
*भारत सरकार*
*रेल मंत्रालय*

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

अनुसंधान अभिकल्प एवं मानक संगठन
रेल मंत्रालय

RESEARCH DESIGNS AND STANDARDS ORGANISATION
MINISTRY OF RAILWAYS

# FUNCTIONAL REQUIREMENT SPECIFICATION (FRS) FOR DESIGN, DEVELOPMENT AND MANUFACTURING OF 30 KW PERMANENT MAGNET (PM) ALTERNATOR WITH CONTROLLER FOR 110V DC SG AC / LHB COACHES

## FRS No. RDSO/PE/FRS/AC/0003-2012 (Rev. 1)



अनुमोदित
APPROVED

कार्य0कारी निदेशक / विद्युत आपुर्ति एवं ई.एम.यू. निदेशालय
ED(PS&EMU)

**No. RDSO/PE/FRS/AC/0003-2012 (Rev.1)** **November 2013**

# FUNCTIONAL REQUIREMENT SPECIFICATION (FRS) FOR DESIGN, DEVELOPMENT AND MANUFACTURING OF 30 KW PERMANENT MAGNET (PM) ALTERNATOR WITH CONTROLLER FOR 110V DC SG AC / LHB COACHES

## 0.0 FOREWORD

In LHB type coaches, FIAT bogies are used with Disc brakes. In these bogies the existing 25kW alternators can not be fitted due to space constraint. Permanent Magnet (PM) alternators are smaller in size and can be fitted in these bogies. As further details regarding manufacturing and standardisation of permanent magnet alternators are not available with Indian Railways, this FRS has been proposed for 30kW permanent magnet alternator and controller.

0.1 As these functional requirements are defined for development of the Permanent Magnet Alternator with controller, better specifications / parameters may be accepted for trial / testing by Indian Railways Deviation in the specified parameters may also be considered by Indian Railways on merit and mutual agreement basis. However, manufacturer must note that once the product is developed and stabilized, Indian Railways reserves the right to freeze / standardize any particular design or may provide its own design which shall be binding on all the manufacturers.

## 1.0 SCOPE

1.1 This specification covers the design, development, manufacture, testing and supply of 30 KW 'V'-belt driven bogie mounted permanent magnet brushless alternator required for LHB broad gauge air-conditioned coaches.

1.2 The permanent magnet 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 or otherwise stipulated in the tender: -

| | | |
|---|---|---|
| i) | 30 kW permanent magnet alternator, complete with one/two'V' grooved alternator pulleys on one/both side | 1 No. |
| ii) | Safety chains | 2 No |
| iii) | Belt tensioning device complete | 1/2 Nos |
| iv) | Axle-pulleys complete with rubber pads and hardware | 1/2 Nos |
| v) | Suspension pin complete with hardware | 1 No. |
| vi) | Maintenance manual including trouble shooting details | 1 copy |

## 2. TERMINOLOGY AND SCHEME

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 controller 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 230A 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 the pre-set values.

2.7 Control Unit - Electronic unit to rectify the AC output of the alternator with control electronics to keep voltage and current within specified range.

2.8 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 30 KW permanent magnet alternators. Other types of air-conditioned coaches e. g. First class AC coaches may be equipped with only one set of 30 KW permanent magnet alternators. The DC output of the alternator will normally supply coach loads consisting of air-conditioning control unit fed from inverter, incandescent and fluorescent lights, air-circulating fans, pantry loads etc. and in addition to charge a bank of 56 Nos. 650Ah VRLA battery at a nominal voltage of 110 V DC.

2.9 The battery is connected to the alternator through control unit, which converts AC output of alternator into regulated DC and prevents the reverse flow of current from the battery to alternator during periods of non-generation. The inverters and coach fans are connected across the main positive and negative. The light fittings 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 the AC output of inverter.

2.10 Control unit shall also have provision of taking 3 phase AC from external supply for battery charging and pre-cooling of the coach in yards/station. Incase of external supply, back feed to Alternator is to be prevented and similarly in case of running train, voltage availability at external supply input points should be prevented for safety.

## 3.0 OPERATING CONDITIONS

3.1 The alternator shall function satisfactorily in the ambient temperature range from $-5^0$ C to $55^0$ C and 98% relative humidity and will be subjected to vibration, dust and rain water in service when installed in the under frame of the coaches. The control unit 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. The design and construction of Alternator with controller shall be suitable to withstand the above service condition. The vibration levels generally are 3g, 3g & 5g.

3.2 The coaches are expected to run up to a maximum speed of 145 kmph in the varying climatic conditions exiting throughout India. All accessories to be mounted on the coach under frame shall be designed to withstand service vibrations and buffing shocks.

3.3 The design of alternator shall be suitable for use with controller and should have

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 initial 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 controller (control unit) shall be 130V &. 230A.

4.2 Weight of Alternator and control unit shall be as low as possible.

4.3 Deleted.

## 5.0 PARTICULARS OF DRIVE

5.1 The mounting arrangement and drive for the alternator shall be generally as per exiting arrangement of conventional coaches. The alternator and axle 'V'-grooved pulleys shall be of the extended groove type for alternator & axle pulley. In the manufacturing of the pulleys, special care shall be taken for strict adherence to the tolerance given in the above mentioned drawings. Pulleys may be out sourced from RDSO approved vendors, if required. The alternator and axle pulley for 30 kW permanent magnet brushless alternator shall generally conform to RDSO Specification No. ELPS/SPEC/TL/ 13 March 1998 or latest. However, dia of the pulley and number of grooves can be decided by manufacturer.

5.2 The rubber pads shall be used from only approved sources of RDSO.

5.3 The coach wheel diameter is 915 mm when new and 813 mm when fully worn out. 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.

5.4 The "V"-belts shall be suitable to run at 145 kmph. Number of belts shall be suitably chosen by the manufacturer and calculation and the same shall be submitted to RDSO. However, at 145 kmph, fully worn wheel dia shall be considered for calculation of alternator speed in rpm.

5.5 The tensioning device shall consist of spring, limiting pipe etc. Punching of capacity i.e. 30 KW along with name of manufacturer shall be done on indicator plate of tensioning device.

## 6.0 OUTPUT CHARACTERISTICS

6.1 The cut-in speed and MFO speed of the alternator shall be as low as possible and consistent. New wheel dia shall be considered for calculation of cut-in and MFO in kmph.

The alternator shall be capable of working at maximum speed of 145 kmph. No negative tolerance is permitted on the voltage and current for measuring cut-in-speed and minimum speed for full output (MFO).

6.2 The alternator output voltage in conjunction with control unit shall be within the tolerance of ± 2% of the voltage setting for any load form 10A to 230A over the speed range of MFO to maximum speed i.e. 145 kmph. The alternator shall be dispatched with the voltage setting of 129±0.5V at 115 A at 110 kmph. The current limiting shall be set between 250A to 255A and voltage shall not drop to less than 120V at 250A.

6.3 Efficiency Test: The efficiency of the alternator with controller taken together shall not be less than 85% at 129±0.5V, 230A and 110kmph.

## 7.0 GENERAL CONSTRUCTIONAL FEATURE OF ALTERNATORS AND ITS COMPONENTS.

### 7.1 Alternator

7.1.1 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. Alternator shall be protected against the ingress of solid foreign bodies and water in accordance with IS: 4691-1985. The degree of protection shall be IP-55.

7.1.2a) 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.

b) Permanent magnets shall be fitted mechanically on the rotor. In such a manner that they do not become loose during life of Alternator

c) The field of permanent magnet shall not have any magnetism/effect outside of alternator body.

7.1.3 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.

7.1.4 The bearing design shall take into account the following :-

a) The calculation of L10 bearing life shall not be less 16 million km at 110 kmph.

b) The bearings shall be of RDSO approved sources. FEA of bearing is to be submitted along with the design details.

c) Finite Element Analysis (FEA) of bearings

d) In addition to provisions of the 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 bearing covers shall be provided to ensure proper retention of grease.

7.1.5 Special care shall be taken in regard to design and manufacture of rotor shafts. The manufacturer shall institute checks to ensure that the raw-material for the shaft is EN-24 or better manufactured by the forging process (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 (100%) test to detect internal as well as surface defects / discontinuities. FEA of the shaft is to be submitted along with the design details.

7.1.6 Each alternator shall be supplied complete with two 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.

7.1.7 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. The design of safety chain shall be such that it will not rub any of the bogie / alternator while in service.

7.1.8 The alternator terminal board details shall incorporate the following essential features:-

a) The terminal block shall not be loose when tightening or loosening the terminal screws.

b) Incoming socket shall be connected to one terminal post and outgoing socket shall be connected to second terminal post ensuring the flow of current through lugs & copper strips avoiding threaded screws and nuts.

c) The temperature rise of any terminal shall not exceed 50 degree centigrade above ambient at continuous rated current.

d) Spring washers shall be used for fasteners.

e) The insulating material used for the terminal board shall be impervious to moisture.

f) The terminal block shall be fixed with terminal box with slotted head hexagonal screws instead of counter sunk screws.

g) Leads coming out from alternator windings to alternator terminal board shall be through independent holes for each lead to avoid any contact with the frame. Holes should be sealed with RTV silicone sealant.

h) Terminal box shall have fuse in each lead. Fuse rating, model & type should be suitably chosen to given trouble free service for the complete range of operation.

7.1.9 Cable from alternator to controller shall be of e-beam type conforming to RDSO's Specification ELRS/SPEC/ELC/0019 Rev-2 of Feb 2011 supplied by the manufacturer.

7.1.10 Provision on the alternator frame to support the outgoing cables is to be made. Material for such arrangement shall be non-hydroscopic insulation material with fire retardant properties such as EP2-IS: 10192

7.1.11 Winding Wires:

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 polyestermide (UP) impregnating resin Dobec-on FT1052/2005 or 500 EK. The winding shall be subjected to pressure impregnation as per the recommended procedure of varnish manufacturer.

(c) Deleted.

(d) The tenderer shall state in his offer the brand names of the insulating materials proposed to be used which is suitable for "H" class.

7.1.12 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.

7.1.13 Deleted.

7.1.14 Colour of Alternator - The equipment shall be finished in the colour code No. 796 dark violet of IS: 5-2007 "Colours for ready mixed paints & enamels". Painting shall be in accordance with the specification and "Code of Practice" issued by RDSO for raw materials, hardware and anti-corrosive treatment of train-lighting equipment.

7.1.15 Alternator serial no. and manufacturers name shall be punched on both the suspension bracket of alternator.

7.1.16 For dimensions and mounting of the alternator and controller, manufacturers are advised to study FIAT bogie / LHB coaches at RCF.

7.2 **CONTROL UNIT:**

7.2.1 The Microprocessor based alternator control unit shall be protected against the ingress of solid foreign bodies and water in accordance with IS: 4691-1985. The degree of protection shall be IP-65. After these tests the unit should work satisfactorily

7.2.2 The ripple content in DC output voltage shall not exceed 2%.

7.2.3 The operating condition shall be as specified in clause 3.1 and 3.2 of this specification.

7.2.4 Subject to the condition that total current of alternator is less than the rated current output, the regulator unit shall regulate the output voltage of the alternator so as to maintain a preset voltage subject to the tolerance indicated in clause 6.2 of this specification at the rectifier terminals under the following conditions:-

i) At speeds from MFO to maximum speed.

ii) At all loads ranging from 10Amps to the rated output of alternator

7.2.5 **OVER VOLTAGE PROTECTION-GENERAL:**

Due to component failure/open circuit in Controller, a separate static over voltage protection unit needs to be provided with no nuisance tripping under no-load or when the system running with VRLA battery connected at the output. During sudden throwing of load (without battery connected), the over voltage static relay may trip but must reset by itself automatically. Latching of the static relay may be achieved under fault condition with battery supply available at DC output. Certain time delay may be provided for static relay operation so that the static relay does not trip when load is thrown off suddenly with battery connected. However, the time delay provided should be less than 2 sec. in order to protect the system under the genuine fault conditions. The tripping voltage of relays may be set at 145±1 V for 30 kW controllers.

Provision for self testing of OVP should be provided stationery condition. The OVP reset button shall be provided on CIP for resetting in case of OVP tripping.

7.2.6 The DC output voltage shall be capable of being set from 124V to 130V at 110kmph at a reference load of 230Amps through keypad.

7.2.7 The semi-conductor devices and other components 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 or otherwise approved by RDSO.

7.2.8 The cut-in speed and MFO speed of the alternator working in conjunction with controller shall be as low as possible consistent with economical design. The controller shall be capable of working at maximum speed of 145-kmph. No negative tolerance is permitted on the voltage and current for measuring cut-in speed and minimum speed for full output.

7.2.9 The current limiting setting of DC output current, battery charging limit shall also be possible to adjust within 20% of rated values.

7.2.10 The control unit shall meet the following requirements:

| | |
|---|---|
| No load DC Output voltage | 135 V (Maximum) |
| DC Output Voltage setting | 129 ±0.5 V, 115A at 110 kmph |
| Voltage regulation | ±2% of set voltage |
| Voltage ripple | within 2% |
| Load variation | 10 A to 230 |
| Speed variation | 0 to **145-kmph** |
| Voltage at 10% over load | 120 V (minimum) at 250 A |
| Current limiting | 250 A at 120V |
| Battery charging current limits (max) | 120 A to 130 A |

7.2.11 Controller shall have IP-65 SS-304 or better cubical. All the connectors/couplers/Terminals shall be IP 65.

7.2.12 Controller shall have separate positive output for battery charging (BC+) and one positive (DC+) and one negative (DC-) output for feeding the load. In case of no generation, load shall be fed through DC+ and BC+ from battery.

7.3 **PRE-COOLING MODE**:

7.3.1 The pre-cooling mode shall be designed for the following rating and other particulars:

| Type | Constant voltage and Constant current |
|---|---|
| Input voltage | |
| • Nominal voltage | 415 V AC 3 phase, 3 wire system |
| • Operating voltage range | 325 V to 480 V 3 phase AC, 50 Hz |
| • DC output Voltage | 120-135 V DC |
| • Output current DC | 120-130A |
| • Operating Modes | The unit shall be suitable to work either in constant voltage or constant current mode, selectable from CIP. |

7.3.2 **REGULATION**

7.3.2.1 **Constant Voltage:** Under this mode, the value of output voltage shall be maintained within ±2% of the set value over the entire range of input AC supply variation and the charging current output variation. It should be possible to set the output voltage between 120V-135VDC through key pad. Factory setting shall be done at 131 V.

7.3.2.2 **Constant Current:** Under this mode of working the unit shall be capable of delivering the output current whose magnitude shall be selected through keypad in CIP. The current shall be maintained within ±2% of the set value for charging of fully discharged battery to full state of charge with the input voltage 325V to 480V.

7.3.3 **EFFICIENCY:** The efficiency of the unit shall not be less than 85% at half load and not less than 90% at full load for entire input voltage range.

7.3.4 **RIPPLE CONTENTS:** The unit shall be designed in such a way that the output voltage ripple factor to less than 2% r.m.s. of the set value of voltage at all loads when measured across a resistive load.

7.3.5 **PROTECTIONS:**

7.3.5.1 **Over voltage (Constant voltage mode charging):** Over Voltage protection shall be employed to avoid the unit giving high voltage beyond the set level. Over voltage protection shall be employed to avoid the unit giving high voltage beyond 140V. Input to the unit shall get disconnected on over voltage tripping instantaneously

7.3.5.2 Current limit (in case of constant voltage**) :** During charging mode, the unit output current shall be limited to 130 A.

7.3.5.3 **Over current protection:** The unit shall be protected against over current at DC output by limiting the output current to a maximum of 115% of its rated current in pre cooling mode.

7.3.5.4 **Input protection:** A MCCB of suitable rating not less than 63Amps MCCB (current setting at 45 amps) shall be provided at input side.

7.3.5.5 Deleted.

7.3.5.6 **Input over/ under voltage protection :** Input over/ under voltage protection shall be provided at 325V and 480 V AC with an audiovisual alarm. The unit output voltage shall automatically be available as and when the AC voltage is within 325V to 480V. This should be prominently displayed with audio/ visual indication in CIP.

7.3.5.7 **Controls:**

The unit shall be provided with the following minimum controls:

i) Deleted
ii) Unit ON/OFF from CIP.
iii) Trip reset push button in CIP.
iv) Mode selection:
  a) Constant current and constant voltage mode.
  b) Deleted

7.3.6 In pre-cooling mode, input and output shall be galvanically isolated.

7.3.7 For pre-cooling, suitable connectors/couplers for 3-phase, 3-wire supply shall be provided. Protection shall be provided that power is not available on terminals of alternator in pre-cooling mode. Similarly, in self generation mode, voltage should not be available on pre-cooling connector / coupler.

7.3.8 **COACH INDICATION PANEL (CIP):**

It will be fitted in AC coach power panel. Its LCD display will show the set parameters and the recorded data.

For on-board display cubicle, minimum 1.6 mm thick metallic cold rolled steel (CRCA) sheet conforming to IS: 513 shall be used. The housing shall be powder coated with grey color to a coating thickness of not less than 50 microns.

7.3.9 Deleted.

8.0 **TESTS**

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

* A manufacturer undertakes to manufacture for the first time or

* A fundamental change in design is introduced.

The prototype tests shall be carried out at the works of the manufacturer by RDSO. Manufacturer shall submit the details of alternator to RDSO as per Annexure enclosed for information before offering the machines for prototype testing. These tests are to be carried out at manufacturer's premises.

b) **Type Tests:** A type test is to be carried out by the manufacturer and the inspection authority on Alternator/control unit equipment picked up at random to ensure compliance with specifications in details as declared by the manufacturer and approved by RDSO.

c) **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.

d) **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.

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

i) Type test results.
ii) 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.

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

e) **Revalidation / Renewal tests:** For renewal of firm, the following tests shall be done at firm's premises after certain time interval as decided be RDSO/IR from previous date of registration / renewal.

The prototype approval shall be valid for a period of three years from the date of issue of approval letter unless specified otherwise. Before expiry, the manufacturer shall have to apply for revalidation of approval. 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, the following information shall be given by the manufacturer.

i) Deviations from the bill of material, QAP approved by RDSO earlier.
ii) Implementation of all maintenance/reliability improvement modifications issued by RDSO.
iii) Addition/Deletion of machinery and plant.
iv) 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 8.1 for revalidation. Following verification shall be done:

i) Q A P
ii) Matching of alternator pulley with shaft as per Clause 7.1.3
iii) Approved make of bearing as per Clause 7.1.4 (b)
iv) Properties of alternator shaft as per Clause 7.1.5
v) Winding details as per Clause 7.1.11

f) **Test Schedule:**

| S. No. | Type of Test | Clause No. | Proto type test | Type Test | Routine Test | Acceptance Test | Renewal of Type Test |
|---|---|---|---|---|---|---|---|
| 1. | Verification of dimensions of all assemblies and sub-assemblies | 8.1.1 | Yes | Yes | Yes | Yes | Yes |
| 2. | Measurement of stator resistance | 8.1.2 | Yes | Yes | Yes | Yes | Yes |
| 3. | Temperature rise test of alternator, controller equipment | 8.1.3 | Yes | Yes | No | No | Yes |
| 4. | Insulation resistance test of alternator | 8.1.4 | Yes | Yes | Yes | Yes | Yes |
| 5. | High voltage test | 8.1.5 | Yes | Yes | Yes | Yes | Yes |
| 6. | Open circuit test | 8.1.6 | Yes | Yes | No | No | Yes |
| 7. | * Load test on Alternator with Controller | 8.1.7 | Yes | Yes | Yes | Yes | Yes |
| 8. | * Current limiting characteristic of alternator | 8.1.8 | Yes | Yes | Yes | Yes | Yes |
| 9. | * Mechanical over speed and induced voltage test | 8.1.9 | Yes | Yes | No | No | Yes |
| 10. | Maximum voltage Generation test | 8.1.11 | Yes | Yes | No | No | Yes |
| 11. | Surge protection test | 8.1.12 | Yes | Yes | No | No | Yes |
| 12. | Hose proof test | 8.1.13 | Yes | Yes | No | No | Yes |
| 13. | Mating of pulley with shaft | 8.1.14 | Yes | Yes | Yes | Yes | Yes |
| 14. | Checking dynamic balancing of rotor and pulley | 8.1.15 | Yes | Yes | Yes | No | Yes |
| 15. | *MFO | 8.1.16 | Yes | Yes | Yes | Yes | Yes |
| 16. | *MHO | 8.1.17 | Yes | Yes | Yes | Yes | Yes |
| 17. | fire retardant test for terminal board | 8.1.18 | Yes | Yes | No | No | No |
| 18. | *Single phasing test | 8.1.19 | Yes | Yes | No | Yes | Yes |
| 19 | Verification of controller overall dimensions and visual check | 8.2.1 | Yes | Yes | Yes | Yes | Yes |
| 20 | Temperature rise test on controller | 8.2.2 | Yes | Yes | No | No | Yes |
| 21 | Insulation resistance test on controller | 8.2.3 | Yes | Yes | Yes | Yes | Yes |
| 22 | High voltage test on controller | 8.2.4 | Yes | Yes | Yes | Yes | Yes |
| 23 | CIP test | 8.2.7 | Yes | Yes | Yes | Yes | Yes |
| 24 | Hose proof test on controller | 8.2.8 | Yes | Yes | No | No | Yes |
| 25 | Special test on controller | 8.2.9 | Yes | Yes | No | No | Yes |
| 26 | Environmental test on controller | 8.2.10 | Yes | No | No | No | No |
| 27 | Total DC isolation test (both positive & negative) for SMPS | 8.2.13 | Yes | Yes | Yes | Yes | Yes |
| 28 | OVP Test | 8.2.14 | Yes | Yes | No | Yes | Yes |
| 29 | Performance test on pre-cooling unit | 8.3.3 | Yes | Yes | Yes | Yes | Yes |
| 30 | Short circuit test on pre-cooling unit on pre-cooling unit | 8.3.4 | Yes | Yes | No | No | Yes |
| 31 | Surge test on pre-cooling unit | 8.3.5 | Yes | Yes | No | No | Yes |
| 32 | Dielectric test | 8.3.6 | Yes | Yes | Yes | Yes | Yes |
| 33 | Insulation resistance | 8.3.7 | Yes | Yes | Yes | Yes | Yes |
| 34 | Output current limit | 8.3.8 | Yes | Yes | Yes | Yes | Yes |
| 35 | Ripple measurement | 8.3.9 | Yes | Yes | No | No | Yes |
| 36 | Endurance test | 8.3.10 | Yes | Yes | No | No | Yes |
| 37 | Power loss Determination | 8.3.11 | Yes | Yes | No | No | Yes |
| 38 | Dry heat & damp heat | 8.3.12 | Yes | No | No | No | No |
| 39 | Salt mist test | 8.3.13 | Yes | No | No | No | No |
| 40 | Efficiency test | 8.3.14 | Yes | Yes | No | Yes | Yes |
| 41 | Temperature rise test | 8.3.15 | Yes | Yes | No | No | Yes |
| 42 | Trigger equipment test | 8.3.16 | Yes | Yes | No | No | No |
| 43 | Load break test | 8.3.17 | Yes | Yes | No | No | Yes |
| 44 | Input U/V & O/V | 8.3.18 | Yes | Yes | Yes | Yes | Yes |
| 45 | Acoustic noise | 8.3.19 | Yes | Yes | Yes | Yes | Yes |

Tests marked with star (*) are to be conducted in both directions of Alternator rotation. The difference in voltage developed in clockwise and anticlockwise direction shall not be more than 1 V during all conditions of load test

8.1 **TEST ON ALTERNATOR:**

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

8.1.1.1 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 of alternators with different Electronic control unit in current use should be ensured.

8.1.2 **Measurement of stator resistance of alternators : -**

Stator resistances shall be measured either by voltmeter ammeter method by 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 resistance at 20 degree centigrade shall be averaged for first 5 machines. The resistance of any stator winding shall not vary by more than ±5% from the prototype value.

8.1.3 **Temperature rise test:**

8.1.3.1 The alternator in conjunction with the control unit shall be run at rated current & voltage at 145 kmph. speed till the temperature stabilizes as evidenced by three consecutive readings of frame temperature at an interval of fifteen minutes between each other, under forced air-cooling of 6m/sec. for alternator. The air velocity at the location where the alternator is to be located for tests shall be adjusted to 6m/sec. prior to mounting of control unit in position under test. The control unit shall be placed in position after obtaining the required ambient conditions Temperature of the stator windings, bearings, terminals and frame of alternator shall be measured. The temperature rise above the ambient of 55 degree centigrade shall not exceed the following values under full load condition (130V, 230A):

| Class of insulation | Temp. Rise. | Method of measurement |
|---|---|---|
| H | 105º 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.

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

8.1.3.3 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 $10^0$C, whichever is higher but within the limits specified in clause 8.1.3.1 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 $8^0$C above the average temperature. Further if the temperature rise is observed to be less by more than $5^0$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.

8.1.3.4 After conducting temperature rise test at rated current as stipulated above, machine shall be subjected to overload at 250A for 1 hr. in continuation to heat run at normal load (at MFO and 145–kmph.). The temperature rise shall not exceed the specified value for 'H' class of insulations used on the machine.

8.1.4 **Insulation resistance test :**

8.1.4.1 The insulation resistance ( IR )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.

8.1.5 **High Voltage test**

8.1.5.1 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 voltages and shall be increased gradually to the full test voltage. 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.

8.1.6 **Open circuit test:**

The alternator shall be run from zero to max speed corresponding to 145 kmph in steps of 25 kmph covering the entire speed range. The output voltage at the alternator terminal shall be recorded and curves plotted".

8.1.7 **Load test on Alternator with Controller:**

The alternator shall be run in conjunction with the control unit. The test shall be conducted with a resistive load. All characteristic tests are to be done at a setting of 129$\pm$.5V at 115 A at 110 kmph.

The test shall consist of the following:-

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

8.1.7.1 **No load test**

In this test, the speed shall be varied covering the entire working range of speed and corresponding DC voltage available at equipment output terminals shall be noted. The voltage variation shall not exceed $\pm$2% of pre-set voltage for the speed range from the

MFO speed to 145 kmph. The cut-in-speed shall also be noted in this test. The speed shall be adjusted from cut in speed to 145 kmph in steps of 25 kmph. This 'no load' test shall be conducted at 10A base load.

**8.1.7.1.1** No load test at 0 A shall be conducted for the above conditions and the no load voltage shall not exceed 135 V.

**8.1.7.1.2** Speed versus DC output voltage graph shall be plotted for 'Base Load' and zero Amp i.e. No load.

8.1.7.2 **Speed versus output voltage characteristic test :**

It shall be done at overload, full rated current, 75%, 50%, 25% of full rated current and base load. The speed shall be varied from MFO to 145kmph in steps of 25 kmph. The voltage shall not vary more than $\pm$2% of pre-set voltage for the range from the MFO speed to 145 kmph from base load to full load.

8.1.7.3 **Current versus voltage characteristics test.**

Current versus voltage characteristic test shall be carried out at 110kmph. The current shall be varied from 10 Amp to rated value of 230 Amps, keeping the speed constant. The voltage variation shall be within $\pm$2% of the pre-set value. The current –Vs-voltage shall be plotted for the load variation.

8.1.8 **Current limiting characteristic test of alternator with controller.**

After the current versus voltage characteristic test, Current limiting test shall be carried out. 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. The DC output voltage shall not be less than 120 V at 250A load. Current limit shall not exceed 255Amps. Load shall be increased till the output voltage dropped to below 70V.

The current-vs-voltage shall be plotted for the load variation including overloading of the controller.

Note: The difference in voltage developed in clockwise and anticlockwise direction shall not be more than 1 V during all conditions of load test and current vs voltage characteristic test.

8.1.8.1 **BATTERY CHARGING CURRENT LIMIT TEST:**

i) Total battery charging current (BCC) in AC coach shall be limited to 130 amps maximum.

ii) BC+ve terminal shall be loaded with resistive load to check the battery charging current limits.

iii) The total load connected across the DC output and BC +ve terminal of the controller shall not exceed the overload rating of the alternator at any given time.

iv) The BC terminal voltage shall be recorded for the load variation from 0A to the battery charging limits keeping the DC +ve terminal without any load. The battery charging current versus DC output voltage shall be plotted.

v) Total DC output current versus DC output voltage shall also be plotted.

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

The test is to be 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 2mts. in each direction with the stator winding open-circuited at the level corresponding to 160kmph. No part of the alternator shall show any sign of damage deterioration.

8.1.10 Deleted

8.1.10 **Maximum Voltage Generation Test:**

8.1.11.1 Alternator shall be run at cut-in, MFO and 145–kmph speed in both the direction. Voltage measurement at alternator terminals shall be done with moving iron voltmeter, digital multi-meter and oscilloscope at No-load, base load, half load, full load and 250A. Voltage across any two wires coming out from alternators shall not exceed 500 V. Waveforms shall be taken for all the measurements.

8.1.12 **SURGE PROTECTION TEST:**

8.1.12.1This test is to be conducted on alternator in conjunction with control unit. A speed of 110 kmph shall be adjusted with full load which 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. 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.

8.1.13 **Hose proof test:**

Alternator shall be protected against the ingress of solid foreign bodies and water in accordance with IS: 4691-1985. This shall be conducted in accordance with IP-55 as per IEC 60529 with the latest amendment.

8.1.14 **Mating of pulley with shaft:**

8.1.14.1Alternator 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 Persian blue as Media.

8.1.15 **Checking dynamic balancing of rotor and pulley.**

The dynamic balancing of rotor and pulley shall be checked individually on a balancing machine. The residual unbalance shall not exceed 2.5 gm-cm/kg. in an case.

8.1.16 **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 be as low as possible as and shall be declared by the manufacturer in design details.

8.1.17 **MEASUREMENT OF MINIMUM SPEED OF HALF OUTPUT (MHO):-**

The minimum speed of half output of the alternator shall be as low as possible as and shall be declared by the manufacturer. The current at 129±.5 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.

8.1.18 **FIRE RETARDANT TEST FOR TERMINAL BOARD:-**

8.1.18.1 The terminal board of Permanent Magnet alternator shall be tested for resistance to spread of flame in the manner given below:

A piece of terminal board of Permanent Magnet alternator 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. Should the specimen get ignited, it shall not continue to burn for more than 50 second after the flame has been finally removed.

8.1.19 **SINGLE PHASING TEST:** –

Fuse of one of the wire/phase shall be removed while alternator is running at 110kmph on full load. Indication should come on CIP for single phasing.

8.2 **TEST ON CONTROLLER:-**

8.2.1 **VERIFICATION FOR DIMENSIONS AND VISUAL CHECK:-**

This is to check the dimensions of assemblies and sub-assemblies i.e. overall dimensions of controller box, terminal arrangement and layout of aux. Equipment as per specifications and constructional details thereof to ensure that they are consistent with good engineering practice. Inter-changeability aspects shall also be ensured "Sound engineering practices should be followed in the manufacturing of controller. Care should be taken for avoiding sharp bend to cables, ensure good welding quality with smooth finish, Use of standard hardware, avoiding sharp edges, proper bunching, routing and support to the cables."

8.2.2 **TEMPERATURE RISE TEST:-**

8.2.2.1 The temperature rise test shall be conducted with the alternator and controller, with forced air cooling of 6m/sec. for alternator and controller.

The temperature rise test shall be conducted on controller in conjunction with alternator of same capacity at MFO and at **145–kmph** speed at rated capacity until the body temperature of alternator gets stabilized as evident from three consecutive readings of frame temperature at half an hour interval. The air velocity at location where the alternator and controller are to be located for tests shall be adjusted as mentioned in above para prior to mounting of equipment in position. For 30 kw, after each

temperature rise test at MFO and **145–kmph** speed, one hour over load test shall be conducted at 250 Amps.

| Capacity kw | Maximum speed | Minimum speed | Rated voltage Volts. | Rated current Amps. | One hour O/L Amps. |
|---|---|---|---|---|---|
| 30kw | 145kmph | MFO | **129±.5 V** | 230 | 250Amps. |

8.2.2.2.1 Deleted.

8..2.2.3 Temperature of Controller components shall be recorded for every one hour up to four hours and thereafter for every half an hour, readings shall be recorded. Three consecutive half an hour readings indicate stabilisation of the body temperature of alternator.

8.2.2.4 In the controller, the following temperature shall be recorded:

i) Diode/IGBT base temperature
ii) Transformer / Choke
iii) Hall effect sensors
iv) HRC fuse
v) Bleeder Resistance
vi) Heat sink of controller
vii) Bus bar
viii) Fuses
ix) Ambient inside the controller
x) PCB/Electronics device

8.2.2.5 In regard to control unit equipment, the temperature rise of IGBT/Power diodes, Hall sensors, HRC fuses, bleeder resisters, current transformer, bus bars etc., shall be less than designed temperature limits of each component under worst operating conditions. The temperature Rise of electronic devices (except power devices), auxiliary power supply module etc. shall not increase more than 20° C above the ambient of 55 degree C. The ambient temperature rise inside the box shall also be recorded and it shall not exceeding 20ºC.

8.2.2.6 The temperature rise of IGBT/Power diodes/ Power devices, ISO-Packs, Hall Sensors, Excitation Transformer (if used), bus-bars etc. Shall not be more than 50°C above the ambient of 55°C. There shall be consistency in the quality during lot production of the equipment whereby achieving consistency in various test parameters such as regulation, temperature Rise etc.

8.2.3 **INSULATION RESISTANCE TEST**:

The insulation resistance shall be measured before and after high voltage test between all live terminals shorted together and body with a 500 V DC Megger and these values shall not be less than 20 meg ohm for control unit**.**

8.2.4 **HIGH VOLTAGE TEST**

Immediately after completion of heat run/performance tests, an AC potential of 1500 V rms at 50 Hz shall be applied between all live terminals shorted together and housing of the equipment. The test shall be commenced at a voltage of less than one third of

the test voltage and shall be increased gradually to the full test voltage. The test voltage of 1500 V for a period of 60 seconds shall be applied after conducting temperature rise test. The leakage current shall not exceed 10 mA for the above tests.

**Note:** During HV test, UVC may be disconnected.

8.2.5 Deleted alongwith sub-clauses

8.2.6 Deleted.

8.2.7 **COACH INDICATION PANELTEST (CIP)**:

8.2.7.1 The coach indication panel working shall be checked for the following:

i) Capacity of alternator
ii) Healthiness of controller
iii) Over voltage Protection
iv) Single phasing.
v) Overload fault.
vi) Downloading of the recorded data as per format given in Clause 8.2.7.8*
vii) Short circuit indication shall be displayed on CIP.
viii) Display of generation/alternator parameters.

* If stoppage is for more than one hour – non-generation time shall not be counted and generation and non-generation time in hours shall be recorded in three digit.

8.2.7.2 During battery charging/discharging test, check shall be conducted to verify the Amp. Hours of discharge/charge indicated on the indication board. A discharged battery of a battery set, preferably of 650 Ah capacity shall be charged/discharged for five hours. The indicated and recorded data shall be of 3% accuracy.

8.2.7.3 Faults shall be created and failure indication shall be checked.

8.2.7.4 The attachment and detachment of the indication board should be checked for ease of maintenance and proper contacts. If the indication board is removed, the performance shall not be affected.

8.2.7.5 Data shall be downloaded by USB Pen Drive of reputed make. Down loading data should be directly openable in MS Office applications like Excel/Word. It should be possible to down load data of at least 24 coaches in one go i.e. without the need to copy the data on laptop. The data display shall be recorded 3% or better accuracy.

8.2.7.6 Memory shall have sufficient capacity to contain minimum 7 days data with a resolution of one minute apart from cumulative data of last 7 days and fault data.

8.2.7.7 Transferring of the Journey data: Normally, the data stored in the portable USB pen drive unit shall be transferred directly to the PC or laptop having USB port.

8.2.7.8 **Reporting Format**: Recording interval shall be one minute and minimum duration of recording shall be seven days. The formats of reporting shall be as follows:

**Format A (1 minute)**

| Date | Time | Controller-1 | | Controller-2 | | Charging Current | Discharging Current | Alternator RPM |
|---|---|---|---|---|---|---|---|---|
| | | Output Voltage | Output Current | Output Voltage | Output Current | | | |
| | | | | | | | | |

**Format B (1 hour)**

| Date | Time | Cumulative Charging Ah | Cumulative Discharging Ah | Generation time | Non Generation time | Distance traveled |
|---|---|---|---|---|---|---|
| | | | | | | |

**Format C for failures**

| Date | Time | Type of Faults | Remarks |
|---|---|---|---|
| | | | |

Types of faults which shall be recorded preferably are as follows:

| |
|---|
| No supply from alternator or alternator failure |
| Over voltage generation |
| controller Failure |
| Power circuit failure |
| OVP Tripped, OVP Reset |
| Over load |
| Short circuit |
| Battery voltage low |

8.2.7.8.1 **DISPLAY UNIT**

The design of the controller shall be provided with a provision of data logger to log both alternators DC output currents, DC voltage/battery voltage, battery charging / discharging current with respect to real time. USB interface shall be available enabling to down load in any commercial pen drive and analyse recorded data directly in MS Office application. The controller shall also be provided with a LCD/alpha-numeric display to indicate its various parameters as given below:

**Following parameters should also be stored in the memory:**

| Parameter | Recording frequency | Cumulative |
|---|---|---|
| Total distance traveled by the particular coach | 1 hour | Yes |
| Alternator rpm | 1 minute | No |
| Total generation and non generation time | 1 hour | Yes |
| Last 32 faults recording | Actual time | No |
| Output voltage Controller -1 | 1 minute | No |
| Output current Controller -1 | 1 minute | No |
| Output voltage Controller -2 | 1 minute | No |
| Output current Controller -2 | 1 minute | No |

| | | |
|---|---|---|
| Battery charging current | 1 minute | No |
| Battery discharging current | 1 minute | No |
| Charging Ah | 1 hour | Yes |
| Discharging Ah | 1 hour | Yes |

Please note the following points:

i) Cumulative data summary must be available at the end of journey.

ii) Output voltage will display battery voltage when train is not running.

iii) At the end of journey if waiting period is more than one hour, then that period shall not be counted as non generation time.

iv) If external charging is done, then, it should not be counted towards cumulative charging ampere hour.

v) It shall be possible to download the data using any commercial USB pen drive from Controller to PC. In case memory becomes full, earlier data should be automatically deleted and data for last seven days should be retained.

It should be possible to downloaded data of at least 24 coach trains without need of laptop. Downloading data should open directly in MS-Office.

All the above parameters shall be displayed by manual selection arrangement on the display unit.

8.2.8 **Hose Proof Test:**

The enclosure of controller shall be protected against ingress of solid foreign bodies and water in accordance with IS: 4691-1985. After these tests the equipment shall work satisfactorily. This shall be conducted in accordance with IP-65 as per IEC 60529 with latest amendment and worked satisfactorily.

8.2.9 **SPECIAL TEST**

8.2.9.1 **Ripple content test**: The voltage and current ripple content in dc output shall not exceed 2% and 10% respectively in the battery charging load and DC output at MFO to 145kmph in steps of 25kmph**.** for 25% load, half load and full load. Ripple content shall be computed from digital storage oscilloscope having interface with the printer/PC. It shall be calculated as under:

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

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

To arrest the ripple, suitable filter circuit may be incorporated in regulator with electronic component of the highest reliability.

8.2.9.2 **SHORTING OF POWER DEVICES:** The Alternator with control unit shall be run at 110kmph at full load with rated voltage. Any of the IGBT/Power diode shall be shorted in running condition. No high voltage should be generated at the output of the controller.

8.2.9.3 **OPENING OF POWER DEVICES:** The Alternator with control unit shall be run at 110kmph at full load with rated voltage. Any of the IGBT/Power diode shall be opened in running condition. No high voltage should be generated at the output of controller.

8.2.9.4 **COMPUTATION OF JUNCTION TEMPERATURE OF SEMI-CONDUCTORS USED IN CONTROL UNIT:**

The junction temperature of power diode/ISO-Packs and auxiliary diodes shall be computed. The temperature of the junction shall not exceed 110 degree centigrade as specified in Specification No. ELRS/SPEC/SI/0015-Oct. 2001. The loading of the various electronic components and other tests shall be as per this specification.

8.2.9.5 **EFFICIENCY TEST:** The efficiency test shall be conducted at the MFO to 145kmph speed in steps of 25kmph at rated load, half load and quarter load for output terminals of control unit. Load versus efficiency curve shall be plotted for different speeds as mentioned above. The efficiency of Alternator and controller taken together at 110 Kmph at full load shall not be less than 85%.

8.2.9.6 Efficiency of alternator shall be measured separately with the help of torque meter and output measurement. Efficiency of control shall be measured by measurement of input and output of controller. Combined efficiency shall be calculated by multiplying the both efficiencies.

8.2.9.7 **OVER CURRENT (SHORT CIRCUIT) PROTECTION**: Short the DC+, DC- and BC+ terminals at the control Unit output. Run the alternator at 110kmph for two minutes and then increase the speed to **145–kmph** and run for two minutes. Run the alternator normally at 145kmph at full load. DC+ and DC- shall be shorted. Indication shall come in CIP. During the test, no damage to alternator, controller or UVC should occur.

8.2.9.8 **FIRE RETARDANT TEST FOR TERMINAL INSULATORS:** The terminal insulators of control unit shall be tested for resistance to spread of flame in the manner given below:

A terminal post insulator shall be subjected to the luminous bat swing flame, preferably supplied by a Bunsen burner. The specimen shall be held 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. Should the specimen get ignited, it shall not continue to burn for more than 50 seconds after the flame has been finally removed.

8.2.9.9 Earth fault test:- Alternator with controller is run at 110kmph at full load. One by one each phase wire coming into controller and going out of the controller shall be earthed with controller body. No effect shall be there on the working of alternator / controller.

8.2.10 **ENVIRONMENT TESTS:** The test shall be conducted on control unit equipment only as per IEC-60571-SECTION FIVE-TESTS", this shall include the following tests:-

a. Temperature rise test (dry heat)
b. Temperature rise test (damp heat)

c. Vibration, shock and bump test.

8.2.10.1 **Dry heat and damp heat test: -** The dry heat and damp heat test shall be conducted on all PCBs as per latest IEC-60571.

8.2.10.2 The control 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

8.2.11 **BURN-IN TEST:**

To ensure the reliability of the components, all the controller cards fitted with components used in the inverter are subjected to 45 Hrs. burn-in tests as per RDSO specification no. ELRS/SPEC/SI/0015 for reliability of electronics used in rolling stock application. Burn-in tests shall be repeated on every 100$^{th}$ cards and records of the tests shall be maintained for all the cards and shall be produced before the representative of the inspecting agency at the time of testing. Also this test may be conducted randomly by the RDSO on the selected cards from the running lot.

8.2.12 **EMI/EMC Test:**

EMI/EMC test shall be conducted as per relevant clauses as mentioned in the IEC 61000 for the following:-

i. RFI RADIATED TEST: as per IEC 61000 – 4 – 3
ii. RFI CONDUCTED TEST: as per IEC 61000 – 4 – 6
iii. ELECTRICAL FAST TRANSIENTS TEST: as per IEC 61000 – 4 – 4
iv. POWER FREQUENCY MAGNETIC FIELD: as per IEC 61000 – 4 – 8

No degradation of the system & malfunctioning shall be allowed during or after the test.

8.2.13 **Total DC isolation test for SMPS**

This test shall be performed by a 500Volts Megger instrument, connecting between DC negative and positive shorted together at one end and UVC, SMPS ground shorted together with all terminals of SMPS together. The minimum permissible insulation resistance shall be more than 20 Mega Ohms.

Note: Test shall be performed during the power off condition.

**8.2.14 OVP Testing for 30 kW Controller:-**

**CONTROLLER SET VOLTAGE:** - 129.5 V, 115 A at alternator speed of 110 kmph.

**OVP SET VOLTAGE:-** 145±1V

| Sl.No. | Load (Amp.) | Speed of testing (rpm) | Condition of Controller | Specified status relay (Tripped/ not-tripped) | Observed status relay (Tripped/not-tripped) | Transient/ Stabilized voltage to be recorded (Volt) | Battery status |
|---|---|---|---|---|---|---|---|
| 1. | 0 | MFO speed | Controller is working normal | Not-tripped | | | Battery not connected at Output |
| 2. | | 110 kmph | | | | | |
| 3. | | 145 kmph | | | | | |
| 4. | 10 | MFO speed | Opening/ Shorting of control | Tripped | | | Battery connected at Output |
| 5. | | 110 kmph | | | | | |
| 6. | | 145 kmph | | | | | |
| 7. | 115 | MFO speed | Opening/ Shorting of control | Tripped | | | Battery connected at Output |
| 8. | | 110 kmph | | | | | |
| 9. | | 145 kmph | | | | | |
| 10. | 230 | MFO speed | Opening/ Shorting of control | Tripped | | | Battery connected at Output |
| 11. | | 110 kmph | | | | | |
| 12. | | 145 kmph | | | | | |
| 13. | Throwing off full load from full load i.e. 230 A to 0 A. | MFO speed | Controller is working normal | Not-tripped | | | Battery not connected at Output |
| 15. | | 110 kmph | | | | | |
| 16. | | 145 kmph | | | | | |
| 17. | Sudden loading from 0A to full load i.e. 230 A. | MFO speed | Controller is working normal | Not-tripped | | | Battery not connected at Output |
| 18. | | 110 kmph | | | | | |
| 19. | | 145 kmph | | | | | |

- During the testing of OVP, the status of static relay (tripping/not tripping) and DC output voltage shall be recorded under the above conditions.
- However, for prototype test machines, the transient/steady state DC output voltage along with rise/fall time shall be recorded using digital storage oscilloscope having suitable interface with PC/Printer for down loading the wave form.
- Battery bank used should be of adequate capacity and the same shall be kept in perfect healthy condition.
- If output voltage increases beyond the set-voltage i.e. 145±1V for 30 kW controller and remains more than 2 seconds it should latch.
- OVP self test button shall be checked by pressing it. Clear indication for healthy and faulty OVP should be there.

8.3 **PRE-COOLING MODE TEST:**

8.3.1 The unit shall include the following minimum protective features in the precooling mode:

- AC MCCB at input side.

- Supply over voltage set at 480±1 V with audio visual alarm.
- Supply under voltage set at 325±1 V with audio visual alarm.
- Output short circuit protection shall preferably be with firing pulse block.
- Over voltage may be set as 140V. Beyond 140V, the unit shall be electrically isolated from the input supply.
- Over load protection and single phase protection.
- Thermal over load of semi conductors and transformers.
- Capacity to withstand input of 510V AC for two minutes without any damage to any part of the unit.
- Complete electrical isolation between input and output

8.3.2 The unit shall have the provision of the following indications in the CIP. Three indications i.e. 'Input AC ON', 'Pre-cooling Unit ON' & Mode of charging shall be provided on 'On Board' display unit through LEDs. Fault shall be displayed with audio signal, if occurred.

| Failure Indication | Other Indication |
|---|---|
| Rectifier Block Fault | Input AC on 3 Phase |
| Firing pulse Block | Pre cooling Unit "ON" |
| Fuse failure (for input fuses | Pre cooling Mode "ON". |
| Earth Fault | Battery charging mode |
| AC Input over voltage | VRLA / Lead Acid battery |
| AC input under voltage | Constant Current charging "ON" |
| | Constant Voltage charging "ON" |

8.3.3 **Performance Test**

Connect the unit to the AC input and record the following parameters at low, nominal and high input voltages of 325 V, 415V and 480 V respectively for 10%, 50% and 100% loads. Record input Watts, input pf, DC output Volts, DC amps, r.m.s & peak-to-peak ripple for voltage and current, % regulation, frequency, firing signals and efficiency in constant voltage, constant current and pre-cooling mode. The value should conform to Clause 7.3 of this specification.

**(i) Constant voltage:**

Set the unit to constant voltage working mode by logging through external key board and set voltage to 2.3V /cell and record parameters as mentioned above for line and load variations at 325V, 415 V and 480V and at 10% load, 50% load, full load.

(ii) **Constant current:**

Set the unit to constant current mode by means of logging through external key board and set the output voltage to 2.3V/cell and load the unit to full rated current. By adjusting the current to set value by logging through external key board, without

disturbing the load, reduce the output current to 80%, 50% and 35% of the rated capacity and record the change in output voltage & current.

Current setting for the input voltage of 325V, 415V and 480 V AC and record the parameters as mentioned above. The variation in set current shall not exceed by ± 1.5 % of the set value. Manufacturers shall endeavor to achieve regulation within ±2%.

**(iii) Deleted.**

8.3.4 **Short Circuit Test**:

**Type test:** Short the output terminals and switch ON the unit at low, nominal and high input AC voltage and measure the short circuit currents. On removal of short, the charger shall start automatically. .

**Routine test**: This test shall be conducted at nominal input voltage only.

8.3.5 **Surge Test:**

**Type test**: This test shall be conducted as per IEC-60571 (clause 10.2.6.2) and record the waveforms through storage oscilloscope.

**Routine test:** Connect the unit to 375 V AC input supply and a fully discharged battery. Immediately, on switching 'ON' of the AC supply, switch 'OFF' and ON the battery for 10 times with interval of 5 seconds between ON and OFF. After the test, check the components for their healthiness.

8.3.6 **DIELECTRIC TEST**:-

When the unit is cold, dielectric test shall be carried out after disconnecting capacitors and shorting power semiconductor devices, primaries of trigger equipment, pulse transformers earthed and disconnecting special card, if necessary, before applying dielectric voltage corresponding to the voltage given below: -

i) 415V AC circuits, 2000V r.m.s, sine wave, 50 Hz for 1 minute.
ii) 110V DC circuits, 1500V rms, sine wave, 50 Hz for 1 minute.
iii) Below 110V DC circuits 1000V rms, sine wave, 50 Hz. for 1 minute.

Test is considered satisfactory if there is no flash over or tripping of dielectric test equipment set at 50 mA leakage current is experienced.

8.3.7 **Insulation Resistance:**

This shall be done with the help of 1000 V megger prior to the starting of all the tests and after heat run. Insulation resistance shall not be less than 10 M-Ohms for all circuits.

8.3.8 **Output Current Limit Test:**

Load the unit at nominal AC input Voltage to its 100% capacity in charging mode and note down DC Voltage and load the unit beyond 100% and record the droop in output voltage.

8.3.9 **Ripple Measurement:**

**Routine Test:** Measure the ripple of the output by using a true RMS multi-meter. It shall not be more than 2% r.m.s of set value for voltage.

**Type test:** The waveform shall be recorded through storage Oscilloscope (having suitable interface with PC or printer for recording the waveform) across precision shunt for 10%, 50%, 100% resistive load at max, min, nominal input voltage. Record r.m.s and peak to peak ripple.

8.3.10 **Endurance test:**

- The unit shall be subjected to test as per IEC60947-1
- The firm shall do rigorous test of the battery charger for minimum 24Hrs. continuously at full load i.e. 130 Amps battery/simulated load and 325V input voltage.

8.3.11 **Power Loss Determination:**

The losses at “No load”, “Light load”, “Full load” and ‘half load’ losses shall be recorded for both complete unit and transformer separately. The efficiency shall be calculated and it shall not be less than 85% at half load and more than 90% at full load for the complete system. The tolerances on losses shall not exceed +10% of guaranteed value.

8.3.12 **Dry Heat and Damp Heat Test:**

The dry heat and damp heat test shall be conducted as per clause 10.24 and 10.25 of IEC60571 on the electronic module.

8.3.13 **Salt Mist:**

Salt mist test shall be conducted as per clause no. 10.2.10 IEC 60571 on the electronic module.

8.3.14 **Efficiency Test:**

The efficiency shall be measured soon after temperature rise test. The efficiency of the unit shall be measured with wattmeter at full and half load at input supply of 415 V, 50 Hz with a resistive load. The efficiency requirement should conform to Clause 7.3.3. The output voltage should also be recorded.

8.3.15 **Temperature Rise:**

The unit shall be loaded to full load current corresponding to 130A DC rating of unit with minimum input voltage of 325V AC at 0.8 power factor. The temperatures rise shall be recorded by temperature recorder having at least 12-14 sensors mounted at the specified reference point on the body of semi conductors, inductors, filter capacitors and other component as agreed between purchaser and manufacturer. The maximum recorded temperature under worst loading condition shall be corrected for 55°c and compared with maximum permissible temperature (the power device at junction). The thermal margin available shall be compared with the safety margin declared by the manufacturer. Under loading condition as specified above, the corrected temperature of the power device shall have a safety margin of minimum 10°C.

Temperature of inductors/high frequency transformers shall not exceed 155°C when corrected to 55°C for "H" class insulation. The unit shall also be subjected for short time rating after continuous loading to ensure the temperature rise is within the electronics devices on the PCBs should not exceed approximately 20°C for industrial grade component suitable for 85°C environment, when measured at half inch away from identified critical components.

.

The temperature rise in the transformer /choke winding also be measured by resistance method.

This test shall be conducted in accordance to clause IS: 2020 at full load with 325 V AC input supply. The pre cooling unit shall be deemed to have reached thermal stability when three consecutive readings of temperature are more or less same. The unit shall be set on pre-cooling mode during this test.

8.3.16 **Trigger Equipment Test:**

The object of this test is to verify that the firing pulses comply with the design and the manufacturers shall furnish the details. The blocking of firing pulses as mentioned in Clause 8.3.1 shall also to be checked.

8.3.17 **Load Break Test:**

A contactor shall be connected in series with the load. After the rated current has been flowing in load for 1 min. the load shall be broken through the contactor. The test shall be repeated three times. No damage shall occur to any part of unit.

8.3.18 **Input Under Voltage Over Voltage:**

The input voltage shall be reduced below 323V and check that unit switches “OFF” and automatically switches “ON” after the input voltage exceed 328 volts.

The input voltage shall be increased beyond 480 V AC and check that unit switches “OFF” above 482 Volts and automatically switches “ON” when the voltage reduces to below 477 V. The input voltage is raised to 510V AC and maintained for two minutes. There shall be no damage of any nature to any of the components of the unit. The unit shall automatically switch “ON’ after the voltage is decreased below the set value.

The design shall incorporate necessary feature of suitable time delay/ hysteresis of 5V to avoid hunting for both under voltage and over voltage tripping.

8.3.19 **Acoustic Noise Measurement:**

The sound pressure level shall be measured in order to ensure that it is not exceeding the limit value of 65 dB (A) at a distance of 1 meter away from the equipment in all the directions. Tests shall be performed at no load, 50% load and full load; however, the manufacturer shall endeavor to reduce the noise level below 60 dB (A).

8.3.20 **Deleted.**

9.0 **MAINTENANCE:**

Firm should submit maintenance manual specifying the minimum maintenance required by the unit. Firm should bring design improvements to reduce the maintenance

requirement further. Bearings of alternator should require greasing after 36 months of service. Maintenance Manual shall be approved by RDSO before given to purchaser by the firm.

10.0 **MARKING:**

10.1 The alternators 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

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

10.2 The serial number of the alternator 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. 12 07 015<br>12 - 2012<br>07 - July<br>015 - Serial No. of machine manufactured in July Serial number of the alternator shall be punched at suspension bracket. | |

11.0 **SAMPLING AND REJECTION**

11.1 The sampling for conducting various tests shall be done as per the following table:

| Classification of Test | Qty. of each type of alternator covered in a purchase order | | | |
|---|---|---|---|---|
| | Qty. upto 49 | From 50 to 149 | From 150 to 299 | 300 and above |
| Prototype | As specified by R.D.S.O. | | | |
| Type | 1 | 2 | 3 | 4 |
| Routine | All | All | All | All |
| Acceptance | All | All | All | All |

Note: Acceptance test will be carried out on 10% of the lot quantity offered by manufacturer for Part.-I / Regular Supplier.

11.2 The rejection procedure shall be adopted as given below.

| Classification of test | STAGE | | |
|---|---|---|---|
| | I | II | III |
| Proto-type | The machines shall not be cleared for regular manufacturing till it passes all the tests. Quantity as specified by RDSO. | | |
| Type | Qty. as per | Twice the no. of alternators | If any alternator fails |

| | | | |
|---|---|---|---|
| | Cl. 13.1 | which failed in any of the tests at stage - I | 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 which failed in any of the tests at stage - I | If any alternator fails in the II stage the entire lot shall be rejected. |

12.0 **Details to be submitted by the manufacturer:**

12.1 The manufacturer shall submit details like make, type, reliability, grade, rating and loading of various Electronic components used in the circuit along with reliability prediction, calculations based on actual loading of various components.

12.2 The manufacturer must submit the following information before manufacturing of prototype unit in printed form and neatly compiled in a booklet form as well as in soft copy.

(a) Clause by Clause compliance to specification.
(b) Detailed specification of the offered Alternator and controller.
(c) Details of protections provided and their effectiveness/proposed set values and range and working principle.
(d) Circuit diagrams along with bill of material and circuit description and working principle.
(e) Safety margins in voltage, current.
(f) Declared output voltage wave-form, power factor and regulation.
(g) Drawings and details of dimensions, mounting arrangement and weight.
(h) Detailed description/explanation of circuit adopted and its salient advantages.
(i) Duty cycle considered for alternator/controller design for continuous and short time ratings.
(j) Service experience for the similar units based on the design offered
(l) Temperature rise of the various components under the most adverse conditions shall also be declared.

13.0 **DRAWINGS & DESIGNS ETC.**

After completion of prototype test manufacturer shall submit following documents in bound booklet in two copies as well as in soft form. 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.
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.

13.1 The following details shall also be submitted:-

i) 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.

ii) Detailed schematic and circuit diagram along with working principle for controller

ii) Dimensioned part drawings with full details of tolerances of dimensions, finish, material specification.

iii) Draft maintenance manual and spare parts.

iv) Shaft stress calculation

v) Bearing life and lubrication interval calculation

13.2 The drawings mentioned in this standard are issued by Research, Designs & Standards Organisation, Lucknow – 226 011. Manufacturer has to comply schedule of technical requirements No. **RDSO/PE/STR/TL/0004-2004 (Rev.1)** or latest, **RDSO/PE/STR/TL/0017-2007 (Rev.0)** and **RDSO/PE/STR/AC/0013-2004 (Rev.0)** or latest**.** 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.

## 14.0 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.

## 15.0 GUARANTEE / WARRANTY

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

15.2 The supplier shall make arrangements for careful study of all units 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.

## 16.0. QAP TO BE FOLLOWED DURING MANUFACTURING OF ALTERNATOR

16.1 The manufacturer shall submit 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.

16.2 The material purchased form 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.

16.3 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.

## 17.0 DESIGN DETAILS OF ALTERNATOR

17.1 Manufacturers shall submit complete detail of components used for alternator along with information as per Appendix/Annexure enclosed before offering the machine for prototype testing.

## 18.0 INFRINGEMENT OF PATENT RIGHTS / ISO 9000 ACCREDITATION

18.1 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 the Alternator 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.

18.2 The firm shall have ISO 9000 accreditation or equivalent certification to ensure its conformance to Quality Systems laid down in the standard for design, manufacturing processes, raw material, testing, quality control at different stages etc.

*****

**Annexure -I**

**Bill of material for 30 KW Alternator**

| S.N. | Description | Specification/IS | Make |
|---|---|---|---|
| 1 | Alternator / axle pulley **** | RDSO Specification No. ELPS/Spec /TL/13 March 1998 | 1) M/s Calcutta Iron Udyog, kolkata<br>2) M/s Vinayak Founders kolkata<br>3) M/s KEL,Kundara<br>4) M/s Rine Engineering Baddi<br>or, other RDSO approved source. |
| 2 | Rubber Pads** | RDSO Drg.No SKEL-4021 alt.2 | 1) M/s Basant Rubber Factory Ltd., Mumbai.<br>2) M/s A.K.Industries, Kolkata<br>3) M/s Manish Rubber Industries Mumbai<br>4) M/s Faively Transport India Ltd., Hosur<br>5) M/s De Engineering Works, Howrah<br>6) M/s M.G.M. Rubber Company, Kolkata<br>7) M/s Elora rubber & Plastic Industries, Kolkata<br>8) M/s. Ray Elastomer, Mumbai<br>9 M/s Swan Rubber Industries, Kolkata |
| 3 | Varnish for VPI | Varnish FT 1052 or 2005/500Ek | 1) M/s Dr.Beck India<br>or, other RDSO approved source. |
| 4 | Ball Bearing / Roller Bearing | -- | 1) M/s. FAG (imported)<br>2) M/s SKF (imported)<br>3) M/s. NSK (imported) |
| 5 | Grease | AP3, RR3 & LL 3 | 1) M/s Castrol<br>2) M/s IOC<br>3) M/s Balmer Lawrie & Co.Ltd. |
| 6 | Silver Brazing electrode | Grade BACuP5 as per IS 2927-1975 | 1) M/s ESAB India<br>2) M/s L & T<br>3) M/s Advani Oerlikon<br>4) Other RDSO approved source. |

**Alternator manufacturer is responsible for ensuring quality of pulleys/Rubber Pads from their sub-vendors as shown above.

*****

**Annexure –II**

Bill of material for 30 KW control unit specifying make of important items

| S.N. | Description | Specification | Make |
|---|---|---|---|
| 1. | ISO Packs bridge / power block diode | | • M/s IXYS<br>• M/s International Rectifier Ltd.<br>• M/s Hind Rectifiers Ltd.<br>• M/s. Semikron.<br>• M/s. Ruttonsha International Rectifier Ltd. |
| 2. | Thyristor | - | • M/s IXYS<br>• M/s. Semikron<br>• M/s International Rectifier Ltd. |
| 3. | Hall Effect Sensor | | • M/s ABB<br>• M/s LEM |
| 4. | LCD Display | - | • M/s. Oriole Electronics<br>• M/s. Lampex<br>• M/s. Noritek |
| 5. | IGBT | - | • M/s IXYS<br>• M/s Semikron<br>• M/s International Rectifier Ltd.<br>• M/s. Siemens<br>• M/s. ABB<br>• M/s. Infineon<br>• M/s. Mitsubishi |
| 6. | Capacitor | | • M/s EPCOS<br>• M/s Alcon<br>• M/s. Kendeil<br>• M/s. Nippon Chemi-Con<br>• M/s. Hitachi |
| 7. | Connector | IP 65 / 68 | • M/s Allied<br>• M/s. Amphenol |
| 8. | HRC Fuse | - | • M/s Cooper Bussman<br>• M/s English Electric Co.<br>• M/s.ABB |
| 9. | Thimble Copper all sizes | - | • M/s. Klipon<br>• M/s. Tyco<br>• M/s. Jenson<br>• M/s. Dowell |
| 10. | Control cables (Sealed Cable) | - | • M/s. Huber & Suhner<br>• M/s. NEXAN<br>• M/s. TEFKOT<br>• Any RDSO approved source |