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सत्यमेव जयते  
भारत सरकार  
रेल मंत्रालय

GOVERNMENT OF INDIA  
MINISTRY OF RAILWAYS  
अनुसंधान अभिकल्प एवं मानक संगठन  
रेल मंत्रालय

RESEARCH DESIGNS AND STANDARDS ORGANISATION  
MANAK NAGAR, LUCKNOW-226011

विशिष्ट सं० आर.डी.एस.ओ./पी.ई./एस.पी.ई.सी./ए.सी./0056-2014(संशो.1)

Specification No. RDSO/PE/SPEC/AC/0056-2014 (Rev. 1)

SPECIFICATION FOR 25 KW BRUSHLESS ALTERNATOR WITH RECTIFIER  
CUM REGULATOR EQUIPMENT FOR 110 VOLT DC SGAC COACHES

SN	DATE OF REVISION	NO. OF PAGES	VERSION	REASON FOR AMENDMENT
1.	July 2004	42	Rev.0	First issue
2.	June 2007	45	Rev.0 with Amendment 1	Second issue
3.	September 2014	32	Rev.1	In view of standardization of Alternator with RRU and to increase the reliability of components.

अनुमोदित  
APPROVED BY

*Nav*  
16.10.14

कार्यकारी निदेशक/पी.एस. एंड ईएमयू  
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**SPECIFICATION FOR 25 KW BRUSHLESS ALTERNATOR INCLUDING RECTIFIER  
CUM REGULATOR EQUIPMENT FOR 110 V, DC SELF-GENERATING AIR  
CONDITIONED COACHES.**

**0.0. FOREWORD**

- 0.1** After development of roof mounted AC package units and need for provision of inverter for its use on self generating coaches, it was seen that the existing alternator i.e. 18 kW and 22.75 kW is not adequate to meet the requirement under extreme service conditions. Therefore, the specification has been modified for procurement of 25 KW alternators, which will meet any additional load also in case certain additional passenger amenity items are proposed to be provided on AC coaches in future. This specification includes salient features like higher efficiency without any marginal changes in the size and weight resulting in higher power to weight ratio.
- 0.2** The fully air conditioned sleeper coaches, composite coaches and chair cars with roof mounted package units will normally be equipped with two roof mounted package units and two sets of 25 KW alternators. Other types of air-conditioned coaches e. g. First class AC coaches may be equipped with only one set of 25 KW alternator. The DC output of the alternators will normally supply coach loads consisting of air-conditioning equipment fed from inverter, incandescent and fluorescent lights, air-circulating fans and in addition charge a bank of 56 Nos. lead acid battery of 800Ah or 1100Ah VRLA battery at a nominal voltage of 110 V DC.
- 0.3** The battery is connected to the alternator through rectifier-cum-regulated unit, which converts AC output of alternator into regulated DC and prevents the reverse flow of current from the battery to the alternator during periods of non-generation. The air-conditioning plant and coach fans are connected across the main positive and negative. The fluorescent lamps are also similarly connected across the main positive and negative. Some of the coaches are fitted with AC fans and lights, which are connected across inverter AC out put.
- 0.4** The drawings mentioned in this standard are issued by Research, Designs & Standards Organisation, Lucknow – 226 011. Manufacturer has to comply schedule of technical requirements RDSO/PE/STR/TL/0004-2004 (Rev.1). The manufacturers are requested to refer to the latest version of the drawings only. Manufacturers are advised to submit their manufacturing drawing / detailed drawing before starting manufacture of prototype and after approval from RDSO, the manufacture shall be undertaken.
- 1. SCOPE**
- 1.1** This specification covers the design, manufacture, testing and supply of 25 KW V-belt driven bogie mounted brushless alternators required for broad gauge different type of air-conditioned coaches.
- 1.2** The brushless alternator covered by this specification shall not have any windings on rotor.
- 1.3** The scope of supply for each set shall include the following unless otherwise stipulated in the tender: -

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- i) 25 kw alternator, complete with two alternator V- grooved pulleys ... 1set
- ii) Safety chains ... 3
- iii) Rectifier-cum-regulating equipment ...1
- iv) Belt tensioning device complete ...2 set
- v) Axle-pulleys complete with rubber pads and hardware ...2 set
- vi) Suspension pin complete with hardware ...1 set
- vii) Maintenance manual including trouble shooting details ...1 copy

**TERMINOLOGY:** For the purpose of this specification, the following definitions shall apply:-

- 2.1 Alternator— An axle driven power-generating machine mounted on the bogie of coach.
- 2.2 Axle pulley- A pulley fitted on the axle of the coach to drive the alternator by V-belts.
- 2.3 Alternator pulley - A pulley fitted on alternator and driven by axle pulley through V-belts.
- 2.4 Cut-in speed - The alternator speed in rev./min. at which rectified out-put is 110V at no load.
- 2.5 Minimum speed for full output- The minimum alternator speed in rev./min at which it gives full rated output current of 193 A at rated voltage of 130V. This will henceforth be termed as MFO speed.
- 2.6 Voltage and current detector. A device to limit voltage and current of alternator to pre-set values.
- 2.7 Rectifying Equipment - A 3-phase full-wave bridge connected assembly of silicon diodes to rectify the AC output of the alternator.


**2.8 REFERENCES:**

Serial Number	IEC/IS/BS No.	Title
1	IEC:61373-1999	Railway applications,rollingstock equipments,shock and vibration tests
2	IEC:60529	Degree of protection provided by enclosures(IP Code)
3	IEC:60571	Electronic equipment used on Railway vehicles
4	IS:2429-1967	Round steel short link chains ( electric butt welded ), grade L( 3 )
5	IS:2927-1975	Brazing alloys
6	IS:1364	Hexagon head bolts, screws and nuts of product grade A and B
7	IS:13411	Glass Reinforced polyester dough moulding compounds
8	IS:13730-13-1993	Polyester or polyesterimideovercoated with polyamide-Imideenamelled round copper wire, class 200
9	IS:13778, Part 1 to 6	Winding wiretest methods

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10	IS:5-1961	Colour for ready mixed paints and enamels
11	IS:5905	Sprayed aluminum and zinc coating on iron and steel
12	IS:1248-1958	Direct acting indicating analogue electrical measuring instruments and their accessories
13	IS:1875-1992	Carbon steel billets, blooms, slabs and bars for forging
14	IS:648	Cold rolled non-oriented electrical steel sheet and strip fully processed type
15	BS:6195-1993	Rubber or silicon rubber insulated flexible cables and cords for coil end leads
16	BS:4579 Part-I	Performance of mechanical and compression joints in electric cable and wire connectors

### 3.0 OPERATING CONDITIONS:

3.1 The alternator shall function satisfactorily in the ambient temperature range from -5° C to 55° C and 100% relative humidity. The equipment shall be designed for mounting on the bogie transom and shall be suitable for working in a heavily dust laden atmosphere which may also contain brake block (conducting) dust.

3.2 The coaches are expected to run up to a maximum speed of 130 km/h in varying climatic conditions existing throughout India. All accessories to be mounted on the coach under frame shall be designed to withstand service vibrations and buffing shocks.

The rectifier cum regulating unit shall be subjected to vibration and shock testing as per IEC 61373 - 1999.

- a) Random vibration test as per clause 8 Table-1, category 1 Class B
- b) Simulated long life test as per clause 9, Table-2, category 1 Class B
- c) Shock test as per clause 10, Table-3, category 1 Class B



Performance tests shall be carried out prior to commencing and on completion of all the tests specified above. RDSO representative shall witness the tests.

3.3 The design shall be of with regulator cum rectifier having magnetic amplifier type control on field excitation etc.

- a) Maximum reliability.
- b) Long life with minimum maintenance by the use of components not liable to wear.
- c) Universal applicability within the speed range.
- d) High power-weight ratio.
- e) Low first cost as well as low annual maintenance cost.
- f) The installation shall also be able to operate without battery.
- g) Well protected against extraneous interference and pilferage.
- h) Self-exciting

### 4.0 RATING:


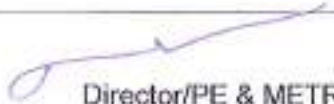
4.1 The standard rating at the DC output terminals of the rectifier-regulator shall be 130V, 193 Amp.

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- 4.2 WEIGHT OF ALTERNATOR – Less than 525 kg.  
WEIGHT OF REGULATOR - Less than 80 kg.**
- 5.0 PARTICULARS OF DRIVE:**
- 5.1** The mounting arrangement and drive for the alternator shall be generally as per RDSO drawing NO.SKEL 4024 alt.1 (or latest).
- 5.2** The alternator and axle V-grooved pulleys shall be of the extended groove type conforming to drawing No. SKEL-3645(Rev.4)-2014 and SKEL-3652 Alt.3 for alternator & axle respectively. In the manufacturing of the pulleys special care shall be taken for strict adherence to the tolerance given in the above mentioned drawings. If pulleys are sourced from sub vendor than RDSO approval shall be required. The alternator and axle pulley for brushless alternator shall conform to RDSO Specification No. ELPS/SPEC/TL/13 (latest).
- 5.3** The rubber pads shall conform to Drawing No. SKEL-4021 Alt.2(or latest)
- 5.4** The coach wheel diameter is 915 mm when new and 813 mm when fully worn. New wheel diameter shall be considered for making calculations of speed of the train in kmph corresponding to cut-in-speed and MFO speeds of the alternator.
- 5.5** The V-belts shall be size 3155Lp, C-122 and shall conform to RDSO's Specification No. RDSO/PE/SPEC/AC/0059-2004 (Rev.0) with Amendment no.1 or RDSO/PE/SPEC/AC/0160-2013 (Rev.0). A set of 12 belts of RDSO's approved make having same grading number shall be provided on the alternator by Railways.
- 5.6** The tensioning device consisting of compression spring limiting pipe etc. shall be as per SKEL-3940 Sheet 1 alt.5 & SKEL-3940 Sheet 2 alt.5. Modified springs shall be as per RDSO drawing no. RDSO/PE/SK/AC/0068-2004 (Rev. 0).Punching of capacity i.e. 25 KW along with name of manufacturer shall be done on indicator plate.
- 5.7** Manufacturer shall advise RDSO and Railways Standard arrangement for removing the bearing.
- 6.0 OUTPUT CHARACTERISTICS:**
- 6.1** The cut-in speed and MFO speed of the alternator shall be as low as possible consistent with economical design.
- The cut-in and MFO speeds shall be lesser than 400 and 800 rpm respectively. The alternator shall be capable of working at maximum speed of 2500 rpm. No negative tolerance is permitted on the voltage and current for measuring cut-in-speed and minimum speed for full output.
- 6.2** The alternator output voltage in conjunction with rectifier regulator shall be within the tolerance of  $\pm 4\%$  of the voltage setting for any load from 10A to 193A over the speed range MFO to maximum speed i.e. 2500 rpm. The alternator shall be dispatched with the voltage setting of 128.0+0.5V at 97 A at 1500 rpm. The current limiting by Potentiometer shall be set between 228 A & 232 A and voltage shall not drop less than 120V at 225A.

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In order to avoid the disturbance of setting limit, the voltage output of potentiometer shall be so designed to give maximum voltage of 140V at 800 rpm on 10A load and for current limiting the max. setting of current potentiometer shall not allow the current to increase more than 232Amps.

- 6.3 Efficiency Test: The efficiency of the alternator and regulating equipment combined together shall not be less than 80% at 130V, 193A and 1800 rpm.

7.0 CONSTRUCTION OF ALTERNATORS AND ITS COMPONENTS:

- 7.1 The alternator shall be of robust construction suitable for the rough usage to be met within rolling stock application, including vibrations, impacts during shunting operation etc. The alternator arrangement shall be in accordance with Drg. No. RDSO/PE/SK /AC /0077-2004 (Rev.0) and suspension hanger pin & split cotter shall be as per SKEL-3943(Rev.1)-2012. The bogie bush shall be as per RDSO drawing no.RDSO/PE/SK/AC/0128-2009 (Rev.0).Wear resistance nylon bush for 25 kW Alternator shall be as per RDSOdrawing no.RDSO/PE/SK/TL/0086-2014(Rev.2) Alteration no.1(or,latest).
- 7.2 The rotor and alternator pulleys shall be dynamically balanced separately on a balancing machine. The residual unbalance shall not be more than 2.5 gm-cm/kg in any case.
- 7.3 The mating of the alternator pulley with the shaft shall not be less than 80%. The alternator number shall be punched on the pulley so that it remains a matched set.
- 7.4 The bearing design shall take into account the following :-
- a) The calculation L10 bearing life shall not be less 16 million km at 1500 rev./min.
  - b) The alternator shall be fitted with cylindrical roller bearing No. NU2215ECJ on terminal box side and spherical roller, cylindrical and tapered bore bearing, type 22215E on the other end. The bearings shall be of SKF /FAG Germany.
  - c) The re-greasing interval shall not be less than 30 month or 6 lac running kms. using an indigenous brand of grease.
  - d) In addition to provisions of required interference tolerances on bearing housings, the bearings covers shall grip the bearing faces to prevent outer race rotation in the housing for fixed bearings.
  - e) Simple gap type seals with labyrinth and two or more grooves in the bearings covers shall be provided to ensure proper retention of grease.
- 7.5 Special care shall be taken in regard to design and manufacture of rotor forged (forging ratio 5:1) shafts. The detailed manufacturing drawing of the forged shaft shall be got approved from RDSO i.e. (Research, Design & Standard Organization), Lucknow – 226011. The supplier shall institute checks to ensure that the raw-material for the shaft is EN-24 (hardened and tempered). At change of sections, smooth ground finish should be obtained after giving maximum possible radius with form tool. Finished shafts shall be subjected to ultrasonic testing (100%quantity) to detect internal as well as surface defects / discontinuities. Alternator manufacturer shall collect the information regarding required surface finish at shaft for fitment of bearing from bearing manufacturers and surface finish at shaft for fitment of pulleys. This shall be implemented in the design / drawing of shaft which shall be verified by RDSO at the time of inspection. This will also incorporated in routine inspection. Manufacturer will submit ultrasonic test pattern for conducting ultrasonic test from both ends of the shaft while the shaft is in assembled condition in alternator.

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- 7.6 Each alternator shall be supplied complete with three safety chains of approved design conforming also to IS: 2429-1967. The overall factor of safety of the chains shall not be less than 4. Allowance shall be made for the stress in the chains due to impact of the falling alternator. The length and fixing arrangements of safety chains shall have the approval of RDSO. The safety chains shall be generally in accordance with RDSO drawing No. SKEL - 4022 alt.3.
- 7.7 Safety chains fitted to the alternator shall not in any way restrict the scope of its adjustments to provide adequate tension for stretched belt. The clearance maintained from rail level when the alternator is hanging freely by safety chains shall not infringe the maximum moving dimensions, i.e. 178 mm from rail level.
- 7.8 The alternator terminal board details shall be generally in accordance with drawing no. RDSO / PE /SK / AC - 0047 – 2003 (Rev.4). The terminal board design shall incorporate the following essential features.
- The terminal block shall not be loose when tightening or loosening the terminal screws.
  - Incoming socket shall be connected to one terminal post and outgoing socket shall be connected to second terminal post ensuring that flow of current through lugs and copper strip avoiding threaded screws and nuts.
  - The temperature rise of any terminal shall not exceed 50 degree centigrade above ambient at continuous rated current.
  - Spring washers shall be used for fasteners.
  - The insulating material used for the terminal board shall be impervious to moisture.
  - The terminal block shall be fixed with terminal box with slotted head hexagonal screws instead of counter sunk screws.
  - 3-phase leads as well as positive and negative leads for field coming out from alternator winding to alternator terminal board shall be through independent holes for each lead to avoid contact with frame, holes should be sealed with RTV silicone sealant.
  - The lead wire (35 sq-mm) shall be brought to terminal board of alternator. The lead wire shall be insulated with varnished glass fabric tapes with an external braiding of glass fibers impregnated with silicon varnish with additional covering of fire retardant silicone elastomer by multidip process or by extrusion process. It should comply BS 6195-1993, type 5, voltage category C. The winding wire and lead wire shall be suitably brazed. Silver brazing with electrode as per BACuP5 grade of IS 2927-1975, for connecting terminal lead and winding wire shall be used. Soldered joints shall not be acceptable. Flexible cable insulation shall be well gripped by the socket tube while doing crimping. The crimped socket and joints shall comply with B.S.4579 Pt. I. The terminal socket used shall be of annealed electrolytic copper having min. radius between palm and tube of 2 mm and thickness of tube shall be 1 mm minimum.
- 7.9 The crimping type sockets suitable for copper conductor cables to be supplied with the alternator and rectifier- regulator shall conform to RDSO's drawing No. RDSO/PE/SK/AC-0047-2003(Rev.4) and shall be as under, unless otherwise specified :
- Main AC output terminals of alternator and AC input terminals of rectifier regulator.
  - Field terminals of alternator and rectifier regulator.

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c) Main dc output terminals of Rectifier-Regulator.

7.10 The sockets shall be fixed by hexagonal screws conforming to IS-1364.

7.11 Cleat has to be provided on the alternator frame to support the outgoing cables. Material of cleat shall be non-hydroscopic insulation material with fire retardant properties such as DMC as per IS: 13411.

7.12 Winding Wires: Following types of winding wires may be used:  
Dual coated enameled winding wires as per IS: 13730-13-1993. Dual coat means that base coat with polyesterimide enamel MT533.39A & topcoat with Allothem 602.35 of Dr. Beck & Co. only.  
The enamel thickness shall comply with IS: 13730 PT. 0 Section M (i) & (ii) mentioned above.

a) The test on enameled winding wires shall be conducted as per IS: 13778 Part 1 to 6. Separate documentation for these tests shall be maintained by the manufacturers, indicating the winding wire supply particulars.

b) Impregnation : Vacuum pressure impregnation (VPI) process shall be adopted, with Dr. Beck & Co.'s solventless unsaturated polyesterimide (UP) impregnating resin Dobec-on FT1052/2005/500 EK. The winding shall be subjected to pressure impregnation as per recommended procedure of varnish manufacturer.

c) Winding of Coil Overhang: The star point of the winding shall be formed inside the stator overhang. The star point shall be adequately brazed and insulated ensuring best workmanship. On the brazed joint apply RTV silicon-sealant and tape with two layers / half lap Nomex tape (20x0.05mm). The joint should be insulated with fibre glass silicon elastomer sleeve of suitable diameter and secured properly by tying with glass cord.

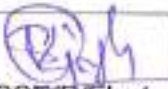

Coil overhangs in the stator winding shall be adequately secured with glass cord and stagger taped and each coil emerging from the slot shall be covered with ¼ lap impregnated glass tape of size 0.3 x 20 mm. Alternatively, coil separator similar to the phase separators may be provided between adjacent coil emerging from the slot.

d) Slot / Inter-phase insulation: Nomex Kapton Nomex shall be used for slot liner and wedge separator. Uncalendered Nomex (Nomex 411) shall be used for inter layer and inter-phase insulation. Epoxy bonded glass fibre laminate shall be used for slot wedges. The tenderer shall state in his offer the brand name of the insulating material to be used which is suitable for "H" class.

7.13 The air clearance between un-insulated live parts and body of alternator shall not be less than 10 mm. The minimum clearance between the un-insulated live parts shall not be less than 4 mm.

7.14 The stator winding between two phase wires shall have nominal resistance,  $0.045 \pm 0.010$  ohm for stator winding and field winding  $8.5 \pm 1.5$  ohm.)

7.15 Colour of Alternator - The equipment shall be finished in the colour code No. 108 air craft blue of IS: 5-1961 "Colours for ready mixed paint". Painting shall be in

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accordance with the specification and "Code of Practice" issued by RDSO for raw materials, hardware and anti-corrosive treatment of train-lighting equipment. The rectifier-regulator housing shall be zinc sprayed conforming to IS: 5905 (latest). The fins for heat sink on regulator may be black anodized.

7.16 Alternator serial no. and manufacturers name shall be punched on both suspension bracket of alternator and RRU S. No. along with name of manufacturer shall be punched on both side of top mounting bracket.

7.17 Suspension hanger pin will be lightly lubricated in order to avoid corrosion and to avoid wear of the bushes. Ultrasonic testing shall be carried out on all (100%) suspension hanger pin.

#### 8.0 RECTIFIER-CUM-REGULATING EQUIPMENT:

8.1 The rectifier-cum-regulating equipment shall generally conform to RDSO Drawing No. RDSO/PE/SK/AC/0076-2004 (Rev.0) Alt.1 and shall be fully interchangeable with other makes in mounting holes, cable entry location and maximum overall dimensions. The enclosure of rectifier-regulating equipment shall be of IP-65 protection level as per IEC 60529. After these tests the equipment should work satisfactorily. All the mounting hardware internal/external fasteners shall be of SS.

8.2 Normally, the magnetic amplifier shall only be epoxy filled. However, if current and voltage detectors are potted extended warranty of six months will have to be given by the supplier. The excitation transformer shall have primary & secondary windings separately.

Six silicon diodes, arranged in 3-phase bridge connection shall be provided for converting ac output of alternator to dc. The selected diode shall not be less than 1200V (PIV) and 320 A mean forward current at 100° C case temperature with sine-wave 180 degree conduction. In case manufacturer provides snubber capacitor, it shall not be less than 1200 V peak matching to diode PIV rating. The offered diodes shall be with normal polarity and stud base cathodes, flexible anode with M 20 x 1.5 mm pitch threading. Similarly diodes used in field excitation circuit and free wheeling diode shall have 180 degree conduction with sine wave and shall not be less than 16 A mean forward current at 100 degree centigrade. Temperature rise shall not exceed 50 centigrade under worst operating condition. The field diodes shall be with normal polarity and stud base cathodes flexible anode with M6 x 1 mm pitch threading. The diode shall be tightened with specified torque as recommended by the diode manufacturer. The surface of heat sink for diode mounting shall have proper finish to match with base of the diode for better thermal conduction. The diode shall be tightened with specified torque as recommended by the diode manufacturer. The surface of heat sink for diode mounting shall have proper finish to match proper with base of the diode for better conduction. Heat sink will be of extruded Aluminum design. Power Block diodes can be discrete type or Isolated Module type and the rating of power diode and heat sink shall be selected accordingly.

8.3 The ripple content in dc output voltage shall not exceed 3%.

8.4 The operating condition shall be as specified in clauses 3.1 and 3.2 of this specification.

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- 8.5 Subject to the condition that total current of alternator is less than rated current output the regulator shall regulate the output voltage of the alternator so as to maintain a pre-set voltage subject to the tolerance indicated in Clause 6.2 at the rectifier terminals under the following conditions.
- At all speeds from 800 RPM to maximum speed.
  - At all loads ranging from 10A to the rated output of alternator.
- 8.6 Current limiting protection shall be provided to limit the output current to the rated value & with tolerance of 20%.
- 8.7 The dc output voltage shall be capable of being set by potentiometer from 124V to 130V at 1500 rpm at a reference load of 96.5 Amp.
- 8.8 Current setting will be step less by means of potentiometer. The potentiometers for current limit and voltage setting adjustments shall be of types and makes approved by RDSO.
- 8.9 The semi-conductors and other parts used shall conform to "Reliability Assurance Specification for Electronic Components used in Rolling Stock". - RDSO Specification No. ELPS/SPEC/SI/0015 of October 2001 unless otherwise approved by RDSO. All the PCBs shall be provided with Conformal Coating. Process for Conformal Coating and curing shall be brought out in QAP.
- 8.10 For the purpose of universal regulator when used with other makes of alternators, the MFO speed can be permitted a tolerance of  $\pm 50$  rev./min. on speeds specified in Clause 6.1.
- 8.11 The three phase bus-bars U, V and W shall be provided with Red, Yellow and blue coloured heat shrinkable sleeves respectively. Similarly, DC (+ve) and DC (-ve) bus-bars shall be provided with Red and Black coloured heat shrinkable sleeves respectively.
- 8.12 CTs, fuse, Potentiometer and Transformer will be as per the concerned IS/IEC.
- 9.0 **STANDARDISATION:**
- 9.1 All mechanical and electrical parts of the alternators shall be common and interchangeable for the same make and capacity, except lamination stack length, stator carcass, shaft, associated field and stator coils and winding wire. Any make of alternator should work with any other make of rectifier cum regulating unit of same capacity. For this performance tests of alternator shall be carried out with three other makes of RRU at ICF / RCF or Railway workshop or firm's premises. For this purpose Load test as per Clause 12.9 and current limiting characteristic test as per Clause. 12.10 shall be carried out.
- 9.2 The rectifier- cum- regulating equipment shall be suitable to work with any make of 25 KW alternators approved by RDSO for use on coaches, without requiring any alteration in voltage settings. It is desirable that voltage regulation and current limit with above setting shall be within specified limits. However, specific relaxations can be granted for universal application with other makes. The type of equipment shall be known as universal type and shall be of magnetic amplifier type design only.

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9.3 All the tests other than in-house shall be conducted by NABL approved lab only.

10.0 **MAINTENANCE:** Firm should submit maintenance manual specifying the minimum maintenance required by the equipment. Firm should bring design improvements to reduce the maintenance requirement further. Bearings of alternator should require greasing after 30 months of service. Maintenance Manual shall be approved by RDSO before given to purchaser by the firm.

11.0 **MARKING:**

11.1 The alternators / RRUs shall be provided with suitable name plates, on which the following shall be marked / engraved.

- a) Maker's name and trade mark;
- b) Rated capacity of the alternator;
- c) Voltage and current rating
- d) Class of insulation.
- e) Weight of alternator /RRU

Space should also be provided on the name plate for the purchaser to mark the Railway Administration's Code initials and serial No.

11.2 The serial number of the alternator and rectifier-regulator shall be as under :-

First two digits : Year of manufacture

Next two digits : Month of manufacture

Next two / three digits : No. of machine manufactured in the particular month

e.g. Serial No. 04 07 015

04 - 2004

07 - July

15 -Serial No. of machine manufactured in July. Serial number of the alternator shall be punched at suspension bracket.

11.3 The rectifier-regulator housing shall have a red coloured plate of approved design marked "Caution – keep the cover tightly closed".

The luminous aircraft blue colour band of 50 mm thickness shall be provided on the cover.



12.0 **TESTS AND PERFORMANCE**

12.1 **Classification of tests**

12.1.1 **Prototype Tests:** A prototype test is the test which is to be carried out on an alternator declared as a prototype under the following conditions :-

- a) A manufacturer undertakes to manufacture for the first time or
- b) A fundamental change in design is introduced.

12.1.1.1 The prototype tests shall be carried out at the works of the manufacturer by RDSO. Manufacturer shall submit the details of alternator with Rectifier Regulator to RDSO as per Annexure enclosed for information before offering the machines for prototype testing. The prototype tests shall be conducted as per clause no. 12.1.1.2.

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## 12.1.1.2 Test schedule

SN	Type of Test	Clause No.	Prototype test	Type test	Acceptance test	Routine test	Renewal of Type test
1.	Verification of dimensions and visual check	12.3	Yes	Yes	Yes (10%)	Yes	No
2.	Measurement of stator and field resistance of alternator	12.4	Yes	Yes	Yes (10%)	Yes	Yes
3.	Temperature rise test	12.5	Yes	Yes	Yes	No	Yes
4.	Insulation resistance test	12.6	Yes	Yes	Yes	Yes	Yes
5.	High voltage test	12.7	Yes	Yes	Yes	Yes	Yes
6.	Open circuit test	12.8	Yes	Yes	No	No	No
7.	*Load test	12.9	Yes	Yes	Yes	Yes	Yes
8.	*Current limiting characteristic test	12.10	Yes	Yes	Yes	Yes	Yes
9.	*Mechanical over speed and induced voltage test	12.11	Yes	Yes	Yes	No	Yes
10.	Short circuit characteristic test	12.12	Yes	Yes	No	No	No
11.	Surge protection test	12.13	Yes	Yes	No	No	Yes
12.	*Efficiency test	12.14	Yes	No	No	No	No
13.	Environmental tests	12.15	Yes	No	No	No	No
14.	Hose proof test	12.16	Yes	Yes	Yes	Yes	Yes
15.	OVP Test	12.12.3	Yes	Yes	Yes	Yes	Yes
16.	*Parallel operation of alternator	12.12.2	Yes	Yes	No	No	No
17.	Special tests	12.16.1	-	-	-	-	-
(i)	Ripple content test	12.16.2	Yes	Yes	No	No	No
(ii)	Mating of pulley with shaft	12.16.3	Yes	Yes	No	No	Yes
(iii)	Shorting of power diode	12.16.4	Yes	Yes	No	No	No
(iv)	Open circuiting of power diode	12.16.5	Yes	Yes	No	No	No
(v)	Computation of junction temperature of semi-conductors etc.	12.16.6	Yes	No	No	No	No
(vi)	Checking of dynamic balancing of rotor and pulley	12.16.7	Yes	Yes	No	Yes	No
(vii)	*MFO at cold and hot condition of alternator	12.16.8	Yes	Yes	No	No	Yes
(viii)	*MHO	12.16.9	Yes	Yes	No	No	Yes
(ix)	Fire retardant test of terminal board	12.16.10	Yes	Yes	No	No	No
(x)	Ultrasonic testing of alternator shaft and the suspension hanger pin	12.16.11	Yes	Yes	Yes	Yes	Yes
(xi)	Chemical composition and bend test of suspension hanger pin	12.16.12	Yes	Yes	No	No	No
(xii)	Proof load test	12.16.13	Yes	Yes	Yes	No	Yes

NOTE:-Tests marked "\*" are to be conducted in both directions of rotation.

**12.1.2 Type tests:** A type test is to be carried out by the manufacturer on alternator / alternators and rectifying-cum-regulating equipments sampling and rejection plan specified in clause 13 to ensure compliance with specifications in details as declared by the manufacturer and approved by RDSO. The type tests shall be conducted as per clause no. 12.1.1.2.

These tests are to be carried out at manufacturer's premises.

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**12.1.3 Routine Tests:** The routine tests are to be carried out by the manufacturers at their premises on every alternator manufactured, to ensure compliance with specification declared by the manufacturer and approved by RDSO. The routine tests shall be conducted as per clause no. 12.1.1.2.

**12.1.4 Acceptance Test:** These tests are to be carried out by an inspecting authority nominated by the Purchaser at Manufacturer's premises to ensure compliance with the specification on alternator / s and rectifier-cum-regulator. The acceptance tests shall be as per clause no. 12.1.1.2.

**12.1.4.1** In addition, the manufacturers shall submit the following test results to the Inspecting Officer at the time of offering the machines for his inspection.

1. Type test results.
2. Routine test results.

The inspecting officer can ask for repetition of any / all tests, if he so desires. However, Inspecting Officer shall witness 'type tests' at least on one machine.

**12.1.4.2** These alternators are used on air-conditioned coaches where high reliability is to be ensured. Therefore, machines are to be accepted after completing all tests as specified in Clause 12.1.1.2.



**12.1.5 Revalidation tests:** For renewal of registration of firm, revalidation tests shall be done at firm's premises after five years or any time decided by RDSO from previous date of registration / renewal. The revalidation tests shall be conducted as per clause no. 12.1.1.2.

**12.2 Test Instruments:** The indicating instruments used in electrical measurement shall conform to IS: 1248-1958 (Specification for Electrical Indicating instruments). Instruments with the following accuracy shall be used:-

1. For prototype, acceptance and routine tests instrument of class 0.5 accuracy.
2. For surge protection test, the amplitude and duration of the surge voltage shall be measured by oscilloscope and stop watch.
3. Stator resistance shall be measured by a micro ohm meter or Ammeter – Voltmeter method.
4. Use of digital type instrument is preferable.
5. The meter used should be calibrated from authorized calibration lab.

**12.3** Verification for dimensions and specifications of assemblies and sub-assemblies.

**12.3.1** This test is to check the dimensions of assemblies and sub-assemblies as per specifications and constructional details thereof to ensure that they are consistent with good engineering practice. Interchangeability aspects with alternators and regulating-cum-rectifying equipment in current use should be ensured. Firm shall ensure the measurement of all the dimensions as per the drawings of alternator, shaft and RRUs. Measurements will be submitted to inspecting authority.

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12.3.2 During manufacturing following type of defects has been reported by the firm during the root cause failure analysis. Hence most care should be taken to prevent the manufacturing lapses.

- 1) Improper crimping of cables in Alternator
- 2) Loose terminal connection in Alternator
- 3) Less track gap in control PCB in RRU
- 4) Interturn short circuit of Magnetic Amplifier in RRU

12.4 **Measurement of stator and field resistance of alternators :** It shall be done by using suitable resistance measuring device when the alternator is at ambient temperature. Ambient temperature at the time of carrying out the test shall also be recorded. The stator and field resistance at 20 degree centigrade shall be averaged for first 5 machines. The resistance of any stator or any field winding shall not vary by more than  $\pm 7\%$  from the declared value.

12.5 **Temperature rise test:**

12.5.1 The alternator in conjunction with the regulating-cum-rectifying equipment shall be run at rated current & voltage at 2500 rev./min. speed till the temperature stabilizes as evidenced by three consecutive readings of frame temperature at fifteen minute intervals between each other, under forced air-cooling of 6m/sec. for alternator and 4m/sec. for regulating-cum-rectifying equipment. The air velocity at the location where the alternator and regulator are to be located for tests shall be adjusted to 6m/sec. and 4m/sec. respectively prior to mounting of equipment in position under test. The equipment shall be placed in position after obtaining the required ambient conditions. Temperature of the stator winding, field windings, bearings, terminals and frame, in case of alternator shall be measured. The temperature rise above the ambient of 55 degree centigrade shall not exceed the following values. While conducting acceptance test, only at 2500 rpm at rated output and one hour overload test at 222A shall be conducted. Under full load condition (130V, 193 A) or one hour over load (222 A) conditions: -

<u>Class of insulation</u>	<u>Temp. rise</u>	<u>Method of measurement</u>
H	115 deg.C	Resistance

The temperature rise of terminals, frames etc. shall be as low as possible. The maximum bearing temperature at the highest ambient temperature of 55 degree centigrade shall not exceed 100 degree centigrade. The temperature measurements on all locations shall be made by point contact pyrometers unless otherwise specified or agreed to.

12.5.2 The temperature rise test shall be repeated at minimum speed for full output, under which conditions also the temperature rise shall not exceed the above values.

12.5.3 In regard to regulating-cum-rectifying equipment, the temperature rise of main diodes, field diodes, current transformers, excitation transformer, magnetic amplifier, dc terminals etc., shall be less than designed temperature limits of each component under worst operating conditions. Class of insulation for various equipments of Rectifier-cum-Regulator equipment like magnetic amplifier, transformer, CT, PT etc. shall be Class F.

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- 12.5.4** While accepting the first lot of the machine, after the approval of prototype, temperature rise test shall be carried out on 5 machines and the temperature rise shall be averaged. This average, temperature rise shall serve as basis of acceptance or rejection of subsequent machines. The temperature rise of the windings of subsequent machines shall be regarded as satisfactory if it does not exceed by more than 8% from the average temperature rise value or 10°C, whichever is higher but within the limits specified in clause 12.5.1 for the class of insulation used. If after the production has stabilized and consistency in production and performance has been achieved and with the approval of RDSO, the temperature rise test is not conducted on all the machines, the temperature rise shall not exceed by 8°C above the average temperature. Further if the temperature rise is observed to be less by more than 5°C in 3 lots continuously, re-averaging of temperature rise shall be done by conducting temperature rise tests on five machines again and the revised values shall hold good for subsequent lots.
- 12.5.5** After conducting temperature rise test at rated current as stipulated above, machine shall be subjected to overload at 222 A for 1 hr. in continuation to heat run at normal load (at MFO and 2500 rpm). The temperature rise shall not exceed the specified value for 'H' class of insulations used on the machine.
- 12.6** **Insulation resistance test :**
- 12.6.1** The insulation resistance shall be measured before and after high voltage test between all live terminals shorted together and body with a 500V DC megger and these values shall not be less than 20 mega. Ohm for alternator and rectifier-cum-regulator. For regulating-cum-rectifying equipment the insulation resistance in rainy season 10 mega ohm shall be accepted.
- 12.7** **High Voltage test:** Immediately after the temperature rise test, an AC potential of 1500 V rms at 50 Hz shall be applied between all external terminals of the alternator shorted together and the frame for a period for 1 minute. The test shall be commenced at a voltage of less than one third the test voltage and shall be increased gradually to the full test voltage. For regulating-cum-rectifying equipment the test voltage shall be applied between all live terminals shorted together and housing of the equipment. During acceptance test, the test voltage of 1500V for a period of 5 seconds shall be applied without conducting temperature rise test. The leakage current shall not exceed 30mA for the above tests.
- 12.8** **Open circuit test:**
- 12.8.1** The alternator shall be run at not less than five speeds viz. 500, 900, 1500, 1800, 2500 covering the entire speed range. The field shall be separately excited and the excitation varied over the range recommended by the manufacturer. The output voltage at the alternator terminal corresponding to each setting of field excitation shall be recorded and curves plotted. The selected speed during the test shall be kept substantially constant.
- 12.9** **Load test :**
- 12.9.1** The alternator shall be run in conjunction with the regulating-cum-rectifying equipment. The test shall be conducted with a resistance load and or with battery. Preferably this test shall be conducted with resistive load and full coach

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set of battery consisting of 56 lead acid cells of 800/1100 Ah capacity. All characteristic tests are to be done at a setting of 128.0 $\pm$ 0.5 V at 97 A at 1500 rev./min.

The test shall consist of the following: -

- a) No load test
- b) Speed vs. output voltage characteristic test.
- c) Current versus voltage characteristics test.

**12.9.2 No load test :** In this test, the speed shall be varied covering the entire working range of speed and corresponding DC voltage available at rectifying equipment output terminals shall be noted. The voltage variation shall not exceed 4% of the preset voltage. The cut-in-speed shall also be noted in this test. The speed shall be adjusted at minimum speed for full output, 1500, 1800 and 2500 rev./min. This 'no load' test may be conducted at 10A base load.

**12.9.3 Speed versus output voltage characteristic test :** It shall be done at full rated current and 50% of full rated current. The speed shall be varied from minimum speed for full output to maximum speed. The voltage shall not vary more than  $\pm 4$  % of the pre-set voltage.

**12.9.4 Current versus voltage characteristics test:** Current versus voltage characteristic test shall be done at 1800 rev./min. The current shall be varied from 10A to rated value of 193 A, keeping the speed constant. The voltage variation shall be within  $\pm 4$  % of the pre-set value.

**12.10 Current limiting characteristic test of alternator and regulator:**

**12.10.1** After the current versus voltage characteristic test, Current limiting test shall be done. At the point when the load is increased and current does not increase, the value of current shall be treated as the limit of current setting. Current limit shall not exceed 230A.



Note: The difference in voltage developed at dispatch setting shall not be more than 1.5 V in both the direction of rotation during all conditions.

**12.11 Mechanical over speed and induced voltage test :**

**12.11.1** The test is to conducted as soon as possible after the temperature rise test or load test, while the alternator is still hot. The alternator shall be run for a period of 2 mts. in each direction with the stator winding open-circuited and field excited separately at the level corresponding to cut-in-speed at a speed of 3035 rev./min. No part of the alternator shall show any sign of damage deterioration.

**12.12 Short circuit characteristic test :**

**12.12.1** The output terminals of the alternator shall be short circuited with an ammeter in circuit before starting this test and excitation shall be adjusted in such a way that 25, 50, 75 and 100% of full load current flows through the armature windings. The test shall be carried out at various speeds covering complete speed range. The speeds selected for this test shall be same as selected for open circuit test. Curves shall be plotted at different speeds for field current versus short circuit current. This test shall be carried out on a 'cold machine'.

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**12.12.2 PARALLEL OPERATION:**

- This test shall be done at 800, 1800 and 2500 at 25%, 50% and 100% of full loads.
- Two alternators shall run in parallel with interconnections between RRUs.
- Individual alternator loads and total load and bus bar voltage shall be recorded.
- The difference of current between alternators shall not exceed 30 amps.

**12.12.3 Over Voltage Protection:** Details of the design, manufacture, testing and supply of Series type Over Voltage Protection Unit shall conform to FRS no. RDSO/PE/FRS/AC/0005-2013(or, latest).

**12.13 Surge protection test :**

**12.13.1** This test is to be conducted on alternator in conjunction with rectifying and regulating equipment. A speed of 1800 rev./min. shall be adjusted with full load shall be thrown off and the output terminal voltage rise shall be noted. The terminal voltage may rise to any value but shall not damage the alternator, regulator-cum-rectifying equipment. Again, only 10A resistive load shall be kept in circuit and balance load shall be suddenly thrown off and output terminal voltage of the alternator shall not rise beyond 400V, and shall drop to normal value in less than 5 sec.

**12.14 Efficiency test :**

**12.14.1** The efficiency test shall be conducted as per Test programme approved by RDSO. The speed versus efficiency curve, plotted at different speeds at rated load at output terminals of the rectifying and regulating equipment. The efficiency at 1800 rev./min. shall not be less than 80 %. Efficiency of alternator and RRU shall be measured separately. Efficiency of alternator shall be measured with the help of torque meter and output measurement. Efficiency of RRU shall be measured by measurement of input and output of RRU. Overall efficiency shall be calculated by multiplying the both efficiencies.

**12.15 Environmental tests :**

The tests shall be conducted on rectifier- regulating equipment only as per IEC-60571.

- Temperature rise test (dry heat)
- Temperature rise test (damp heat)
- Test in a corrosive atmosphere
- Combined dust humidity and heat test
- Vibration, shock and bump test (refer clause 3.2).

**12.16 Hose Proof Test :** The enclosure of rectifier-regulating equipment shall be of IP-65 protection level as per IEC 60529. After these tests the equipment shall work satisfactorily.

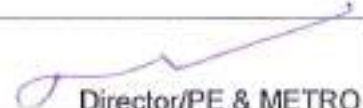
**12.16.1 Special Tests:**

- Ripple content test
- Mating of pulley with shaft
- Shorting of power diode
- Open circuiting of power diode
- Computation of junction temperature of semi-conductors etc.
- Checking dynamic balancing of rotor and pulley.

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- g. Measurement of (MFO) minimum speed for full output at cold and hot condition of alternator.
- h. Measurement of (MHO) minimum speed for half output.
- i. Fire retardant test for terminal board
- j. Ultrasonic testing of alternator shaft and the suspension hanger pin
- k. Chemical composition and bend test of suspension hanger pin
- l. Proof load test

**12.16.2 Ripple content test :** The ripple content in dc output shall not exceed 3 % and ripple content shall be computed from oscilloscope measurements as under :

$$\text{Ripple content} = \frac{V_{\max} - V_{\min}}{V_{\max} + V_{\min}} \times 100$$

Where,  $V_{\max}$  = Maximum voltage  
 $V_{\min}$  = Minimum voltage

**12.16.3 Mating of pulley with shaft :** Alternator pulley shall be checked for mating on shaft. The area in contact shall not be less than 80%. The test shall be conducted using plug and ring gauges and Prussian blue as Media. Apply blue lightly and evenly on entire taper surface of gauge. The amount of blue applied is very important. Too little will not transfer the blue colour to the component. Too much blue will not show the taper defect of the component. Insert the gauge on/in the pulley and press firmly. Do not hammer or tap the gauge or else it will get locked in to the component. Rotate the gauge clockwise by about 10°. This rotation is required to transfer the blue colour. Rotation should not be more than 20°. This back and forth movement should be once or twice only. Remove gauge from component. The taper angle is satisfactory if about 90% of the gauge surface makes contact with the component. This can be seen either by appearance of the blue colour from the gauge. In case blue matching is below 80%, the pulley needs replacement.

**12.16.4 Shorting of power diode:** The Alternator with Rectifier Regulator shall be run at 1800 rpm and preset the full load. Stop the alternator, any one power diode shall be shorted and the alternator with rectifier regulator shall be run at 1800 rev./min. The pre-set full load shall be connected across DC output terminals for 2 minutes. After the test no component of alternator or rectifier regulator shall get damaged. DC output voltage & current shall be recorded.

**12.16.5 Opening of power diode:** The alternator with regulator shall be run at 1800 rpm and pre set the full load in three steps. Stop the alternator. Then any one power diode shall be opened and alternator with rectifier regulator shall be run at 1800 rev./min at no load for 2 minutes and then the full load shall be applied gradually in three steps and run for 2 minutes. After the test no component of alternator or rectifier regulator shall get damaged.


**12.16.6 Computation of junction temperature of semi-conductor used in rectifier regulator equipment shall be done as per conditions of clause 3.0.**

The junction temperature of power diode and auxiliary diodes shall be computed. The temperature rise of the junction shall not exceed 110 deg.C

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**12.16.7 Checking dynamic balancing of rotor and pulley:** The dynamic balancing of rotor and pulley shall be checked individually on a balancing machine along with key. The residual unbalance shall not exceed 2.5 gm-cm/kg. in an case. Alternator manufacturer shall specify the numbers of holes, depth of holes and spacing between the holes to be permitted during dynamic balancing. These values shall be incorporated in the design / drawing and QAP of rotor & pulley which shall be verified by RDSO at the time of inspection. This will also incorporated in routine inspection.

**12.16.8 Measurement of MFO speed at cold and hot condition of alternator:** The minimum speed of full output of the alternator both in cold and hot condition shall not be more than 800 rev. /min.

**12.16.9 Measurement of minimum speed of half output (MHO):** The alternator shall be run at a speed of 600 rev./min. The current at 130 V output setting shall be measured. It shall not be less than 50% of rated current. The speed at which 50% rated current is available shall be measured.

**12.16.10 Fire retardant test for terminal board:**

The terminal board of brushless alternator and rectifier-regulator shall be tested for resistance to spread of flame in the manner given below.

A piece of terminal board of brushless alternator and rectifier regulator material measuring about 150x25 mm shall be subjected to the luminous bat swing flame, preferably supplied by a Bunsen burner. The specimen shall be held with the flat side up at an angle of 45 degree to the horizontal. The flame shall be 25 mm in width across the tips.

The flame shall be applied to the specimen at the lower end for 30 seconds and removed for similar period and then applied again to the same end for a second period of 30 seconds and then again removed. This test shall be carried out with the decorative surface facing upward and also the decorative surface facing downwards. The specimen should get ignited. It shall not continue to burn for more than 50 second after the flame has been finally removed.



**12.16.11 Ultrasonic testing of alternator shaft and the suspension hanger pin:** Ultrasonic testing shall be done of all finished shafts and suspension pin (100%) by the manufacturer. Manufacturer will submit the ultrasonic test results of all the shaft and suspension pin to inspecting authority. Inspecting authority shall inspect ultrasonic testing of 10% of the suspension pin as part of the acceptance test.

**12.16.12 Chemical composition and bend test of suspension hanger pin:** Chemical composition and bend test of suspension hanger pin shall be as stipulated by IS 1875-1992.

**Proof load test:** Proof load test of each safety chain assembly shall be more than 2500 kgf as per drawing no. SKE-4022 Alt-3) (or, latest).

### 13.0 SAMPLING AND REJECTION:

**13.1** The sampling for conducting various tests shall be done as per the following table.

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S. No.	Classification of Test	Qty. Of each type of alternator covered in Purchase Order.			
		Qty. Upto 49	From 50 to 149	From 150 to 299	300 and above
(a)	Prototype	As specified by RDSO			
(b)	Renewal of type approval	As specified by RDSO			
(c)	Type	1	2	3	4
(d)	Routine	All	All	All	All
(e)	Acceptance	10% (minimum 2 nos.)	10%	10%	10%

**13.2** The rejection procedure shall be adopted as given below.

Classification of test	STAGE		
	I	II	III
Prototype	The machines shall not be cleared for regular manufacturing till it passes all the tests. Quantity as specified by RDSO.		
Type	Qty. as per Cl. 13.1	Twice the no. of alternators /RRU which failed in any of the tests at stage - I	If any alternator fails in the II stage the entire lot shall be rejected.
Acceptance	Qty. as per Cl. 13.1 Test as per sub clause 1,2,5,6,9 & 10 of Clause 12.1.4	If any machine fails in any of the test in the I – stage, test shall be carried out on 100% machine for part I & II suppliers.	The failed machines shall be re-offered for inspection in the subsequent lot after rectification.
	Qty. as per Cl. 13.1 Test as per sub clause 3,4,7 & 8 of Clause 12.1.4	Twice the no. of alternators /RRU which failed in any of the tests at stage - I	If any alternator fails in the II stage the entire lot shall be rejected.

**14. DRAWINGS & DESIGNS ETC.**



**14.1** After completion of prototype test manufacturer shall submit following documents in bound booklet for in two copies. One copy duly approved shall be returned to manufacturer. This booklet should be made available to the inspecting agency. Booklet should contain :

- 1) ISO certificate
- 2) Design details
- 3) Circuit diagrams and detailed drawings of alternator and regulator.
- 4) Bill of material.
- 5) Quality assurance plan.
- 6) Prototype test results and field trial reports.

Soft copy of drawings in auto cad should also be given along with hard copy.

**14.2** The following drawings shall be sent to RDSO for taking approval of prototype:-

- 1) Diagram of electrical connections together with assembly drawing showing full particulars of stator and field windings, dimensions, shape, size and number of turns, sections, weight and length per coil.
- 2) Dimensioned part drawings with full details of tolerances of dimensions, finish, material specification.

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3) Circuit diagram of regulator and part drawing diagram of regulator and part drawing of regulator.

4) Rectifier-cum-regulator component's nomenclature, rating and loading.

5) Draft maintenance manual and spare parts.

14.3 The following shall be supplied as required by purchaser:

1. Reproducible prints / ferro prints of drawings showing the over all dimensions of the alternator supplied including dimensions of suspension boss and pulley in position.
2. Ten sets of approved maintenance manual with spare parts catalogue for every lot of 100 Nos. alternators or part there-of

14.4 The following details shall be submitted to RDSO before offer for prototype / type testing.

1. Shaft stress calculation
2. MTBF prediction calculation for rectifier-regulator
3. Bearing life and lubrication interval calculation
4. Details for the finished shaft as per the table given below alongwith calculation.

SN	Shaft X-section	Designed value			Operating value			Factor of safety		
		Bending Moment	Shear Stress	Tensile Strength	Bending Moment	Shear Stress	Tensile Strength	Bending Moment	Shear Stress	Tensile Strength

5. Manufacturer will submit the ultrasonic test pattern of all section of shaft to RDSO.
6. Manufacturer will submit the copy of ultrasonic test report of shaft to inspecting authority.

#### 15.0 APPROVAL BY RDSO:

15.1 The prototype alternator shall have the approval of RDSO (Research, Designs & Standard Organisation, Lucknow - 226011) before commencement of supply to railways by manufacturing units. For this purpose the manufacturer shall submit to RDSO the details as per clause 14.

15.2 The manufacturer shall afford all facilities to RDSO for conducting the prototype tests as per Clause 12.1.1. In case it is necessary to conduct any of the prototype tests at a testing house / institution, the full cost of such tests shall be borne by the manufacturer.

#### 16.0 RENEWAL OF PROTOTYPE APPROVAL:

16.1 Type test/Prototype approval shall be valid for a defined period (as decided by RDSO). Subsequent extensions shall be valid for a defined period (as decided by RDSO). Before expiry, the manufacturer shall have to apply for extension. However, RDSO may conduct the type tests at short interval in case of need for implementation of design related modification or ensuring reliability. While applying for renewal of type test approval following information shall be given by the manufacturer.

- a) Deviations from the bill of material, Q A P approved by RDSO earlier.
- b) Implementation of all maintenance / reliability improvement modifications issued by RDSO.

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- c) Addition/Deletion of machinery and plant.
- d) Details of purchase orders executed in last three years i.e. PO No., Qty., Rate (including taxes), Date of supply, consignee.

Retype tests shall be done as per clause 12.1.1.2 for revalidation. Following verification shall be done:

- (1) Q A P
- (2) Mating of alternator pulley with shaft as per Clause 7.3
- (3) Approved make of bearing as per Clause 7.4 (b)
- (4) Properties of alternator shaft as per Clause 7.5
- (5) Winding details as per Clause 7.12
- (6) Characteristics of power diodes used as per Clause 8.3.

17. **INFORMATION TO BE SUPPLIED BY THE PURCHASER:**At the time of tendering the purchaser shall define the scope of supply with reference to Clause 1.3.

18.0 **GUARANTEE / WARRANTY:**

- 18.1 Guarantee / warranty shall be applicable for a period as mentioned in IRS condition of contract or tender conditions as given by purchaser.

- 18.2 The supplier shall make arrangements for careful study of all equipment failure reported in service. Periodic reports containing analysis of the failures and remedial measures proposed shall be furnished by the manufacturer to RDSO, ICF and user railways. Such failures will also be periodically reviewed at MSG (TL & AC) Meeting organized by RDSO periodically. Manufacturer should prepare preventive and corrective action plan by visiting Railway workshops based on failure data.

19.0 **QAP TO BE FOLLOWED DURING MANUFACTURING OF ALTERNATOR:**

- 19.1 The manufacturer shall intimate to RDSO regarding their internal quality assurance process being followed by them. Certificates of the QAP will also be given with each lot of alternator to Inspecting Authority.

- 19.2 The material purchased from outside agencies shall conform to the relevant Standard Specification as specified in RDSO / IS Specification. The certificate conforming to RDSO / IS Specification should also be made available for each lot of machines. It is also preferred that in-house test facilities for purchased items should be developed by the firm so that testing of these materials can be done within the factory premises so that as check can be exercised by the Inspecting Authority in case necessary, otherwise, the testing of these materials should be done by Government recognized Testing Houses conforming to RDSO / IS Specification.

- 19.3 The Ultrasonic testing shall be conducted on each rotor shaft and certificate of the same shall be attached with each lot at the time of Inspection.

- 19.4 Following items shall also be considered and incorporated in QAP:

- i) **Packing** – Packing of incoming material for your brought out items need to be improved so as to avoid corrosion, rust, damages during transit and storage of the material at your works.
- ii) **Storage** – Storage of the items need to be improved so as to avoid deterioration of the material due to adverse weather condition. Material should not be kept on the shop floor and open spaces.

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- iii) **Handling** – Handling should be according to the material. For example shaft, finished shaft, diodes, rubber gaskets etc., should be handled properly to avoid damages during handling process.
  - iv) **Process** – Process should be such that during the manufacturing of the equipment, no unwanted damages should be taken place.
  - v) **Traceability of the record** – Traceability of the record should be implemented as per the ISO procedure and QAP of RDSO so that component of equipment which are failed are identifiable by the manufacturers so as to trace from which supplier the material was received from which lot it was.
  - vi) **Painting** – Quality of painting also need to be improved so as to improve the life and the appearance of the product.
  - vii) **Gasket** – Gasket quality design, fixing and preferably in single piece should be implemented.
  - viii) **Hinges, fasteners etc.** – Hinges, fasteners etc. need to be improved.
  - ix) **Welding** – Quality of welding should be improved and welder should be trained properly.
- 20.0 No design change shall be undertaken by manufacturer from prototype without prior approval of RDSO.
- 21.0 **DESIGN DETAILS OF ALTERNATOR & RECTIFIER REGULATOR:**
- 21.1 Manufacturers shall submit complete detail of components used for alternator and rectifier regulator to RDSO along with information as per Appendix/Annexure enclosed before offering the machine for prototype testing.
- 22.0 **INFRINGEMENT OF PATENT RIGHTS / ISO 9000 ACCREDITATION:**
- 22.1 Indian Railways shall not be responsible for infringement of patent rights arising due to similarity in design, manufacturing process, use of similar components in the design & development of this item and any other factor not mentioned herein which may cause such a dispute. The entire responsibility to settle any such disputes/matters lies with the manufacturer/ supplier.  
Details / design/documents given by them are not infringing any IPR and they are responsible in absolute and full measure instead of railways for any such violations. Data, specifications and other IP as generated out of interaction with railways shall not be unilaterally used without the consent of RDSO and right of Railways / RDSO on such IP is acceptable to them.
- 22.2 The firm seeking RDSO's approval for manufacture and supply of Alternator/RRU conforming to this Specification shall have ISO 9001 accreditation or equivalent certification to ensure its conformance to Quality Systems laid down in the standard for design, manufacturing processes, raw material, testing, and quality control at different stages etc.

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## Appendix – A

**SCHEDULE OF TECHNICAL DATA TO BE FURNISHED BY THE MANUFACTURER  
ALONG WITH THE TENDER**

Serial No.	Particulars to be filled in	Measurement in
A.1	Alternator particulars	
A.1.1.	Rated capacity	-----Amps
A.1.2	Maker's type	
A.1.3	Full load voltage range	From-----V To-----V
A.1.4	Cut-in- speed	-----rev./min,
A.1.5	Min. speed for full output	-do-
A.1.6	Max. permissible speed	-do-
A.1.7	Drive	
A.1.8	Mounting	Underframe / Bogie
A.1.9	Weight of alternator with pulley	-----Kg.
A.1.10	Class of insulation	a) Stator b) Field
A.1.11	Make and type of bearing	a) Drive end b) Non drive end
A.1.12	Recommended grease (specify I.O.C. brand), frequency of Greasing including quantity and method of greasing.	
A.1.13	Forged shaft	Yes/No
A.2	Regulator particulars	
A.2.1	Make	
A.2.2	Dimensions- length x width x height	-----mm
A.2.3	Weight	-----kg.
A.2.4	Voltage adjustment range	-----V
A.2.5	Current adjustment range	-----A

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## Annexure - I

## Details to be furnished by Alternator Manufacturers

## I. Alternator particulars

S.No.	Description	S.No.	Description
a)	Rated capacity	g)	Drive/Mounting
b)	Maker's type	h)	Overall length
c)	No load to full load voltage range	i)	Overall dia
d)	Cut in speed	j)	Wt. Of alternator without pulley
e)	MFO speed	k)	Weight of pulley:- Alternator Axle
f)	Max. permissible speed	l)	Both side bearing particulars

## II. Alternator Shell particulars



S.No.	Description	S.No.	Description
a)	Material of the shell	d)	Inner dia of the shell
b)	Length of the shell	e)	Drg. of the Shell with all tolerances and manufacturing process
c)	Outer dia of the shell		

## III. Alternator Stator particulars

S.No.	Description	S.No.	Description
a)	Inner dia of stamping	h)	Power loss per kg
b)	Outer dia of stamping	i)	Material specification
c)	Thickness of stamping	j)	Details of locking arrangement of stator core of both side.
d)	No. of stampings used	k)	Pressure used to install the lamination in position
e)	Wt. Of stator core	l)	Checking methods adopted to ensure true-bore of stator
f)	Grade of magnetic material used	m)	Total length of stator lamination
g)	Supplier's name		

## IV. Alternator Rotor particulars.

S.No.	Description	S.No.	Description
a)	Total length of rotor shaft	j)	Supplier's name
b)	Material of rotor shaft	k)	Power loss per kg
c)	Inner dia of stamping	l)	Material specification
d)	Outer dia of stamping	m)	Details of locking arrangement of rotor stamping of both side
e)	Total length of stamping	n)	Pressure used to install the lamination in position
f)	Thickness of stamping	o)	Checking methods adopted to ensure outer dia of rotor
g)	No. of stampings used	p)	Finished shaft drawing clearly indicating bearing seat, dimension on shaft and dimension of bearing with tolerances.
h)	Wt. Of rotor core	q)	Both ends end-shield manufacturing drawing
i)	Grade of Magnetic material used	r)	Rotor skew angle

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## V. Windings of alternators.

S.No.	Description	S.No	Description
a)	Size of copper wire (Stator with specification and maker)	g)	Type of slot insulation used
b)	Size of copper wire (Field with specification & maker)	h)	Type of wedge insulation used
c)	No. of turns per coil (stator)	i)	Type of insulation used on overhang
d)	No. of turns per coil (field)	j)	Details of lead wire
e)	Type of varnish used for impregnation	k)	Method of lead and winding wire joint.
f)	Method of impregnation used	l)	Type of winding used.

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## Annexure - II

## Details of Rectifier Regulator

Main Circuit:

S.No.	Description	S.No.	Description
i)	Working principle	ii)	Wiring diagram

A) Current Sensing:  
(a) CT/Shunt

S.No.	Description	S.No.	Description
i)	Type	iv)	Bus Bar Size
ii)	Rating	v)	Accuracy/ burden details.
iii)	Type of insulation		

(b) Rectifier

S.No.	Description	S.No.	Description
i)	3 Phase full wave bridge	vi)	Make
ii)	No. of diodes	vii)	Heat Sink
iii)	Current (I)	viii)	Temperature rise (Max.)
iv)	PIV	ix)	Capacitor
v)	Type		

(c) Potentiometer (current)

S.No.	Description	S.No.	Description
i)	Rating	iv)	Type
ii)	Numbers	v)	Tolerance
iii)	Make		

(d) Zener Diode

S.No.	Description	S.No.	Description
i)	Current (I)	iv)	Make
ii)	PIV	v)	Heat Sink
iii)	Type	vi)	Rating (Voltage, Wattage)

B) Potentiometer (Voltage)  
(a)

S.No.	Description	S.No.	Description
i)	Rating	iv)	Type
ii)	Numbers	v)	Tolerance
iii)	Make		

(b) Zener Diode

S.No.	Description	S.No.	Description
i)	Current (I)	iv)	Make
ii)	PIV	v)	Heat Sink
iii)	Type	vi)	Rating (Voltage, Wattage)

(c) Rectifier

S.No.	Description	S.No.	Description
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i)	3 Phase full wave bridge	vi)	Make
ii)	No. of diodes	vii)	Heat Sink
iii)	Current (I)	viii)	Temperature rise (Max.)
iv)	PIV	ix)	Capacitor
v)	Type		

C) Magnetic amplifier  
(a) Main Winding

S.No.	Description	S.No.	Description
i)	No. of windings	iv)	Current paths
ii)	Turns	v)	Insulation (Class of insulation)
iii)	Size of winding wire	vi)	Temperature rise(Max)

(b) Control Winding

S.No.	Description	S.No.	Description
i)	No. of windings	iv)	Current paths
ii)	Turns	v)	Insulation (Class of insulation)
iii)	Size of winding wire	vi)	Temperature rise(Max)

D) Excitation Transformer

S.No.	Description	S.No.	Description
i)	Current Rating of Primary and Secondary	iv)	Current paths
ii)	Turns	v)	Insulation
iii)	Size	vi)	Temperature rise (max)


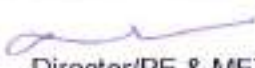
(E) Main Rectifier

S.No.	Description	S.No.	Description
i)	Full wave	vi)	Make
ii)	No. of diodes	vii)	Temperature rise (Max.)
iii)	Current (I)	viii)	Type of thread
iv)	PIV	ix)	Type of polarity
v)	Type		

(F) Snubber network (if provided)  
Details of condenser /resistors

S.No.	Description	S.No.	Description
i)	Type	iii)	Rating
ii)	Make	iv)	Type of Insulation

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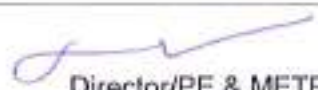


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## Annexure -III

## Bill of material of 25 KW Alternator

SN	Description	Specification /IS	Make
1.	Stator / Rotor stampings	IS : 648 0.5 thick M 45 CRNO	M/s. SAIL
2.	Enamelled copper wire dia 1.25 mm / 1.40 mm/1.50 mm	IS: 13730 (Pt.13)	1)M/s Swarnagiri Wire Insulation Pvt.Ltd. Hubli 2)M/s. Ram Ratan Wires, Mumbai 3)M/s. GK Winding wires, Ghaziabad 4)M/s. ALCO wires product, Secunderabad 5)M/s. Precision wires, Mumbai 6)M/s. Mimani wires, Indore 7)M/s. Khaitan winding wires, Kolkata 8)All the part-I sources appearing in RDSO/CLW master list of approved vendors.
3.	Varnish for VPI	Varnish FT 1052 or 2005/500Ek	M/s. Dr. Beck India
4.(a)	Spherical Roller, cylindrical and tapered bore bearing 22215ECJ	22215E	(a) M/s. SKF/Europe/India (b) M/s. FAG/Germany (c) M/s. NSK/Japan
(b)	Cylindrical Roller single row bearing NU 2215ECJ	NU 2215ECJ	(a) M/s. NSK/Japan (b) M/s. SKF/Germany /Austria/ (c) M/s. FAG/Germany /India
5.	Grease	AP3, RR3 & LL 3	1) M/s. Castrol 2) M/s. IOC 3) M/s. Balmer Lawrie & Co.Ltd.
6.	Silver Brazing electrode	Grade BACuP5 as per IS 2927	1) M/s. ESAB India 2) M/s. L & T 3) M/s. Advani/Oerlikon
7.	Lead wires for stator & field windings	BS:6195 type 8b category 'C' (80/0.4)	1) M/s. Universal Cable Co, Satna (M.P) 2) M/s. R.J. Industries Corporation, Roorkee 3) M/s. Remco Wire., Ulhasnagar 4) M/s. Fort Gloster, Kolkata 5) M/s. 3 A Associates Incorporated, Mumbai
8.	Rubber Pad	IRS:R48-88 (Polychloroprene Rubber)	1) M/s. Basant Rubber Factory Ltd., Mumbai 2) M/s. A. K. Industries, Kolkata 3) M/s. Manish Rubber Industries, Mumabai 4) M/s. Faively Transport India Ltd., Hosur 5) M/s. De Engineering Works, Howrah 6) M/s. M.G.M. Rubber Company, Kolkata 7) M/s. Elora Rubber & Plastic Industries, Kolkata 8) M/s. Ray Elastomer, Mumbai 9) M/s. Swan Rubber Industries, Kolkata 10) M/s PI Engineering Works, Ghaziabad (U.P) 11) M/s Central Gasket Co., Mumbai 12) M/s Ameenji Rubber Pvt. Ltd., Secunderabad
9.	Forged shaft	*****	All the sources appearing in RDSO master list of



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		----	approved vendors for traction motor shaft.
	Alternator / Axle Pulley**	ELPS/SPEC/ TL/13-March, 1998	1) M/s. Calcutta Iron Udyog, Howrah 2) M/s. Kerala Electrical and Allied Engineering Co. Ltd., Kundara 3) M/s. Vinayak Founders Pvt. Ltd., Kolkata 4) M/s. Rine Engineering Pvt. Ltd., Baddi 5) M/s. NSS Stores Supply Agency Pvt. Ltd. Howrah
11.	Springs for belt tensioning device	----- ----	1) M/s. Super India Spring Manufacturing Co., Howrah 2) M/s. B.N. Electronics, Kolkata 3) M/s. Ayappa Engineerings, Coimbatore 4) M/s. A.N. Spring Engineering, Howrah 5) M/s. All India Spring Engineering Co. Pvt. Ltd., Kolkata 6) M/s. Mini Iron and Alloys Pvt. Ltd., Kolkata 7) M/s. Bera Enterprise, Howrah 8) M/s. International Industrial Springs, Mumbai 9) M/s. Alam Spring, Coimbatore

\*\*Alternator manufacturer is responsible for ensuring quality of pulleys for their sub-vendors, as shown above.

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## Annexure -IV

## Bill of material of 25 KW RRU

S.N.	Description	Specification/IS	Make
1.	Power Diode 320 UM 120	320 A, VRRM 1200V	1) M/s. IXYS 2) M/s. International Rectifier Ltd. 3) M/s. Hind Rectifiers Ltd. 4) M/s. Semikron 5) M/s. Ruttonsha International Rectifier Ltd.
2.	Field Diode 16 FMN120	16A VRRM 1200V	1) M/s. IXYS 2) M/s. International Rectifier Ltd. 3) M/s. Hind Rectifiers Ltd. 4) M/s. Semikron 5) M/s. Ruttonsha International Rectifier Ltd.
3.	HRC Fuse 160A, 16A, 10A & 6 A	-	1) M/s. Cooper Bussman 2) M/s. English Electric Co. 3) M/s. ABB
4.	Thimble Copper	-	1) M/s. Dowells, Mumbai 2) M/s. KSE Electrical, Kolkata 3) M/s. Tyco Electronics, Delhi 4) M/s. Jenson, Mumbai 5) M/s. Klipon
5.	MA core	-	Mecagis, France
6.	Enamelled copper Wire	IS 13730 (PL13)	1) M/s. Swarnagiri WireInsulation Pvt.Ltd. Hubli 2) M/s. Ram Ratan Wires, Mumbai 3) M/s. GK Winding wires, Ghaziabad 4) M/s. ALCO wires product, Secunderabad 5) M/s. Precision wires, Mumbai 6) M/s. Mimani wires, Indore 7) M/s. Khaitan winding wires, Kolkata 8) All the part-I sources appearing in RDSO/CLW master list of approved vendors.
7.	Capacitor 1500 $\mu$ F, 450V	Professional grade with screw terminal type PG6D1	i) M/s. Alcon Electronics (P) Ltd. ii) M/s. Keltron Component iii) M/s. EPCOS iv) M/s. Kendeil v) M/s. Nippon Chemi-Con vi) M/s. Hitachi

Followings items will also be incorporated in the BOM to be submitted by the Firm.

SN	Description	SN	Description
i	Bus bar	vii	Fasteners SS/cadmium plated and zinc passivated
ii	Sleeve( heat shrinkable sleeve)	viii	Gaskets (FR Grade)
iii	Heat sink	ix	Hinges SS/cadmium plated and zinc passivated
iv	RRU Box	x	Heat conductive power/paste, if used.
v	Bimetallic washer	xi	Silicon compound used for anti-vibration purpose, if any.
vi	Locks SS/cadmium plated and zinc passivated	xii	Insulations sheets.

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Note:-Format of BOM to be submitted by the firm:-

Serial No.	Item	Specification Referred (IS/IEC etc.) / Drawing No.	Rating/Size	Setting (Wherever applicable)	Make	Model / Code No.	Quantity	Unit

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