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भारत सरकार  
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**GOVERNMENT OF INDIA  
MINISTRY OF RAILWAYS**

**SPECIFICATION FOR POWER SUPPLY  
AND ELECTRICS FOR FREIGHT BRAKE  
VAN**

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अनुसंधान अभिकल्प और मानक संगठन  
लखनऊ-226 011.

**RESEARCH DESIGN & STANDARDS ORGANISATION  
MANAK NAGAR, LUCKNOW-226 011**

## **SPECIFICATION FOR POWER SUPPLY AND ELECTRICS FOR FREIGHT BRAKE VAN**

### **0.0 INTRODUCTION**

- 0.1 This specification lays down guidelines for design, development, supply and commissioning of electrics for guard brake van.
- 0.2 The Power supply system for the guard brake van of freight trains shall be generated by a system consisting of either bogie or transom mounted axle driven alternator and static rectifier cum regulator and battery. This system is to provide light and fan facility for the guard in the brake van.
- 0.3 This specification is intended to serve as a guideline for development of 2KW alternator with Rectifier-cum-Regulator for providing 110V DC supply to light and fan load in the brake van of freight locomotive.
- 0.4 The specification has been prepared based on design evolved through M/s KEL. However, after satisfactory performance with M/s KEL electrics, the specification will be later revised to adopt electrics supplied by other reputed suppliers also.
- 0.5 The firm shall commission the brake van power supply system to the satisfaction of the agency nominated by Indian Railways. All the necessary arrangements required for commissioning of the complete system including transportation of the equipment up to designated site, installation on the brake van and testing shall be made by the supplier at it's own cost.
- 0.6 The alternator shall be driven from freight wagon axle through 'V' grooved pulleys and 'V' belts.
- 0.7 The alternator shall work in conjunction with rectifier-cum-regulator unit. The battery shall be connected in parallel to the output of rectifier-cum-regulator unit. The battery shall consist of 54 numbers of lead acid type cells in parallel for supplying loads such as fan, light, etc. The rectifier cum regulator unit shall mainly rectify the three phase AC output of the alternator to DC and regulate the voltage generated by the alternator at set value.

### **1.0 SCOPE**

- 1.1 This specification covers the design, testing, supply and installation of brush-less alternators along with static type regulators and rectifier equipment and accessories for Freight Brake Van for supplying essential amenities viz lighting and ventilation etc. for guards.
- 1.2.1 The alternators are to be supplied as per drawing approved by RDSO/Lucknow.

- 1.2.2 Rectifier-cum-regulating equipment is to be supplied as per drawing approved by RDSO/Lucknow.
- 1.2.3 Schematics, design and ratings of all the other equipment such as light, fan, etc. shall be got approved by RDSO.
- 1.3 This specification shall also apply for procurement of alternators and rectifier-cum-regulating equipment individually. Alternator and regulator when procured separately shall be tested with existing regulator and alternator respectively.
- 1.4 The Scope of supply for the Power Supply System for brake van consists of the following, unless otherwise specified:
- 1.4.1 a) One number 2KW brush-less Alternator type KELA02120.  
b) Alternator Pulley with securing nut and locking arrangements.  
c) Crimping socket for alternator & regulator for outgoing / incoming cable.  
d) The hanger pin to suspend the alternator with safety chains.  
e) Tensioning arrangement, if any.  
f) Axle Pulley and set of rubber pad, fasteners etc. for V-belt driven alternators.

The firm shall submit the drawings and other technical details of all the major equipment to RDSO/Lucknow for approval.

- 1.4.2 Rectifier-cum-Regulating equipment type KELC02120.
- 1.4.3 M/s Exide make lead Acid battery of 20AH, 2 Volts, 54 Nos. cells as per Specification No: IRS.S.88/93.
- 1.4.4 Two numbers of Brush-less DC Railway Carriage fans as per RDSO specification No: RDSO/SPEC/TL/0021/2000 (REV.0)
- 1.4.5 Three numbers of Fluorescent lamps with electronic choke .The firm has to submit drawing for RDSO's approval.
- 1.4.6 Control circuit and power circuit along with protection & indication equipment. A 20A, 110V DC Double Pole miniature circuit breaker (MCB) shall be included in the power circuit to switch ON and OFF the complete system.
- 1.4.7 Mounting arrangement of the complete system.
- 1.4.8 Provision of theft-proof arrangement for all equipment.
- 1.5 QAP of all the major equipment like Alternator, Rectifier cum Regulator etc. and technical details of out-sourced items shall be submitted by the firm to RDSO for approval.

## 2.0 TERMINOLOGY

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

- 2.1 Alternator – an axle driven power – generating machine. It will be either bogie mounted or transom mounted.
- 2.2 Axle Pulley – A pulley fitted on the axle of the freight brake van to drive the alternator by ‘V’ belt.
- 2.3 Alternator Pulley – A pulley fitted on alternator and driven by axle pulley through ‘V’ belt.
- 2.4 Cut-in-speed – The alternator speed in rev./min at which rectified output is 108V at no load.
- 2.5 Minimum speed for full output (MFO) – The minimum alternator speed in rev/min at which it gives full rated output current at rated voltage.
- 2.6 Voltage and Current regulator - A device to limit voltage and current of alternator to pre-set values.
- 2.7 Rectifying equipment - A three – phase full-wave bridge connected assembly of silicon diodes to rectify the ac output of the alternator.

## 3.0 OPERATING CONDITIONS

- 3.1 The complete power supply system for Brake Van shall be required to work continuously at full load under following operating conditions:

Maximum temperature (Atmospheric)	(i) 70 °C (under sun). (ii) 47 °C (in shade)
Minimum temperature (Atmospheric)	-20 °C.
Humidity	Up to 100% during rainy season
Altitude	Max. 1200 meter above mean sea level
Reference site conditions	(i) Ambient temp. 60 °C (ii) Altitude 160 m.
Annual rainfall	Between 1750 mm to 6250 mm.
Dust	Extremely dusty and desert terrain in certain areas. The dust content in air may reach as high a value as 1.6 mg / m <sup>3</sup> .

Atmospheric conditions in coastal areas in humidity salt laden and corrosive atmosphere	(a) Maximum PH value : 8.5 (b) Sulphate : 7 mg / liter. (c) Max. concentration of chlorine : 6 mg / liter (d) Maximum conductivity : 130 micro semen / CM.
Vibration Limits	As per IEC-34 for alternator and IEC-60571.1 (1998 - 02) for rectifier cum regulator.

The Power Supply system for the Brake Van shall be suitable for rugged service normally experienced for rolling stock where locomotives are expected to run up to a maximum speed of 110 kmph in varying climatic conditions existing throughout India. All the electronic equipment and their mounting arrangement shall be designed to withstand vibrations and shocks as specified in IEC-60571.1 (1998 - 02) (second edition). Necessary precaution should be taken against high degree of electromagnetic pollution anticipated in the locomotive

3.2 The alternator and other associated equipment shall fulfill the following broad requirements of service :

- a) High reliability.
- b) Long life with minimum maintenance.
- c) Satisfactory operation for full speed range of freight brake van and to provide full output above MFO speed irrespective of direction of motion.
- d) Suitable for Operations without battery on wagons.
- e) Self existing.
- f) Protected from unauthorized interference and pilferage.
- g) Fully charged battery shall be used up to 16 hours (with load of 2-fans & 3-lamps) after loco shutdown and half charged battery shall be suitable for 8 hours supply.
- h) Suitable under-voltage relay shall be provided in the control circuit that will cut-OFF the battery supply connections to limit the battery discharge voltage to 105 volt when brake van is lying in the yard for some days. This will ensure that at least 8AH (40% of full rated capacity) battery capacity will be available when brake van is again put on line. After that, cut-in for charging can be done once the wagon attains the specified speed. The incoming guard shall be able to switch ON the battery supply on his boarding.
- i) The regulator shall control the output voltage closely around 110 VDC. Output over voltage can occur only in case of malfunctioning of regulator circuit. Therefore over-voltage protection shall be provided with a setting of  $145 \pm 2$  volts which shall cut-off the alternator field supply in order to protect the battery from over-charging and also to

safeguard the connected load. After correcting the problem, normal operation may be possible by resetting the OVP switch.

- j) The Alternator output circuit shall be provided with current limiting facility by which the output voltage shall automatically drop in case of overloading of the alternator for more than 21 A.

#### 4.0 RATINGS

4.1 The standard ratings at the DC output terminals of the rectifying cum regulating equipment shall be –

- (a) 2KW, 17A, 120V
- (b) Rating & type of the fan : Fan shall be brushless DC type having rating of 32 Watts at 110 Volts with 400 mm Sweep.
- (c) Rating of Fluorescent lamp shall be 11 Watt at 110 Volts.
- (d) Minimum rated capacity of the battery shall be 20AH.

#### 5.0 PARTICULARS OF DRIVE

5.1 The mounting arrangements and drive for the alternator shall be as under depending on the type of brake van :

- (a) 2KW Bogie – mounted with V belt drive.
- (b) 2KW transom mounted with 'V' belt driven for BG Coaches.

5.2 The V belt driven alternator shall be suitable for drive from a pulley fitted on the Wagon axle. The layout and mounting details of alternator, regulator and battery box are given in drawing nos. 13-A1005 ALT-1 and 13-A 1034 ALT-3 respectively (attached with this specification) . The standard size of axle pulley for V belt drive and Wagon wheels are given below for guidance.

Gauge mm	Dia. of the wagon wheel (New) (mm)	Dia of Wheels (mm) Fully Worn	Pitch circle dia of axle pulley (mm)
1675	1007	926	572.6

5.2.1. V belt used for the drive shall conform to IS: 6583-1989 with annexure – I

5.3 'V' belt driven alternators shall be transom mounted and shall be suitable for taking drive from 'V' grooved axle pulleys mounted on the axle. Drawing of 'V' belt pulley and detailed calculation shall be submitted by the firm for approval .

5.3.1 'V' belts used for 'V' belt driven alternators shall be of 'C' section size C-122 conforming to RDSO specification No: ELPS/SPEC/TL/04 June 94 or latest.

5.4 The bogie mounting arrangement with axle drives shall be so designed as not to infringe the standard moving dimensions for rolling stock.

- 5.5 Alternator shall be designed to work satisfactorily at 2.5 KW ,which is over load output for a duration of 15 minutes under specified operating conditions.

## **6.0 OUTPUT CHARACTERISTICS**

- 6.1 The cut-in speed of alternator shall be as low as possible consistent with economical design. It shall correspond to a road speed not more than 13 Km/h ie, 250 rev./min. with new wheels. The minimum speed for full output shall not exceed 400 rev./min. in cold conditions of the alternator. The alternator shall be capable of working at maximum road speed of 132 Km/h ie, 2500 rev./min. with new wheels. No negative tolerance is permitted on the voltage and current for measuring cut-in speed and minimum speed for full output. The minimum alternator speed in rev./min. at which it gives full rated current at rated voltage shall be measured. Temperature rise test at MFO shall also be done at this setting. For all other tests specified in the specifications, the settings shall be made at 1500 rev./min., which shall not be changed for meeting any test requirement. The equipment shall be dispatched at 124V setting and half rated current unless otherwise specified by the purchaser. For performance test at any speed a tolerance of  $\pm 5\%$  of the set voltage is permissible.

- 6.2 The alternator output in conjunction with the regulator and rectifier shall remain constant at all speeds above the minimum full output speed. The permissible tolerance on output voltage variation over the speed range from minimum full output speed to the maximum speed shall be within + 5% of the voltage setting with a constant current output of 17A. The maximum limit of the rectifying cum regulating unit shall not be more than 25 Amps.

- 6.3 The efficiency of the alternator and the rectifying cum regulating equipment combined together shall not be less than 85% at full load and 1800 rev. /min.

## **7.0 CONSTRUCTION OF ALTERNATOR AND ITS COMPONENTS.**

- 7.1 The brushless alternator shall be of robust construction and will be suitable for hazards encountered in service, at repair facilities and on shop floor.

- 7.2 The alternator should be able to generate at least 2 VAC (rms) due to residual magnetism, at 250 rev/min for proper functioning of rectifier cum regulator equipment.

- 7.3 The brushless alternators shall not have any winding on the rotor. The winding shall be in the stator and shall be accessible by removing the complete rotor from one end.

- 7.4 The yokes shall be of robust construction so as to withstand the vibrations and impacts normally observed in service without any distortion

- 7.5 The rotor and pulley of the alternator shall be dynamically balanced separately. The permissible residual unbalance shall be less than 1.5gm-cm/kg. at 1500 rev./min. The mating of pulley with shaft shall be 90%
- 7.6 Safety Chains – All alternators for freight Brake Van shall be supplied with complete safety chains. The safety chain shall conform to IS: 2429-1969 'Electric butt welded steel chain short link and pitched or calibrated grade 30 for lifting purposes. The overall factor of safety of the chains shall not be less than 4. The allowance shall be made for the stress in chain due to impact of the falling alternator. The technical details and drawing of the safety chain shall be submitted by the firm to RDSO for approval.
- 7.7 Safety chains fitted on the alternator shall not in any way restrict the scope of its adjustments to provide adequate tension for stretched belt. The clearance maintained from the rail level when the alternator is hanging freely by safety chain shall not infringe with the maximum moving dimensions.
- 7.8 Alternator Pulley – Design of alternator pulley and selection of belts shall be made with sufficient safety margin for supplying of 2 KW power with trouble free long service life with practically no maintenance. The drawings shall be submitted by the firm to RDSO for approval.
- 7.9 Alternator Terminals - The terminal box shall be welded as an integral part of the frame. It shall be located such that the center of the terminal box is in the horizontal plane in line with the center to the axle viewed from the non-drive end. The terminals shall be provided with suitable threaded fasteners in steel zinc/cadmium plated and passivated diameter of not less than 10mm dia for phases and 6mm and 4mm dia for field positive and negative respectively for fixing cable sockets of crimped type.

Copper PVC insulated cables (unsheathed) to IS: 434 shall be used for 2KW brushless alternators. Copper cable of phase wire shall be minimum of 126/0.40 (16 Sq.mm) and field wire shall be 84/0.30 (6 Sq.mm). DC output Aluminium wires from regulator to junction box in the upper frame shall be of size 35 Sq.mm for 2KW.

- 7.9.1 The design shall incorporate terminal block with the following 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 that flow of current through threaded screws and nuts shall be avoided.
  - c) The temperature rise of terminal post shall not exceed 50 °C at continuous rated current.
  - d) Spring washer should be used for fasteners.
  - e) The insulating material used for the terminal board shall be impervious to moisture and resistant to heat & corrosion with long lasting feature. Terminal post shall have through holes up to the edge of terminal board instead of blind hole.



- f) The terminal block shall be fixed with the terminal box with slotted head hexagonal screws instead of counter sunk screws.
- g) The cover of the terminal box shall be with hinged arrangements.
- h) Terminal block assembly on alternator shall be provided with grommets of approved type.
- i) 3 - phase leads as well as positive and negative lead for the field coming out from alternator winding to the alternator terminal board shall be through independent hole for each lead.
- j) The size of the terminal box without cover (Outer) shall be 170mm x 220mm.

7.9.2 Suitable anchoring arrangements shall be made for the main AC Cables to avoid stress coming through the cables at the termination points in the terminal block assembly.

7.9.3 Crimping sockets indicated below shall be supplied along with the alternator. The cable sockets upto 16 Sq.mm shall be of insugrip type, which shall grip the insulation of the cable.

- Socket suitable for 16 Sq.mm copper cable size – 126/0.40 for M10 Stud – 06 Nos.
- Socket suitable for 6 Sq.mm copper cable size – 84/0.30 for (-)ve field terminal for M4 Stud - 02 Nos.
- Socket suitable for 6 Sq.mm copper cable size – 84/0.30 for (+)ve field terminal for M4 stud - 02 Nos.

7.9.3.1 Single core unsheathed flexible copper cable conforming to IS: 694-1990 shall be used from alternator terminal board to the rectifier regulator. The size of cables shall be as given in Clause 7.9.3

7.9.4 The air clearance between un-insulated live parts and body of alternator shall not be less than 10mm all around. The minimum air clearance between the un-insulated live parts shall not be less than 5mm.

7.10 Insulation – The insulation to be used in the alternator winding shall be of class 'F' type conforming to IS : 1271-1958. The insulation scheme shall be submitted by the firm for approval.

7.10.1 Super enameled winding wire conforming to IS: 13730 Part 13 1993 shall be used for field and stator winding coils. The windings wire shall be purchased only from RDSO's approved sources.

7.10.2 The Stator and field windings shall be brought to terminal box by lead wires and bush. These should be indicated in the drawing submitted by the firm.

7.10.3 Connection to the alternator terminal board shall be brought from winding by uninyvin type glass braided flexible cable or silicon rubber flexible glass braided cable having minimum cross-section of 13.3 Sq.mm for phase wire and 3.3mm for field wire (+ve, -ve)

- The flexible lead shall be capable of withstanding dielectric value of 5KV rms for 1min. Silver brazed (minimum 43% silver) fused joints for connecting terminal lead and winding wire shall be used.
- 7.11 For transmission of Power through belts, it is essential that belts are provided with adequate initial tension. While in V belt drive arrangement, initial tension will be provided by suitable tensioning devices. The drawing of tensioning device for transom-mounted 2 KW alternator shall be submitted by the firm to RDSO for approval.
- 7.12 Facilities for checking alignment of alternator with respect to track rails: The alternator shall have necessary arrangements to check its alignment to ensure proper installation.
- 7.13 Bearing and the end shields - The bearing shall be identical for 2KW alternator. The end shields shall be of robust construction. The bearing housing shall be dust proof. The bearing used shall have L10 life of not less than 16 million kilometers at 1500 rev/min. The re-lubrication interval shall not be less than 30 months or 6 lac Kms. which ever occurs first. NU 311 bearings shall be used on drive end and 6309 shall be used on non-drive end. Bearings of RDSO approved sources shall only be used.
- 7.14 Color of alternator & rectifier cum regulating equipment - The equipment shall be finished in the GREY color. Painting should be in accordance with specification and code of practice for raw materials, hardware and anti corrosive treatment of train lighting equipment. The fins of heat sink or regulator may be painted black. The rectifier regulator housing shall be zinc sprayed conforming to IS: 5905.
- 8.0 RECTIFIER CUM REGULATING EQUIPMENT:**
- 8.1 The drawing for housing of rectifier-cum-regulating equipment shall be supplied by the firm to RDSO for approval. The housing shall be water and dust proof.
- 8.2 It is desirable that voltage regulation and current limit with above setting shall be within the specified limits.
- 8.3 The Power diodes used shall have average forward current at 180 degree conduction not less than 26A. The peak repetitive reverse voltage (VRRM) shall not be less than 1200V (PIV). The power diodes shall be with stud cathode only for easy maintenance. Field diodes shall have average forward current at 180 degree condition not less than 12A and the peak repetitive reverse voltage (VRRM) shall not be less than 1200 V (PIV). The field diodes shall be with stud base cathode only for easy maintenance. The threading in power diodes shall be M8 x 1.25 and in field diode (12A rating) shall be M6 x 1.
- 8.4 The output shall be set for full rated current. After making the required setting, tolerance on the marked value shall not exceed  $\pm 5\%$ .

- 8.5 The DC output voltage shall be capable of being set at 120, 122 and 124 volts at 1500 rpm at a reference load of 9 Amp.

Suitable terminals for voltage setting will be brought out and connected to a rotary switch enabling selection of any particular setting. Current setting shall be by means of shunt.

- 8.6 The ripple content in DC output shall not exceed 15%
- 8.7 Current limiting protection device shall be provided to limit output current to the rated value with maximum tolerance of 15%. When current is increased to 115%, the voltage should reduce automatically and it should become difficult to get more than 115% current. For the purpose of testing, 115% current remains for a short time, which may not be indicated by indicating instrument. However, it should be recorded properly by testing authority.
- 8.8 The semi-conductors and other parts used shall conform to “Reliability Assurance Specification for Electronic Components used in Rolling Stock” – RDSO specification No: ELRS/SPEC/SI/0015 of Oct. 2001 unless otherwise approved by RDSO.
- 8.9 Necessary de-rating, screening and quality control of electronic components, resistances and capacitances etc. shall be as per RDSO specification No: ELRS/SPEC/SI/0015 of Oct. 2001.

## **9.0 SAFETY CONSIDERATIONS**

- 9.1 Appropriate warning labels and safety provisions shall be made in all the equipment to prevent direct human contact to any electrical live part or rotating shaft / belt during operation of the system.

## **10.0 WARRANTY**

The complete brake van power supply system (including Alternator, rectifier cum regulating equipment) shall be warranted for satisfactory and trouble free operation for a period of two years from the date of commissioning or three years from the date of supply whichever is earlier. The warranty for battery shall be one year for the date of commissioning or one and half year for date of supply whichever is earlier. All aspects of workmanship and design shall be covered by this warranty excluding all wearing parts which require recurring replacements. A list of such wearing parts shall be furnished in the offer.

## **11.0 SPARES AND MAINTENANCE MANUAL**

- 11.1 A list of spares for the complete brake van power supply system required for a period of 2 years maintenance shall be submitted with the offer in printed form and neatly compiled in a booklet form.

- 11.2 Operating and Maintenance manual of the complete system for routine maintenance & overhaul/test purposes shall be submitted to RDSO for approval. Three copies of the approved operating and maintenance manual shall be given to RDSO/purchaser by the firm. Complete details of installation, maintenance, circuit diagram with voltages at salient points to locate faults, list of components with brief specifications and suppliers, trouble shooting and test procedure after repair shall be supplied. In addition, component handling and precautions to be taken for preventive maintenance shall also be included in the maintenance manual. A lubrication chart shall also be enclosed containing the manufacturer's recommendations on indigenously available lubricants, quantity and periodicity of lubricants etc. Bearings of alternators should require greasing after at least 30 months of service.

## **12.0 INFORMATION TO BE FURNISHED BY THE SUPPLIER**

The tenderer shall submit the technical information with the offer as detailed below:

- a) Technical specifications, test results, ratings, performance data and characteristic curves of all the major equipment such as alternator, rectifier cum regulating equipment, battery, MCCB etc. used.
- b) Circuit diagrams along with bill of material and complete circuit description.
- c) OGA drawings of all the major equipment and details of their mounting arrangement on the brake van.
- d) Declared output voltage, current, power, ripple factor and regulation of the power supply system. Details of cut-in speed of loco, MFO and voltage / current at these operating points.
- e) Details of protections provided and safety margins in voltage, current and thermal (junction temperature for semiconductor diodes) along with limit values for all the major equipment. Details of protection in case of transient / short circuit conditions as well as for battery under voltage (discharging) and over voltage (charging) conditions.
- f) Duty cycle considered for continuous and short time operation.
- g) Details of cooling arrangement used (if any).
- h) Details of switch board and function of each switch and fault indication device.

### **13.0 APPROVAL OF DESIGN / DRAWINGS**

- 13.1 After placement of order, the approval of detailed design and drawings will be advised by RDSO for which detailed design calculations, specification and drawings of various equipment are to be submitted by the tenderer. The comments received from purchaser railways shall also be studied and discussed with RDSO.
- 13.2 Based on provisional approval of design / drawings, prototype unit shall be manufactured after incorporating all the modifications found necessary during inspection / testing without any additional charges.

### **14.0 INSPECTION AND TESTING**

All the major equipment of the prototype power supply system shall be type tested by RDSO at manufacturer's works or at a reputed test facility (to be accepted by RDSO). The manufacturer shall also make all arrangements for testing of the complete brake van power supply system on site to be witnessed by RDSO representative(s). The routine tests are to be carried out by the manufacturer and record kept in proper format. Nominated representative of railways may ask and see the routine test results conducted.

- 14.1 Test program of alternator and rectifier cum regulating equipment is attached at **annexure-A**. The tenderer shall submit a detailed type and routine test plan to RDSO for approval before commencement of the tests. RDSO may also decide to carry out some special tests on the equipment, which are not covered by relevant IEC specifications. Special tests, if required, shall be carried out as per mutually agreed test program and the total cost shall be borne by the manufacturer.
- 14.2 In general, the equipment used in the brake van power supply system shall conform to relevant IEC/IEEE (latest revisions) specifications and the same shall be indicated by the tenderer for each equipment. However, the maximum temperature rise limits specified in these standards shall be reduced by 20° C for the equipment used in brake van power supply system to account for the higher ambient temperatures observed in India. In case any deviation is proposed from the said standards or from this specification, the standards followed shall be clearly indicated by the tenderer.
- 14.3 After successful type test and fitment on the brake van, the equipment will be kept for field trials for a period of one year. All the modifications required due to defects noticed or design improvements found necessary as a result of the test / trial shall be carried out by the tenderer in the least possible time. Total cost of such modifications / design changes shall be borne by the manufacturer.

## **15.0 FAILURES DURING WARRANTY PERIOD UNDER MAINTENANCE CONTRACT**

- 15.1 The complete details of failures, action taken to arrest re-occurrence of similar failure in future, failure analysis report etc. are to be submitted to RDSO and purchaser railways.
- 15.2 In case of repeated failures, necessary changes in design on the units put in service or in production line are to be made by the manufacturer. Investigation tests, if considered necessary, are to be arranged/conducted by the manufacturer.

## **16.0 MARKING AND PACKING**

- 16.1 All the major equipment of brake van power supply system shall bear for identification a serial number and manufacturer's name as well as the ratings.
- 16.2 The alternators shall be provided with suitable nameplates, on which the following shall be marked:
- a) Manufacturer's name and trade mark,
  - b) Month and Year of manufacturer/Batch No.,
  - c) Serial No. of the alternator,
  - d) Capacity of the alternator in KW.
  - e) DC Output voltage and current.
  - f) Rated speed and over-speed range,
  - g) Over-load capacity in KW and duration in sec.,
  - h) Class of Insulation

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

- 16.3 All equipment of the brake van power supply system shall be suitably packed in strong water proof boxes to prevent any damage during transit and handling.

**ANNEXURE - A****TESTS**

The tests as mentioned in subsequent clauses shall generally conform to following Standards :

IEC-60349  
 IEC-60577  
 IEC-61287  
 IEC-60571  
 IS- 4722

## 11.1 Classification and definitions of tests:

## 11.1.1 Prototype Test:

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.
- b) An important change in design of the machine is introduced.
- c) Specification is modified necessitating re-designing of equipment.

The prototype tests shall be carried out at the premises of the manufacturer by RDSO/Lucknow.

The following shall constitute the prototype tests:

- 1) Verification of dimensions and specifications of all assemblies and sub-assemblies including checking of reliability aspects.
- 2) Measurement of stator and field resistances of alternator.
- 3) Temperature rise test of alternator and regulator-cum-rectifying equipment.
- 4) Insulation resistance test of alternator and regulator-cum-rectifying equipment
- 5) High Voltage Test
- 6) Open Circuit Test
- 7) Load Test
- 8) Mechanical Over speed and induced voltage test
- 9) Short circuit characteristic test
- 10) Drooping voltage characteristics test
- 11) Current limiting characteristics of alternator and regulator.
- 12) Over Voltage Protection Test
- 13) Surge Protection Test
- 14) Efficiency Test
- 15) SPECIAL TESTS :
  - i) Ripple Content Test
  - ii) Mating of Pulley with shaft

- iii) Shorting of Power Diode
- iv) Open Circuiting of diode
- v) Computation of junction temperature of semi-conductor etc.
- vi) Checking dynamic balancing of rotor and pulley
- vii) Measurement of MFO (Minimum speed for full output) in cold and hot conditions of alternator.
- viii) Measurement of MHO (Minimum speed for half output) of alternator
- ix) Hose Proof Test
- x) Maximum field current temperature rise test for regulator only.
- xi) Fire retardant test for terminal boards.
- xii) Environmental tests for rectifier-cum-regulator as per IEC: 60571

### 11.1.2 TYPE TEST:

A type test is to be carried out by the manufacturer on alternator / alternators and regulating-cum-rectifying equipment picked up at random at the rate of one out of every fifty numbers of equipment manufactured to ensure compliance with this specification in detail. These tests are to be carried out at manufacturer's premises. This test shall again be conducted once in every five years or at the time of renewal or major design change in presence of RDSO representative without any additional cost. The following shall constitute type tests:

- 1) Verification of dimensions of assemblies of alternator, regulator-cum-rectifier equipment as a whole including checking of reliability aspects.
- 2) Temperature Rise Test
- 3) Insulation Resistance Test
- 4) High Voltage Test
- \*5) Load Test
- \*6) Mechanical over speed and induced voltage test
- \*7) Dropping voltage characteristics test
- \*8) Current Limiting characteristics test
- 9) Over Voltage Protection Test
- 10) Surge Protection Test
- 11) Measurement of Stator and field resistances.
- 12) Measurement of MFO (Minimum speed for full output) at cold and hot conditions.
- 13) Measurement of MHO (Minimum speed of half output).
- 14) Computation of Junction Temperature of semi-conductor devices used in rectifier equipment.
- 15) Shorting of Power Diode.
- 16) Open Circuit Characteristics.

Note: Tests marked as \* are to be conducted in both the direction of rotation.



**11.1.3 ROUTINE TEST:**

The routine tests are to be carried out by the manufacturer at their premises on every alternator and rectifier-cum-regulating equipment manufactured, to ensure compliance with specification declared by the manufacturer and approved by RDSO. The following shall constitute routine tests:

- 1) Verification of dimensions as a whole including checking of reliability aspects.
- 2) Insulation resistance test
- 3) High Voltage Test
- 4) Load Test
- 5) Current Limiting Characteristics test
- 6) Measurement of stator and field resistance.
- 7) Over Voltage Protection/Under Voltage Protection (Only 1 in 20).

**11.1.4 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 of the equipment picked up at random as specified. In addition, the manufacturer shall submit the following test results to the Inspecting Officer at the time of offering the machines for inspection.

- 1) Type Test results
- 2) Routine test results
- 3) Drawing and design booklet approved by RDSO

The inspecting officer can ask for repetition of any/all tests even on more samples as laid down in clause 11.2.1, if it is so desired. However, inspection officer shall witness type test at least on one machine. The following shall constitute acceptance tests.

- 1) Verification of dimensions as a whole and checking of reliability aspects.
- 2) Insulation resistance test
- 3) High Voltage test
- 4) Load Test
- 5) Current Limiting Characteristics Test
- 6) Over Voltage Protection Test
- 8) Measurement of stator and field resistances.
- 9) Dropping Voltage Characteristics.
- 10) Hose proof test.

**11.1.5 REVALIDATION TESTS:**

For renewal of registration of the firm, following re-type test shall be done at firm's premises after five years from previous date of registration / renewal:

- 1) Measurement of stator and field resistances

- 2) Temperature rise test
- 3) Insulation resistance test.
- 4) High Voltage Test
- 5) Load Test
- 6) Mechanical Over speed and induced voltage test
- 7) Over voltage protection test

### 11.1.6 INSTRUMENTS USED FOR TESTING :

The indicating instruments used in electrical measurement shall conform to IS : 1248-1956 (Spec. for Electrical Indicating Instruments). Instruments with the following accuracies or better shall only be used:

- 1) For prototype, acceptance and routine test – instruments of class 0.5 accuracy are required.
- 2) For surge protection test the amplitude and duration of the surge voltage shall be measured by oscilloscope.
- 3) Stator resistance shall be measured by a micro ohmmeter or ammeter - voltmeter method.
- 4) Use of digital type instruments is preferable.

### 11.2 SAMPLING AND REJECTION PLAN:

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

Classification of Test	Qty. of each type of equipment offered for inspection & produced by manufacturer.			
	Qty. Upto 49	From 50 to 149	From 150 to 299	300 and above
a) Prototype	As specified by RDSO			
b) Re-Prototype	- do -			
c) Type	1	2	4	4
d) Routine	ALL	ALL	ALL	ALL
e) Acceptance*	2	4	6	8

\* Acceptance is not mandatory and it depends upon the discretion of the inspecting authority.

11.2.2 The rejection procedure shall be adopted as given below:

Classification	Stage		
	I	II	III
Prototype	As specified by RDSO		
RE-prototype	As specified by RDSO		
Type	Qty. as per Cl.11.1.12	Twice the No. of alt. which failed in any of the tests at state I	If any alt. fails in the 2 <sup>nd</sup> stage, the entire lot shall be rejected
<b>ACCEPTANCE</b>			
a) Visual	If any of the samples selected as recommended Clause 11.2.1 fail , instruct manufacturer to rectify defects so that rest lot is with out defects	Select twice the No. of samples chosen earlier at random and check	If any sample fails in the 2 <sup>nd</sup> stage reject the whole lot.
b) Insulation Resistance Test	If any selected samples as recommended in clause 12.2.1 fails,	Check 100% basis & accept the machines which pass the test.	
c) High Voltage Test	Instruct manufacturer to correct and re-tender the whole lot.	Ask manufacturer to correct the defective machine	
d) Current Limiting Test		Check 100% basis to pass the test	
e) Load test		Machines and re-tender for 100% inspection	
f) Dropping voltage characteristic	If any selected samples as recommended in clause 12.2.1 fails, Instruct manufacturer to correct and re-tender the whole lot.	Check 100% basis to pass the test	

**11.3 Verification of dimensions and specification of assemblies and sub-assemblies.**

This test is to check dimensions of assemblies and specifications thereof to ensure that they are consistent with good engineering practice and where interchangeability aspects with alternator and regulating-cum-rectifying equipment in current use are to be borne in mind. Details of tests/checks shall be prepared by the manufacturer in consultation with RDSO and got approved by RDSO. The de-rating, screening and quality control shall be ensured as per RDSO specification No.: ELRS/SPEC/SI/0015 of Oct: 2001.

**11.4 Measurement of stator and field resistances of alternator:**

Stator and field resistances shall be measured either by voltmeter-ammeter method or 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 manufacturer shall declare the value of the field and phase-to-phase resistances at 20 °C based, on the average of first 10 machines. The resistance of any stator and field winding shall not vary by more than  $\pm 5\%$  from the declared value.

**11.5 Temperature Rise Test:**

The test shall be conducted under the following two conditions separately.

- 1) At minimum speed for full output
- 2) At 2500 rev/min.

The alternator in conjunction with the regulating-cum-rectifying equipment shall be run at rated current and voltage for a period of 24 hours 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 ventilation conditions.

Alternatively an accelerated test for about 3 hours for type testing can be done. For prototype, 24 hours testing is essential. Initially the machine will be run without any ventilation and frame temperature shall be noted. As soon as frame temperature rise is less by 5 °C to the temperature rise observed in 24 hours testing, the ventilation of 6m/sec. for alternator and 4m/sec. for rectifier –cum-regulator shall be switched on. Frame temperature reading shall be taken every 15 minutes till temperature stabilizes as evidenced by three consecutive readings of temperature but not earlier than 3 hours.

Temperature rise of the terminals and frame in case of alternator shall be measured. Temperature rise of stator winding & field winding shall be

measured by resistance method. The temperature rise above the ambient of 50 deg. C shall not exceed the following values:

<u>Class of Insulation</u>	<u>Temperature Rise</u>	<u>Method of measurement</u>
F	100°C	Resistance.

Temperature rise of terminals, frames, etc. shall be as low as possible. The maximum bearing temperature at the highest ambient temperature of 50°C shall not exceed 100°C. The temperature measurement on all locations shall be measured by point contact pyrometers unless otherwise specified.

With regard to regulating-cum-rectifying equipment, the temperature rise of main diodes shall be less than designed temperature limits of each component under worst operating conditions.

While accepting first lot of machines after approval of the prototype, temperature rise test should be carried out on five machines and the temperature rise shall be averaged. This average temperature shall serve as the 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 10°C of the declared Average temperature rise value. If averaging of temperature rise of five machines is not possible due to certain reasons, the prototype test results conducted by RDSO may be treated as "average" temperature rise figure, with prior approval of RDSO for specific period. The temperature rise shall be recorded within 40 seconds of commencement of cooling and successive readings shall be taken at an interval of 20 seconds. A curve shall be plotted in accordance with IEC-60349 to ascertain correct temperature rise by extrapolation.

#### **11.6 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 500V DC Megger and these values shall not be less than 20 mega ohm. For regulating-cum-rectifying equipment the insulation resistance shall be measured with all live parts shorted together and the body.

#### **11.7 High Voltage Test:**

Immediately after the temperature rise test, an ac potential of 1500V rms at 50 Hz shall be applied between all external terminals of the alternator shorted together and the frame for a period of 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 body 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 20mA for the above tests.

### **11.8 Open Circuit Test:**

The alternator shall be run at not less than seven speeds viz. 250, 400, 900, 1500, 1800, 2200 and 2500 rpm 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 of the alternator terminals corresponding to each setting of field excitation shall be measured and curve plotted. Selected speed during the test should be kept substantially constant.

### **11.9 Load Test:**

The alternator shall be run in conjunction with the regulating-cum-rectifying equipment. The test shall be conducted with a resistive load and / or with battery. Preferably this test shall be conducted with a resistive load and a full coach set of battery consisting of 54 cells (each of 2 Volts) lead acid 40Ah capacity. The test shall consist of the following:

- a) No load test
- b) Speed Vs output voltage characteristics at half & full load
- c) Current Vs voltage characteristics

**11.9.1** For no load test the speed shall be adjusted at MFO, 900, 1500, 1800 and 2500 rev./min and corresponding dc voltage available at output terminals of rectifying equipment shall be measured. The voltage variation should not exceed  $\pm 5\%$ . The cut-in-speed shall also be noted in this test. For conducting the no load test, base load of 1A shall be allowed

**11.9.2** Speed versus output voltage characteristic shall be done at full rated current and 50% of full load rated current. The speed shall be adjusted at MFO, 900, 1500, 1800, 2500 rev./min. The voltage shall not vary by more than  $\pm 5\%$ . The minimum speed for full output shall be noted.

### **11.9.3 Current Vs voltage characteristics test**

This test shall be done at full rated output at 1800 rev./min. The current shall be varied from minimum to maximum, after keeping the speed constant. The voltage variation shall be within  $\pm 5\%$ . Current limiting characteristic shall also be checked as specified in clause 11.13.1.

### **11.10 Mechanical over speed and induced voltage test**

This test is to be conducted as soon as possible after temperature rise test or load test while the alternator is still hot. The alternator shall be run for a period of 2 minutes 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

3000 rev. /min. No part of the alternator shall show any sign of damage/deterioration.

#### **11.11 Short circuit characteristics test:**

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 field windings. The test shall be carried out at various speeds covering complete range. The speeds selected for this test shall be same as given for open circuit test, clause 11.8. This test shall be carried out on a cold machine.

#### **11.12 Dropping voltage characteristics test:**

This test is to be conducted on alternator in conjunction with rectifying & regulating equipment, if this facility has been provided in the design of regulating equipment. The purpose of this test is to find out whether battery can be protected against over charging. The voltage setting of regulator shall be 120V & current setting shall be rated current. When the total load on alternator is less than 40%, the preset voltage will be reduced; however the reduction shall not be more than 2 volt. This test can be done at any convenient speed.

#### **11.13.1 Current Limiting characteristic test for alternator and Regulator:**

This test is to be conducted at any speed, which is more than minimum speed for full output. The voltage setting shall be kept at 120V and current setting at full rated current. When current is increased from full rated current value, the necessary drop in set voltage shall be observed to ensure that alternator is protected against over-loading. The increase in current may be in steps of 2A

#### **11.13.2 Over Voltage Protection/Under Voltage Protection:**

Due to component failure / open circuit in regulator, over voltage can occur, therefore, over voltage protection circuit should be provided with no nuisance tripping under no load or when the system running with Conventional lead acid battery connected at output. During sudden throwing of load without battery connected, the over voltage may trip but must reset automatically. Latching of the relay may be achieved under fault condition with battery supply available at the DC output. Suitable time delay (within 3 sec.) may be provided for relay operation so that relay does not trip when load is thrown off suddenly with battery connected. However, the time delay provided should be minimum in order to protect the system under genuine fault condition. The tripping voltage of relay may be set at  $145 \pm 2V$ , which will be verified during type testing. It should be solid state relay only and circuit should use electronic components of industrial grade and reputed make. Over voltage protection shall be tested as per following programme.

Sl. No:	Load	Speed of testing	Condition of RRU	Status of relay	Remarks
1	0 Amp DC	250, 400, 600 1500, 2500 rpm	Control winding Zener intact (RRU normal working)	Tripping/ Not tripping	Transient/ Stabilized voltage to be recorded.
2	1 Amp DC	600, 1500, 2500 rpm	(a) Opening of control winding (b) opening of reference Zener for voltage	- do -	- do -
3	8.5 Amp DC	- do -	- do -	- do -	- do -
4	17 Amp DC	- do -	- do -	- do -	- do -
5	Throwing off 17.0 Amp load to no load	- do -	Control winding Zener intact (RRU normal working)	- do -	- do -
6	Sudden loading from No load to full load	- do -	- do -	- do -	- do -

## Note:

- 1) During the testing of OVP, the status of relay (tripping/not tripping) and DC output voltage shall be recorded under the above conditions. However, for prototype test 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 downloading the wave form.
- 2) OVP shall not trip under condition at item 1, 5 & 6
- 3) Battery circuit shall be kept out of circuit while testing OVP as per condition mentioned at item no: 1, 5 & 6.
- 4) OVP testing as mentioned at S.No:2,3 & 4 shall be done using battery bank of adequate capacity (preferably 20 AH) and same shall be kept in perfect healthy condition.

The under voltage relay shall be provided to protect the battery from completely drained-off in conditions of alternator being standstill for long hours. The setting voltage shall be at  $105 \pm 2V$



**11.14 Surge Protection Test:**

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 rated current output. Then suddenly full load shall be thrown off and the output terminal voltage rise shall be noted. The terminal voltage may rise to any value but it should not damage alternator and regulator-rectifying equipment. Again, only 1A resistive load shall be kept in circuit and balance load shall be suddenly thrown off and output voltage of alternator dropped to normal value.

**11.15 Efficiency Test:**

The efficiency test shall be done by the manufacturer on the prototype machine by separation of losses method at 1800 rpm by dynamometer / direct coupling / V belt drive. The speed Vs efficiency curve shall be plotted at full load (at output terminals of the rectifying cum regulating equipment) and 1800 rev./min, i.e, regulator losses shall also be considered and overall transmission efficiency of the belt drive, alternator and regulator-cum-rectifier equipment shall not be less than 70%. The test shall be conducted conforming to IS: 4889-1968.

**11.16 Special Tests:**

- a) Ripple Content Test
- b) Mating of Pulley with shaft.
- c) Shorting of Power diode
- d) Open circuiting of power diode
- e) Computation of junction temperature of semi-conductor etc.
- f) Checking dynamic balancing of rotor & pulley
- g) Measurement of (MFO) minimum speed for full output in cold and hot conditions of alternator.
- h) Measurement of (MHO) minimum speed for half output.
- i) Hose Proof Test
- j) Maximum field current temperature rise test for regulator only.
- k) Fire retardant test for terminal board.
- l) Environmental test for rectifier regulator.

**11.17 Ripple Content Test:**

The ripple content in the DC output shall not exceed 15% and ripple content shall be computed from oscilloscope measurement as under:

$$\text{Ripple Content} \quad : \quad \frac{V_{\text{Max}} - V_{\text{Min}}}{V_{\text{Max}} + V_{\text{Min}}} \quad \times 100$$

Where V Max       :       Maximum voltage  
       V Min         :       Minimum voltage

This test shall be carried out at 2000 rev./min.

#### **12.16.1 Mating of Pulley with shaft:**

Alternator pulley shall be checked for mating on shaft. The area in contact shall not be less than 90%. The test shall be conducted using plug and ring gauge and Prussian blue as media.

#### **12.16.2 Shorting of Power Diode:**

The alternator with RRU shall be run at 1800 rpm at full load. Stop the alternator, then any one power diode shall be shorted and alternator with RRU shall be run again at 1800 rpm. The preset full load shall be connected across DC output terminal for 2 minute. After the test, no component of alternator or rectifier-regulator shall get damaged. DC output voltage and current shall be recorded.

#### **12.16.3 Open Circuiting of Power Diode:**

The alternator with rectifier regulator unit shall be run at 1800 rev./min and set the full load in three steps. Stop the alternator then any power diode shall be opened and alternator with RRU shall be run again at 1800 rpm at No load for 2 minute & then the full load shall be applied gradually in 3 steps for 2 minutes. After the test, no component of alternator or rectifier regulator shall get damaged. DC output voltage & current shall be recorded.

#### **12.16.4 Computation of Junction temperature of semi-conductor devices :**

The junction temperature of power diodes, auxiliary diodes and transistors shall be computed. The temperature rise of the junction shall not exceed 110 °C

#### **12.16.5 Checking dynamic balancing of rotor & Pulley:**

The dynamic balancing of rotor and pulley shall be checked individually on a balancing machine at 1500 rev./min. The residual unbalance shall not exceed 2.5gm-cm/kg. in any case.

#### **12.16.6 Measurement of MFO at cold & hot conditions of alternator:**

The minimum speed for full output of the alternator both in cold and hot conditions shall not exceed 400 rev./min.

#### **12.16.7 Measurement of Minimum speed of half output (MHO)**

The alternator shall be run at a speed of 350 rev./min. The current at 120V output setting shall be measured. It shall not be less than 50% of rated current. The rev./min at which 50% rated current is available shall also be measured.

**12.16.8 Hose Proof Test:**

The rectifier cum regulator equipment shall be tested for water tightness by spraying water through a water hose for 15 minutes. Rectifier regulating housing shall be checked for water ingress to ensure that there is no water ingress. The test shall be conducted as per IS: 4691-1968.

**12.16.9 Maximum field current temperature rise test:**

The field current is maximum between cut-in-speed and minimum speed for full output. Machine shall be run for 30 minutes at the speed corresponding to maximum field current with maximum load, which it can take without drop in pre-set voltage and without any air-cooling of the equipment. Junction temperature of semi-conductors shall be computed. The temperature rise of the junction shall not exceed 110 °C. Similarly temperature rise of winding of magnetic amplifier will be noted to see that it is below designed limit.

**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:

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

The flame shall be applied to the specimen at the lower side 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 downwards.

Should the specimen get ignited, it shall not continue to burn for more than 50 seconds after the flame has been finally removed.

**12.16.11 Environmental test:**

This test shall be conducted as per IEC-60571. This shall include following tests:

- a) Temperature rise test (dry Heat)
- b) Temperature rise test (damp heat)
- c) Test in a corrosive atmosphere
- d) Combined dust, humidity and heat test
- e) Vibration, shock and bump test.