - 9 (value 1). This simplified table lists the vibration limits by kVA range and speed for acceptable genset operation.

VIBRATION LEVELS AS MEASURED ON THE GENERATOR				
Engine Speed Min $^{-1}$	**Set Output kVA**	**Vibration Displacement**	**Vibration Velocity**	**Vibration Acceleration**
4 POLE 1500 rpm 50Hz 1800 rpm 60 Hz	≥10 kVA	-	-	-
	>10 but ≤50 kVA	0.64	40	25
	>50 but ≤125 kVA	0.4	25	16
	>125 but ≤250 kVA	0.4	25	16
	>250 kVA	0.32	20	13
The 'Broad band' is taken as 2 Hz – 300 Hz				

Table 6

IMPORTANT !	**Exceeding either of the above specifications will have a detrimental effect on the life of the bearing. This will invalidate the generator warranty. If you are in any doubt, contact Newage International Limited.**

If the vibration levels of the generating set are not within the parameters quoted above: -

1. Consult the genset builder. The genset builder should address the genset design to reduce the vibration levels as much as possible.

2. Discuss the impact of not meeting the above levels on both bearing and generator life expectancy.

Where requested, or deemed necessary, Newage will work with the genset builder in an attempt to find a satisfactory solution.

BEARING 'SERVICE LIFE' EXPECTANCY

Bearing manufacturers recognise that the "service life" of their bearings is dependent upon many factors that are not in their control, they cannot therefore quote a "service life".

Although "service life" cannot be guaranteed, it can be maximised by attention to the generating set design. An understanding of the genset application will also help the user to maximise the service life expectancy of the bearings. Particular attention should be paid to the alignment, reduction of vibration levels, environmental protection, maintenance and monitoring procedures.

We does not quote life expectancy figures for bearings, but suggests practicable replacement intervals based on the L10 life of the bearing, the grease and the recommendations of the bearing and grease manufacturers.

For general-purpose applications, providing the vibration levels do not exceed the levels stated in ISO 8528-9* and

BS5000-3* and the ambient temperature does not exceed 50℃ the following approximations can be applied wh en planning bearing replacements.
*(See section on vibration)

Sealed for Life Bearings. - Approximately 30,000 hours.

Re-greaseable bearings. - Approximately 40,000 hours.

This is provided the correct maintenance is carried out, and only Kluber Asonic GHY 72 grease (or equivalent) is used in all bearings.

It is important to note that bearings in service, under good operating conditions, can continue to run beyond the recommended replacement period. It should also be remembered that the risk of bearing failure increases with time.

7.3 AIR FILTERS

Air filters for the removal of airborne particulate matter (dust) are offered as an addition to the standard build option. Filters on it's need to be ordered with the generator.

Air filters need to be charged with oil before the genset is put to work (see 7.3.2).

The frequency of filter maintenance will depend upon the severity of the site conditions. Regular inspection of the elements will be required to establish when cleaning is necessary.

 Danger !	**Removal of filter elements enables access to LIVE parts. Only remove elements with the generator out of service.**

7.3.1 CLEANING PROCEDURE

Remove the filter elements from the filter frames. Immerse or flush the element with a suitable degreasing agent until the element is clean.

As an alternative procedure a high-pressure water hose with a flat nozzle can be used. Sweep the water spray back and forth across the element from the clean side (fine mesh side of element) holding the nozzle firmly against the element surface. Cold water may be adequate depending upon type of contamination although hot water is preferable.

The element can be inspected for cleanliness by looking through the filter towards the light.

When thoroughly clean, no cloudy areas will be seen. Dry elements thoroughly before attempting to carry out the recharging procedure.

7.3.2 RECHARGING (CHARGING) AIR FILTERS

Charging is best done by totally immersing the dry element into a dip tank containing "Filterkote Type K" or commercial lubricating oil SAE 20/50. Oils of higher or lower viscosity are not recommended.

Allow elements to completely drain before refitting the elements into the frames and putting into service.

7.4 FAULT FINDING

IMPORTANT !	**Before commencing any faultfinding procedures, examine all wiring for broken or loose connections.**

Two types of AVR can be fitted to the WH generator. The Refer to the generator nameplate for type of AVR fitted.

7.4.1 MX341 AVR, FAULT FINDING

No voltage build-up when starting set	1. Check link K1-K2 on auxiliary terminals 2. Follow Separate Excitation Test Procedure to check machine and AVR. Refer to subsection 7.5.
Loss of voltage when set running	1. First stop and restart set. If no voltage or voltage collapses after short time, follow Separate Excitation Test Procedure. Refer to subsection 7.5.
Generator Voltage high followed by collapse	1. Check sensing leads to AVR. 2. Refer to Separate Excitation Test Procedure. Refer to subsection 7.5.
Voltage unstable, either on no-load or with load	1. Check speed stability. 2. Check "STAB" setting. Refer to Load Testing section for procedure. Refer to subsection 4.6.
Low voltage no-load	1. Check speed. 2. Check link 1-2 or external hand trimmer leads for continuity.
Low voltage on-load	1. Check speed. 2. If correct check "UFRO" setting. Refer to subsection 4.7.1.1.

Table 7

7.5 SEPARATE EXCITATION TEST PROCEDURE

The generator windings, diode assembly and AVR can be checked using the appropriate following sections.

7.5.1 GENERATOR WINDINGS, ROTATING DIODES and PERMANENT MAGNET GENERATOR (PMG)
7.5.2 EXCITATION CONTROL TEST.

7.5.1 GENERATOR WINDINGS, ROTATING DIODES & PERMANENT MAGNET GENERATOR (PMG)

IMPORTANT!	**The resistances quoted apply to a standard winding. For generators having windings or voltages other than those specified refer to factory for details. Ensure all disconnected leads are isolated and free from earth.**
IMPORTANT!	**Incorrect speed setting will give proportional error in voltage output.**

Checking Generator Windings and Rotating Diodes

This procedure is carried out with leads X and XX disconnected at the AVR or transformer control rectifier bridge and using a 12 volt d.c. supply to leads X and XX.

Start the set and run at rated speed.

Measure the voltages at the main output terminals U, V and W. If voltages are balanced and within +/-10% of the generator nominal voltage, refer to 7.5.1.1.

Check voltages at AVR terminals 6, 7 and 8. These should be balanced and between 170-250 volts.

If voltages at main terminals are balanced but voltage at 6, 7 and 8 are unbalanced, check continuity of leads 6, 7 and 8.

If voltages are unbalanced, refer to 7.5.1.2.

7.5.1.1 BALANCED MAIN TERMINAL VOLTAGES

If all voltages are balanced within 1% at the main terminals, it can be assumed that all exciter windings, main windings and main rotating diodes are in good order, and the fault is in the AVR or transformer control. Refer to subsection 7.3.2 for test procedure.
If voltages are balanced but low, there is a fault in the main excitation windings or rotating diode assembly. Proceed as follows to identify: -

Rectifier Diodes

The diodes on the main rectifier assembly can be checked with a multimeter. The flexible leads connected to each diode should be disconnected at the terminal end, and the forward and reverse resistance checked. A healthy diode will indicate a very high resistance (infinity) in the reverse direction, and a low resistance in the forward direction. A faulty diode will give a full deflection reading in both directions with the test meter on the 10,000 ohms scale, or an infinity reading in both directions. On an electronic digital meter a healthy diode will give a low reading in one direction, and a high reading in the other.

Replacement of Faulty Diodes

The rectifier assembly is split into two plates, the positive and negative, and the main rotor is connected across these plates. Each plate carries 3 diodes, the negative plate carrying negative biased diodes and the positive plate carrying positive biased diodes. Care must be taken to ensure that the correct polarity diodes are fitted to each respective plate. When fitting the diodes to the plates they must be tight enough to ensure a good mechanical and electrical contact, but should not be over-tightened. The recommended torque tightening is 4.06 - 4.74Nm
(36-42lb in).

Surge Suppressor

The surge suppressor is a metal-oxide varistor connected across the two rectifier plates to prevent high transient reverse voltages in the field winding from damaging the diodes. This device is not polarised and will show a virtually infinite reading in both directions with an ordinary resistance meter. If defective this will be visible by inspection, since it will normally fail to short circuit and show signs of disintegration. Replace if faulty.

If after establishing and correcting any fault on the rectifier assembly the output is still low when separately excited, then the main rotor, exciter stator and exciter rotor winding resistances should be checked (see Resistance Charts), as the fault must be in one of these windings. The exciter stator resistance is measured across leads X and XX. The exciter rotor is conne
Main Excitation Windingscted to six studs that also carry the diode lead terminals. The main rotor winding is connected across the two rectifier plates. The respective leads must be disconnected before taking the readings.

7.5.1.2 UNBALANCED MAIN TERMINAL VOLTAGES

If voltages are unbalanced, this indicates a fault on the main stator winding or main cables to the circuit breaker.
NOTE: Faults on the stator winding or cables may also cause noticeable load increase on the engine when excitation is applied.
Disconnect the main cables and separate the winding leads U1-U2, (U5-U6), V1-V2, (V5-V6), W1-W2, (W5-W6) to isolate each winding section.
Note: - leads suffixed 5 and 6 apply to 12 wire windings only.

Measure each section resistance - values should be balanced and within +/-10% of the value .

Measure insulation resistance between sections and each section to earth.

Unbalanced or incorrect winding resistances and/or low insulation resistances to earth indicate rewinding of the stator will be necessary. Refer to removal and replacement of component assemblies' subsection 7.5.3.

7.5.2.1 AVR FUNCTION TEST

All types of AVR's can be tested with this procedure:

1. Remove exciter field leads X & XX (F1 & F2) from the AVR terminals X & XX (F1 & F2).
2. Connect a 60W 240V household lamp to AVR terminals X & XX (F1 & F2).
3. Set the AVR VOLTS control potentiometer fully clockwise.
4. Connect a 12V, 1.0A DC supply to the exciter field leads X & XX (F1 & F2) with X (F1) to the positive.
5. Start the generating set and run at rated speed.
6. Check that the generator output voltage is within +/- 10% of rated voltage.

The lamp should glow for approximately 8 seconds and then turn off. Failure to turn off indicates faulty protection circuit and the AVR should be replaced. Turning the "VOLTS" control potentiometer fully anti-clockwise should turn off the lamp with all AVR types.

Should the lamp fail to light the AVR is faulty and should be replaced.

IMPORTANT!	**After this test turn VOLTS control potentiometer fully anti-clockwise.**

7.5.3 REMOVAL AND REPLACEMENT OF COMPONENT ASSEMBLIES

METRIC THREADS ARE USED THROUGHOUT

CAUTION!	**When lifting single bearing generators, care is needed to ensure the generator frame is kept in the horizontal plane. The rotor is free to move in the frame and can slide out if not correctly lifted. Incorrect lifting can cause serious injury to personnel.**

7.5.3.1 ANTI-CONDENSATION HEATERS

 **Danger !**	**The external mains electricity supply used to power the anti-condensation heater must be switched off and safely isolated before attempting any work adjacent to the heater, or removal of the non drive end endbracket on which the anti-con heater is mounted. Ensure that the engine is inhibited prior to work in generator.**

7.5.3.3 REMOVAL OF BEARINGS

IMPORTANT!	**Position the main rotor so that a full pole face of the main rotor core is at the bottom Remove PMG of the stator bore if fitted.**

The generators in this manual will be fitted with one of two different bearing arrangements. There may be two different arrangements on a two-bearing generator.

Removal of the bearing may be effected either after the rotor assembly has been removed or more simply by removal of endbracket(s).

Be sure to note the location of all components during removal to assist during the assembly process.

BEARING REPLACEMENT

Environment

Every effort must be made to establish a clean area around the generator when removing and replacing bearings. Contamination is a major cause of bearing failures.

Equipment

Suitable cleaning solvent
Bearing puller, two or three leg
Thin protective gloves
Lint free cleaning cloth
Induction heater.

Preparation

Remove the lubrication pipework if fitted
Position the rotor so that the full pole face of the main rotor is at the bottom of the stator bore.
Remove the end bracket, see 7.5.3.4 for procedure.

NOTES:
- It is not necessary to remove the rotor.

- Ensure that the bearing contact surface shows no sign of wear or corrosion prior to fitting the bearing.
- Never refit used bearings, wave washers or 'O'rings.
- Never refit used bearings, grease flingers, wave washer or 'O' rings.
- Only the outer race should be used to transmit load during assembly (NEVER use the inner race).

REMOVAL OF REGREASABLE BEARINGS

The bearings are a press fit on the shaft and can be removed with standard tooling, i.e. 2 or 3 legged manual or hydraulic bearing pullers.

To remove bearings proceed as follows :

1. Remove 4 screws holding bearing cap.
2. Remove cap.
3. Non drive end - remove wave washer and circlip (single bearing only).
4. Remove bearing cartridge housing complete with bearing (and grease flinger if fitted).
5. Remove bearing from cartridge.
6. Discard the old bearing 'O' rings and wave washer where fitted.

The bearing cap(s) and cartridge(s) must be thoroughly flushed out with clean solvent and checked for wear or damage, before re-assembly. Damaged components should be replaced before refitting the bearing.

ASSEMBLY OF REGREASABLE BEARINGS

NOTE: Gloves must be worn at all times when handling the bearings, grease and solvent.

1. Wipe clean the assembly surface, using cleaning solvent on lint free cloth.
2. Wipe clean: Bearing Cartridge, Wave Washer, Bearing Cap, grease flinger, all re-lubrication pipes and fittings (internal and external). Visually inspect all components after cleaning, for contamination.
3. Place all components on the clean assembly surface. Do not use an air line to blow off excess fluid.
4. Thoroughly clean the external surface of the grease gun nozzle using lint free cloth.

Bearing preparation

1. Remove the bearing from its packaging.
2. Wipe off the preservative oil from the surface of the inner and outer rings - using lint free cloth only.
3. Place the bearing on the clean assembly surface, with the bearing designation marking facing down.

Bearing Assembly (Lubrication, see TABLE 17)

Cartridge:

1. Apply the specified cartridge grease fill quantity to the back face of the bearing housing.
2. Apply a small amount of grease to the grooved sealing surface in the cartridge.
3. Apply anti-fretting lubricant (MP14002 - Klüber Altemp Q NB 50) to the bearing housing circumference. Apply paste in a thin coherent layer by use of a lint free cloth (DO NOT rub in) (use clean protective gloves).
4. Non-drive end - fit new 'O' Rings into the 'O' Ring grooves in the bearing housing circumference.

Bearing:

1. Apply half the specified bearing grease fill quantity (see table 16) to the upper face of the bearing (opposite side to the bearing designation markings).
2. Thumb the applied grease into the bearing, ensuring good penetration into the raceways/balls (use clean protective gloves).

Assemble Bearing into Cartridge

1. Heat the bearing cartridge to 25° C above ambient with an induction heater (Do not exceed 100℃).
2. With greased face of the bearing facing the cartridge bore, assemble the bearing into the bearing housing. Ensure the bearing outer race contacts the location shoulder.

Assemble Bearing onto Shaft

Bearing Cartridge

1. Heat the Bearing and Cartridge assembly to 80℃ above ambient with an induction heater. (use induction heater, no other heat source is suitable)
2. Slide the Bearing and Cartridge assembly over the shaft, pushing it firmly against the bearing seating shoulder.
3. Rotate the assembly (including inner race) 45° in either direction, to provide correct alignment. The bearing must be held firmly in place until it is cool enough to positively locate.

NOTE: Ensure cartridge is at ambient temperature before assembling bracket.

Cap/Flinger:

Apply the specified cap grease fill quantity to the inside face of the cap (see table 16).

1. Fill the grease exhaust slot with grease.

2. Apply a small amount of grease to the grooved sealing surface in the cap.

3. Fit circlip.
(single bearing only).

4. Heat flinger to 120°C and place on shaft up to the bearing inner race. Hold firmly until positively located.

5. Place wave washer in cap, fit cap to bearing cartridge.

REMOVAL OF SEALED FOR LIFE BEARINGS
With Bearing Cartridge

The bearings are a press fit on the shaft and can be removed with standard tooling, i.e. 2 or 3 legged manual or hydraulic bearing pullers.

To remove bearings proceed as follows:

1. Remove 4 screws holding bearing cap.

2. Remove cap.

3. At the end, remove wave washer and circlip (single bearing only).

4. Remove bearing cartridge housing complete with bearing.

5. Remove bearing from cartridge.

6. Discard the old bearing, 'o' rings and wave washer where fitted.

The bearing cap(s) and cartridge(s) must be thoroughly flushed out with clean solvent and checked for wear or damage, before re-assembly. Damaged components should be replaced before refitting the bearing.

Assembly of Sealed for Life Bearings with Cartridge

Pre-assembly, cleaning.

NOTE: Gloves must be worn at all times when handling the bearings, grease and solvent.

1. Wipe clean the assembly surface, using cleaning solvent on lint free cloth.

2. Wipe clean: Bearing Cartridge and Bearing Cap (internal and external). Visually inspect all components after cleaning, for contamination.

3. Place all components on a clean assembly surface. Do not use an air line to blow off excess fluid.

4. Thoroughly clean the external surface of the grease gun nozzle using lint free cloth.

Bearing preparation:

1. Remove the bearing from its packaging.

2. Wipe off the preservative oil from the surface of the inner and outer rings – using lint free cloth only.

3. Place the bearing on the clean assembly surface, with the bearing designation marking facing down.

Bearing Assembly

Cartridge :

1. Apply anti-fretting lubricant (**MP14002 – Klüber Altemp Q NB 50**) to the bearing housing circumference. Apply paste in a thin coherent layer by use of a lint free cloth (**DO NOT rub in**) (use clean protective gloves).

2. Fit 'O' Rings into the 'O' Ring grooves in the bearing housing circumference.

Assemble Bearing into Cartridge

1. Heat the bearing cartridge to 25° C above the am bient temperature (with an induction heater, do not exceed 100℃) and assemble the new bearing into the cartridge. Ensure that the bearing designation is visible after assembly.

2. With greased face of the bearing facing the cartridge bore, assemble the bearing into the bearing housing. Ensure the bearing outer race contacts the location shoulder.

NOTE: Only the outer race should be used to transmit load during assembly (NEVER use the inner race).

Assemble Bearing and Cartridge onto the Shaft

1. Heat the Bearing and Cartridge assembly to 80°C above ambient. (use induction heater, no other heat source is suitable)

2. Slide the Bearing and Cartridge assembly over the shaft, pushing it firmly against the bearing seating shoulder.

3. Rotate the assembly (including inner race) 45° in either direction, to provide correct alignment. The bearing must be held firmly in place until it is cool enough to positively self locate.

4. Non drive end only – fit circlip (single bearing only) and wave washer.

5. Fit the bearing cap.

6. Rotate the bearing assembly on the shaft to check for free movement.

Note : Ensure cartridge is at ambient temperature before assembling bracket.

7. Refit the end bracket and PMG where fitted.

7.5.3.4 MAIN ROTOR ASSEMBLY

Single Bearing Machine

NOTE: On single bearing machines, before removal from, or re-assembly to the prime mover, position the rotor, if possible, such that a full pole face is at bottom dead centre.

1. Remove all access covers and terminal box lid.

2. Ensure that these leads are free to come away with the non-drive endbracket when removed.

3. Remove the 8 bolts holding the drive end adaptor to the frame.

4. With a rope sling around drive end adaptor, tap adaptor out of its spigot location; guide over fan and remove.

5. If the generator is fitted with a cartridge. Remove the 4 bolts retaining the end bearing cartridge in the non drive end endbracket (outer 4 bolts).
   (This includes all regreasable options).

6. Remove the 8 bolts securing the non drive end bracket to the frame.

7. Supporting the non-drive end bracket with a hoist, insert two M10 bolts in the two holes provided for 'jacking' purposes (on the end bracket horizontal centre line). Screw in the bolts until the end bracket spigot is clear of the locating recess, lower the whole assembly until the main rotor is resting in the stator bore.
   Still supporting the non drive end bracket, tap the bracket off the non drive end bearing cartridge (taking care that the exciter stator does not foul exciter rotor windings) and remove.

8. To withdraw the rotor from the stator the rotor must be supported by a rope at the drive end and eased out of the stator core until half the main rotor is protruding out of the stator. At this point it is safe to release the weight from the rope sling.

9. Tightly bind a rope sling around the rotor core, and supporting the non-drive end of the rotor, guide it clear of the stator.

 **Warning!**	**The rope sling may not be at the centre of gravity of the rotor and guidance at the ends of the rotor is essential. THE FULL WEIGHT OF THE ROTOR GIVEN IN THE TABLE BELOW MUST BE SUPPORTED BY THE CRANE AND SLING. If the rotor core is allowed to drop more than a few millimetres at this point, it will make contact with the stator windings and may damage them.**

Maximum weight of the rotor assembly

Table 13

RE-ASSEMBLY IS A REVERSAL OF THE ABOVE PROCEDURE.

Before assembly of a single bearing rotor into stator housing check that the drive discs are not damaged or cracked or showing any other signs of fatigue. Also check that holes in the discs for drive fixing screws are not elongated.

Damaged components must be replaced.

TWO BEARING MACHINES

NOTE:
Position rotor, if possible, such that a full pole face is at bottom dead centre.

The procedure for removal of a two bearing rotor is similar to that outlined for single bearing machines with the exception of Steps 4 and 5 relating to the drive end adaptor.

For removal of this item proceed as follows :-

1. Remove the 8 bolts holding drive end adaptor to frame and 4 bolts retaining bearing cartridge in drive end bracket (outer 4 bolts), if fitted.

2. With rope sling around the shaft extension, supporting the rotor weight tap the drive end bracket spigot out of its locating recess and lower rotor assembly to rest in the stator bore.

3. Take the weight of the drive end bracket on the sling and tap the bracket off the drive end bearing cartridge, guide over the fan and remove.

Re-assembly is a reversal of the above procedure.

7.6 RETURNING TO SERVICE

After rectification of any faults found, remove all test connections and reconnect all control system leads. Restart the set and adjust VOLTS control potentiometer on AVR by slowly turning clockwise until rated voltage is obtained. Refit all terminal box covers/access covers and reconnect heater supply.

Failure to refit all guards, access covers and terminal box covers can result in personal injury or death.

SECTION 8
SPARES AND AFTER SALES SERVICE

8.1 RECOMMENDED SPARES

Service parts are conveniently packaged for easy identification. Genuine parts may be recognised by the product brand on the packaging.

We recommend the following for Service and Maintenance. In critical applications a set of these service spares should be held with the generator.

1. **Diode Set (6 diodes with Surge Suppressors)**
2. **SX460, SX440, MX341, MX321 AVR**

When ordering parts the machine serial number or machine identity number and type should be quoted, together with the part description.

8.2 AFTER SALES SERVICE

A full technical advice and on-site service facility is available from our Service Department at us or through our subsidiary companies.

8.3 KLUBER ASONIC GHY72 GREASE

We recommends the use of this Ester Oil/Polyurea grease. All bearing trials and calculated life expectancy are based on the use GHY 72.
Kluber has a world-wide distribution network, contact the manufacturers for your nearest stockist. Alternatively supplies can be purchased from our parts department in handy packages at advantageous rates. We also offer a suitable grease dispenser.

A.C. GENERATOR WARRANTY

WARRANTY PERIOD

In respect of a.c. generators the Warranty Period is eighteen months from the date when the goods have been notified as ready for despatch by us or twelve months from the date of first commissioning (whichever is the shorter period).

DEFECTS AFTER DEIVERY progressing asset essential

We will make good by repair, or at our option, by replacement, any fault that under proper use appears in the goods within the warranty period. Provided, on examination by us, the defect is solely due to defective material or workmanship. The defective part is to be promptly returned, carriage paid, to us at the factory, our Subsidiary of or, if appropriate to the Dealer who supplied the goods. All identification marks and numbers must be intact to aid identification.

Any part repaired or replaced, under warranty, will be returned to the customer by us free of charge.
We shall not be liable for any expenses that may be incurred in removing or replacing any part sent to us for inspection or in fitting any replacement part supplied by us.
We shall be under no liability for defects in any goods which have not been properly installed in accordance with our recommended installation practices as detailed in the 'Installation, Service and Maintenance Manual' . We shall be under no liability for defects on products that have been improperly used or stored or which have been repaired, adjusted or altered by any person except our authorised agents or ourselves.
We shall not be liable for any second-hand goods, proprietary articles or goods not of our own manufacture although supplied by us, such articles and goods being covered by the warranty (if any) given by the manufacturers.

All claims must contain full particulars of the alleged defect. The description of the goods, the Serial Number, the date of purchase, and the name and address of the Vendor, (as shown on the manufacturers identification plate). For Spare Parts, claims must contain the order reference under which the goods were supplied.

Our judgement, in all cases of claims, shall be final and conclusive and the claimant shall accept our decision on all questions as to defects and the exchange of a part or parts.

Our liability shall be fully discharged by either repair or replacement as above, and in any event shall not exceed the current list price of the defective goods.

Our liability under this clause shall be in lieu of any warranty or condition implied by law as to the quality or fitness for any particular purpose of the goods, and save as expressly provided in this clause we shall not be under any liability, whether in contract, tort or otherwise, in respect of defects in goods delivered or for any injury, damages or loss resulting from such defects or from any work undone in connection therewith.

Extensions to the warranty period can be purchased, subject to additional terms and conditions pertaining to the specific application. Apply to our Warranty Department

MACHINE SERIAL NUMBER