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No. SPEC/E-11/1/02

RESEARCH DESIGNS AND STANDARDS ORGANISATION

SPECIFICATION
FOR
STATIC BATTERY CHARGER
(IN) For
ac ELECTRIC LOCOMOTIVES

SPECIFICATION NO. SPEC/E-11/1/02
(DRAFT COPY)

NOVEMBER, 1971

SPECIFICATION FOR STATIC BATTERY CHARGER IN AC ELECTRIC LOCOMOTIVES

1 SCOPE

This specification covers the design, manufacture and supply of static battery charger for use on 25 kV, 50 Hz ac, Broad Gauge electric locomotives of Indian Railways.

2 SERVICE CONDITIONS

2.1 The equipment covered in this specification shall be suitable for service in ambient temperatures varying from $0^{\circ}C$ to $55^{\circ}C$ with maximum relative humidity of 100% in altitude upto 1000 metres above mean sea level and in dusty atmospheric conditions.

2.2 The equipment and its mounting arrangement shall be of robust design for traction duty and shall withstand satisfactorily the vibrations and shocks normally encountered in service as indicated below:

a) Maximum vertical acceleration	-	1.0 g
b) Maximum lateral acceleration	-	0.5 g
c) Maximum longitudinal acceleration	-	3.0 g

3 GOVERNING SPECIFICATION

3.1 The equipment shall comply with the latest revision of the International Electro-Technical Commission (I.E.C.) publication No. 146 for battery charger (Thyristor equipment).

3.2 Any deviation from the standard laid down with a view to improving the performance may be given due consideration provided full particulars with their justifications are furnished. No deviation in the specified overall and mounting dimensions shall be allowed.

4 GENERAL DESCRIPTION

4.1 The battery charger shall be of thyristor or magnetic amplifier type and will be used for charging the battery, simultaneously supplying power to the control circuit in the locomotive.

4.2 The battery shall comprise of 50 lead-acid cells connected in series in 10 mono-block units, each unit consisting of 5 cells and shall normally remain floating across the battery charger. The battery shall have 75 Ah capacity at 5 hour discharge rate. The internal resistance of each cell is about 8 to 10 milli-ohms. The control circuit which

will be fed from the battery/battery charger comprises of lamps and inductive coils of relays, contactors and electro-magnetic valves.

5 RATING

5.1 The input to the battery charger shall be at 380 V ± 22½% single phase, 50 Hz. The frequency of ac supply system may vary by ± 5%.

5.2 The charger shall have the following output:

Rated voltage:	110 V ± 1% nominal volts dc adjustable to ± 5% manually by tappings under variation of load current from zero to full load and input voltage from 290 to 460 V. Tappings shall be provided to adjust the voltage in steps of 2½% to ± 5% manually.
Rated current	20 A
Ripples & noise	Ripple not to exceed 1%
Characteristics	Constant voltage characteristics upto 125% of rated current followed by constant current characteristics with steep fall in voltage

6 EQUIPMENT AND DESIGN ASPECTS

6.1 Thyristor or Magnetic amplifier type equipment

6.1.1 Thyristor or Magnetic Amplifier type equipment shall be used for:

i) stabilisation of output voltage, and

ii) control and regulations of load current

6.1.2 For all thyristor and semi-conductor control equipment, the supplier shall furnish the full technical data and design calculations for arriving at the overall circuit performance. Special attention shall be paid to the overload/short-circuit protection and cooling arrangement.

6.1.3 The equipment shall be suitably protected against over-loads and each arm of semi-conductor bridge shall be protected by HRC fuse against short circuit.

6.1.4 Resistance-capacitance network shall be provided as protections for thyristors/diodes against surges (induced or switching surges) originating from the input and output side.

6.1.5 Complete data and characteristics of protective equipment shall be furnished.

7 GENERAL DESIGN ASPECTS

7.1 A general circuit arrangement of ac power supply and dc output is given in RDSO drawing No. SKEL 1540 at Annexure 1. In order to prevent operation ofearth fault relay QOA, it may be necessary to provide an isolating transformer on the input side.

7.2 A blocking diode shall be provided before the output terminal to avoid drainage of the battery into the equipment, when the ac input supply is off.

7.3 Suitable filters shall be provided in the circuit to avoid radio and telecommunication interference as well as to prevent overheating of the battery cells by capacitive currents.

7.4 Provision shall be made for giving visual indication (lamp glowing) on the driver's desk when the battery charger is not functioning. This may be achieved with or without the use of a relay, on the dc output side. The relay, if required, will not form a part of the battery charger. However, suitable terminals with internal connections shall be provided at a convenient location for connecting this relay.

7.5 A suitably calibrated ammeter of moving coil type to indicate the output current shall be provided.

7.6 The battery charger shall be housed as a compact unit in a steel cubicle of robust construction with suitable floor mounting. ~~The overall dimensions shall not exceed the limits indicated in Annexure 2, attached to this specification and the mounting arrangement shall preferably, be as shown in the drawing.~~

7.7 All replaceable parts such as fuses, printed cards etc. shall be of plug-in type and shall be easily accessible from the front.

7.8 Suitable arrangement for lifting shall be made on the battery charger unit.

8 CLASS OF INSULATION

E or B class

9 COOLING ARRANGEMENT

The unit shall be naturally cooled.

10 TEMPERATURE RISE LIMITS

The maximum temperature rise permissible on the windings of the magnetic-amplifier (if used) shall not be more than the values specified below:

E class insulation — 45°C

B class insulation — 55°C

11 TERMINAL BOARD AND WIRING

11.1 The unit shall be completely wired and the terminals brought out to a terminal board located inside the cubicle on the front side. The cables used for internal wiring shall be of tinned stranded copper. Special care shall be taken in the design to provide adequate creepage distance between terminals. The terminals shall be clearly marked for input, output and for relay connections and their arrangement such as to ensure against accidental short-circuiting of input and output terminals. A separate terminal shall be provided for making earth connections.

11.2 All the terminals of the unit shall be brought out on a suitableterminal board. The input and output terminals shall be legibly and indelibly marked on the plate. The terminal arrangement shall be subject to approval of the indenting officer, prior to manufacture.

11.3 Suitable spring washers and nuts for external connections shall be provided on all the terminals including earth terminal.

11.4 All components including bolts, nuts, washers, screws etc. of the unit shall be suitably protected against corrosion and rust.

12 FINISH

The equipment shall be finally finished and painted light grey in colour in accordance with IS: 1650-1960 (Colours for building and decorative finishes).

13 MOUNTING

13.1 Mounting arrangement shall be subject to the approval of the indenting officer prior to manufacture.

14 RATING PLATE

14.1 A rating plate in anodised aluminmum shall be provided in the unit to show the rating, insulation, method of connection with necessary circuit diagrams,etc. The following particulars shall be clearly and indelibly marked on the rating plate:

a) Name or trade mark of the manufacturer

b) Manufacturer's serial number

c) Year of manufacture

d) Rated input voltage/voltage range

e) Rated output voltage/voltage range

f) Tappings

g) Rated current

h) Rated frequency (with permissible variation)

i) Ripple and noise

j) Input power factor (maximum and minimum)

k) Class of insulation

15 DRAWINGS

15.1 ~~RDSO~~ Drawing No. ~~SK-EH~~ (to be supplied by purchaser) ~~Annexure-2~~ giving overall limiting dimensions is attached with this specification.

16 TECHNICAL DOCUMENTS

16.1 The manufacturer shall supply the following technical documents along with supply of first batch of equipments:

		CLW	RDSO
i)	Type test reports	18 copies	2 copies
ii)	Routine test reports along with each unit	4 copies	-
iii)	Maintenance instructions including overhauling procedure, trouble shooting, spare parts catalogue, tools required for maintenance	1 copy with each machine supplied	6 copies

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	CLW	RDSO
iv) Detailed 'as made' or 'completion' drawings with two sets of reproduceable tracings/ prints	6 copies	2 copies

16.2 The technical documents indicated above shall be sent simultaneously to Director General (Electrical)/RDSO, Alambagh, Lucknow-5 and General Manager (D), Chittaranjan Locomotive Works, Chittaranjan with the first batch of equipments supplied.

17 TOOLS

17.1 The supplier shall supply a complete set of tools for maintenance with each batch of 20 sets of equipments supplied. The list of tools to be supplied shall be furnished along with the tender.

18 SCHEDULE OF PARTICULARS

18.1 The schedule of particulars of the battery charger to be furnished with the tender are included in Annexure 3.

19 TESTS

19.1 Tests are classified as type tests and routine tests. Type tests shall be carried out on one equipment for a batch of 20 sets of equipment supplied.

19.2 Type tests

19.2.1 Preliminary checking

Preliminary checking shall be done to check connections and wiring diagram before the following tests are carried out on the equipment:

19.2.2 Measurement of resistance and 50 Hz impedance of the following windings of magnetic amplifier (if used) measured by voltmeter and ammeter method and values recorded:

a) 380 V winding

b) 110 V winding

c) Control winding

19.2.3 Load characteristics including current limitation tests at normal supply voltage and frequency.

	CLW	RDSO
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c) Control winding

19.2.3 Load characteristics including current limitation tests at normal supply voltage and frequency.

19.2.4 Load characteristics at stipulated [illegible] and minimum voltage and frequency.

With the input at nominal voltage and frequency and the rated current maintained at the full rated value, measured by resistance method, the continuous temperature rise of the magnetic amplifier winding (if used), the temperature of magnetic amplifier core, transformer core, heat sink of power diodes and thyristors (if used) shall also be measured by thermometer and recorded when the steady state conditions are reached.

The above tests shall be carried out as follows:

Connect the input of the battery charger to an ac, single phase, 50 Hz supply source. Varisble resistance load of a maximum capacity of 5 kV at 110 V (continuous rated) or a suitable water rheostat shall be connected across the output terminals. Measuring instruments shall be connected to enable various measurements being taken.

Adjust the input voltage to nominal rated value and maintain it constant at this voltage. Vary the load current from zero to the rated value of the battery charger in steps of 4 A. Beyond the rated value the current shall be varied in steps of 1 A until the charger voltage drops to such a value that further increase in load current is not possible. Record the input voltage load current, and output voltage in each step.

Repeat the above test with input voltages maintained at maximum(460 V, ac 50 Hz)and minimum(290 V ac 50 Hz)of the rated values and record the results.

All the above tests shall be carried out with the input to the battery charger at the minimum (47.5 Hz) and maximum (52.5 Hz) of rated frequency also.

19.2.5 Heat run test

With the input at nominal voltage and frequency and the output current maintained at the full rated value, measure by means of thermometer the temperature rise of magnetic amplifier (if used), core, transformer core, heat sink of power diodes and thyristors (if used) and covers in the vicinity of the above at an interval of 30 minutes from the commencement of the test. Continue the test until all the equipments under observation attain steady state temperature. The temperature rise of magnetic amplifier windings shall be measured by resistance method.

iv) Vice-versa of test at (iii) above.

Repeat the above voltage application and observe with 50% rated load on the battery charger.

Record the test voltages and frequencies, the load current, the time taken for stabilization of output voltage oscillographically.

19.2.9 Insulation resistance test

The insulation resistance between

i) Input terminals and earth (cubicle frame)

ii) output terminal and earth, and

iii) input and output terminals

shall be measured using 500 V megger. The resistance measured shall not be less than 5 meghom.

19.2.10 Dielectric test

A test voltage of 2 kV (rms), 50 Hz shall be applied for a duration of one minute between (i) input terminals and frame (ii) output terminals and frame, when the battery charger is hot. The equipment should withstand the voltage for the specified duration.

Immediately after the dielectric test check the insulation resistance of the battery charger using a 500 V megger and record the values obtained.

19.2.11 Ripple content in the output voltage

Check the ripple content in the battery charger output voltage by means of oscilloscope (preferably double beam) with the input supply at nominal voltage and frequency. The ripple content should not be more than the specified value of 1%.

19.2.12 Surge test

With the input open circuited, an ac voltage of 280V, 50 Hz shall be applied between the output terminals of the charger instantaneously and switch off. Three such switches shall be repeated as quickly as possible. After the tests, various diodes, thyristors, transistors shall be tested for normal duty.

19.2.13 Inspection and weighing

The unit shall be subjected to a thorough inspection after the above tests for any abnormalities. The complete assembly in working order shall finally be weighed.

19.3 ROUTINE TESTS

19.3.1 Load characteristics including current limitation tests at normal supply voltage and frequency.

Same as 19.2.3

19.3.2 Load characteristics at stipulated maximum and minimum voltage and frequency.

With the input at nominal rated voltage and frequency the test shall be carried out as per clause 19.2.4.

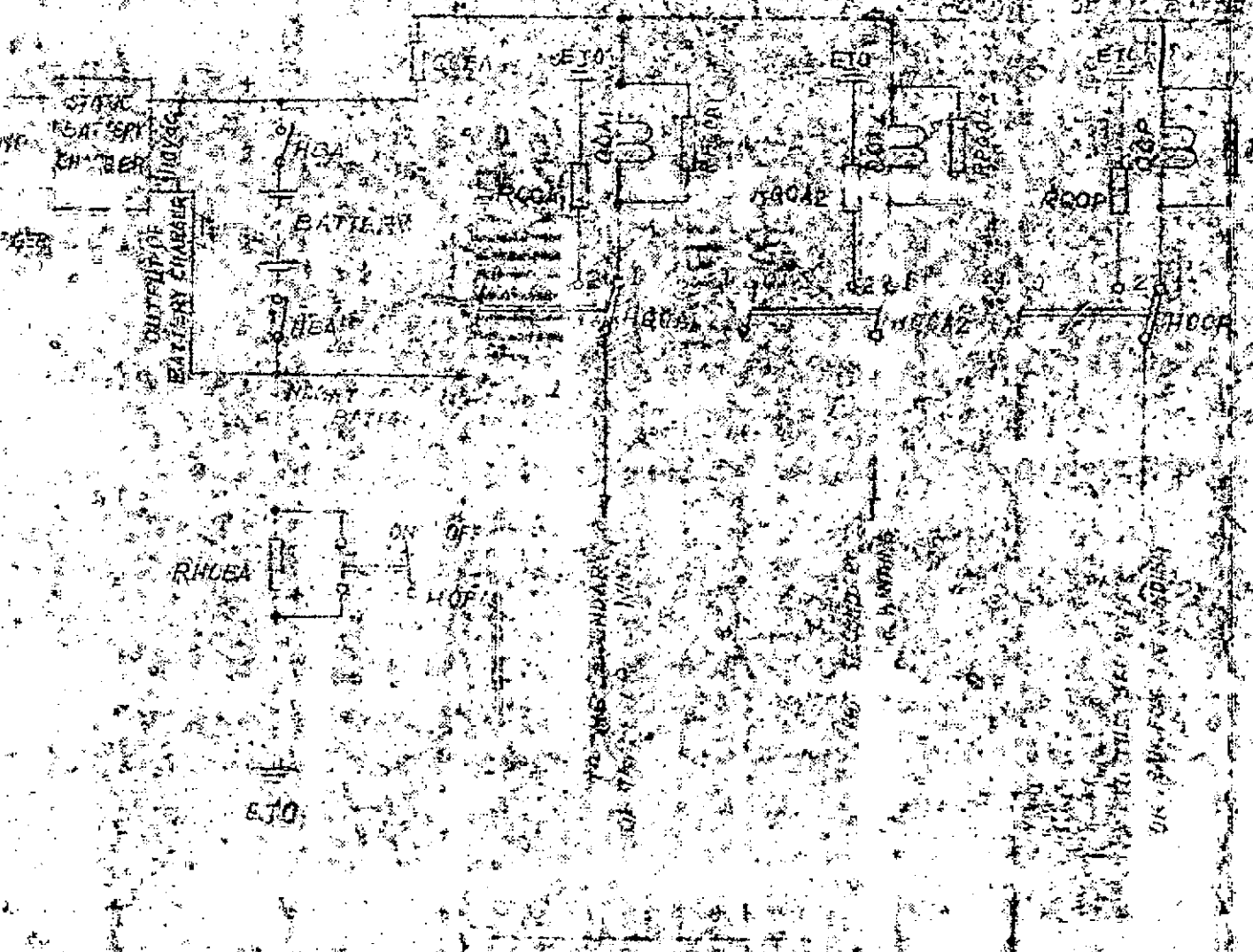
19.3.3 Insulation resistance test

This test shall be carried out as per clause 19.2.9.

19.3.4 Dielectric test

Same as type test 19.2.10 but immediately after the load characteristics test.

ANNEXURE-1



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Annexure - 3

Schedule of guaranteed performance, technical and other particulars.

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1 Name of the manufacturer

2 Type, make and model

3 Standard specification on which the performance data is based

4 Continuous maximum rating for specified cooling, temperature rise and ambient temperature

5 Number of phases

6 Volts: Input, Output (range of variation)

7 Full load current; input, output

8 Continuous and overload ratings and input power factor

9 Class of insulation and its details with drawings

10 Method of ventilation

11 Maximum temperature rise in windings (of magnetic amplifier, if used)

12 Maximum temperature rise at the junction (of thyrister, if used)

11 and 12 should be done by means of resistance method specified in test of this specification, over maximum ambient temperature of $55^{o}C$

13 Maximum temperature rise of the core (of magnetic amplifier, if used)

14 Efficiency at full load at nominal supply voltage of 380V.

15 Winding data (of magnetic amplifier if used)

a) Type of winding

b) Number of turns of

i) 380 V winding

ii) 110 V winding

iii) Control winding

c) Winding conductor size of (b)

d) Insulation covering on conductors

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(Indicate the specification to which they comply)

e) Type of jpints in the winding, if any

f) Resistance of windings at 20°C

i) 380V winding

ii) 110V winding

iii) Control winding

g) Details of varnish for impregnation and impregnation procedure.

h) Insulation resistance of windings

i) 380V winding

ii) 110V winding

iii) Control winding

16 Core data

a) Maximum flux density in core (furnish magnetization curve)

b) Thickness of iron stampings

c) Insulation between core laminations

d) Type of joints between core, limb and Yoke

e) Number of stampings of each type

17 Data of thyrister to be furnished,(if used)

1. Type and make

2. Forward off-state Voltage V D

3. Breakover voltage V BO

4. Holding current I H

5. Latching current I HD

6. On-state current iF, I FAV

7. On-state voltage V F

8. Nominal average on-state current I FN

9. Limiting average on-state current I FAVL

10. Maximum allowable rms on-state current I FRMSL

11. Limiting repetitive peak on-state current I FRL

12. Forward overload current, intermittent operation I FINT

13. Forward overload current I F(ov)

14. Limiting forward overload current I F(ov) L

15. Surge current I FSL

16. Pt rating

17. Limiting repetitive peak forward off-state voltage V DRL

18. Maximum forward off-state transient voltage V DSL

19. Reverse current iR

20. Reverse voltage VR

21. Limiting repetitive peak reverse voltage VRRL

22. Maximum reverse transient voltage VRSL

23. Gate trigger current I GT

24. Maximum gate trigger current I GTHS

25. Minimum gate trigger pulse duration

26. Trigger pulse generator data

27. Gate trigger voltage V GT

28. Maximum gate trigger voltage V GTHS

29. Minimum gate trigger voltage V GDLS

30. Extended gate input characteristic curves and limiting peak gate power dissipation

31. Gate controlled turn-on time 1 gt

32. Gate controlled delay time 1 gd

33. Gate controlled rise time 1 gr

34. Circuit commutated turn-off time I q

35. Reverse re-carry time

36. Maximum allowable rate of rise of applied forward voltage (dvd/dt) max

37 Maximum allowable rate of rise of forward current (dif/dt) max

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38. Off-state losses P D, PR

39. Gate losses P G

40. Switching losses PT

41. Forward on-state losses, PF

42. Junction temperature T j

43. Case temperature Tc

44. Temperature of cooling medium T A

45. Current rating versus temperature

46. Operating temperature range

47. Storage temperature range

48. Thermal resistance Rin

49. Thermal resistance, junction to case R in jc

50. Thermal resistance case in cooling- medium Rin CA

51. Thermal resistance, junction to cooling-medium Rin JA.

52. Mounting torque in kg-m

53. Weight in kg of a) Cell
b) Case or heatsink

18 Characteristics of thyrister cells

1. Forward on-state characteristic: Instantenous forward on-state voltage.

2. Forward on-state losses versus forward on-state current

3. Maximum allowable case temperature versus limiting average on-state current.

4. Maximum allowable cooling medium temperature versus limiting average on-state current with natural cooling and forced cooling.

5. Maximum allowable forward on-state current during intermittent operation versus duty ratio with natural cooling and forced cooling.

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6. Overload characteristics: Forward overload current versus time with natural cooling and forced cooling.

7. Transient interval thermal resistance versus time.

8. Total thermal resistance versus time.

9. Temperature dependent gate characteristics and gate input characteristics.

10. Maximum reverse recovery charge versus rate of decay of the forward on-state current.

19 Protective fuse characteristics

20 Data of thyrister assembly

1. Number of cells in series in each string.

2. Number of strings in parallel per arms.

3. Number of cells per rectifier unit.

4. Total number of cells.

5. Detailed characteristics of protective devices against overloads.

6. Devices used for protection against surge voltages.

7. Device used for checking defective cells in the rectifier.

8. Diagram showing connections between cells in each cubicle.

9. Cooling system (rating and characteristics of blower assembly) for operating motor voltages - 296, 380 & 465 V.

10. Characteristics and type oof the protective relay to indicate blower failure.

11. Weight of complete equipment with its auxiliaries.

21 Design calculations

1. Detailed calculations with the number of cells in series and in parallel.

2. Calculations of the number of cells in series based on

a) repetitive voltage
b) switching surge
c) lightning surge.

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3. Calculations of number of cells in parallel based on

   a) starting current
   b) circuit current

22 Type and particulars of terminal box and cable entry (furnish drawing).

23 Type, make and model of capacitors

24 Type, make and characteristics of transistors (if used) in the regulating circuit

25 Type and make of resistances

26 Manufacturers'/suppliers' name for 23,24 & 25

27 Rating of capacitors and resistances

28 Performance test certificate for capacitors

29 Dimensions of the assembled unit

   i) from base to top most point

   ii) overall breadth

   iii) overall length

30 Total weight of the unit in kg

31 Details of proposed mode of packing

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Annexure - 4

1 Test for withstanding vibration and shock

1.1 Conditions to be satisfied

The complete assembly shall be able to withstand without deteriorating the following tests:

1.1.1 In each of the 3 directions, viz., vertical, longitudinal and transverse sustained sinusoidal vibration in the frequency range from 1 to 50 Hz having amplitude given by the following equations

$$a = \frac{25}{f} \quad \text{for values from 1-10 Hz}$$

and $$a = \frac{25}{f^2} \quad \text{for values from 10-50 Hz}$$

1.1.2 In the direction corresponding to the longitudinal movement of the vehicle, shocks producing maximum acceleratic of 3.0 g (g being the value of acceleration due to gravity).

1.1.3 In addition, the units and accessories of the resistors shall not exhibit harmful reasnance for the frequency in the above range.

1.2 Method of testing

The equipment is secured in a convenient position to a machine producing sinusoidal vibrations with adjustable amplitude and frequency and is then subjected to the tests described in paragraphs 1.3 to 1.5.

1.3 Determination of resonant frequency

1.3.1 In order to determine the possible existence of critical frequencies producing resonance, the frequency shall be varied progressively over the whole range of 1 to 50 cycles within a time of not less than 4 minutes, the amplitude of the oscillations being that indicated as a function of the frequency.

1.3.2 If resonance is produced, the corresponding frequency shall be maintained for a few minutes in each case with the apparatus alive. A check shall be made that no ill effects result on the operation ofthe apparatus (the dropping out of any part of the equipment, sparking at the contacts, temperature rise etc.).

1.4 Tests with sustained vibration

1.4.1 The equipment at no load is subjected to a test with sustained vibration for a period of 20 minutes when cold and afterwords for 20 minutes when hot (1) either at the critical frequency if any such well defined frequency has been

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established in course of previous test (2) otherwise at a frequency of 10 Hz.

1.4.2 In both the cases the amplitude of vibrating table is adjusted to the value corresponding to frequency concerned.

1.4.3 The test is considered to be satisfactory if there is no resulting damage or out of course operation.

1.5 Tests to simulate the effect of shunting shocks

In the direction corresponding to the longitudinal movement of the vehicle on which it is to be mounted, the equipment while hot is subjected for 2 minutes to 50 Hz vibration of such a nature that the maximum acceleration is equal to 3 g.

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Annexure - 5

Special instruction to Tenderers to be included suitably in the Tender Papers to be issued to prospective Tenderers.

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1 The tenderer should be asked to submit his tender in six copies. Each copy of the tender should be complete in all respects. Thecopies should be marked "Original", "Duplicate" and so on. All copies of the tenders shall be exact replica of the original in all respects.

2 Drawings required to be submitted by the Tenderer with the Tender

i) General outline drawing ofthe proposed static battery charger and its mounting arrangement.

ii) Circuit diagram of the battery charger with all its associated control circuit and regulating circuit diagrams.

iii) Schematic diagram of the static battery charger.

iv) Drawing indicating complete insulation particulars on the static battery charger.

3 APPROVAL OF SAMPLES

3.1 The supplier shall make ready at least two prototypes of the equipment for inspection and tests at his Works and when ready, advise Director General (Electrical)/RDSO, Alambagh, Lucknow-5.

3.2 The supplier shall provide all facilities to the Inspecting Officer of RDSO to inspect and test the equipment at various stages of manufacture and also the complete equipment at his Works. Necessary testing and measuring apparatus for carrying out the tests at manufacturing place shall be provided by the supplier.

3.3 If it is considered necessary by the representatives of Director General (Elec)/RDSO, Alambagh, Lucknow-5 to carry out any further tests or trial on the prototype at RDSO, the supplier shall arrange to send the equipment by the quickest means.

3.4 Improvements suggested after the tests shall be incorporated in the bulk supply without affecting the guaranteed deliveries.

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3.5 Notwithstanding the fact that the design, working drawings etc. prepared by the supplier have been vetted and the testing and approval of the prototype has been done by the purchasers' nominee, this shallin in no way relieve the supplier of his responsibility under the terms of the contract for faulty design, defective material, workmanship, etc.

3.6 No equipment of series production shall be offered to the Inspector authorised under the contract until the prototype has been finally approved.

3.7 The prototype static battery charger should be ready within months after the issue of the Letter of Acceptance of Tender.

4 MAINTENANCE SPARES

The manufacturer should be asked to furnish the list of maintenance spares required for two years, indicating cost of each item, along with the tender. The supplier should supply the agreed maintenance spares with each batch of 20 sets of equipments supplied.

5 CONDITIONS OF CONTRACT

5.1 Guarantee

5.1.1 The supplier shall give a guarantee of clear 12 months on all components of the equipment from the date the equipment goes into service. The date of commissioning the locomotive shall be deemed as the date of the equipment going into service. Any damage or defect noticed during this period due to defective design/material/workmanship shall be replaced by the supplier free-of-cost.

5.1.2 The supplier shall send a representative for the investigation of the cuase of the failure of the equipment to the place (any where on the Indian Railways) where the equipment is in service. Any modification or improvement thought of shall be incorporated in the design only after the approval of Director General (Elec)/RDSO, Lucknow. All modifications/repair work shall be attended to at great speed. The supplier shall keep adequate spares of both the components and their complete unit so that while attending to the defects, the locomotives are not unduly detained.

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