

SECTION -V

SPECIFICATIONS FOR ALTERNATING CURRENT GENERATORS, EXCITERS, VOLTAGE REGULATORS AND ACCESSORIES

5.1 SCOPE

This section of the specifications covers the design, manufacture, test at works, supply, delivery at site, erection, testing at site and commissioning of Three (3) Nos. of Horizontal AC generators complete with excitation system, voltage regulating equipment, neutral grounding and generator terminal equipments including CTs. PTs, (as per protection schemes) surge protection equipment, etc., and auxiliaries such as CO₂ generator fire fighting equipment (if required), lubrication system (if required), oil, water and air piping with valves and fittings, instrumentation, controls and safety devices (as required), spares for 5 years operation of the plant, special tools and testing devices as described and detailed in the specifications and in the annexed schedule of requirements. The scope of supply shall include all parts, accessories, spares etc., which are essential for construction, operation and maintenance of the complete generator even though these are not individually or specifically stated or enumerated. Corresponding components of all the generators and associated equipments and the spares shall be of the same material, dimensions and finish and shall be interchangeable.

The generator manufacturer shall co-ordinate with the turbine supplier so that the generators to be coupled to the turbine is matched in respect of speed direction of rotation, runaway speed, moment of inertia, overload capacities, coupling and other relevant requirements

5.2 TYPE AND RATING

The generators shall be of the horizontal shaft water wheel driven alternating current type. The direction of rotation shall be in accordance with turbine. The rating and other details of the generators are given below.

(i)	Rated output	1875 kVA (1500 KW)
(ii)	Power factor	0.8
(iii)	Frequency	50Hz
(iv)	No. of Phases	3
(v)	Rated terminal voltage between phases	3.3 kV
(vi)	Range of voltage variation between phases for rated output	± 10%
(vii)	Range of frequency variation	± 3%
(viii)	Stator winding connection	star connection
(ix)	Speed	750 rpm.
(x)	Short Circuit ratio	not less than 0.8
(xi)	Inertia constant	not less than 1.0

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The generator shall be capable of delivering maximum continuous output of 110% of the rated output at rated power factor. The tenderer may offer his nearest standard. The generator will be connected to the turbine directly or through speed increaser which will be supplied by the turbine supplier. All generator terminals shall be brought out of the stator frame for insertion of current transformer for protection, metering and surge protection apparatus. The generator neutral shall be grounded suitably and the generators shall be designed to safely withstand any mechanical/magnetic stresses resulting from either a three phase or a single phase fault.

Each generator shall comply in all respects with the requirement of the latest issue of Indian Standard IS:4722 except where specified otherwise.

5.3 SPEED RISE AND RUNAWAY SPEED

The moment of inertia of the generator together with the moment of inertia of the turbine and flywheel (if any) shall be such that the maximum momentary speed rise on full load rejection shall not exceed 35 % of the rated speed. The generator manufacturer shall co-ordinate with the turbine manufacturer to limit the speed rise to this value.

Each generator shall be designed and constructed so as to be capable of running for a period of 15 minutes at the maximum runaway speed. The runaway speed test shall be considered successfully if after undergoing the test 'no injury' is apparent. The runaway speed test may be carried out at site for which the purchaser would provide suitable foundations that will withstand the test.

5.4 NOISE LEVEL

The noise level shall not exceed 90 db (A) when measured at a distance of 1m from any component of the generator.

5.5 INSULATION AND TEMPERATURE RISE

Insulation shall be provided as follows:

- | | |
|--------------------|------------------------------------|
| (i) Stator winding | material corresponding to class F. |
| (ii) Rotor winding | material corresponding to class F. |

The generator shall be capable of delivering rated output continuously at any voltage and frequency in the operating range at rated power factor without exceeding the following values of temperature rise over ambient temperature (30°C)

- | | |
|--------------------|-------|
| (a) Stator winding | 60° C |
| (b) Rotor winding | 60° C |
| Stator Core | 55° C |

The maximum temperature rise when the generator is delivering maximum output corresponding to continuous overload capacity for conditions stated above shall not exceed 60° C for both stator and rotor windings.

5.6 EFFICIENCY AND OUTPUT GUARANTEES

Within the limits of temperature rise specified in clause 5.5 above, the rated continuous output of the generator shall be guaranteed under penalty with a rejection limit of minus 2% for the rated generator terminal conditions.

The weighted average efficiency of the generator shall be guaranteed under penalty with a rejection limit of minus 2%. The efficiencies shall be determined by the summation of losses method as specified in latest Indian Standard IS:4889. For any shortfall in the test value of output and weighted average efficiency (as determined below) from the guaranteed figures, the penalty shall be at the rate of 5% of the ex-works value of generator per generator for every 1% by which the test figure is less than the guaranteed figure. The weighted average efficiency = 0.30 x efficiency at full load + 0.50 x efficiency at 80% full load + 0.20 x efficiency at 60% full load. The penalty on account of output and efficiency shall be computed separately and the total amount of penalty shall be the sum of the two. The ceiling on the total amount of penalty on account of shortfall in the weighted average efficiency and output will be 10% of the total unit price of the generators.

No tolerance shall be permitted over test figures of output. Tolerance in determination of efficiency shall be as per relevant Indian Standard.

5.7 BID EVALUATION

For the purpose of comparison of tenders, the equalization on account of differences in the weighted average efficiencies between various offers will be made on the same basis as indicated for penalties, i.e., the prices of generators with lower efficiencies will be loaded at the rate of Rs. 50,000.00 (Rupees Fifty Thousand) each 0.10% (one tenth) difference in weighted average efficiency as compared with the highest weighted average efficiency.

5.8 STRUCTURAL DETAILS

5.8.1 STATOR

5.8.1.1 Stator frame

Frame shall be fabricated from M.S. plates and to be rigid enough to take the stresses transferred during core assembly. Ventilating ducts of suitable dimensions with wire mesh shall be provided on outer periphery of the frame. The frame shall have its own foundation plate, which shall be fixed with the existing foundation bolts if possible. The bidder shall coordinate with

turbine supplier for details of centerline of stator frame to be kept. If necessary, suitable fabricated structure to be provided to fix the generator sole plates with the existing foundations.

Stator core

Stator core material shall be of high quality Electro technical sheet sheets of grade 50C 270 as per IS 648. Core punching may be in one piece or in segments. Punching shall be degreased cleaned & dried before varnishing. Core plate varnish with class 'F' properties shall be applied and over dried. Both side thickness of the varnish shall be restricted to 6-7 microns. Insulation resistance shall be measured and recorded. The segments shall be assembled in stator frame with the help of wedges. In case punching are in segments these shall be staggered in alternate layers. The punching shall be pressed between pressing plates welded with fingers as per bidders shop specifications. However, no looseness in core assembly shall be permitted. Bidders shall ensure monolithic stator core frame inside to outside. Assembled core shall be tested for core losses & hot spots if any. Proper record shall be kept for the test procedures & observations. After completion of core loss test, stator slot portion shall be painted with conducting varnish.

5.8.1.3 Stator Windings

Windings shall be multi turn with tip to tip class 'F' insulation system, manufactured by VPI system. The copper for elementary conductors shall be ETP as per IS 191. The section shall be rectangular in shape. The self insulation of elementary conductor shall be glass braiding with class 'F' varnish. Other insulation details like liners, packers & slot wedges shall also be of class 'F' material. Over hang portion of the winding on both sides shall be supported on suitable binding rings and lashed properly with packers of suitable thickness to provide adequate rigidity to the over hanging portion against dynamic forces . Three main & 3 neutral terminals shall be brought out.

5.8.2 ROTOR

5.8.2.1 Shaft & Spider

Generator shaft shall be of forged steel in one piece including extension for mounting the turbine runner. The shaft shall be heat-treated & accurately machined. Spider shall be of fabricated type with central bush to be shrink fitted on the shaft. Suitable arrangements shall be provided to fix the poles on the rotor body. Generator supplier shall coordinate with turbine manufacturer for mounting the turbine runner on the extended portion of the generator shaft and flywheel required for turbine governing. If any additional flywheel is required excluding generator rotor effect, it shall also be mounted on the generator shaft. The high frequency generator shall also be mounted on the generator shaft.

5.8.2.2 Poles

The field poles shall be laminated from stamped sheets of suitable thickness, and fixed between iron plates and fitted to the rotor rim/spider/rotor body. The form of pole shoe shall be such that sine wave of voltage at no load performance of the generator is achieved.

Field windings shall be made of copper bends on edges. The subsequent turns shall be insulated with pretreated Nomex paper of suitable thickness of class 'F' properties. The body of the poles shall be isolated with glass insulation. Temperature limits for field windings shall be 60°C which shall ensure the reliability of operation and long life of insulation system. Pole coil connections shall be soldered with suitable grade of material.

5.8.2.3 Current carrying leads

Suitable arrangement from diode wheel shall be provided for transferring power from diode wheel to the field poles. The field current shall be fed directly from diode wheel to the rotor winding through cable. The cable /current carrying leads shall be insulated with class 'F' insulating material. The leads shall be secured perfectly for any slippage due to centrifugal forces.

5.8.3 Bearings

There shall be two bearings one on either side of the generator, the bearing shall be of pedestal type with bearing sleeves in two half. The bearings shall be cooled by circulating oil coolers mounted in the oil bath. Suitable temperature measuring devices viz. RPT&TSD with two contacts shall be provided for measurement of bearing metal temperature. Suitable flow relays in water flows system with alarm & tripping for low water supply shall also be provided. Bidder shall furnish the complete details of bearing being provided alongwith the offer. The bearing metal temperature rise shall not exceed 20-25°C. The bearing shall be capable to withstand forces due to earthquake of magnitude 0.3g in both the directions.

5.8.4 Ventilation System

Cooling system for the generator shall be open ventilating type. Two fans of suitable design shall be provided at both ends of the generator rotor. These fans shall suck the cold air from sides and hot air after cooling stator winding & core shall be exhausted form the ducts provided on the stator frame.

5.8.5 Heating Of Generator In Stand Still Conditions

At each end of the generator heating elements of suitable capacity shall be installed to avoid condensation when the unit is under shutdown. The temperature to be maintained shall be 5°C above the surrounding temperature. Necessary thermostat to be provided for auto on/off of the heating elements.

5.8.6 Bearing Oil Coolers

Coolers shall be manufactured with cupro-nickel tubes grade Cu Ni 30 as per IS 1545. Adequate surface shall be provided to evacuate the bearing losses. These shall be plugged to the oil bath. Necessary cooling water flow arrangement shall be provided for oil cooling. Oil temperature at full load shall be less than 25°C.

5.9 FIRE PROTECTION FOR GENERATOR (OPTIONAL)

An automatic carbon dioxide fire protection system complete with CO₂ cylinders, ring headers, discharge nozzles, temp. detectors etc., shall be provided as a common system for all the generators. The temperature detectors shall be of the rate of the rise of temperature type. Automatic control shall be arranged to discharge CO₂ into the generator in the event of operation of temperature detector or of the differential relay of the generator (if provided). The system shall be complete with manual operation arrangement to release CO₂ and with all necessary pipes, fittings, directional valves, etc.

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5.10 OIL AND GREASE

The tenderer shall indicate this requirement and give his recommendations with detailed specifications regarding type of oil/grease to be used for lubrication of generator bearings. The oil if used for generator bearing lubrication, etc., shall be identical with that used for the pressure oil system of governor. The generator and turbine manufacturers shall cooperate to ensure that their recommendations regarding oil are identical. The first filling of oil with 20% extra shall be supplied alongwith the generator.

5.11 THE FLYWHEEL

A separate flywheel of ample dimensions shall be supplied in case the required moment of inertia for limiting the speed rise/runaway speeds in case not available from the generator rotor (through the speed increaser, if envisaged).

Necessary provision for receiving the piston of the brake cylinder on application of brakes shall be made in the flywheel.

5.12 EXCITATION SYSTEM

5.12.1 General

The excitation system of static type consisting of high performance fully controlled solid state converter bridge, dry type excitation transformer of suitable capacity, static voltage regulator, field breaker, field flashing unit, field discharge resistor, etc., conforming to acceptable relevant international standards may be supplied. The excitation shall be completely described in the tender.

Brushless excitation system or self-excited self-regulated excitation may also be offered.

5.12.2 Generator Field Discharge Equipment

A totally enclosed field air circuit breaker, drawout type, complete with auxiliary contacts, capable of breaking, without generating dangerous overvoltage, the maximum field current that can occur under conditions of normal operation or when interrupting the transient D. C. component of the field current due to a three-phase fault at generator terminals, shall be furnished with each set of excitation equipment. The field circuit breaker shall be suitable for both manual and electrical operation. Alternatively, an A. C. circuit breaker on the secondary side of the rectifier transformer instead of D. C. field circuit breaker may be offered.

The field circuit breaker discharge contacts, discharge resistors, or other equipment shall be mounted together to form a self-supporting assembly of the excitation control equipment of each

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generator. A suitable hinged door, locking handle, inspection windows, foundation bolts etc., shall be provided with each excitation cubicle.

5.12.3 Automatic Voltage Regulator (If Not Already Included In The Excitation System)

An automatic voltage regulator, complete with an enclosed master element, voltage adjusting rheostat, contactors, etc., shall be provided with each generator for the automatic control of the generator exciter. The voltage regulator shall be anti-hunting. The voltage regulator shall be capable of maintaining the generator terminal voltage at and pre-set value and at the same time sharing the reactive kVA of the load between the two similar units.

The voltage regulator shall be sensitive to the change of plus or minus 0.5 (one half)% of normal voltage (average of three phases) of the generator when operating under steady load conditions for any load or excitation within operating range and shall initiate corrective action without hunting.

After the initial maximum voltage following any load rejection up to 110 (One hundred and ten)% of rated load, the automatic voltage regulator shall restore the terminal voltage to a value not more than 5(five)% above or below the voltage being held before the load rejection and shall maintain the voltage within these limits throughout the period of generator overspeed. The voltage regulator shall be provided with cross-current compensating devices for parallel operation of generators.

A voltage adjusting rheostat suitable for manual and also for motor operation by remote control shall be furnished with each voltage regulator equipment. The range of the voltage control shall extend from 90 (ninety)% to 110 (One hundred and Ten)% of rated voltage of generator.

5.13 LINE TERMINAL AND NEUTRAL GROUNDING CUBICLES

The generator suppliers shall supply 1 no. terminal cubicle for each machine housing surge capacitor, potential transformers, current transformers, lightning arresters, cable boxes, etc., as given in the enclosed drawing. The cubicle shall be complete with necessary tappings for excitation system, etc. The rating of the CTs for AVR shall be decided by the supplier taking into account the requirements of AVR.

The generator supplier shall neutral grounding cubicle one for each machine housing single phase distribution transformer, secondary loading resistor, current transformer, cable boxes, etc., as shown enclosed drawing.

The cubicles shall be sheet suitably compartmentalized with doors and shall be furnished complete with base mounting arrangement, foundation bolts, etc. The internal illumination for cubicles shall be provided with guarded lamps with on/off switches. Copper/Alluminium conductors of appropriate size shall be used for bus bars and connections in the cubicles. The bus bar and main connecting conductors shall be suitably insulated to make them compatible with generator

temperature rise and insulation. The support insulators for the bus connection will be provided as necessary. GI earth bus of adequate cross section will be provided in the cubicle.

5.14 POTENTIAL TRANSFORMERS

The potential transformers will be single phase, epoxy cast, dry type units. Potential transformer will be protected on primary and secondary side by current limiting fuses. The PT shall conform to IS:3156. The potential transformers shall be rated as given in the drawing.

5.15 CURRENT TRANSFORMERS

The current transformer will be epoxy cast, dry type unit conforming IS:2705. The current transformer shall be designed to withstand the thermal and magnetic stresses resulting from the maximum short circuit current.

The technical requirement and location of the CTs are given in the drawing. The generator suppliers shall supply suitable transformer for the protection scheme and these shall be installed in the neutral grounding and line terminal cubicles.

The current transformers should be suitable for metering and protection.

The following protections are recommended:

- (i) Three-pole differential relay (87 G)-3 CTs on the neutral of the generator and 3 CTs on the phase.
- (ii) Over-current and earth fault relay (50/51 and 64)
- (iii) Rotor earth fault protection single stage (64 R)
- (iv) Stator earth fault protection (64 G)
- (v) Over voltage protection (59)
- (vi) Field failure protection (40)
- (vii) Negative phase sequence (46)
- (viii) Reverse Power Protection (32)
- (ix) Over speed frequency protections (81)
- (x) Voltage restrained over current relay (SIV)

In case the generators are provided with static excitation system with excitation transformers, high set instantaneous over-current relay (50) IDMT and over-current relay (51) would be provided in the tapping for excitation transformer for protection of excitation transformers.

5.16 LIGHTNING ARRESTORS

The lightning arrestors shall be heavy duty indoor station class non-linear resistor type suitable for repeated operation to limit voltage surges on alternating current power circuits and to interrupt power follow current. The arrestors shall conform to IS:3070 (latest edition) Part-I. The nominal discharge current of lightning arrestor shall not be less than 10KA.

5.17 SURGE CAPACITORS

The surge capacitors shall conform to the latest edition of IS:2834 and shall be rated 0.25 microfarad. The capacitors shall be connected in parallel with lightning arrestors and shall be provided with a built-in discharge resistor. The capacitor shall be suitable for indoor mounting.

5.18 UNIT CONTROL BOARD AND GENERATOR INSTRUMENTATION AND CONTROL

The generator supplier shall supply all equipment and devices for control, instrumentation and safety relating to the generator. These together with the equipment supplied by the turbine supplier shall constitute a complete and coordinated set of instruments, gauges, control and safety devices for control of the units during normal running and in emergencies.

Indicating instruments, gauges, control and safety devices will be mounted on the unit control board to be supplied by the generator supplier. The turbine supplier shall supply necessary loose items for mounting on the unit control board. The generator manufacturer shall fully coordinate with the manufacturer of turbine to ensure a neat and functional arrangement of the cubicles. A tentative list of indicating instruments, controls and safety devices to be supplied by the generator supplier is given in Tables A. The generator manufacturer may increase/decrease items according to requirements to suit the type and design and also for proper and satisfactory operation of the units. The alarm and annunciation panel with all necessary annunciation relays, aux relays, alarm bell, terminal bolts etc., and adequate number of alarm annunciation fascia windows for both turbine and generator shall be provided. The generator manufacturer shall fully co-ordinate with the turbine manufacturer in this regard.

5.19 SPARES

The unit rates shall be quoted for the spares as listed in Table-B The tenderer shall also indicate in the tender any additional spares that he would recommend for 5 years' operation and furnish item wise unit prices for the same.

5.20 TESTS

The first generator shall be completely assembled at works and types tests as specified below shall be conducted on the assembled unit and auxiliaries as per the latest edition of IS:4722.

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5.20.1 Type Test on First Generator

- (a) Temperature rise test.
- (b) Dielectric test.
- (c) Efficiency test.
- (d) Excess current test.
- (e) Runaway speed test.
- (f) Moment of inertia of rotating parts (by mutual agreement between the purchaser and the contractor)
- (g) Wave form
- (h) Determination of characteristic:
 - (i) Reactances – Synchronous, transient, subtransient, negative phase sequence and zero phase sequence.
 - (ii) Rated current, zero power factor lagging saturation curve.
 - (iii) No load and short circuit saturation curve.

5.20.2 Routine Tests on all the Generators

- (a) High voltage test on stator coils and stator sections and on assembled stator.
- (b) High voltage test on field coils and poles.
- (c) Insulation resistance tests.
- (d) Impedance and voltage test on field coils.
- (e) Accuracy test for RTDs and dial type thermometers.
- (f) Hydraulic tests on oil, and air coolers.

5.20.3 Tests on Exciters and Regulating Equipment (For Rotating Exciters)

- (a) High voltage test.

- (b) Temperature rise test.
- (c) Measurement of resistances.
- (d) Measurement of insulation resistance.
- (e) Regulation test.
- (f) Commutation test.
- (g) Excitation response ratio.
- (h) Routine tests on static excitation equipment.

5.20.4 Additional test, if any, as recommended by the supplier.

5.20.5 Tests At Site

Site test for each generator shall include the following:

- (a) Mechanical run.
- (b) Measurement of stator and rotor winding insulation resistance.
- (c) High voltage dielectric test.
- (d) Measurement of shaft voltage (if applicable)
- (e) Measurement of stator and rotor winding resistance.
- (f) Phase sequence test.
- (g) Load acceptance and rejection test at selected loads from no load to full load.
- (h) Overall response of machine and excitation system to system voltage changes.
- (i) Adjustment of AVR.
- (j) Synchronising test.
- (k) Checking and commissioning of various other auxiliary equipment.

5.20.6 Test on other equipment like CTs, PTs, Las shall comply with the routine tests, etc., as per relevant standards.

Test report for all type tests on the generator, CTs, PTs, etc., carried out on similar equipment already supplied shall be furnished for approval.

5.21 TESTING EQUIPMENT

A list of field testing equipment along with item-wise rental prices rental prices shall be indicated in the tender.

5.22 SPECIAL TOOLS

The contractor shall supply a complete set of special tools and other equipment that may be necessary or desirable for operation and maintenance of the generator and auxiliary equipment of his supply. The tenderer shall submit a list of the above and include the price in tender.

Any special reamers or broaches and brazing equipment for all work which must be done in the field, shall be provided by the contractor.

5.23 DRAWINGS

In addition to the drawings called for in Section II the following drawings and data shall be submitted with the tender.

The drawings containing all the information required for designing the civil works shall be supplied within 60 calendar days of the placement of letter of intent:

- (i) The general arrangement and overall dimensions of the generators, exciters (where applicable) and bearings, and showing positions of main and neutral terminals.
- (ii) Description of lubrication system alongwith drawings.
- (iii) Physical and schematic drawings of excitation system and AVR alongwith descriptive literature.
- (iv) Graphs showing predicted characteristic of the generator.
- (v) Generator layout drawings showing overall dimensions and layout of all ducts, cables, piping, relative positions of auxiliaries, etc.

5.24 GUARANTEED TECHNICAL PARTICULARS

The guaranteed and technical particulars of generator and associated auxiliary and ancillary equipments shall be furnished in the tender as per schedule of Guaranteed Technical Particulars.

5.25 SCHEDULE OF REQUIREMENT

THREE (3) Nos. 1875kVA 0.8 Pf 3.3Kv 50Hz +3%, 3 phases horizontal synchronous generators with excitation system. Each generator shall be equipped as follows and in accordance with the specifications described in the preceding clauses.

One No.	Generator stator complete with frame, soleplates, core, winding with accessories and terminals.
One No.	Generator rotor complete with shaft, spider rim, poles with windings and accessories.
One set	Bearings.
One set	Anti-condensation space heater.
One set	Excitation and voltage regulation equipment.
One set	Fabricated base plate for generator and its bearings (for horizontal machines).
One set	Resistance type temperature detectors.
One set	Dial thermometer with electric contacts for alarm and trip for bearings.
One No.	Multi-point temperature indicator cum recorder.
One	Neutral grounding cubicle.
One	Line terminal cubicle.
One set	Unit gauge panel with instruments, controls and safety devices for generators
One set	Mechanical overspeed devices with electrical contacts.
One set	Bearing oil coolers
One	Dome light.

COMMON EQUIPMENT FOR BOTH GENERATORS

- i)** One set of special tools.
- ii)** One set of testing devices.
- iii)** One set of spares for five years' normal operation of the generator.

TABLE- A**SCHEDULE OF INSTRUMENTS AND SAFETY DEVICES FOR EACH UNIT**

Sl. No.	Purpose	Type of instruments	Qty.	Remarks
01	Temperature of stator windings	PRT	3	PRT shall be 100 Ω platinum resistance & 3 wire system for indication & recording
02	Temperature of stator core	PRT	3	PRT shall be 100 Ω platinum resistance & 3 wire system for indication & recording
03	Temperature of pedestal bearings			PRT shall be 100 Ω platinum resistance & 3 wire system for indication & recording
	Bearing sleeves	PRT TSD	2 2	Indication / recording Alarm / Trip
04	Temperature of cooling water outlets for bearings	PRT	2	Indication / Record
05	Control of stator heaters	Thermostat	1	Control
06	Flow of water in oil coolers of bearings	Flow Relay	1	Indication / Alarm
07	Level of oil in oil baths for bearings	Level Relay (Low & High)	1	Indication / Alarm

TABLE- B**LIST OF MANDATORY SPARES**

1.	1/3 rd of stator windings of one generator with necessary slot insulation including wedges.	1 Lot	
2.	Two Nos. complete field coil with connecting clamps and all necessary insulation.	2 Nos.	
3.	Set of shells of bearing	1 Set	
4.	One of each type of PCB, auxiliary relay contained in the excitation system	1 Set	
5.	Diode wheel complete with diodes.	1 No.	
6.	Oil cooler for bearing	One	