

**Specification No. ELRS/Spec/RSI/0030**

GOVERNMENT OF INDIA  
MINISTRY OF RAILWAYS



SPECIFICATION FOR  
COMPACT DESIGN OF  
UPRATED SILICON RECTIFIER  
FOR  
AC SINGLE PHASE LOCOMOTIVE

DEC - 2003

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## CHAPTER 1- GENERAL

### 1.0 SCOPE & OBJECT:

This specification covers requirements of silicon rectifiers with associated protection and other accessories for 25 kV, single-phase ac, 50 Hz Electric Locomotives. These rectifiers convert ac supplies to dc for feeding power to dc traction motors on locomotives.

Two single-phase full bridge diode rectifiers are used in the locomotive, each feeding to three traction motors connected in parallel. There are two traction windings in the locomotive transformer feeding to one block each and output of each of rectifier block is fed to TM through smoothing reactor provided to filter the ripple content.

### 1.2 CONTRACTOR'S RESPONSIBILITY

The contractor's responsibility will extend to the following:

- 1.2.1 Supply of detailed instruction for installation of the equipment on the locomotive.
- 1.2.2 Commissioning, testing & field trial of the prototype equipment in service and deputing team of engineers for this purpose. The supplier shall arrange to carry out detailed test & field trial jointly with CLW/RDSO.
- 1.2.3 The design shall be developed as per requirement given in the specification. The detailed design shall be submitted to RDSO for scrutiny and approval before commencing the manufacturing. Here "approval" means the "approval of design features" only. The suppliers shall be responsible for performance of complete system.

#### 1.2.4 Warranty

The supplier shall warrant that everything to be furnished hereunder shall be free from all defects and faults in material, workmanship and manufacture and shall be of the highest grade and consistent with established and accepted standards of material of the type ordered and in full conformity with specifications and drawings. The supplier shall be responsible for any damage to equipment provided in the locomotive due to defective design, materials, workmanship up to a period of 30 months after commissioning on the locomotive or 36 months from the date of supply, whichever is earlier. The period of warranty will be extendable in case of recurring problems attributable to defective design, material or manufacturing. The supplier's liability in





the respect of any complaints, defects and /or claim shall be limited to the furnishing and installation of replacement parts free of any charge. In respect of silicon diodes, the guarantee shall be 60 months from the date of commissioning or 66 months from the date of dispatch, whichever is earlier.

- 1.2.5 The supplier shall be responsible for carrying out all the modifications required for satisfactory operation of the equipment as per technical specification at his own cost on any part of the equipment during the period of warranty. For any technical decision the final authority from the purchaser's side is RDSO.

### 1.3 Railways' Responsibility

Railway will be responsible for followings:

- 1.3.1 The cabling required in loco.
- 1.3.2 Labor, consumables and electrical energy required for erection, testing & commissioning of rectifier will be provided by Indian Railways, free of cost.

### 1.4 Reference to various specifications

1. IS: 7788-1975 Specification for single phase Traction Power converters
2. IS: 10192-1982 Specification for synthetic Resin banded glass fiber (SRBCF) sheets for electrical purpose.
3. IS:1367-1991 Technical supply condition for threaded steel fasteners.
4. IS:9000-1977 Basic environmental testing procedures for electronic and electrical equipment.
5. IS:2705- 1992 (Part 1 to 3) Current Transformers.
6. IEC-61287-1995-07 Power converters installed on board rolling stock: characteristics and test methods.
7. RDSO Spec no. ELRS/SPEC/SI/0015 for "Reliability of Electronics used in Rolling Stock application".
8. IEC-310 (1991) – Rules for traction transformer & reactor.
9. CLW Spec no. E-5/1/01 – Specification for damping condensers for rolling stock.
10. CLW Spec no. CLW/ES/T-4/A – Specification for Current Transformer
11. IEC 60571 (1998) – Electronic equipment used on rail vehicles.

### 1.5 Documentation

The tenderer must submit the following information with the offer in neatly compiled, booklet form. Offer with incomplete information may not be considered.



- a) Detailed design of the offered rectifier, major equipments like ac & dc damping circuit & fuses, bill of material, data sheet etc as per details listed at Annexure-IV.
- b) Detailed operation of panel and function of each switch, indications and fault diagnostic feature.
- c) QAM (Quality assurance manual)
- d) ISO 9000 certification - Railways reserves the right to procure the item from ISO certified manufacturers only.
- e) Details of infrastructure, manufacturing and testing activities in line with guidelines issued vide RDSO spec. No.ELRS/SPEC/SI/0015

#### 1.6 Infringement of Patent Rights

Indian Railway shall not be responsible for infringement of patent rights arising due to similarity in design, manufacturing process, components used in design, development and manufacturing of rectifier and any other factor, which may cause such dispute. The responsibility to settle any issue lies with the manufacturer.

#### 1.7 Terminologies Used

Terms/abbreviations used frequently in the document are explained here:

1. MVS1 : Motor for silicon rectifier cooling blower
2. RSILM : Current transformer for silicon rectifier.
3. QVSI : Vacuum relay used for indicating airflow to rectifier.

#### 1.8 List of enclosures:

1. Annexure -I: Reliability assurance specification.
2. Annexure -II: Quality assurance testing of diodes.
3. Annexure-III: List of approved supplier for various items used on RSI block.
4. Annexure- IV: Technical data to be furnished by the tenderer.





## CHAPTER 2 – TECHNICAL SPECIFICATION

### 2.0 GENERAL

- 2.0.1 Each locomotive shall have two-bridge connected rectifier cubicles. Each rectifier cubicle shall be fed from separate winding of main transformer. Its DC output will be fed to 3 Traction Motors connected in parallel through a smoothing reactor provided on locomotive in series to it.

The over voltage and over current protection for each rectifier bridge have been provided in the locomotive. Besides, thermal protection as well as monitoring of proper ventilation will be part of equipment protection. In case of rectifier ventilation failure the driver will be alarmed and defective rectifier cubicle shall be isolated through motor contactors if the temperature of devices increase beyond permissible limit and the locomotive operation shall be maintained with three traction motors isolated.

- 2.0.2 a) Any deviation from the specification can be considered with a view to improve the performance, utility and efficiency of the equipment if tenderer furnishes full particulars with details. However due to limited availability of space on locomotive no increase in overall dimensions and mounting arrangement be allowed.

- b) Input to blower motor:

Blower motor for ventilation of silicon rectifier shall be fed from Arno or static converter. Arno 3 phase output supply may vary from 320 to 500V with nominal voltage of 415V. Voltage may drop to 255V for short duration in emergency conditions. The 3-phase output of the Arno converter has an unbalance factor of 5%.

- c) The supply for control circuit is from a battery of nominal 110V dc with a range of variation from 70 to 125V dc.

### 2.1 Technical requirement

#### 2.1.1 Input:

- a) Each rectifier is fed from separate traction winding of Nominal Voltage=1000 Vrms.
- b) No load secondary winding voltage based on 30 kV catenary's voltage = 1334 Vrms.

- 2.1.2 Technical requirements for each block connected to three traction motors in parallel of a bogie is given below:



A	Systems of connections of diodes	Bridge
B	Surge voltage protection level	3.7 kV
C	Direct current rating of rectifier with all bridges healthy with blower.	4050A -- 5 min. 3150A -- 10 min. 3300A -- Cont.
D	DC rating of rectifier bridge with all bridges healthy without blower motor for minimum period of 30 minutes.	2700 Amps.
E	Design short circuit capacity corresponding to traction motor flashover not less than (This corresponds to N-1 condition)	36.65 kA (Asymmetric) for 100ms during continuous loading of 2700A with asymmetric factor of 1.6.
F	Design short circuit capacity corresponding to short circuit within rectifier before smoothing reactor. (This corresponds to all devices being healthy)	60 kA for 10ms during continuous loading of 2700A.
G	Duty cycle with N-1 devices in service (Rectifier provided with N devices in parallel should perform normally with one device in parallel isolated).	2700A -- Cont. 0A -- 1 min. 4050A -- 2 min. 3600A -- 7 min. 2880A -- 1 hr. 2700A -- Cont.
H	Noise level at 1 meter from the equipment shall be less than	85 db

### 2.1.3 Cooling System

Recommended cooling air velocity (All design calculation shall be based on this cooling air velocity only.)	6 m/Sec
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The tenderer will specify the quantity of air volume for the design offered.

## 2.2 General design feature

2.2.1 Materials/Components to be used in the manufacture of the unit shall comply with the latest Indian Standards Specification.

2.2.2 Tenderer should offer proven devices and design for rolling stock application.



### 2.2.3 Safety factor

- a) Preference will be given to offers involving minimum number of devices with adequate current and voltage-rating margin. **Devices in series connection are not acceptable.**
- ✓ b) Current unbalance of 10% for less than 5 diodes in parallel and 15% for 5 and more diodes in parallel will be assumed for current rating of devices.
- c) The rectifier shall be liberally designed for voltage and current ratings specified above. However the VRRM of diode shall not be less than 4.3 K V.
- d) Maximum junction temperature of diode on worst service condition shall have a thermal margin of 10°C over the declared junction temperature of the diode.

2.2.4 The diode matching components, i.e. resistor, capacitor, fuses etc. shall match with the device rating and not just with normal rated service conditions. In case of single diode per string, cell damping or D.C damping unit may be offered. The RC damping network and surge arrester or voltage limiter shall clamp the voltage well below the rectifier voltage rating. The firm should submit calculation to indicate the clamping voltage.

2.2.5 All electrical connections, including those of diodes, its associated components etc. shall be of high quality using crimped terminals, standard lugs, nuts, bolts, plated spring steel washers to ensure good electrical connections and facilitate maintenance.

2.2.6 The ac bus bars and dc bus bars shall be diametrically located with adequate electrical clearance. The height of the bus bar terminations will be kept at a height of 300 mm from bottom. Hole of 18mm dia will be made for external connection at height of approx 335 mm from bottom. The location of isolating links in ac bus bars shall be easily accessible.

2.2.7 All wiring shall be done with high quality multistrand Copper wires/cables with PTFE or elastomeric insulation and shall be separately laid for power, auxiliary and control circuit according to high, medium and low voltages. The wires shall be numbered at both ends according to wiring diagram and terminated at suitable terminal board for easy connections.

2.2.8 All the equipments, insulators, cables, fiber glass etc. used for fabrication of rectifier cubicle shall be with suitable insulation level for traction application and shall be able to withstand high operating temperatures, vibration etc. without any deterioration.



- 2.2.9 The current density in cable and bus bar etc. shall be kept reasonably low so that the temperature under working conditions does not exceed the normal limits. The recommended maximum limit of current densities is  $2.5\text{A/mm}^2$  for cables and  $4.0\text{A/mm}^2$  for bus bar/links for ambient temperature of  $55^\circ\text{C}$ .
- 2.2.10 Adequate clearance and creepage distance shall be maintained in the cubicle layout to avoid internal flashover. Generally clearance through air should not be less than 40mm and creepage distance along the surface should not be less than 70mm.
- 2.2.11 Dust proof cover shall be provided for the program switch.
- 2.2.12 Insulating boards used shall be made out of EP3 grade (IS: 10192 of 1982.) glass fiber reinforced sheet minimum 3 mm thickness for covers and 10 mm for ac/dc damping board.
- 2.2.13 The indicating devices provided on the cubicle shall be clearly visible from the vehicle corridor and functional switches, push buttons and pacco switches etc. shall be easily accessible for operation.
- 2.2.14 In addition to the above, tenderer shall specifically confirm the features given in the "Reliability Assurance Specification" forming as Annexure-I of this specification.

### 2.3 Protection

The following protective devices shall be provided.

- a) AC and DC voltage surge diverters (RC network, voltage limiter, earthing capacitor etc.)
- b) Hole storage capacitor if required across diode.
- c) Thermal Protection:  
A double layer of protection to be provided for the ventilation circuit.
  - i) Vacuum relay (QVSI) for ventilation failure indication. Driver will ascertain whether it is failure of MVSI or QVSI and operate cautiously observing the device temperature made available on the equipment panel.
  - ii) Suitable temperature sensing will be provided on the heat sink of 4 hottest devices. Circuit breaker will be tripped if temperature exceeds allowable junction temperature.
- d) Current transformer in the AC input circuit duly mounted inside the rectifier cubicle and over current relay (QRSI) mounted at suitable location to trip the circuit breaker in case of overload on traction motor end.





- e) Bridge/string fuse with LED indication using inbuilt micro switch of fuse to give failure indication on the rectifier cubicle and driver desk. Fuse will only blow in case of short circuit before smoothing reactor.
- f) Any other additional equipment, if considered necessary.

#### 2.4 Rectifier blower motor set.

This has to be supplied with the rectifier cubicle and only one blower shall be used per cubicle. This will be procured from CLW approved sources. The technical requirement of rectifier blower motor approved for silicon rectifiers by CLW is as under:

Type	Axial.
Fan Impeller	Aluminum with steel cone in the hub.
Motor	
Enclosure	Totally enclosed.
Rating	To be marked out and submitted as part of design. Voltage-415V nominal & varying between 290 to 500V with 5% phase unbalance, 3 phase, 50 c/s.
Air delivery	Minimum air velocity of 6m/sec will be ensured even with 50% blocked of air filters, if used. Tenderer will specify the air volume during design proposal stage.

The blower motor will be mounted in the separate tray at the bottom of the cubicle. It should be possible to take it out for maintenance from front access on corridor side.

#### 2.5 Current Transformer

Current transformer shall be supplied duly mounted and wired in the rectifier cubicle. Current transformer shall be procured from CLW's approved sources as per Annexure - III only.

- 2.6 Earthing capacitor and RC network on the ac input to rectifier are to be supplied along with the rectifier cubicle as loose items suitable for mounting outside the cubicle. Four capacitors of approved make of ICAR/GE as per item No. 4 of ANNEXURE-III will be put in series to meet voltage requirement. Detailed design of ac/dc damping panel and earthing panel will be submitted. The dimensions of mounting panel will also be defined in the proposal.



## 2.7 Mechanical construction

- a) The mechanical construction of rectifier cubicle shall generally conform to IS: 6619 of 1973 suitably modified for traction application wherever necessary.
- b) The rectifier cubicle shall be compact in size and shall not exceed 630 mm (L) x 620 mm (W) x 1650 mm (H) including covers and projection if any. The rectifier cubicle should be with a strong metal framework to withstand normal vibration and shocks in service as indicated under service condition.
- c) Inter hole distance between mounting holes will be 580 mm (L) X 570 mm (W). M16 high tensile bolts will be used for mounting.
- d) The color of the cubicle shall be light gray to clause 631 of IS: 5 of 1994. Blue and red parallel bands of 20 mm width each shall be given on the top front and side covers of each cubicle. Blue would be aircraft blue No.108 and red shall be fire red No. 536.
- e) Easily removable covers shall be provided on the front and sides to provide quick and easy accessibility to the equipment fitted inside the cubicle.
- f) The rectifier cubicles shall be supplied either in the form of pairs bolted together or in the form of each cubicle covered on all sides as desired by purchaser.
- g) Weight of each cubicle will be approx 300 kgs. inclusive of MVSI

## 2.8 Maintainability

- i) The layout of the equipments in the cubicle shall provide for easy accessibility of equipment for maintenance/replacement without having to remove associated components.
- ii) The rectifier cooling blower motor set shall be mounted at the bottom of the cubicle and suitably connected to the rectifier-cooling duct. The air entry should be provided from the top of the cubicle and exit from the bottom towards the blower motor set. It shall be possible to remove the blower motor set for maintenance purpose without having to lift the rectifier cubicle or other equipment inside the cubicle. Adequate resilience shall be provided between blower and rectifier duct to reduce the vibrations and allow for manufacturing tolerance of the blower and rectifier assembly. At the top of the cubicle expanded metal/mesh shall be provided at the air inlet and over the entire area.
- iii) The diodes and its associated matching components, protective equipments (QVSI, cell damping unit, d.c. damping unit or cell cum d.c. damping unit, current transformers etc.) shall be mounted inside the rectifier cubicle.
- iv) The tendered will specify the kind and periodicity of maintenance required.





## 2.9 Indications

- i) LED indication will be used for showing healthiness of fuses.
- ii) LED indication at the panel for trip indication of the rectifier due to overload.
- iii) LED indication at the panel as well as driver's desk for healthiness of blower for Rectifier. The terminals shall be provided for connections to driver's desk for indication of rectifier fault.

## 2.10 Rating Plate

A rating plate in anodized aluminum and chemically etched shall be provided on rectifier cubicle front cover. The following particulars shall be clearly and indelibly marked on the rating plate.

- a) Manufacturer's name, brand and monogram, if any.
- b) Manufacturer's SI.No.
- c) Year and month of manufacture.
- d) Voltage and current (input/output) ratings.
- e) No. of devices and type of device used.
- f) A nameplate denoting HIGH CAPACITY RECTIFIER for WAP4/WAG7 shall be affixed at the top of front cover.



### CHAPTER 3 – SERVIC/ENVIRONMENTAL CONDITION

- 3.1 The rectifier block will be fitted in locomotive machine room where the temperature will be:
- |    |                      |                                   |         |
|----|----------------------|-----------------------------------|---------|
| a) | Maximum temperature  | } Stabled Locomotive under sun    | : 70° C |
|    |                      | } On board Working loco under sun | : 55° C |
| b) | Minimum temperature  |                                   | : 0° C  |
| c) | Average temperature. |                                   | : 47° C |
- 3.2 Humidity: Up to 100% during rainy season.
- 3.3 Altitude: Up to 1200 m above mean sea level.
- 3.4 Rainfall: Very heavy in certain areas. The loco equipment shall be designed suitably.
- 3.5 Atmosphere during hot weather: Extremely dusty and desert terrain in certain areas. The dust concentration in air may reach a high value of 1.6 mg/cub.
- 3.6 Coastal area: The equipment shall be designed to work in coastal area in humidity and salt laden and corrosive atmosphere. The maximum values of the condition will be as follows:
- |    |                                |                        |
|----|--------------------------------|------------------------|
| a) | Maximum pH value               | : 8.5.                 |
| b) | Sulfate                        | : 7 mg per liter.      |
| c) | Max. Concentration of chlorine | : 6 mg per liter.      |
| d) | Maximum conductivity           | : 130 micro siemens/CM |
- 3.7 Electromagnetic Pollution – High degree of electromagnetic pollution is anticipated in locomotive machine room, where the equipment will be mounted. Necessary precaution should be taken in this regard.
- 3.8 Power Interface –
- The nominal voltage at input of rectifier is 1000V rms. corresponding to 22.5 kV catenary's voltage. The catenary's voltage can vary from 19.0 kV to 30 kV. However, voltage may dip down to 17.5 kV, which may lasts for up to half an hour.
  - Input power frequency = 50 Hz  $\pm$  6 %.
  - Panto bouncing duration up to 45 ms (limit of zero pressure contact) should not affect rectifier with or without loads.
  - For the purpose of design, the temperature of cooling air inside the locomotive (ambient) shall be taken as 55°C and a further temperature of 20°C may be assumed as rise in the rectifier cooling air duct i.e. 70°C shall be considered as cooling air temperature for temperature rise calculation and selection of devices.





#### CHAPTER 4 - SCOPE OF SUPPLY

- 4.1 The scope of supply covers design, development and supply of complete set of rectifier block for 25 kV ac locomotives.
- 4.2 A set of rectifier consists of two blocks, which can be mounted at separate locations or can be fixed together and mounted side by side.
- 4.3 Each rectifier block will be equipped with –
- i) One current transformer (CT) as per CLW Spec. CLW/ES/T-4/A.
  - ii) Earthing capacitor & ac damping panel on input side. This will be supplied as loose items.
  - iii) DC damping circuit on output side. This will be fitted inside the rectifier cubicle.
  - iv) Blower motor for rectifier block (MVSI) procured through CLW approved sources.



## CHAPTER 5 - TESTS

### 5.0 General

- 5.1 The tests shall include type test and routine tests on rectifier assembly, tests on signaling and ventilation equipment, and verification of control circuits and installation and commissioning tests. For other associated equipment/components, relevant IS & IEC or purchaser's equivalent specification may be followed.
- 5.2 The tenderer shall specify the relevant characteristic curves and limit values for each test for the offered equipment in the test protocol. This will be approved by RDSO and be provided to inspectors for reference.
- 5.3 Tests on Silicon Rectifier Assemblies

The tests will be carried out as per IS: 7788-1975 and IS: 10192.

S.N	Items	Reference	Type	Routine
1	Visual Inspection & Dimension with tolerance	Cl. 5.10.1	✓	✓
2	Ventilation air-flow Test	IS:7788 Cl. 10.2.2	✓	X
3	Mechanical Vibration and shock tests	IS:7788 Cl. 10.2.3	✓	X
4	Temperature Rise test of diode	IS:7788 Cl. 10.2.6	✓	✓
5	Starting duty cycle test	IS:7788 Cl. 10.2.7	✓	X
6	Current distribution test	IS:7788 Cl. 10.2.5	✓	✓
7	Impulse Voltage Test	IS:7788 Cl. 10.2.8	✓	X
8	Losses and Efficiency Test	IS:7788 Cl. 10.2.12	✓	X
9	Short Circuit Test	IS:7788 Cl. 10.2.15	✓	X
10	Insulation & Dielectric test	IS:7788 Cl. 10.2.9	✓	✓
11	Noise measurement	IEC: 61287 Cl. 2.4.6.11	✓	X
12	Moisture Absorption test	IS:10192	✓	X
13	Check of diode characteristics	IS:7788 Cl. 10.2.13	✓	X

**Note:** If diode failure takes place during any of tests at Sr.No.9 & 13, the manufacturer shall replace the failed diodes at his own expense and the test concerned shall be repeated twice. If further failure occurs, the manufacturer will meet the reasonable requirements of the purchaser for correcting the fault concerned. If failure of converter occurs due to mal operation of clearing equipment or any other associated vehicle equipment, no liability shall rest with the converter manufacturer.





- 5.4 The suppliers shall submit complete test Program for type and routine test to RDSO for its approval. RDSO may also decide to carry out certain special tests on the equipment, which are not covered by relevant IEC specification. Manufacturer will carry out the test as per mutually agreed test Program at his own cost.
- 5.5 The prototype rectifier units will be inspected & tested by the engineers of CLW/RDSO at the factory premises or at mutually decided venue where all the facilities should be made available for carrying out the prototype test. The prototype unit will be kept in field trials for a period of six months. The CLW/RDSO engineers will associate and witness the tests in the locomotive also till they are successfully completed. Any defects noticed/ design improvement found the tenderer shall carry out necessary as a result of the test/trial in the least possible time.
- ✓ 5.6 Type test will be performed on one unit of given design to verify that product meets the requirements specified and agreed upon between users & manufacturer. The type tests shall be repeated once in five years by RDSO to confirm the quality of the product. Type test will also be repeated in following cases.
- Modification of equipment, which is likely to effect its function.
  - Failure or variations established during type or routine test.
  - Resumption of production after an interruption of more than two years.
- 5.7 Routine tests are to be carried out by the manufacturer on each equipment to verify that properties of the product correspond to those measured during type tests.
- 5.8 RDSO/CLW may conduct surprise check on manufacturing process and quality control along with any of the test to ensure quality of product and its conformance to the specification.
- 5.9 **Instrumentations**  
All the instruments used for testing should be duly calibrated. The calibration certificates are to be shown to inspecting authority on demand.
- 5.10 Following clarifications are issued on the tests included in 5.3
- 5.10.1 **Visual inspection**
- The objective of visual inspection is to check that the equipment is as per approved drawing and free from defects. Bill of materials will be submitted to the inspecting authority by the firm. The make, rating of equipments and subassemblies will be checked with the details as per approved design proposal. Any change in make or rating of important



equipments, sub-assemblies will have prior approval of RDSO. Modified Rectifier with modified equipments, subassemblies will be given separate revision number. All the important dimensions will be measured and should be in permissible tolerance.

#### 5.10.2 Ventilation Air-Flow Test

This test shall be carried out at the ambient temperature in order to measure airflow distribution passing through various components cooled by forced air. The test shall be carried out on completely assembled rectifier with blower motor voltage supply at:

- a) Rated voltage  $U_L$
- b) Over voltage of  $1.21U_L$
- c) A voltage of  $0.75 U_L$
- d) A voltage of  $0.70 U_L$  for 10 minutes only.

The test may also be carried out as per mutually agreed procedure to check the effectiveness of the means provided on the rectifier assembly to restrict dust entry.

#### 5.10.3 Mechanical vibration and shock test

The unit will not be operative during the test. The tests are considered satisfactory if there is no resulting damage or abnormality in operation and unit under test withstands successfully the routine electrical tests.

#### 5.10.4 i) Temperature Rise test of diode

- (a) With blower motor fed at  $0.75 U_L$ , the rectifier shall be loaded at continuous unidirectional current corresponding to design value i.e.  $\sim 3300A$  for a period till steady state value of diode base temperature is obtained. The recorded value shall not exceed the limit value of junction temperature of diode after correcting base temperature for  $70^\circ C$  ambient i.e. an ambient of  $55^\circ C$  and a temperature rise of  $15^\circ C$  taking place in the rectifier cooling air duct.
- (b) Rectifier will be tested at full load of  $2700A$  without blower motor for a minimum period of half an hour. The recorded value shall not exceed the unit value of junction temperature of diode after correcting base temperature for  $70^\circ C$  ambient i.e. an ambient of  $55^\circ C$  and a temperature rise of  $15^\circ C$  taking place in temperature in the rectifier cooling air duct.

The test will be conducted at low ac input voltages, with the converter dc output terminals short-circuited.





✓ ii) **Temperature Rise test of Bus bar**

Bus bar temperature to be recorded at a unidirectional current of 3300A for 10 minutes followed by 2700A continuous current. The temperature of the bus bar is again recorded when after steady state is reached. The recorded bus-bar temperature shall not exceed the limit of 100°C after correcting the temperature for 70°C ambient i.e. an ambient of 55°C and a temperature rise of 15°C taking place in the rectifier cooling air duct.

Temperature should specifically be checked at the contact points of the diode also.

5.10.5 **Starting duty cycle test**

This test shall be carried out with one bridge eliminated and keeping the hottest diode in circuit by loading the silicon rectifier assembly to starting duty cycle given at clause 2.1(G) of this specification.

The test will be conducted at low input ac voltage.

5.10.6 **Current distribution test**

During temperature rise test at continuous current corresponding to designed d.c. rating of rectifier, the current distribution of the parallel-connected diodes shall be measured. During the tests, the internal assembly of the rectifier cubicle should conform to the unit in actual service and should not be disturbed for taking measurement.

The measurement will be taken by means of clip round ammeter or by measuring voltage drop across diode leads/fuses.

Test will be carried out at a low input ac voltage.

5.10.7 **Impulse Voltage Test**

Impulse voltage test will be carried out at 3.7 kV. If standard pulse generator is not available, an impulse can be generated by means of charging a capacitor of 1.2 MFD to a voltage level of 3.7 kV. The rectifier shall be subjected to impulse voltage test by discharging this capacitor across 10-ohm resistor in parallel to rectifier using a fast acting semiconductor switch. The shape of impulse voltage applied will be as specified in IEC 61287.

5.10.8 **Losses and Efficiency Test**

The test shall be performed as per clause 48 of IEC: 60411-2 (1978-01) and clause 10.2.12 of IS: 7788.



#### 5.10.9 Short Circuit Test:

With normal ventilation and after a continuous load of 3300A the rectifier shall be subjected to a short circuit level of 16.5kA peak for a period of 100 m sec at nominal input voltage of 1000V (RMS). In case the facility is not available at the works of manufacturer or recognized test houses, it can be carried out in the loco with mutual agreement. The test scheme will be as per Cl. 10.2.15 of IS:7788. Alternatively, the device can be preheated in oven to achieve the junction temperature corresponding to 3300A load and after stabilization of junction temperature, a short circuit pulse of 16.5 kA is applied through the full rectifier block. A voltage level of 1000 Vrms will be applied across the device during the test. If the test is not done on the full unit but a device level the current in balance factor as per clause 2.2.2(b) will be taken for load current and 20% for calculating, the current in pulse value per device.

The short circuit test is recorded by means of an Oscillograph.

#### 5.10.10 Insulation & Dielectric test

- a) Insulation resistance test will be conducted before the dielectric test with suitable megger of:

- i) 2500 V for power circuit.
- ii) 1000 V for circuit below 500V rms.

Insulation resistance should not be less than 100 m ohms at 70% RH for all the circuits. Damping circuit will also be kept disconnected.

- b) The dielectric test will be carried out after shorting/removing the fuse, diodes and related circuitry. Damping circuit will also be kept disconnected.

- i) Main Circuit:  
3.7kV (RMS), Single phase, 50Hz, for 60 Sec. *HP*
- ii) AC auxiliary circuit  
2.1kV (RMS), Single phase, 50Hz, for 60 Sec. *MP*
- iii) Battery Circuit:  
1.5 kV (RMS), Single Phase, 50Hz for 60 Sec. *Battery*

*L.P. Aux. Circuit*





- a) The leakage current will not be more than 10mA.
- b) Fiberglass sheet/section shall also be tested for dielectric strength at a proof test voltage of 10KV for one minute.

#### 5.10.11 Moisture Absorption test

Moisture absorption test shall be carried out on all fiberglass sheets/sections used in the assembly of rectifier cubicle in accordance with relevant IS. Test sample should pass both transverse and surface dielectric test after moisture absorption.

#### 5.11 Tests on Ventilation and Signaling Equipment

- I) Operation of airflow relay:  
The function of airflow relay shall be checked by manual operation and also by switching off the blower motor set.
- II) Checking the sequence operation of blower motor pacco switch:  
The sequence of blower motor pacco switch shall be verified for proper and correct functioning.

#### 5.12 Test on other accessories for rectifier assemblies

All accessories of Rectifiers viz. capacitors, surge suppressors, fuses, wires, cables and insulating sleeves etc. shall comply with the relevant IS or IECs. Type and Routine tests on accessories shall be agreed as to between purchaser and the manufacturer.



## ANNEXURE - I

RELIABILITY ASSURANCE SPECIFICATION FOR SINGLE PHASE POWER  
CONVERTORS FOR TRACTION APPLICATION

## 1.0 Introduction:

The power converter design, assembly and manufacture shall be as per the specification. In addition, it shall also comply with this Reliability Assurance Specification. This reliability Assurance Specification elaborates certain special requirements from the point of view of detailed design, specification of components and assembly on and above those covered in IS: 7788.

The Reliability Assurance Specification also lays down the code of practice for assembly, layout, wiring etc with a view to ensure the highest level of reliability and durability under the severe service conditions of traction application.

## 1.2 Bus-Bar

1.2.1 The bus bars shall be electrolytic copper as per IS: 613.

1.2.2 The bus bars shall be nickel-plated. The nickel-plating shall be done after bending, drilling holes etc. and bare copper shall not be used anywhere. Thickness of the plating shall not be less than 8 micrometers.

1.2.3 Joints in bus bars shall be avoided as far as possible. In case joints are to be provided, the joints shall be away from the bent portion.

1.2.4 Sharp bends in the bus bars must be avoided. The inner radius of cold bend should be large as possible, but not less than the following: -

Annealed hard drawn electrolytic copper  $2 \times T$

(Where, 'T' Thickness or diameter of the flat or rod.)

1.2.5 The above limits of bend radius shall apply not only to thick bus bars, but also to thin wires, such as resistor and capacitor leads etc.

1.2.6 Where, it is not possible to accommodate the radius specified above, specific approval for deviation shall be obtained.

1.2.7 The bus bars shall be provided with the following color code to identify ac, dc, and positive and negative connection:





AC		Yellow
DC	Positive	Red
	Negative	Black

- 1.2.8 All power connections to the bus bars and bulbar joints shall be directly made without any insulating support.
- 1.2.9 Bus bar supports shall be made with separate insulators and not by making use of insulating members of the assembly.

### 1.3 Welding

Arc welding shall be used for fabrication of framework. Fillet welding must be avoided as far as possible. There should be no undercuts in fillet welds.

### 1.4 Fasteners

- 1.4.1 Hexagonal nuts only shall be used. Socket headed screws will be used only at the locations where use of hexagonal nuts is not feasible. All the nuts will be suitable for tightening with a spanner only and not with screw drivers.
- 1.4.2 The minimum size of screws or bolts shall be M-6. Any bolt or screw of sizes less than M10 shall be of high tensile steel (preferably clause 8.8) as per IS: 1367.
- 1.4.3 All the nuts, which are not normally required to be opened for repair/maintenance, shall be locked. Locking may be done in case of small nuts either with drop of araldite or locktite compounds. Nylock Nuts are not to be used for locking.
- 1.4.4 All bolted connections shall be provided with spring washers.
- 1.4.5 Tightening of the bolts shall be done to the maximum extent to avoid fatigue failures.
- 1.4.6 Hardware shall be procured only from approved sources of CLW.

### 1.5 Components

#### 1.5.1 General

- 1.5.1.1 Only components of rating, make and type approved by CLW shall be used for assembly.
- 1.5.1.2 No deviation from the rating, type and make of the approved device list shall be made without prior approval of RDSO. For any deviation in the



rating, type and make of any component, full details along with reasons for deviation, shall be furnished to RDSO for approval.

- 1.5.1.3 All bought out components shall be subjected to lot acceptance tests as per the laid down specification. The manufacturers will establish strict quality control so as to achieve the highest reliability of the components.
- 1.5.1.4 All the electrical and electronic components shall be subjected to 100% screening tests before using them for assembly, in addition to lot acceptance tests. The screening tests for the various components are detailed in APPENDIX-I.
- 1.5.1.5 Complete records of the lot acceptance tests, screening tests and routine tests shall be kept separately. These records shall be made available for the scrutiny of the representative of RDSO.
- 1.5.1.6 Reliability cannot be tested, but has to be built in by attention to design, manufacturing process and stage inspection. It is, therefore, necessary that the manufacturer lay down detailed quality assurance program for the manufacture of devices and the assembly of the converters. Copies of quality assurance programmers, details of the tests at various stages of inspection, check lists etc shall be furnished at the time of evaluation of detailed design. Any changes made in these programmers shall be advised to RDSO.
- 1.5.1.7 Reliability check shall be carried out against each order by CLW's Inspection wing.

## 1.6 Silicon Diodes

- 1.6.1 Stud type devices are not acceptable. Diodes with soldered junction and soldered external seal construction are also not acceptable.
- 1.6.2 'Quality Assurance Testing of Silicon Diodes' at Annexure-II shall govern quality assurance testing and screening method of the devices.
- 1.6.3 Flexible leads of the devices shall be fully insulated either with silicon rubber or PTFE sleeving.
- 1.6.4 In case of flat base devices, a suitable cover of either silicon rubber or PTFE shall be provided over the device to avoid occurrence of external flash over by foreign materials.
- 1.6.5 Surface finish and flatness of the surface of the device in contact with heat sink shall be as under:



Surface finishes	less than 1.525 micrometer
Surface flatness	Total Indicator Reading (TIR) To be held from 0.0005 to .001 mm

1.6.6 The size of the base-mounting studs shall be not less than M-6.

## 1.7 Heat Sink

1.7.1 Heat sinks shall be of extruded construction. Sand cast head sinks are not acceptable. For any other type, specific approval of RDSO shall be taken.

1.7.2 The area of device seat on the heat sink shall have proper surface finish and flatness to minimize mounting resistance due to surface problems. Flatness and surface finish shall be as under:

Surface flatness	Total indicator reading (TIR) To be held from 0.0005 to .001 mm
Surface finishes	less than 1.525 micrometer.

1.7.3 Current collection through the heat sink is to be avoided. In case it is not possible, then the heat sink device mounting surface and current collection contact area shall be suitably treated to prevent electrical corrosion. Full details of the proposed treatment shall be furnished to RDSO at the time of detailed evaluation of design for approval.

## 1.8 Capacitors

The capacitors shall be suitable for case temperature from 20°C to +85°C. The case temperature rise shall not exceed 10°C under the design current and voltage rating of the converter.

## 1.9 Fuses

Fuses suitable for semiconductor application complying with IEC 269-4 shall be used. The same shall be procured from approved source of CLW. (ANNEXURE-III)

## 1.10 Assembly of the heat sink and device

1.10.1 In case of disc type of devices, the design of the clamping system shall be such that the required clamping force must be applied perpendicular to the disc surface. The clamp shall be provided with a mechanical force gauge to indicate the applied forces as well as to indicate that the set force for a particular device has been applied. Individual clamp arrangement shall be provided for each assembly. Common clamp for the stack is not acceptable.



- 1.10.2 In case of flat base devices, pressure plate or mounting spring with safety bracket shall be provided between the base and the mounting studs so that the spring/pressure plate becomes flat when proper mounting pressure is applied.
- 1.10.3 Mounting arrangement of the device shall be such that the pressure is uniformly distributed over the total contact area. The pressure shall be applied in a staggered fashion such as tightening of opposite corners to one half of the recommended torque and then finally apply the necessary remaining torque in the same staggered fashion.
- 1.10.4 Recommended optimum mounting pressure for the offered device type shall be determined by suitable tests and full details of which should be furnished to CLW.
- 1.10.5 In order to optimize the contacts between mating surfaces of the device and heat sink, suitable thermal compound shall be used to fill up the voids between the mating surfaces before assembly. The thermal compound shall have low thermal resistance and shall seal the joint against moisture.

#### 1.11 Cables

- 1.11.1 Single strand solid shall not be used for inter-connection between components/sub-assemblies. All inter-connection shall be with multi-stranded flexible insulated cables, either PTFE or elastomeric EPR/CSP.
- 1.11.2 Bare copper multi-stands cables insulated with fiber glass/rubber sleeving shall not be used.
- 1.11.3 Minimum size of the cable shall be 2.5 Sq. mm except for cabling of LED indication panel where, 1.5 sq. mm PTFE cable may be used.
- 1.11.4 PTFE (Poly Tetra Fluro Ethylene) insulated cables procured from CLW approved sources shall be used for all inter-connections to the snubber circuits and signaling fuses.
- 1.11.5 Elastomeric cables as per CLW's spec. No. CLW/ES/C-22/C (as amended from time to time) may be used for all other locations.
- 1.11.6 The voltage grade shall be 3KV (ac) for damping and snubber circuits and 750 V for ventilation blower and other auxiliary circuits.





## 1.12 Terminal Boards

**1.12.1 GENERAL** The design shall generally comply with the following –

- i) The size of the connection studs shall have adequate current ratings and the minimum size shall not be less than M5
- ii) The studs shall be cadmium plated steel as per BS: 3382-61 (Part I)
- iii) Provision of insulation barriers between the terminals.
- iv) Electrical connection shall be made in such a way that the contact tightening force is not passed through the insulating board.
- v) Terminal board shall be made of DMC compound of CLW's approved source.

1.12.2 Not more than 2 terminations shall be provided at one stud, in case more connections are required, providing copper connection strips may extend the terminals.

1.12.3 Copper strips shall be used for interconnections at the terminal board instead of small cable loops.

1.12.4 Separate terminal boards shall be provided for 110V dc and 380V ac circuits.

1.12.5 Positive and negative terminals shall be separately located. Four spare terminals shall be provided in each terminal board for emergency use

1.12.6 Terminal boards shall be installed in the vertical position to avoid dust collection and accidental short circuits.

## 1.13 Cable Terminations – soldered joints

1.13.1 Soldered cable terminations and connections shall be avoided. In case soldered connections are unavoidable, full details shall be furnished to RDSO for prior approval.

1.13.2 Trained staff shall make soldered joints with 100% tin solder with suitable soldering equipment, which maintains the bit temperature constant.

1.13.3 Only pure resin is to be used as a flux. Use of acidic/corrosive flux is prohibited.

1.13.4 Trained inspector for checking the soundness of the joint and the proper wetting of the surface being joined shall carry out visual inspection of each soldered joint.



#### 1.14 Cable sockets

- 1.14.1 All cable ends shall be socketed with crimped type sockets.
- 1.14.2 Pre-insulated sockets shall only be used. The crimping is to be done in such a way that the insulation of the cable gets crimped with the insulated sleeve to prevent failures due to flexing action of the unsupported length.
- 1.14.3 The crimped sockets shall be of proper dimension for a particular size of the cable.
- 1.14.4 Proper tools and dies shall be used for crimping and frequent checks shall be carried out by examination of cut samples and milli-volt drop to ensure quality of the crimping. Pull out tests shall be made on 1% of crimped joints to check quality of crimping tools and dies. The pull out force shall not be less than 80% of the U.T.S. of the wire.

#### 1.15 Wiring Layout

- 1.15.1 The quality of workmanship and layout of the wiring shall be of the highest standard so as to ensure long life of wiring as well as to prevent deterioration/damage of insulation in service. For the layout of wiring the following guidelines will be kept in view:
  - a) Complete separation of low, medium and high voltage wires shall be ensured.
  - b) Only wires of same potential will be bunched together. The cables of different voltages shall be separately bunched and routed.
  - c) As far as possible, all wires, which are temporarily energized, shall be bunched separately and no permanently energized wire should be included in this bunch.
  - d) The positive and negative wires in dc circuit shall be separately bunched.
  - e) Sharp bends shall be avoided in the wiring layout. The closed insulated minimum radius of the bend shall be at least 10 times the outer diameter of the cable.
  - f) Wherever the cables/wires travel through holes, orifices, cut ways, etc. suitable rubber grommets shall be provided. The grommets shall be provided such that they do not get dislodged due to vibrations, shocks and bumping experienced in service.
  - g) Insulated stiffeners or laid-in cable ducting shall suitably support all the cable runs.
  - h) The cable bunches shall be neatly tied up with straps at adequate intervals. In order to have neatness and easy maintenance, the number of wires in each bunch shall not exceed ten.





### 1.16 Cable Marking

All wires shall be numbered and provided with cable ferrules of approved style and design at either end of cable terminations. The marking shall be indelible and unalterable. The use of metallic labels/tags, etc. is prohibited. Separate series of numbering shall be followed for low, medium and high voltage cables and the adopted scheme shall have the approval of the purchaser.



## APPENDIX - I OF ANNEXURE - I

### SCREENING METHODS FOR THE COMPONENTS

#### 1.0 Resistors, fixed, wire wound, vitreous enameled corrugated type (Power Type)

##### a) Short time overload

Test - The resistors shall be subjected to an over voltage which will result in 10 times rated wattage for 5 seconds. DC resistance shall be measured after the resistor has cooled down to room temperature.

Acceptance criteria - There shall be no evidence of arcing, burning or charring. Change in resistance value shall not exceed 2% at 25°C.

##### b) Life Test

Test - DC resistance shall be measured at 25°C. Resistor will be loaded with rated power at an ambient of 70°C for a period of 100 hours. No forced ventilation is to be provided.

Acceptance criteria - Change in resistance value shall not exceed 3% and there is no evidence of mechanical damage.

#### 2.0 Capacitors:

##### a) Test (Thermal Shock)

<u>Step No.</u>	<u>Time</u>	<u>Temp.</u>	<u>No. Of cycles</u>
1	30 Mts.	- 20°C	5 cycles.
2	5 Mts.	+ 25°C	
3	30 Mts.	85°C	
4	5 Mts.	+ 25°C	

Acceptance criteria - The capacitor shall withstand the extremes of high and low temperature without any visible damage.

##### (b) Life Test (Operating burn-in)

Test - Each capacitor shall be subjected to the maximum rated voltage and case temperature for a period of 100 hours.

Acceptance criteria - The change in the capacitance shall not exceed +5% at +20°C. The capacitance value shall be within the specified tolerance even after the burn-in.





ANNEXURE – II

**QUALITY ASSURANCE TESTING OF DIODES FOR SINGLE PHASE TRACTION POWER CONVERTOR**

**1.0 Introduction:**

High reliability of the equipment is the pre-requisite for traction application. Traction application calls for devices of the rectifier to work under arduous service conditions of thermal cycles, dusty and salt laden atmosphere, high humidity, voltage transients and continuous vibrations and shocks. Therefore, devices are required to be of high reliability for traction application.

After the device has been properly selected to meet with the duty requirements, reliability of the device is the responsibility of the manufacturer.

The purpose of this quality assurance test programme is to lay down detailed procedure for lot inspection and type approval for user's inspection as required vide clause 10 of IS-7788 of 1975 as well as audit checks to ensure periodical monitoring of the quality of the production and use of reliable devices for assembly of the traction rectifier sets.

**2.0 Type Approval of the devices**

2.1 Any new device proposed or up rated by a manufacturer shall be subjected to the type tests as per APPENDIX – A. The devices shall not be used for assembly of the converters till type approval is accorded for the device by RDSO. All facilities for carrying out the type and investigation tests shall be provided by the manufacturer. The tests shall be conducted in the presence of nominated representatives.

2.2 The sampling plan for type tests shall be as under. Samples shall be selected by RDSO representative.

Lot quantity (Nos.)	Sample rate of the lot
Upto 200	20% Subject to minimum of 40 devices
200 to 500	12%
500 to 1000	10%
Above 1000	7.5%

2.3 In case of bulk orders, the lot offered for type testing and inspection shall be at least 50% of the total order.

2.4 The programme of the type tests on the samples selected shall be as per APPENDIX-A.

### 3.0 Validity of the type approval.

The type approval for a particular device shall be normally for a period of five years. Complete type test tests as per clause 2.1 will be repeated before the validity of the approval is renewed. However, at the discretion of RDSO, conducting of complete type test programme may be waived off or modified programme repeated.

### 4.0 Manufacturer's Quality Assurance Programme

It is at the manufacturing stage, from beginning to end, that the reliability is to be introduced into the devices. It starts with the choice of supplier for the components and continues with incoming inspection, on line process controls, processing after construction and quality assurance testing. It is therefore incumbent upon the manufacturer to lay down quality control programme to monitor the manufacturing. This quality assurance programme should form part of the offer. Any changes made subsequently will be advised. The representative of RDSO to ascertain the implementation of the quality assurance programme shall carry out audit checks from time to time.

### 5.0 Routine Test

5.1 Routine tests shall be carried out on all devices as per APPENDIX-A by the manufacturer. The manufacturer will keep separate records for these routine tests carried out on the devices, which will be made available for inspection of the representative of CLW.

5.2 A certificate, as per the following Performa shall be furnished for each cubicle or for the lot of the spare diodes supplied in respect of routine tests.

Certified that all the diodes type No. as per the enclosed serial numbers used for the assembly of the cubicle S. No. \_\_\_\_\_ against contract/order No. \_\_\_\_\_ Dt. \_\_\_\_\_ have been subjected to the laid down routine test and comply with the declared limits of the various finalised parameters of the device.

### 6.0 Audit check of the Routine tests

6.1 Audi check of the devices from each cubicle offered for inspection, picked up at random by the representative of the Inspecting authority, shall be subjected to routine tests, as indicated in APPENDIX-A in presence of the representative of the inspecting authority.





- 6.2 In case any device, out of 10% sample lot, does not comply with the declared parameters, the following procedure shall be followed:
- a) In case more than one loco set is offered for inspection, than 20% of the devices will be taken as sample from each of the balance cubicles and subjected to routine tests. In case any device from this lot out of these samples also does not comply with the declared parameters, then the whole offered lot shall be **treated as rejected**.
  - b) In case all the sample devices as per 6.2 (a) above meet with the specification, than the particular cubicle will only be taken as rejected. The firm shall do re-screening before offering it for re-inspection.
- 6.3 In case of failure of the device during 10% audit checks occurring on more than two occasions in a year, the approval for the devices will be treated as withdrawn.



## APPENDIX - A OF ANNEXURE - II

### TEST PROGRAMME FOR SILICON DIODES

#### 1.0 General

- 1.1 The type, routine and investigation tests on the silicon diodes shall be conducted as per IS: 7788 of 1975 or latest in the classifications furnished hereunder. Some additional tests, not included in IS: 7788 of 1975 are also to be conducted as type, routine or special tests, as clarified below:
- 1.2 Based on this general type and routine test Programme, the manufacturer shall submit particular test Programme, applicable for the offered device, indicating limit values of various parameters and test conditions such as voltage and current, base temperature, duration of test, reference temperature etc. The details of empirical relations proposed to be used for working out the value of the parameters shall be indicated in the test Programme.
- 1.3 The detailed Performa for recording readings, test results, observations, conclusions etc. shall be submitted along with the particular test Programme.

#### 2.0 Summary of the tests.

S. No.	Nature of work	Reference	Type Test	Routine test
1.	Visual Inspection	As per Cl. 3.1 below	✓	✓
2.	Forward characteristic	IS: 7788-1975 cl. 10.1.2	✓	✓
3.	Reverse characteristic	IS: 7788-1975 cl. 10.1.3	✓	✗
4.	Reverse current	IS: 7788-1975 cl. 10.1.4	✓	✓
5.	Reverse voltage	IS: 7788-1975 cl. 10.1.5	✓	✓
6.	Reverse recovery charge	IS: 7788-1975 cl. 10.1.6	✓	✗
7.	Thermal resistance	IS: 7788-1975 cl. 10.1.7.1	✓	✓
8.	Transient thermal impedance	IS: 7788-1975 cl. 10.1.7.2	✓	✗
9.	Thermal cycling	IS: 7788-1975 cl. 10.1.8	✓	✗
10.	Surge forward limit current	IS: 7788-1975 cl. 10.1.9	✓	✓
11.	Surge forward current	IS: 7788-1975 cl. 10.1.10	✓	✗
12.	Load	IS: 7788-1975 cl. 10.1.11	✓	✗
13.	Deterioration	IS: 7788-1975 cl. 10.1.12	*	*
14.	Encapsulation	IS: 7788-1975 cl. 10.1.13	✓	✓
15.	Blocking life	As per cl. 4.1 below	✓	✓
16.	Salt mist test	IEC 60571 Cl. 10.2.10	✓	✗
17.	Damp heat	IEC 60571 Cl. 10.2.5	✓	✗
18.	Shock and vibration	IEC 60571 Cl. 10.2.11	✓	✗
19.	Robustness of termination	as per cl. 4.5 below	✓	✗
20.	Operating life	as per cl. 5.1 below	*	*

- Investigation test





### 3.0 Additional details of the tests covered by IS: 7788 – 1975

Following additional details shall apply for the tests covered by IS: 7788 – 1975

#### 3.1 Test no. 1 visual inspection Following will be inspected :-

- a) Poleface flatness ( flatness <  $1\mu\text{m}$ )
- b) Poleface roughness ( roughness <  $1.525\mu\text{m}$ )
- c) Outline conformity – as per dimension submitted by the manufacturer as part of design.

#### 3.2 Test No. 2 Forward characteristic

The forward characteristic drop (FVD) grouping shall be classified based on 50mV peak group corresponding to main rated device current rating. It will be verified that the characteristic is within the specified FVD group.

#### 3.3 Test No. 3 reverse characteristics.

Full reverse characteristic shall also be exhibited on the oscilloscope. It shall be free from defects. The leakage current corresponding to PIV rating of the device shall be reordered.

#### 3.4 Test No. 9 Thermal cycling

The test shall be conducted as per clause 10.1.8 of IS: 7788 – 1975. The test shall be conducted for 20,000 cycles and no parameters shall change. The test shall be further continued if any of the parameters exceed the limit value/abnormal variation is noticed or the device fails.

All the parameters that may be affected by the test i.e. forward voltage drop, reverse leakage current, thermal resistance, etc. shall be measured and recorded at the beginning of the test and thereafter every 5000 cycles till no change in parameter is noticed. The moment any change is noticed, the parameters shall be checked after every 1000 cycles till the change in any parameter is found beyond limit or device fails. The test will be considered satisfactory in case there is no change in the value recorded earlier for the device under test at the beginning.



### 3.5 Test No. 11 surge forward current

The test will be carried out with 50% reverse voltage applied between current pulses.

### 3.6 Test No. 12 Load Test

The forward characteristic, reverse characteristic, thermal resistance, etc. shall be measured at the beginning and at the end of the test. The test will be considered satisfactory in case there is no change in the value of the parameters recorded for the device under test at the beginning.

### 3.7 Test No. 14 encapsulation test

The test shall be carried out with Helium gas detector method for the type test.

## 4.0 Additional test not covered by IS: 7788 – 1991

### 4.1 Blocking life This test will be carried out as per IEC 747.

- a) **Type test** – This test shall be carried out by applying rated peak reverse voltage (either fully or half wave rectified) on the devices in an ambient temperature equal to the maximum rated junction temperature for a period of 30 days. Leakage current shall be measured at the beginning of the test and then checked after every 7 days. The test will be considered satisfactory in case no change of leakage current takes place.
- b) **Routine test** – This test shall be carried out on every device in the same way as type test, but for a period of 24 hrs.

### 4.2 Environment tests

#### 4.2.1 Test No. 18.1 Damp heat

This test will be carried out as per IS: 9000 (Pt.IV) 1979 with the following details:

Conditioning	Temperature of $55 \pm 2^\circ\text{C}$ and relative humidity of $93\% \pm 2$ The device shall be placed with the base facing upwards.
Severities Final measurements	21 days
Visual inspection	Condition of the plating of the base, flexible lead, etc.
Electrical	Insulation resistance before and after the test.





#### 4.3 Salt mist test

4.3.1 This test shall be carried out as per clause 10.2.10 of IEC 60571. The duration of the test shall be 48 hrs. The device shall be subjected to visual examination for corrosion of the plating, etc. at end of the test.

#### 4.3.2 Robustness of the termination

This test is required for single side devices only. The details of the test will be mutually finalised. The manufacturer shall declare the tensile strength of terminals and the proof load will be at least 2 times the declared terminal strength.

### 5.0 Investigation tests

#### 5.1 Operating life test

This test will be carried out on the devices under the following operating conditions:

- I) Loaded to the maximum rated forward current.
- II) Maximum repetitive peak voltage applied.
- III) At rated case temperature.

The test will be carried out for a period of 30 days. All the parameters, viz. forward voltage drop, reverse leakage current and thermal resistance shall be recorded at the beginning of the test and then checked after every 7 days. The test will be considered satisfactory in case there is no change in any of the parameters for device under test.



**ANNEXURE - III**

**APPROVED SOURCES OF COMPONENTS**

S. N.	ITEMS	SPECIFICATION	SUPPLIERS
1	Air flow relay	CLW/ES/R-34	M/s Switzer Instruments Co., Channai
2	Program switch	Siemens type K 138 x 24 to IS: 4064 Pt.I & II, open execution with 4 pockets. AC3 motor duty 415V, 16A, 10 HP & AC 21 duty 500V, 25A, Assembly as per Siemens WSCR drawing no. 2A-0001-0100314-001 with MS front plate & bakelite push	M/s Siemens India
3	Current Transformer	CLW/ES/T- 4/A	M/s Lemco Automatic Electric M/s Gilbert Maxwell, Baroda
4	Capacitor for AC & DC damping circuit	CLW Spec No. E-5/1/01 25 mfd/450V GE type 61L281 or 97F8217, ICAR type MLR-25 M 50	M/s GE, USA M/s ICAR, Italy
5	Capacitor for AC earthing circuit	CLW Spec No. E-5/1/01 0.47 mfd/660V GE type 2BF 5668, ICAR type CCR25EI,	M/s GE, USA M/s. ICAR, Italy
6	Capacitor for Hole Storage application	CLW Spec No. E-5/1/01 0.47 mfd, 2000V, GE type 28F5675, ICAR type Bio-Energy A 11.B.0.47-280	M/s. GE, USA M/s. ICAR, Italy
7	Blower		M/s Flakt India M/s Arco M/s Samal Harand M/s GTR/Calcutta (Dev)
8	Main Fuse		M/s Lucien Ferraz, France M/s Bussman, Denmark
9	Hardware		M/s GKW, Howrah M/s Fit Tight Nuts & Bolts, Ltd. M/s Hindustan Fasteners Ltd. Mumbai M/s Precision Fasteners Ltd. Mumbai M/s Sundram Fasteners Ltd., Channai





10	Resistance	CLW/ES/R-20	M/s Precision Electronics M/s Lakshmanan Electronics M/s R V Mehta & Sons
11	Heat sink		M/s Hindal Co., India
12	Wire PTFE	Type EE of MIL-W-16878D, High conductivity annealed and tinned/silver plated multistrand copper wire as per IS:8130, colour-black/orange	M/s Garg Associations M/s R J Industries, Rootk M/s Tonk Associate M/s Allied Industries, Delhi
14	Elastomeric cable	CLW Spec No. CLW/ES/C-22/2	

Note: For any other source of supply RDSO's prior approval is required.



## ANNEXURE - IV

### TECHNICAL DATA TO BE FURNISHED BY THE TENDERER

1.0 Details of data, drawing and design of equipment and components required to be furnished by the tenderer, are given below:-

#### 2.0 General

- I) Descriptive features of the design offered, complete with explanatory notes and relevant power circuit, control circuit and schematic diagrams.
- II) Special features of the design offered.
- III) Details of semiconductor devices, matching components and other accessories used, their specifications and data sheet.
- IV) Design calculations including the calculation of safety margin in voltage, current, junction temperature along with their limit value for power devices.
- V) Details of protection system including indication, proposed set values and range.
- VI) Bill of material with separate list of imported and indigenously procured items along with their sources.
- VII) Mechanical drawings of complete cubicles as well as subassemblies/rack with details of dimensions, mounting arrangement and weight, which are required to be taken out for maintenance.
- VIII) General internal layout and assembly drawings of the rectifier cubicle. Separate detailed drawings for diode, heat sink, diode assembly rack, bus bar, ac-dc damping panel and earthing capacitor circuit.
- IX) Particulars and design details of the blower motor set and protective equipment.
- X) Type test report of diode, if already conducted by the manufacturer.

#### 3.0 TECHNICAL DATA OF SILICON DIODE:

The following technical data concerning diodes shall be furnished:

- I) Make/Type
- II) Type of Junction
- III) Type of anode & cathode connection
- IV) Rated average forward current for single phase half wave:
  - At 'I' case = 55°C and 15°C rise in the air duct.
  - Forced cooling at 6m/sec.
- IV) Surge current rating with/without reverse voltage applied between the current pulses for:
 

- 10 ms and $T_j$	=	(Cold)
- 10 ms and $T_j$	=	(Hot)
- 100 ms and $T_j$	=	(Cold)
- 100 ms and $T_j$	=	(Hot)



VI)  $I^2t$  values for:

- 10 ms and  $T_j$  = (Cold)
- 10 ms and  $T_j$  = (Hot)
- 100 ms and  $T_j$  = (Cold)
- 100 ms and  $T_j$  = (Hot)

VII) Voltage ratings at rated junction temperature:

- Recommended crest working reverse voltage (BCWV)
- Rated repetitive peak inverse voltage (PIV)
- Rated non-repetitive peak inverse voltage (PTV)
- a) With repetitive voltage applied
- b) With pulse method, if applicable.

VIII) Peak inverse current versus peak inverse voltage curve at rated junction temperature.

IX) Maximum allowable case temp. versus average forward current.

X) Peak forward voltage drops characteristics at cold and rated junction temperature with the offered FVD group/groups.

XI) Forward watt loss versus forward current curve.

XII) Repetitive forward overload characteristic curves.

XIII) Maximum peak surge current curve at cold and rated junction temperature with and without reverse voltage.

XIV) Maximum peak surge current values as above for 10 and 100 m. sec. period and for different pre-loading factors.

XV)  $I^2t$  curve for cold and rated junction temperature condition.

XVI)  $I^2t$  values less than 10 Ms. if the offer is with fuses.

XVII) Junction temperature:

- Rated average value
- Peak value
- Under surge conditions.

XVIII) Temperature limit for cell storage.

XIX) Heat sink data:

- Type
- Material
- Cooling surface
- Size (L x W x H)

XX) Thermal resistance of

- Diode ( $^{\circ}\text{C/W}$ )
- Heat sink ( $^{\circ}\text{C/W}$ ) (at specified cooling air velocity of 6m per sec/natural).



- XXI) Transient thermal impedance curve:
  - diode
  - heat sink (at 6m per sec. air/natural.)
- XXI) Recommended conductive grease.
- XXII) Maximum fixing torque for screw for single side cooled device.
- XXIII) Data of diode matching components.
- XXIV) Fuse data/characteristics:
  - a) Make/type
  - b) Rated current/voltage
  - c) Current versus time curve for full wave & half wave (melting time current characteristic)
  - d) Arc voltage characteristic
  - e) Total  $I^2t$  characteristic
  - f) RMS continuous current v/s ambient temperature curve
  - g) Total  $I^2t$  let through at maximum prop

#### 4.0 TECHNICAL DATA OF RECTIFIER ASSEMBLY

Technical data concerning rectifier assembly indicated below shall be furnished:

- I) No. of devices in parallel
- II) Number of cells:
  - per bridge
  - per locomotive
- III) Continuous current rating of rectifier at rated voltage and ambient temperature of:
  - 45°C
  - 55°C
  - 75°C

With all healthy cells and one string isolated.
- IV) Short time current rating of rectifier at 55°C ambient and 15°C at temperature rise in the cooling duct for:
  - 1 minute
  - 3 minute
  - 5 minute
  - 7 minute
  - 10 minute

With all healthy cells and one string isolated if applicable.





- V) Size of rectifier cubicle and equipment layout drawing.
- VI) Detail characteristics of protective devices used and blower motor set
- VII) Brief specification of devices used for protection against surge voltages, voltage level and effective values.
  - Surge arrestor
  - ac damping network
  - earthing condensers
  - dc damping network
- VIII) Device for checking defective cell/cells or string in the rectifier and functions achieved.
- IX) Diagram showing connections between cells fuses/cell check and other components in a vehicle.
- X) Characteristics of blower motor set for operating voltage 290, 320, 415 and 500V.
- XI) Characteristics and type of protective equipment used for blower motor set and ventilation failure.
- XII) Weight of complete equipment with its auxiliary.

#### 5.0 Design calculations:

The following calculations shall be submitted by the tendered along with their offer:

- I) Calculation for number of cells in series and parallel.
  - a) Calculation for number of cells in series based on:
    - Repetitive voltage.
    - Switching surges.
    - Lightening surges.
  - b) Calculation of number of cells in parallel based on duty cycle and short circuit capacity for period as specified under clause No.2.1.2 C, D, E, F & G
  - c) Proposed setting of rectifier overload relay.
- II) Calculation for junction temperature for duty cycle as per clause 2.1.1G
- III) Calculation for string bridge fuse matching for conditions specified in clause 2.1.2 F and voltage rating.

#### 6.0 Technical details of components:

- I) Technical details of fiberglass material conforming to relevant standard showing the thermal properties etc.
- II) Technical details of insulator etc.
- III) Technical data of LEDs used for indication.



**GOVERNMENT OF INDIA**  
**MINISTRY OF RAILWAYS**  
**RESEARCH DESIGNS AND STANDARDS ORGANISATION**  
**MANAK NAGAR, LUCKNOW - 226 011**

No. EL/3.2.185

Dated: 16.01.2004

**AMMENDMENT No. 1**

Sub: Amendment of specification No. ELRS/Spec/RSI/0030 (Rev '0') Dec. 2003 Specification for compact design of uprated silicon Rectifier for AC single-phase locomotive.

Clause No.	Amendment
5.10.4. (I) a,b & 5.10.4 (II)	Temperature rise of 15° C is to be read as 20° C

(S S JOSHI)  
For Director General (Electrical)

Copy to: 1) The Secretary Electrical (RS)  
Railway Board, Rail Bhavan, New Delhi

2) Chief Electrical Engineer,  
CLW, Chittaranjan - 713 331  
West Bengal





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**MANAK NAGAR, LUCKNOW - 226 011**

No. EL/3.2.185

Dated: 03.06.2004

**AMMENDMENT No. 2**

Sub: Amendment of specification No. ELRS/Spec/RSI/0030 (Rev '0') Dec. 2003 Specification for compact design of uprated silicon Rectifier for AC single-phase locomotive.

Clause No.	Amendment
3.8 5.10.4 (i) a & b 5.10.4	Temperature for 70° C ambient is to be read as 75° C
5.10.4(ii)	Temperature for 15° C is to be read as 20° C

(RAM PRAKASH)  
For Director General (Electrical)

Copy to: 1) The Secretary Electrical (RS)  
Railway Board, Rail Bhavan, New Delhi

2) Chief Electrical Engineer,  
CLW, Chittaranjan - 713 331  
West Bengal



**GOVERNMENT OF INDIA  
MINISTRY OF RAILWAYS  
RESEARCH DESIGNS AND STANDARDS ORGANISATION  
MANAK NAGAR, LUCKNOW – 226 011**

No. EL/3.2.185

Dated: 06.08.2008

**AMMENDMENT No. 3**

Sub: Amendment to specification No. ELRS/Spec/RSI/0030 (Rev '0') Dec. 2003 Specification for compact design of uprated silicon Rectifier for AC single-phase locomotive.

Clause	Exisiting	Revised
2.3 (b)	Hole storage capacitor if required across diode	Hole storage of capacitor should be provided across the diodes as per Annexure III S. No. 06 of specification.
S. NO. 4 of Annexure III	ICAR type MLR25 M50 25mfd 500V	ICAR type MSR 25D-22-50 Self healing capacitor 22 mfd-550V

**Clause No. 5.3: Tests on Rectifier Assemblies.**

S.N	Items	Reference	Type	Exisiting Routine Test	Revised Routine Test
1	Visual Inspection & Dimension with tolerance	IS:7788 Cl. 5.10.1	✓	✓	✓
2	Ventilation air-flow Test	IS:7788 Cl. 10.2.2	✓	X	✓
3	Mechanical Vibration and shock tests	IS:7788 Cl. 10.2.3	✓	X	X
4*	Temperature Rise test of diode	IS:7788 Cl. 10.2.6	✓	✓	✓ Only With Blower motor on
5	Starting duty cycle test	IS:7788 Cl. 10.2.7	✓	X	X
6	Current distribution test	IS:7788 Cl. 10.2.5	✓	✓	✓
7	Impulse Voltage Test	IS:7788 Cl. 10.2.8	✓	X	✓
8	Losses and Efficiency Test	IS:7788 Cl. 10.2.12	✓	X	X
9	Short Circuit Test	IS:7788 Cl. 10.2.15	✓	X	X



10**	Insulation & Dielectric test	IS:7788 Cl. 10.2.9	✓	✓	✓
11	Noise measurement	IEC: 61287 Cl.2.4.6.11	✓	×	×
12	Moisture Absorption test	IS:10192	✓	×	×
13	Check of diode characteristics	IS:7788 Cl. 10.2.13	✓	×	×

\* One unit of after every ten units will be tested as per IS: 7788 clause 10.2.6

\*\* IR tests during routine inspection may be done without any limit of RH. IR value should be more than 100 megohms irrespective of the RH value. However, one unit of after every ten units will be tested as per IS: 7788 clause 10.2.6

(M K GUPTA)  
For Director General (Electrical)

Copy to: 1. The Secretary Electrical (RS) (attn. Sri Mohit Chandra, Director /RS)  
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