NO. ELRS/SPEC/DBR/0028 (Rev '0')

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

(RAILWAY BOARD)

# TECHNICAL SPECIFICATION

# FOR

# DYNAMIC BRAKING RESISTORS

# WITH

# A.C./D.C. MOTOR DRIVEN COOLING BLOWERS

# FOR

# A.C. ELECTRIC LOCOMOTIVES

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ISSUED BY

RESEARCH DESIGNS AND STANDARDS ORGANISATION
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# SECTION 1: GENERAL

## 0. FOREWORD

0.1 The specification covers requirement of vertical type high capacity Rheostatic Braking Resistors complete with Blower Motor set covered for provision on Machine Room of Electric locomotives to control speed of the train.

0.2 Dynamic braking is considered necessary on all modern locomotives as it provides an alternate brake for smooth control of speed, particularly helpful in operation in graded sections. Its use is also desirable in controlling train speeds on flat sections, as it saves on wear and tear of mechanical brakes and time to release brakes after each operation. These brakes, however, are not effective at low speeds or for stopping the trains for which mechanical brakes are to be used.

0.3 This specification consists of the following Sections:

Section 1 - General
Section 2 - Resistor Grid Block.
Section 3- Motor
Section 4 - Blower set
Section 5 - Annexures and Drawings



0.4 **Governing Specifications**

Assistance has been taken from the following specifications in preparation of this specification:

| | |
|---|---|
| IEC:349–1993 | Rules for rotating machines for Rail road vehicles |
| IEC:322–1970 | Rules for Ohmic Resistors used in power circuits of Electrically Powered vehicles. |
| IS:3588-1987 | Specification for Electric Axial Flow Fans. |
| IS:12075-1991 | Mechanical vibration of Rotating Electrical Machines. |
| IS: 691-1985 | Degree of protection provided by enclosures for rotating electric machinery. |
| IS:6195-1969 | Insulated flexible cables and cords for coil leads. |
| IS: 5 – 1994 | Colours for ready mixed paints and enamels. |
| IS: 10192-1982 | Synthetic resin bonded glass fibre(SRBGF) sheets for electrical purposes |
| IEC: 626-3 1996 | Combined flexible materials for electrical insulation-Specifications for individual materials |

## 1.0 SCOPE :

1.1 The Specification covers the manufacture and testing of Rheostatic Braking Units duly assembled in a steel frame in accordance with the general arrangement drawing No. CLW/ES/SK-1/R-29 Alt. M. Rheostatic Braking Resistor Unit shall be used on 25 kV AC Electric Locomotives of Class WAG-5/WAG-7/WAP4 on the Indian Railways.

1.2 The following accessories shall be within the scope of supply as shown in drawing no CLW/ES/SK-1/R-29, Alt.M.

i) Terminal block for power with internal connections as well as cable sockets for external connections duly secured in place with M16 fasteners.
ii) Terminal block for Auxiliary with internal connections to suit M5 terminals and label for wiring diagram.
iii) Rubber gasket secured top the bottom flange with M12 fasteners.
iv) Bell mouth arrangement as per Sketch No. CLW/ES/SK-9/R-29, Alt. M.

## 2.0 SERVICE CONDITIONS

2.1 Ambient Temperature: The general ambient temperature of the air at the inlet to the blower will be 0 $^0$C to 65 $^0$C (maximum).

2.2 Relative Humidity: Varying upto 100%.

2.3 Maximum Altitude: 1000 meters above Mean Sea Level.

2.4 The equipment and mounting arrangement shall be of robust design for traction duty and shall withstand satisfactorily the vibrations and shocks normally encountered in service.

a) Maximum vertical acceleration 1.0 g
b) Max. Longitudinal acceleration due to shock 3.0 g
c) Max. Transverse acceleration 1.0 g

2.4.1 The vibrations are of sine wave form and the frequency of vibration is between 1 Hz and 50 Hz. The amplitude `a', expressed in millimeters is given as a function of `f' by the equation :

$$a = \frac{25}{f}$$ for values of f from 1 Hz to 10 Hz

$$a = \frac{250}{f^2}$$ for values of f exceeding 10 Hz and upto 50 Hz.

2.4.2 In the direction corresponding to the longitudinal movement of the vehicle, the equipment is subjected for 2 Min to 50 Hz vibration of such a value that the maximum acceleration is equal to 3 g (amplitude a = 0.3 mm).

Note: Although no test to assess the suitability of motors under vibration levels as indicated in clause 2.4, 2.4.1 & 2.4.2 has been proposed, the manufacturer shall take these factors into consideration while designing various components e.g. shaft, bearings, mounting arrangements etc. and their necessary mechanical features.

2.4.3 The elements and accessories of equipment shall not exhibit harmful resonance for the frequencies in the above range.

2.5 The locomotive shall be required to operate in heavy rain and areas with dusty storms. The machine compartment of locomotive itself may have some oil fumes. The design of the unit shall take due account of all these factors.

## 3.0 APPROVAL OF DRAWINGS

The successful tenderer shall be asked to submit and finalise the detailed component drawings of the equipment offered in association with CLW and RDSO. The design of equipment shall not include such of the items and design features that have been giving problems/failures on similar application. The tenderer shall incorporate such of the features that have been proven in service on similar applications on Indian Railway rolling stock, based on the technical discussions during finalisation of the above drawings.

## 4.0 HARDWARE

All the hardware used shall be metric threads only. However, high tensile fasteners are to be used only from the firms M/s Unbrako, M/s Sundaram Fasteners or M/s LPS. The spring washers of `FORBE' make only should be used.

## 5.0 NAME-PLATE

Each resistor box/frame and motor blower set shall be provided with a plate displaying the following information:

- Manufacturer's name
- Indication of type and series
- Important ratings
- Year of manufacture
- Weight.

## 6.0 INSPECTION & TESTS ON DBR UNIT

6.1 Tests are classified as Type Tests, Routine Tests and Investigation Tests. The Type Tests are those made on single piece of apparatus of the given design. The successful tenderer shall make arrangement in his works to carry out complete Type Tests on one unit, simulating loco conditions to the extent possible including the roof grill and bottom as shown in Drawing No. CLW/ES/SK-2/R-29, Alt.M. Routine Tests are those made on every equipment of the same order. Investigation Tests are special tests that are optional & made on a single item in order to obtain additional information on this apparatus, their execution may only be required if they are specifically specified in the order.

6.2 **Schedule of Tests:**

Complete set of Type Tests and Routine Tests to be carried out on Resistors, Motors and Blowers described in Section 2,3 and 4 are listed below:

| S. No. | Tests | Type Test (Clause No.) | Routine Test (Clause No.) |
|---|---|---|---|
| A. | **On Resistors** | | |
| 1. | General Inspection | 9.3 | 9.3 |
| 2. | Check on Characteristics of resistor element material. | 9.4 | 9.4 |
| 3. | Resistance measurement | 9.5 | 9.5 |
| 4. | Air Flow Measurement | 9.6.1 | 9.6.2 |
| 5. | Temp. rise test (Stationary condition) | 9.7 | - |
| 6. | Test for withstanding vibration and shock | 9.8 | - |
| 7 | Hygroscopic Test | 9.9 | - |
| 8. | Test for performance in rain | 9.10 | - |
| 9. | Di Electric Test | 9.11 | 9.11 |
| 10. | Insulation resistance test | 9.12 | 9.12 |
| 11. | Function of air flow relay | 9.13 | 9.13 |
| 12. | Condition of resistor after test | 9.14 | 9.14 |
| 13. | Dimension measurement | 9.15 | 9.15 |
| 14. | Weight Measurement Complete Unit | | |
| | | | |
| B. | **On Motor** | | |
| 1. | Measurement of Resistance (cold) | 12.2 | 12.2 |
| 2. | Direction of rotation | 12.3 | 12.3 |
| 3. | No-load test | 12.4 | - |

| | | | |
|---|---|---|---|
| 4. | Temperature rise test | 12.5 | 12.5.1 |
| 5. | Max. & Min. voltage operation test | 12.6 | - |
| 6. | Over speed test | 12.7 | 12.7 |
| 7. | Starting test | 12.8 | - |
| 8. | Commutation test | 12.9 | 12.9.1 |
| 9. | Interruption test | 12.10 | - |
| 10. | Voltage jump test | 12.11 | - |
| 11. | Dielectric test | 12.12 | 12.12 |
| 12. | Insulation Resistance test | 12.13 | 12.13 |
| 13. | Enclosure Protection test | 12.14 | 12.14.1 |
| 14. | Weight measurement | 12.15 | - |
| | | | |
| **C.** | **On Blowers :** | | |
| 1. | Air Delivery Test | 14.2 | - |
| 2. | Starting time test | 14.3 | - |
| 3. | Starting duty test | 14.4 | - |
| 4. | Endurance test | 14.5 | - |
| 5. | Vibration measurement test | 14.6 | - |
| 6. | Checking of critical dimensions, fixing and locking arrangement. | 14.7 | 14.7 |
| 7. | Weight measurement | 14.8 | - |

6.3 **Dimensional Inspection :**

All dimensions, overall mounting arrangements, terminal/bus-bar arrangement etc. shall be checked with the drawings. The overall dimensions of the assembly shall not exceed the limits indicated in the drawing No. CLW/ES/SK-1/R-29, Alt. M, i.e., 880 x 1010 x 1850 (height) (including lifting hook). Lifting hook shall be of hinged type secured with the sides so as to keep it in level with the top surface when not required.

6.4 **Approval of Prototype :**

A Prototype unit manufactured as per approved drawing shall be offered for Type Test at firm's premises. After successful completion of all tests mentioned in Clause 6.2, prototype unit shall be approved.

6.5 The supplier shall provide all facilities to the Inspecting Officer at his works, to inspect and test the equipment at various stages of manufacture and also of the complete equipment.

6.6 Any testing and approval by the purchaser of the design, working drawings and prototype shall in no way absolve the supplier of his responsibility under the terms of the contract for the equipment supplied.

# SECTION-2

## RESISTOR GRID BLOCKS

## 7.0 TECHNICAL SPECIFICATION OF RESISTOR ELEMENTS

### 7.1 Rating of the Resistors:

| | |
|---|---|
| Continuous rated current of the resistance | 900 A |
| Value of resistance per traction motor at Operating temperature of 600$^0$C | 0.5 Ω +7%/ - 5% |
| Total Number of Traction Motors | 06 |
| Hot spot temperature | 850 $^0$C |
| Peak over load rating | 1.25 times the rated Power for 10 min. |
| Total heat dissipated in the resistors corresponding to 900A braking current. | 2430 kW |
| Average temperature of resistor element | 600 $^0$C. |
| Average exit air temperature | less than 300 $^0$C. |

7.2 The resistance shall be designed for a continuous rated current of 900A as well as to cater for 5% increase in the braking current on account of permissible tolerance in the current setting of the overload relay. The resistance values mentioned above correspond to the actual working temperature of the resistance carrying a braking current of 900 A for each traction motor group.

## 8.0 Design of the Resistors

8.1 The resistance units shall be of a very robust design for meeting the arduous traction duty and all materials used for the assembly shall be suitable to withstand a temperature of the order of 850 $^0$C continuously. The cubicle shall be provided with screwed covers. The front and rear end covers shall be insulated with Epoxy sheet. The front cover (Terminal side) shall be in two halves, top & bottom. The resistor banks enclosure shall consist of temperature resistant insulating material such that the temperature rise of the insulating material corresponding to the maximum enclosure temperature is well within its capability with a margin of at least 80$^0$C. The temperature of enclosure shall not be more than 20$^0$C above the ambient temperature. The temperature rise at point above 100 mm away from the enclosure shall not be more than 15$^0$C. The blower shall be arranged to draw the air through the circular suction cone underneath the locomotive and blow out air through the loco roof without roof cowls.

8.2 The material for the resistor grids shall be Nickel, Chromium and Iron alloy with 60% Ni, 15% Cr and rest iron. It shall have a minimum lifetime of 100 hours (to be measured by carrying out the accelerated life test as per ASTM-8-76). The melting point of the grid material should be more than 1400 $^{0}$C.

Resistance of all trays shall be same irrespective of whether DC or AC induction motor is used to drive the DBR fan.

The resistance grids shall be so designed as to be accommodated in the mounting dimensions as shown by RDSO Drawing No SKEL/4671.

Each resistor tray shall be designed such that there is uniform heat flow over the entire surface of the resistor elements. No separator shall be used between adjacent resistor elements/ribbons to minimize the resistance to the airflow.

8.3 The resistor elements shall be held in such a way that the thermal expansion at high temperature (of the order of 900$^{0}$C) does not result in the deterioration/sagging of the grids. The tenderers shall furnish details of the arrangement for supporting the elements and allowing for thermal expansion at high temperature.

8.4 The resistor elements in each tray shall preferably be in one length without any joints. However, if joints are unavoidable, it shall be a spot welded joint and the electrical resistance of the joint shall not be more than the equal length of the parent element. Similarly, the mechanical strength of the joint shall not be less than the parent element.

8.5 The insulators with which the resistor elements will be in contact directly or through metallic connectors shall be made of temperature-resistant, non-hygroscopic, shockproof ceramic material capable of withstanding 1500$^{0}$C continuously without any adverse effect on its electrical and mechanical properties. The ceramic material used for the insulators should be free from Sulphur to prevent corrosion of Nickel-Chromium resistor alloy due to emission of Sulphur Dioxide at the high temperature.

8.6 The maximum weight of the complete unit shall not exceed 900 kg. The tenderer shall mention the actual weight of the assembly and the individual sub-assemblies.

8.7 The terminals of the resistor banks to which the external cables are to be connected shall be designed so that temperature at the joint of the cable sockets is less than 70$^{0}$C to prevent damage to the cable insulation. The cable socket for external connection shall also be supplied duly secured on the terminals conforming to drawing no. CLW/ES/SK-5/R-29 Alt. M. Flexible copper cables for internal connections shall be of suitable insulation to

withstand high temperature. Alternatively, copper bus bars can be used for internal connections.

8.8 **Enclosure:**

Main framework of the enclosure shall be of welded angle iron construction. The upper compartment will house the resistor box and the lower half blower motor set and air diffuser. On one side, part of the cover shall comprise of silicon varnish impregnated non asbestos based insulating material sheets with suitable slots through which the power connections will be brought out for connecting cable 2x150 $mm^2$ as per drawing No. CLW/ES/SK-1/R29 Alt. M. Suitable insulation lining shall be provided to prevent rubbing of cables with sharp edges wherever applicable.

8.9 Adequate clearance and creepage distance shall be maintained in the cubicle to avoid flashover. The clearance through air shall not be less than 40 mm and creepage distance along the surface shall not be less than 70 mm. Whenever such clearances are not possible to maintain, insulating sheet shall be provided of Grade EP3 to IS 10192 of 1982.

8.10 **Cooling of the Resistor :**

Resistor box comprising six resistance trays shall be forced cooled by a vertically mounted motor blower set. The blower shall draw air from bottom of the locomotive and after cooling the resistor elements the hot air shall be discharged from the top of the locomotive through roof grill. Proper and uniform distribution of air over entire area of resistor box shall be ensured with the help of suitable diffuser and baffle plates.

Either 3-phase induction motor or a DC series motor shall drive the blower, to be specified by the purchaser. The specification of the motor are covered in Section-2 (Motors).

8.11 The resistors and their cooling system shall be so designed that the heat radiated inside the locomotive is restricted to the minimum to prevent excessive temperature rise of the equipment inside the locomotive. The average exit air temperature shall not be more than 300 $^{0}C$.

8.12 In order to improve the suction of air, inlet suction cone has to be provided underneath the locomotive below DBR Unit as per CLW Drawing No. CLW/ES/SK-9/R-29 Alt. M and this is in the scope of supplies of manufacturer.

8.13 **Colour Scheme:**

Colour of main framework of enclosure shall be of colour No. 631 Night grey of IS 5-1994 and Bellmouth should be of colour No. 632, dark admiralty grey of IS 5-1994.

8.14 **Embossing:**

Name of the manufacturer, Serial No., month and year of manufacture shall be embossed on each component e.g., on Resistor Box Assembly, Motor Fan and Air Motor Blower Casing.

## 9.0 TEST PROGRAMME FOR RESISTORS

9.1 Type Tests and Routine Tests shall be carried out on the DBR units as detailed in Clause 9.2. However, not withstanding the provisions of this clause, the purchaser may require prototype tests to be repeated on any particular unit, under certain circumstances such as change in designs or materials, modifications for improvements and such other considerations. Carrying out of the repeat type tests will be subject to agreement between the purchaser and the supplier of the equipment.

9.2 **Tests on Resistor Boxes:**

The Type Tests and Routine Tests to be carried out on resistor boxes are indicated in the table below. The Clause and Sub-clause Number to be referred are also mentioned:

| S. No | Tests | Type Test (Clause No.) | Routine Test (Clause No.) |
|---|---|---|---|
| 1. | General Inspection | 9.3 | 9.3 |
| 2. | Check on Characteristics of resistor element material. | 9.4 | 9.4 |
| 3. | Resistance measurement | 9.5 | 9.5 |
| 4. | Air Flow Measurement | 9.6.1 | 9.6.2 |
| 5. | Temp. rise test (Stationary condition) | 9.7 | - |
| 6. | Test for withstanding vibration and shock | 9.8 | - |
| 7 | Hygroscopic Test | 9.9 | - |
| 8. | Test for performance in rain | 9.10 | - |
| 9. | Di Electric Test | 9.11 | 9.11 |
| 10. | Insulation resistance test | 9.12 | 9.12 |
| 11. | Function of air flow relay | 9.13 | 9.13 |
| 12. | Condition of resistor after test | 9.14 | 9.14 |
| 13. | Dimension measurement | 9.15 | 9.15 |

**9.3 General Inspection:**

General inspection is to be carried out with regard to the deformity, breakage etc. The resistance elements should be equally spaced throughout the element grids. All joints should be tightened properly. The element end connection with bus bar should be rigid. To strengthen the end connection a same size element piece of suitable length should be spot-welded. Precautions should be taken to give adequate protection against corrosion for all the components, specially contact surfaces.

9.4 **Check on characteristics of resistor element material**:

The resistivity and the average value of temperature co-efficient over the range between the ambient and maximum operating temperature will be determined from test piece taken from the alloy forming the resistor elements. Special test for verifying the composition of the material and lifetime shall be carried out (As per the requirement of clause 8.2).

9.4.1 In case joints are used in the resistor element, suitable tests shall be carried out to verify the requirement of the Clause 8.4.

9.5 **Check on rated resistance**

9.5.1 Check on the rated value of resistance for each resistance tray carried out by using voltmeter and ammeter or Kelvin double bridge or digital micro ohm meter. Readings are taken at ambient Temperature and corrected to the reference temperature of $20^0$C and $600^0$C. The allowable tolerance on resistance values in relation to the rated values shall be limited to +7% and –5%.

9.5.2 Resistance measurements shall be repeated at the end of temperature rise test described in Clause 9.7. The resistance increase noted should approximate to the value calculated on the basis of the temperature co-efficient determined during the test described in Clause 9.4.

9.5.3 After the temperature rise test, the resistance shall be measured again at the ambient temperature. The value obtained as corrected at $20^0$C and $600^0$C shall not exceed by more than 3% the value measured before temperature rise test.

9.6 **Air Flow Measurement :**

9.6.1 **Type test:**

Perform the following set of tests on complete DBR Unit with bottom suction cone by giving external voltage supply equal to rated voltage, 70% of rated voltage and 500 Volts respectively to the motor:

9.6.1.1 Create suitable resistance to airflow path so as to achieve specified total pressure head of 180 mm WG in the DBR Unit. Measure the air velocities at 100 points as per drawing No. CLW/ES/SK-6/R-29 Alt.-M at the level of roof outlet mesh guard. Calculate the average air velocity and volume flow rate. The volume flow rate should not be less than specified value, i.e. 11 $m^3/s$.

9.6.1.2 Remove the resistance to airflow path. Measure air velocity and calculate average volume flow rate as above. Measure and record total pressure head.

9.6.2 **Routine Test:**

Perform the set of tests similar to Clause 9.6.1.1 and 9.6.1.2 on complete DBR unit with bottom suction cone by giving rated voltage supply to the motor.

9.7 **Temperature Rise Test (Stationary condition):**

The Temperature Rise Tests are carried out on a finished and mounted resistor installed in conditions as identical as possible to those on the vehicle, especially in regard to the cross-section of connecting lead, the resistor position etc. The cooling conditions shall be so arranged as to reproduce the normal service conditions, as clearly as possible.

9.7.1 The Temperature Rise Test shall be conducted on each resistor box/frame at the following values of current:

200 A, 400 A, 560 A, 750 A, 800 A and 900 A.

During the test, the temperature rises observed must not exceed the specified limits. On completion of Temperature Rise Test, the resistors must be in perfect working order. In particular, they must be capable of withstanding the di-electric tests prescribed in Clause 9.11.

9.7.2 During the Temperature Rise Test, the temperatures of the inside and outside all of the enclosure shall also be measured and shall conform to the limits as laid down in Clause 8.1

9.7.3 During the Temperature Rise Tests, the temperature of the terminals shall also be measured and it shall not exceed the limits laid down in Clause 8.7.

9.7.4 Temperature Rise Test shall also be conducted to verify the over load rating of the resistor, i.e., 1.25 times the rated Power for 10 minutes. Average temperature of the resistor, exit air temperature and hot spot temperature should be within specified limit.

9.7.5 After Temperature Rise Tests, the elements shall be physically examined to check for any distortion or sag.

9.7.6 The test results for verifying the electrical and mechanical properties of ceramic material used in the resister assembly before and after subjecting them to continuous temperature of $1500^0$C shall be submitted by manufacturer. The manufacturer shall also submit results of shock proofness tests of ceramic insulating material.

9.8 **Tests for withstanding vibration:**

The complete block shall be fixed in a suitable position on to a machine producing sinusoidal vibrations of adjustable amplitude and frequency then subjected to the tests of sub-clause 9.8.1 and 9.8.2. The resistor box/frame is then fixed on a suitable device and subjected to the tests of sub-clause 9.8.3. After these tests, the resistor box or frame must be able to withstand successfully the electrical tests and particularly the dielectric strength tests described in Clause 9.11.

9.8.1 Investigation of Resonant Frequencies:
With a view to find out the possible presence of critical frequencies causing resonance in the parts of resistors box or frame, the frequency shall be gradually increased from 1 Hz to 50 Hz in a time at least equal in 4 minutes, the amplitude of the oscillation being that shown in Clause 2.4.

9.8.2 Sustained Vibration Tests:
In each of three directions i.e. vertical, longitudinal and transverse, the resistor box/frame, when cold shall be subjected for a time not less than 15 minutes, to a sustained vibration test-

- either at the critical frequency if such a frequency, well defined, has been detected during the test described in Clause 9.8.1;
- or, otherwise, at 10 Hz.

In both cases, the amplitude of vibration table is adjusted to the value corresponding to the frequency considered (see clause 2.4).

9.8.3 Tests Simulating Buffing Shocks :
In the direction corresponding to the longitudinal movement of the vehicle on which it will be mounted, the resistor box or frame shall be subjected to a series of three successive impacts each corresponding to a maximum acceleration of 3g.

9.9 **Hygroscopic Test** :

The resistor box or frame shall be placed in a humid enclosure at a temperature of 20 $^0$C to 25 $^0$C and showing a relative humidity of at least 95% for 24 hrs.

As soon as possible, and in any case, not more than five minutes after removal from the humid enclosure and wiping off extraneous surface moisture with a clean cloth, a Dielectric test shall be carried out, using test voltages of values 1000 Volts less than the values shown in Clause 9.11

**9.10 Test for Performance in rain :**

9.10.1 Inject rated current (900A) to the resistor assembly until stable temperature is reached.

9.10.2 Isolate the power to resistor and blower unit. Then spray should be made with water at ambient temperature in a direction in the vertical plane from an angle 45$^0$ with the direction of motion and with an output of 3 mm/min for 5 minutes. Repeat the test at least three times or until total wetting of the DBR unit is achieved.

9.10.3 Carry out Dielectric test at 50 Hz for one minute duration in each case, using test voltages as given below:

(i) Primary insulation(Element to Tie rods) – 2.0 kV
(ii) Secondary insulation(Tie rods to Earth) – 2.25 kV

9.10.4 After the test, check that no water leakage/seepage occurred from the DBR at all joints, covers cover strips or crevices that might allow penetration of water.

9.11 **Dielectric Test** :

These tests shall be carried out at the normal temperature of the test site on each resistor box, frame or block. Each resistor box/frame shall be subjected to the test voltages mentioned below for one minute. The test voltage at the nominal frequency of 50 Hz shall be as nearly as possible sinusoidal.

a) Resistance with single insulation : 2.5U + 2000 Volts.
b) Resistor with double insulation :
i) Primary Insulation : 3000 Volts
ii) Secondary insulation : 2.5U + 2000 Volts

'U' is the rated voltage of the circuit, e.g. 750V.

**9.12 Insulation Resistance:**

Measure the Insulation Resistance before and after the dielectric test with 1000V meggar.

**9.13 Test for Airflow Relay function:**

9.13.1 For DC Blower Units: Disconnect the DC MVRF terminal from the terminals of top grid on front panel, connect indication lamp across the contacts of QVRF. Connect external DC source to MVRF. Run the blower by gradually increasing the DC voltage till the QVRF picks up and indication lamp glows. Record the MVRF voltage and current at which relay QVRF picks up. This relay should pick up well within 85V DC if it is properly set to pick up between –12 (+0, -2) mm WG.

9.13.2 For AC Blower units: Connect indication lamp across the contacts of QVRF. Supply rated voltage across AC MVRF. Check the functioning of the relay.

9.14 **Condition of resistor after test** :

After the tests specified in Clause 9.3 to 9.13, check shall be made that

i) No screw and nut is loose.
ii) The elastic inserts have correctly fulfilled their purpose.
iii) There is no distortion or corrosion or scaling of any components.
iv) The resistor elements are not cracked or broken.
v) The insulators have suffered no damage.

9.15 **Dimension Measurement**:

Measure the mounting dimension, overall dimension and other critical dimensions as per drawing No CLW/ES/SK-1/R-29 Alt. M.

## SECTION 3

## MOTOR

**10.0 Motor**

The driving motor for the blower shall be either 3-phase AC induction motor or DC Series motor to be specified by the purchaser.

**10.1 AC Motor**

The AC motor shall be fed from static converter unit provided on the locomotive. Suitability of the motor to work with static converter supply shall be kept in consideration while designing the motor. The salient design details of the AC motor shall be as follows:

| | | | |
|---|---|---|---|
| i) | Type | : | 3 phase AC induction motor |
| ii) | Power | : | 30 kW |
| iii) | No of Poles | : | 2 |
| iv) | Frame | : | 200 (Integral cast steel construction) |
| v) | Cooling | : | Surface cooled by DBR fan |
| vi) | Mounting | : | Vertically mounted |
| vii) | Protection | : | IP 56 |
| viii) | Insulation | : | Class H |
| ix) | Temp. rise limit | : | $80^0$ C |

The AC motor shall conform to RDSO specification No ELRS/SPEC/AUX/0023 of October 2002.(Technical Specification for Converter fed three phase induction motors for driving Auxiliary Machines of AC Electric Locomotives.)

**11.0 DC Motor**

11.1 Salient design details of the DC Series Motor are as follows:

| | | | |
|---|---|---|---|
| i) | Type | : | DC Series Motor |
| ii) | Power | : | 36 kW |
| iii) | No of Poles | : | 4 |
| iv) | RPM | : | 3000 |
| v) | Frame | : | 200 (Integral cast steel construction) |
| vi) | Cooling | : | Surface cooled by DBR fan |
| vii) | Mounting | : | Vertically mounted |
| viii) | No of Brush Holders | : | 2 |
| ix) | Protection | : | IP 56 |
| x) | Insulation | : | Class H |

xi) Temperature rise limit :

| | | |
|---|---|---|
| Field | : | TI - 80 |
| Armature | : | TI - 80 |
| Commutator | : | 85 $^0$C |

xii) Absolute Bearing Temp: 90 $^0$C (max)

(Where TI = Temp. Index of Insulation System used.)

11.2 Due to constraints in accessibility for in-situ maintenance, the motor shall be designed to have single inspection cover for commutator, having 2 brush holders separated by 90° on periphery. The armature shall be wave wound.

11.3 Since the system is open to atmosphere from the top, protection of the motor from water and dust ingress is of paramount importance. The motor shall strictly adhere to IP 56 level of protection. The inspection cover for commutator shall be provided with adequate fastening arrangement. Use of sealant like RTV etc, however, shall not be permitted on the inspection cover as a design feature.

11.4 **Brush Gear:**

i) Brush holder will be of single piece construction.

ii) Brush holder spring shall be conical spiral type. The spring pressure shall remain fairly constant over the entire wearing length of the brushes. Provision will be made to adjust the spring pressure in steps as the brushes wear out in service, if a constant pressure spring is not used.

iii) The design of the brush holder should be such that the brush box is close to the support and the spring anchor at the far end with removable casing.

iv) The brush holder-insulating stud shall be provided with PTFE sleeves.

v) It should be easy to remove and examine the brushes easily during inspection. Separate spring test will be provided to hook the spring in released position for attending to the brushes.

vi) Carbon brush grades shall be either EG367 of Carbon Lorraine or EG105 of Assam Carbon. In case any other grade is proposed to be used, prior approval of RDSO shall be mandatory.

11.5 **Winding Wires:**

The armature and field shall preferably be wound with dual coat super enamelled copper winding wire in metric size with medium covering

conforming to IS:13730 Pt. 13 – 1993. Manufacturer shall carry out tests on all the enamelled winding wires as per the tests laid down in IS: 13730 Pt. 13.

11.6 **Impregnation:**

Vacuum/pressure impregnation shall be adopted for the field and armature using solventless resin, viz., FT 2015/2005/500 EK of Dr. Beck & Co.

11.7 **Terminal Plate:**

Epoxy moulded terminal block/plate should be used.

11.8 **Terminal Leads:**

i) Terminal leads should be flexible, insulated, fibre glass copper connecting lead wire with fire retardant silicon elastomer suitable for temperature $-50^{\circ}$ C to $+180^{0}$C as per BS 6195 of 1969 having BDV of 6 kV per minute.

The flexible lead should be covered with suitable flexible insulated fibreglass sleeve with coating of fire retardant silicon elastomer applied by extrusion or multidip process. The silicon sleeve shall have temperature index of $180^{0}$C as per BS 2848 type 1/180 Tb, shall have overall thickness of 0.7 mm and shall be capable of withstanding a minimum BDV of 5 kV for one minute.

ii) For connecting terminal leads, only silver brazed joints shall be used. Soldered joints are not acceptable.

11.9 **Slot Insulation:**

Nomex-Kapton-Nomex conforming to IEC-626-3 shall be used in the slot of armature as insulation along with other insulating tapes for Class H motors.

11.10 **Bearings:**

i) Either deep groove ball bearings or roller bearings of adequate design should be used to withstand the vibration encountered on the locomotive.
ii) Minimum L10 life shall be 100,000 hours.
iii) Sealed bearings should not be used.
iv) Bearing should have C3 class of clearance. Bearing should be filled with Servogem RR3 grease of M/s IOC.
v) Manufacturer should supply the lubrication schedule and the quantity during maintenance.

vi) Label for lubricating instructions shall be provided adjacent to the nipples.

vii) Grease nipples for the bearings of the motor shall be suitably extended to facilitate easy lubrication and should include a vent for overflow of old grease. The grease nipples should be of industrial round head type.

viii) The tolerance between inner race of the bearing and shaft shall preferably be to K5 type. Actual tolerance between inner race of bearing and shaft shall be specified.

ix) The tolerance between outer race of the bearing and housing shall be of `J6' type. Actual tolerance between outer race of the bearing and bearing shall be specified.

x) Tolerances on boundary dimension shall be adopted as per IS: 5682-1970 of O class.

xi) Maximum temperature of bearing cap should be restricted to $90^0$C.

11.11 **Shaft:**

i) Material used for the shaft shall be of EN 24 or equivalent steel of higher quality of alloy steel.

12.0 **Test programme for DC Motor:**

12.1 All motors shall be generally tested in accordance with IEC Publication No. 349-1993. The type tests and routine tests to be carried out on motor are given below:

| S. NO | Tests | Clause of Type Test | Clause of Routine Test. |
|---|---|---|---|
| 1. | Measurement of resistance (cold) | 12.2 | 12.2 |
| 2. | Direction of rotation | 12.3 | 12.3 |
| 3. | No Load Test. | 12.4 | - |
| 4. | Temperature Rise Test | 12.5 | 12.5.1 |
| 5. | Maximum & Minimum Voltage Operation Test | 12.6 | - |
| 6. | Over speed test | 12.7 | 12.7 |
| 7. | Starting Test | 12.8 | - |
| 8. | Commutation Test | 12.9 | 12.9.1 |
| 9. | Interruption Test | 12.10 | - |
| 10. | Voltage Jump Test | 12.11 | - |
| 11. | Dielectric Test | 12.12 | 12.12 |
| 12. | Insulation Resistance Test | 12.13 | 12.13 |
| 13. | Enclosure Protection Test | 12.14 | 12.14.1 |
| 14. | Weight Measurement Test | 12.15 | - |

12.2 **Measurement of Resistance (cold):**

The resistance of the armature, main field, interpole etc., when cold, shall be measured either by a bridge or by the Ammeter Voltmeter Method. Record the method of test, winding temperature, voltage, current and resistance. Tabulate resistance value for each of the terminals (connected to winding) which are brought out. The temperature differences may also be corrected, if necessary. The average value for the first five motors shall be considered as the typical value of reference in Routine Tests. During Routine tests, the value of resistance recorded shall not differ from the corresponding typical value by more than $\pm 2$ %.

12.3 **Direction of Rotation:**

Direction of rotation, clock-wise or anti-clockwise, marked on the machine shall be verified and recorded.

12.4 **No Load Test:**

No load characteristics of the machine shall be determined at the speed corresponding to the rated voltage and current by running the machine as a separately excited generator. Draw curve between the excitation current in series, shunt fields and EMF generated. Measure no load losses for rated voltage and RPM.

12.5 **Temperature Rise Test:**

As cooling of the motor is forced ventilation by DBR fan, an arrangement should be made to simulate the service condition. Preferably Temperature Rise Test shall be carried out with DBR, Blower and its casing. The following tests shall be carried out:

a) One hour temperature rise test at rated voltage and current.
b) Steady state temperature rise test at rated voltage and current.

Measure voltage, current, input power, speed, frame temperature bearing temperature and total head of the blower, temperature of cooling air inlet and outlet.

The temperature rise for the winding shall be measured by resistance measurement method after one hour and after all parts of the motor have attained steady state temperature. Temperature of the commutator shall be measured with thermometer.

For accurate measurement of the temperature by resistance method, hot resistance of the winding shall be measured immediately after switching off

(in any case not later than 30 seconds). Subsequent measurements should be carried out at intervals not exceeding 15 seconds for the first two minutes and 20 seconds for the following 3 minutes. The data shall be used for extrapolation to find the maximum temperature in accordance with IEC 349. Record the method of tests and measurements and various measured and calculated values. The efficiency of the motor shall also be calculated and recorded.

One-hour Temperature Rise Test results shall be statistically evaluated for first 5 motors and used for the purpose of comparison with the Routine Test Results. A limit of $\pm 2\ \sigma$ can be used as typical value.

The temperature rise of armature, field and commutator shall not exceed the temperature limit laid down below:

| | Temperature rise (°C) |
|---|---|
| Armature | TI - 80 °C |
| Field | TI - 80 °C |
| Commutator | 85 °C |

TI = Temperature Index of the insulation system. In the absence of TI, class of the insulation shall be treated as Temperature Index.

12.5.1 Temperature Rise Routine Test:

Temperature Rise Test on Motor Blower set shall be carried out for one hour. The method of test shall be as per Type Test (Clause No. 12.5). Temperature rise of Armature field and commutator shall not exceed the typical values of type test results obtained during 1-hour temperature rise test carried out on first 5 machines.

12.6 **Maximum and Minimum Voltage Operation Test:**

Immediately after Temperature Rise Test at rated voltage run the motor for 60 minutes at 70% of the rated voltage by keeping the arrangement same as during temperature rise test at rated voltage. After the 60 minutes run, stop the motor and measure the hot resistance of Armature and Field. Measure the commutator surface temperature by thermometer. Calculate the temperature rise, which should not exceed the temperature rise limit laid down in Clause 12.5.

Immediately after the above test, increase the voltage to 500V and run the motor for 60 minutes. At the end measure the hot resistance of Armature and field and surface temperature of the commutator. Calculate the temperature rise. It should not exceed the limits laid down in Clause 12.5.

12.7 **Over Speed Test:**

The motor when hot shall run at an over speed of 1.2 times the rated speed for 2 minutes. There should not be any deformation. The bearing conditions shall be checked before and after the test by means of Shock Pulse Meter.

12.8 **Starting Test:**

While at a continuous rating temperature the motor shall be subjected to 5 successive starts, with an interval of 2 minutes between the starts, at the minimum voltage 70% of the rated voltage and five successive starts at 500V against full load torque. No mechanical distortion, flashover, or permanent damage should occur.

12.9 Commutation Test:

The test shall be carried out with the machine hot. The motor should withstand the test without mechanical deterioration, flashover or permanent damage. Permanent damage being that which would affect the satisfactory operation of the machine after completion of the test.

The commutation test shall be carried out at following points:

i) At maximum speed, maximum voltage.
ii) At rated current and speed.
iii) At maximum current (1.5 times rated current).

12.9.1 Commutation test shall be carried out at rated voltage at 100% and 150% of the rated current.

12.10 Interruption test:

Test shall be carried out with the motor equipped with starting protective gear suitable for simulating conditions in normal service. The supply shall be interrupted and restored 5 times in succession, along the normal load conditions to be re-established between the successive interruptions, the motor operating at its continuous rating with the weakest field that can be obtained in service. The time interval between the incidents of interruption and restoration of supply shall be approximately one second.

12.11 Voltage Jump Test:

Motor shall be supplied at maximum voltage (70% of rated voltage) through a series resistance which when short-circuited, will cause the voltage to rise to the maximum value (500V).

The test shall be carried out five times in succession, the minimum voltage conditions being restored between each voltage jump.

12.12 **Dielectric Test:**

On hot winding perform the dielectric test at 4 kV for one minute between each winding and motor frame.

12.13 **Insulation Resistance Measurement:**

Measure the insulation resistance of the winding before and after dielectric test. There should be no appreciable difference in insulation resistance values.

12.14 **Enclosure Protection Test:**

The motor shall be tested against the ingress of water as per procedure and conditions laid down in IS: 4691 for IP 56 protection.

12.14.1 Enclosure Protection Test during routine tests shall be carried out on 10% of the motors or part thereof selected randomly from each offered lot subject to a minimum of 1 motor per lot. The test shall be done on motor alone.

12.15 **Weight Measurement:**

Measure and record the weight of the motor.

## SECTION 4

## BLOWER SET

### 13.0 Blower Set

### 13.1 Drive and Coupling:

The fan impeller shall be directly mounted on the motor shaft. In case of cast aluminium impellers a steel boss of hexagonal shape should be cast integrally with the impeller. Alternatively steel hub may be bolted/riveted suitably with aluminium cast impellers. A key of adequate strength with the impeller may lock the drive in position by a securing bolt and washer at the shaft end. Locking plates shall further lock against the securing bolt unscrewing in service.

The impeller mounting arrangement shall be subject to prior approval of RDSO/CLW.

### 13.2 Impeller:

The impeller shall be of axial flow type with aerofoil profile of blades and should be capable of meeting the following duty point at rated voltage.

| | | | |
|---|---|---|---|
| i) | Air quantity | - | Not less than 11 $m^3$/sec. |
| ii) | Total head | - | 180 mmWG |
| iii) | RPM | - | 2950 |
| iv) | Fan diameter | - | 760 mm |

The impeller shall be rated for continuous operation at the rated output. The standard air density of 1.2 kg/m3 shall be considered while designing airflow.

13.2.1 The impeller shall be so designed that it can deliver minimum rated air quantity and total head when driven either with an AC motor as specified in the Clause 10.1 or with a DC motor as specified in the Clause 11.1.

### 13.3 Fan Efficiency:

The impeller shall be so designed as to achieve maximum possible fan efficiency at operating point. The fan efficiency shall be higher than 65%. Impeller designs having higher efficiency shall be preferred.

13.4 **Special Constructional Features:**

As the blowers operate for long periods at high speeds, the end ring and impeller blades etc. should be designed with a higher margin of safety as compared to normal industrial designs.

Cast aluminium impellers should be of single piece casting with steel boss of hexagonal shape cast integrally with the impeller or hub bolted/riveted with impeller.

Non cast impellers shall be fabricated out of high tensile steel of weldable quality conforming to either Domex 400E or ST-55-HTW of IS 961 or ST 52 of IS 1079 or SAILMA 350 of `SAIL' or any other steel having superior or similar quality which has been adequately tested to ensure mechanical strength and dimensional uniformity. The cold pressed blades shall be stress relieved. The blades shall be fixed to the end ring by high quality welding.

13.5 **Casing:**

Casing should be of scroll type of heavy-duty industrial design. It should be capable of holding the motor and impeller inside the casing and air diffuser and resistance box at the top. It should be of single side axial intake direction and axial discharge direction. All welds of the housing should be welded continuously.

13.6 A suitable design of air diffuser may also be provided at the discharge side of the impeller to keep the airflow uniform at the entire resistance grid area to avoid hot spots on the resistance grid.

13.7 **Direction of Rotation:**

An arrow indicating direction of rotation shall be permanently marked on the blower casing.

13.8 **Inspection Cover on Casing:**

Inspection cover shall be provided on casing that should be perfectly aligned with motor inspection cover so that motor can be attended in position.

13.9 **Balancing:**

Impeller shall be dynamically balanced individually and with motor to the balancing quality grade of G2.5 conforming to ISO: 1940 or IS: 11723.

13.10 **Vibration:**

Vibration level at blower casing shall not exceed 15 Micron Peak to Peak when blower is running at rated voltage.

13.11 **Mounting Arrangement:**

Motor coupled with impeller shall be mounted vertically on supports welded on casing. The mounting arrangement shall be able to withstand vibration and shocks encountered in service. However, the mounting arrangement shall be subject to prior approval of RDSO/CLW.

13.12 **Lifting Arrangement:**

Suitable lifting arrangement shall be provided to lift the complete blower assembly and motor separately.

13.13 **Interchangeability:**

The motors, impellers and casing shall be interchangeable without affecting the performance of the blower unit.

13.14 **Name Plate:**

Each blower unit shall have a suitable nameplate having the following information engraved on it:

i) Manufacturer's name.
ii) Type and Serial Number
iii) Air delivery ($m^3/s$)
iv) Total head at $20^0$ C (mmWG)
v) Rated speed.
vi) Make of the motor
vii) Power consumption in kW
viii) Impeller diameter (mm).
ix) Weight of blower unit (kg)
x) Manufacturing date and year.

Manufacturers' name and DBR serial number should be engraved on impellers also.

13.15 **Protection against failure of Blower:**

An air flow relay shall be provided on the suction side of the impeller for ensuring airflow to the cooling resistors. The relay shall have a pair of normally open contacts rated for 2 Amps inductive load at 110V DC. The

airflow relay (QVRF) has to be set to pick up between –12 (+0, -2) mmWG. This relay should pick up at MVRF speed, corresponding to 75-85 volt DC supply to MVRF. For reliable operation of QVRF relay, the location of the suction nipple should be 25±5 mm below the bottom sweep of the impeller blades.

## 14.0 Tests on Blower Motor Set :

14.1 Type Tests and Routine Tests shall be carried out on the Blower Motor sets as detailed in Clause 14.2. However, not withstanding the provisions of this clause, the purchaser may require type tests to be repeated on any particular unit, under certain circumstances such as change in designs or materials, modifications for improvements and such other considerations. Carrying out of the repeat type tests will be subject to agreement between the purchaser and the supplier of the equipment.

The Type Tests and Routine Tests to be carried out on blower sets are indicated in the table below. The Clause and Sub-clause Number to be referred are also mentioned:

| S.No. | Tests | Type Test (Clause No.) | Routine Test (Clause No.) |
|---|---|---|---|
| 1. | Air Delivery Test | 14.2 | - |
| 2. | Starting time test | 14.3 | - |
| 3. | Starting Duty Test | 14.4 | - |
| 4. | Endurance test | 14.5 | - |
| 5. | Vibration measurement test | 14.6 | |
| 6. | Checking of dimensions, fixing and locking arrangement of impeller and workmanship. | 14.7 | 14.7 |
| 7. | Weight measurement | 14.8 | - |

14.2 Air Delivery Test:

Unless otherwise specified in the contract the test and the method of measurement adopted shall comply with IS: 3588 (Axial flow fans). The test shall be carried out at rated voltage, 70% of the rated voltage and at 500V. Adequate number of observations shall be made on both sides of the operating point to plot the characteristic curve. Measure the following quantities:

Line voltage, line current, power input, speed, static pressure readings, ambient temperature, suction and exit air temperature.

The manometer pressure readings shall be taken at 4 points to arrive at a mean value. Calculate the blower output at standard conditions. Record

method of test, details of equipment used and their calibration for observed and calculated values. Plot curves between total head (mmWG), Static head (mmWG) speed, efficiency, shaft power (kW), Input Power (kW) against air delivery output ($m^3/s$) system resistance line should be plotted to obtain the operating point of the blower.

14.3 **Starting Time Test:**

With supply equal to 70% and 110% of the rated voltage and at 500 Volts, measure the starting current, final load current and time to come up to the full speed. In order to study the effect of sudden voltage variation on the blower, arrangement shall be provided to switch supply from one voltage to the other voltage while the blower is still running due to inertia. The blower should work satisfactorily.

The starting time obtained shall not exceed 6 seconds at rated voltage.

14.4 **Starting Duty Test:**

The blower motor unit shall be subjected to repeat start and stop cycle 100 times at a supply of rated voltage. The `ON' and `OFF' period shall be 1 minute in each case.

If the unit takes more than 1 minute to stop freely, the next start shall commence immediately after the unit has stopped.

At the end of the test the efficacy of impeller locking device shall be checked and impeller shall then be dismantled and various parts like key, key-way and the fit of impeller on shaft shall be examined for any abnormal wear.

14.5 **Endurance Test:**

This test shall be carried out for a period of 48 hours with rated output and head and with rated voltage supply at motor terminals.

After the test, the blower and the motor shall be dismantled and examined for wear and tear of the parts, condition of rings blades and bearings etc.

14.6 **Vibration Measurement Test:**

For the measurement of vibration intensity an electronic vibration measurement equipment having a frequency range of 5 to 2000 Hz shall be employed. The machine under test shall be mounted in accordance with IS 4729. Vibration measurement shall be made on the casing of the blower when it is running at rated voltage and speed. The peak to peak value shall not exceed 15 microns.

14.7 Check the overall dimensions, fixing dimensions and other critical dimensions as per approved drawing.

14.8 **Weight Measurement:**

Measure the weight of impeller, motor casing and complete motor blower unit and record it.

# SECTION- 5

## ANNEXURES & DRAWINGS

### 15.0 Design data to be submitted

15.1 The design data to be submitted by the tenderer is enlisted in Annexure 1 to 3 as follows:

Annexure 1: Resistors
Annexure 2: Motors
Annexure 3: Blowers.

**ANNEXURE- I**

## DESIGN DATA OF BRAKING RESISTORS

1.0 Resistors

1.1 Resistance Material.

1.1.1 Chemical composition

1.1.2 Specific Resistance at 20$^0$C

1.1.3 Temperature Co-efficient at 20 $^0$C
300$^0$C
500$^0$C

1.1.4 Maximum permissible service temperature

1.1.5 Specific heat

1.1.6 Melting point

1.1.7 Co-efficient of linear expansion

1.1.8 Heat conduction

1.1.9 Density

1.1.10 Average outlet temp. of cooling air at rated output.

1.2 Details of Resistors :

1.2.1 Ohmic value of Resistor at 20$^0$C

1.2.2 Ohmic value of each resistor tray at 600$^0$C

1.2.3 Effective ohmic value of Top Tray with Blower Motor connected in parallel at :-

i) 20$^0$C
ii) 600$^0$C

1.2.4 Size of Element Strip

1.2.5 Developed length of element per turn

1.2.6 No. of turns per element

1.2.7 No. of elements per tray :

i) Series
ii) Parallel

1.2.8 Weight of active material per tray

1.2.9 Weight of resistor box.

1.2.10 Total weight of assembly with blower and motor.

1.3 Temperature of the elements

1.3.1 Average working temperature of element and hot spot

1.3.2 Temperature time constant

**1.4 Insulation**

1.4.1 Insulation in between resistor element and support

i) Primary
ii) Secondary

1.4.2 Type of separators between resistor elements, if any.

**1.5 Drawings**

Detailed drawing showing the arrangement of resistor elements, mounting electrical tappings and terminals, overall dimensions and fixing arrangements to be enclosed.

**ANNEXURE-II**

## DATA SHEET OF BLOWER

A.1 Type, model and make

A.2 Air delivered in cubic meter per minute at static and total pressure head in mmWG corrected to 20 deg.C and 760 mm baromatric pressure.

(a) at rated voltage
(b) at lowest voltage of the driving motor.

A.3 Design Data –

c) Impeller
d) Type of impeller blades
e) Number of blades
f) Method of fixing of the blades
g) Clearance between inlet cone and impeller (maximum and minimum)
h) Maximum shaft speed of the impeller
i) Motor shaft and impeller bore diameter (max. and min.)
j) Method of fixing of impeller on motor shaft and locking arrangement.
k) $GD^2$ value of the impeller (indicate the maximum variation in manufacture)

Note : $GD^2$ value of the impeller will be made use of for calculating the starting performance of the blower with regard to the specified electric motor. As such the value to be furnished should take into account the inertia, the friction and the resistive torque of the impeller while it is being started.

A.4 The manufacturer shall furnish the speed-torque characteristic of the blower. This is required for matching the motor and the impeller.

A.5 Torque necessary for the blower when working against constant rated head and delivering the rated output.

A.6 The supplier shall enclose the following characteristic curves at $20^0$c and $55^0$C.

a) Total and static head vs air delivery
b) Total and static efficiency vs air delivery
c) Air horse power vs air delivery
d) Power absorbed vs air delivery
e) Speed vs air quantity in $m^3$/sec.

A.7 Vibration level in microns.

A.7A Quantity of air required as per design to meet the DBR rating specified in ,

Clause 4.1.1

A.8 Necessary dimensioned drawings of the blowers and its component showing the constructional and assembly details, along with material specification, should be submitted.

A9. Separate drawing of impeller to be submitted.

A.10 Total weight of blower including motor.

**ANNEXURE – III**

## SCHEDULE OF PARTICULARS FOR DC MOTORS (TO BE SUPPLIED BY ALL TENDERERS)

**A. GENERAL DATA**

1. Type, model and make.
2. Nominal voltage
3. Rated speed (rev./min.)
4. Continuous rating (HP/kW)
5. Rated current –
   a) at rated voltage.
   b) At minimum voltage
6. Class of insulation –
   a) Armature
   b) Field
   c) Commutator
   d) Varnish
7. Type of enclosure
8. Method of ventilation for Motor
9. Material specification of the motor ventilating fan.
10. Cooling air temperature assumed in the design of the motor.
11. Amplitude of vibration of the motor
12. Temperature rise at full load on-
    a) Rated voltage
    b) Minimum voltage
    c) Maximum voltage.
13. Starting torque and current at –
    a) Rated voltage

b) Minimum voltage
c) Maximum voltage.

14. Full load current and torque voltage in item 13.

15. $GD^2$ value of armature.

16. Graph showing torque speed characteristics of the motor at –
a) Normal
b) Maximum
c) Minimum voltages

17. Weight of the armature

18. Weight of the motor in working order.

B. **DESIGN PARTICULARS –**

(i) **Main Dimensions :**

1. Diameter of armature.
2. Gross core length mm.
3. Ducts (number and width)
4. Iron length
5. Air gap length
6. Depth of core below slots
7. Commutator diameter
8. Commutator length – effective

(ii) Armature

1. Type of winding connection and number of parallel paths.
2. Number and size of slots.
3. Number of conductors per slot and No. of wires in parallel per conductor.
4. Coil pitch, No. of coils, turns per coil.
5. Conductor size, covering and cross sectional area.
6. Current density in Amp./$mm^2$
7. Resistance of windings at $20^0$C
   a) Series winding.
   b) Shunt winding
   c) Interpole winding.
8. Average Flux Density.
9. Air Gap
10. Name the tests which are conducted for reliability of the winding after assembly.
11. Weight of copper wire.
12. Length of mean turn.

13. Specification for core stamping.
14. Type of impregnation vacuum/flood.

(iv) **Commutator**

1. Diameter, new/condemning
2. Size of commutator segments
3. Commutator bar pitch.
4. Insulation thickness between bars
5. Reactance voltage and its calculation.
6. Time of commutation.
7. Voltage per bar
8. Reversal of current per milli second.
9. Average bar/brush.
10. Commutation zone calculation

(v) **Brush**

1. Grade
2. Dimensions (length x width x thickness) of new condemning size.
3. Current density $A/Cm^2$
4. Brush pressure
5. No. of sets of brush holder.
6. No. of brushes/ holder.

(vi) Field

1. Number of main poles.
2. Dimensions of main pole and interpole.
3. Size, covering, cross-sectional area of –
   a) Series field conductor.
   b) Shunt field conductor, if any; and
   c) Interpole conductor, if any.
4. Resistance of winding at 20°C
   (a) Series winding
   (b) Interpole winding
5. Details of permanent field shunt.
6. Field Ampere Turns per pole.
7. Type of impregnation
8. Flux density chosen in pole/ interpole.
9. Current density in conductor of main pole/ interpole.
10. Copper weight for field and interpole.
11. Pole steel material specification.

(vii) **Banding:**

1. Material specification.
2. Number of turns on commutator end.
3. Number of turns on evolute end.
4. Size of banding wire.
5. Tension of banding wire in Kg.
6. Band width
7. Banding strength calculation

(viii) **Terminal Box :**

1. Type of protection used.
2. Method of cable entry.
3. Terminal Block – Material Specification.

(ix) **Bearing:**

1. Type/ make of bearing.
2. Size of bearing.
3. Tolerances on size of the bearing, D, B, d etc.
4. Type of clearance.
5. Class of tolerance –
   a) between inner race & shaft.
   b) Between outer race & housing.
6. L10 bearing life calculation based on relevant data of driven machine e.g. axial and radial thrust/produced by driven machine.
7. Nature of tests which have been conducted for reliability etc. before and after mounting.

(ix) **Shaft :**

1. Diameter at different positions.
2. Factor of safety against maximum torque developed by motor during starting.
3. The factor of safety at various locations where section changes i.e. at various fillets.
4. The fatigue limit of shaft material.
5. The basis for the factors assumed for fatigue load etc.
6. The factor of safety against torsion and vibration and critical speed.
7. Details of the motor and the finish at various positions of the shaft.
8. If fan load has been taken into consideration for calculating stresses and torque etc. for shaft ?
9. Material specification for shaft.

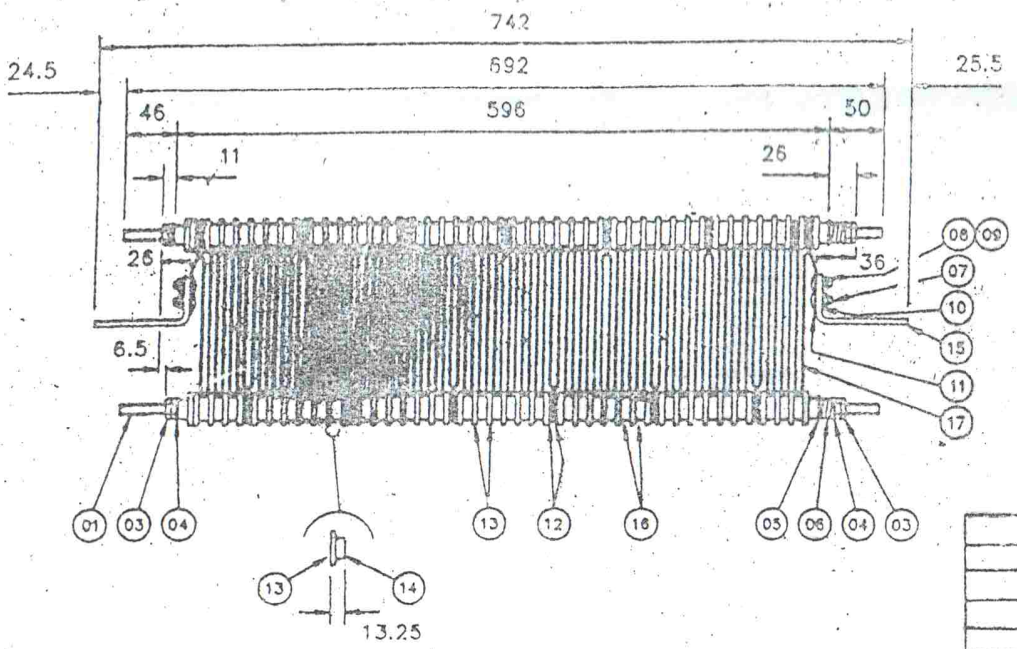
## C. DESIGN PARAMETERS

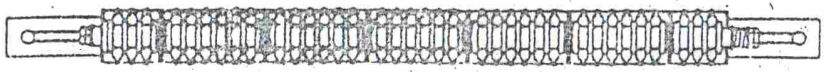
1. Specific magnetic loading (wb/$m^2$)
2. Specific electric loading (amp. Conductors/metre).
3. Air gap flux density (wb/m2)
4. Ratio $\frac{\text{Field AT}}{\text{Armature AT}}$ at full field.
5. Specific power (Watts/$cm^3$)
6. Frequency of flux reversal.

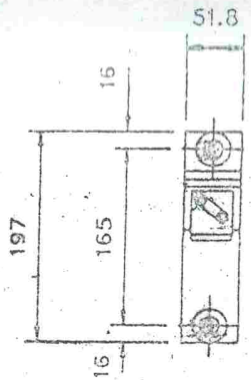
## D. DRAWING

1. Cross-sectional drawing with dimensions of motor.
2. Longitudinal sectional drawing of motor with dimensions.
3. Field/interpole drawing with dimension.
4. Armature winding.
5. Shaft drawing with tolerances at different positions.
6. Assembly drawing of motor.
7. Mounting arrangement of motor.
8. Coupling arrangement of motor with driven equipment with details.
9. Winding diagram, slot drawing with dimensions.
10. Brush box assembly.
11. Terminal box.

**NOTE :** (a) Drawings at Sl .Nos. 1,2,6 & 7 shall be submitted by all tenderers.
(b) All drawings will be submitted by the successful tenderer.






| REF. | PART No. | DESCRIPTION | DETAIL DRG No | NO | MATL. |
|---|---|---|---|---|---|
| | 17 | 7 LEG RESISTOR ELEMENT | | 12 | Ni/Cr 60/16 |
| | 16 | ELEMENT RETAINING CUP | | 72 | STAINLESS STEEL |
| | 15 | TERMINAL LUG | | 02 | COPPER |
| | 14 | PACKING WASHER | | 89 | FILAMIC |
| | 13 | HI-TEMP INSULATOR | | 89 | STETTA C9 |
| | 12 | THRUST WASHER | | 28 | STAINLESS STEEL |
| | 11 | TERMINAL LUG | | 02 | STAINLESS STEEL |
| | 10 | CLAMPING STRAP | | 02 | STAINLESS STEEL |
| | 09 | M8 FULL NUT | | 04 | STAINLESS STEEL |
| | 08 | M6 DISC SPRING | | 04 | STAINLESS STEEL |
| | 07 | M6 COACH HEAD SCREW | | 04 | STAINLESS STEEL |
| | 06 | COMPRESSION SPRING | | 02 | STAINLESS STEEL |
| | 05 | M12 FLAT WASHER | | 02 | STAINLESS STEEL |
| | 04 | M10 FLAT WASHER | | 04 | STAINLESS STEEL |
| | 03 | M10 LOCK NUT | | 08 | STAINLESS STEEL |
| | 02 | INSULATING TUBE | | 02 | FILAMIC |
| | 01 | M10 TIE ROD | | 02 | HI-TENSILE STEEL |

RESISTANCE PER BANK = 0.472 OHMS ± 3% AT 20°C

Note : This drawing is only for Guidance on mounting Dimensions. The manufacturer shall submit their Own detailed drawing for Grid elements for E valuation and approval.

REF. SCALE: NTS APPD. BY 29/4/03

# GRID ELEMENT ASSEMBLY FOR D.B.R

FIRST ISSUED

SUPERSEDES

| STATUS | ALT. | REF No. | DESCRIPTION | APPD BY | DATE |
|---|---|---|---|---|---|
| | | | | | |

RDSO. ELEC. DTE SKEL 4671

SUPERSEDED BY

29.4.03 SKS EL/3.2/29

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लखनऊ - २२६०११
Government of India - Ministry of Railways
Research, Designs & Standards
Organization, LUCKNOW – 226011

No. EL/3.2.29/5

Dated 02.6.2006

# Amendment No. 1

**(RDSO Specification No. ELRS/SPEC/DBR/0028 Rev `0' of Sept.,2003)**

**Sub**: Technical Specification for Dynamic Braking Resistors with AC/DC Motor Driven cooling blowers for Electric Locomotives – Amendment No.1.

**Ref**: RDSO Specification No. ELRS/SPEC/DBR/0028 Rev `0" of Sep. 2003, issued vide RDSO letter No.EL/3.2.29 dated 15.10.2003

The following clauses of above specification are being amended :

1. Clause No. 10.1

Replaced Clauses are given below:

## CLAUSE NO. 10.1

The AC Motor shall be fed from either Static Inverter or Rotary Arno converter. The output details of both types of supplies are as follows:

Arno Converter Supply :

1. Voltage 415V
2. Voltage variation 290V-500V
3. Voltage unbalance 5%

Static Inverter Supply :

| | | |
|---|---|---|
| (a) | KVA | 180kVA, 3 Phase AC |
| (b) | AC Voltage (L-L) | 415V $\pm$5% |
| (c) | Frequency (Nominal) | 50Hz $\pm$ 3% |
| (d) | Short time rating | 600A for 5 sec. |
| (e) | Total Harmonic distortion (THD) in the output voltage to the 3 phase Motor. | Less than 10% |
| (f) | dv/dt | Less than 1000V/micro sec. |

Motor shall be designed to have all features essential for Static inverter fed motor and shall also be suitable for Arno supply i.e. voltage variation 290-500V with 5% unbalance. The salient design details of AC Motor shall be as follows :

| | | |
|---|---|---|
| 1. | Type; | 3 Phase induction motor |
| 2. | Power | 30 KW |
| 3. | No. of Pole | 02 |
| 4. | Frame size: | 225 (integral cast steel construction) |
| 5. | Cooling | Surface cooled by DBR fan. |
| 6. | Protection | IP-56 |
| 7. | Insulation | Class H |
| 8. | Temp. rise limit | 80 $^{0}$C |

The AC motor shall conform to RDSO specification **No. SPEC/E-10/3/08 (revised) of Sep, 95 with its amendments No. 1 & 2.**( Tech. Specification and Test Schedule for three phase induction motor for Driving Blower, Compressors, Exhausters and Pumps for AC Electric locomotive).

In addition to the above specification suitability of the motor to work with Static Inverter converter supply shall be kept in consideration and essential measures to ensure reliability with converter supply should be incorporated in design. Some of the measures are as follows :-

- Use of corona resistant dual coated wire.
- Adequate brazing of joints.
- Adequate insulation of joints to withstand voltage surges.
- Increased insulation between phases.
- Increased slot insulation.
- Ensuring proper VPI following stipulated procedure.

27/6/2006

(M K Singhal)
For Director General (Elec)

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Government of India - Ministry of Railways
Research Designs & StandardsOrganization
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No. EL/3.2.29 Dated 14.07.2006

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- North Central Railway, Hastings Road, Allahabad- 211001
- Eastern Railway, Fairlie Place, Kolkata -700 001.
- East Central Railway, Hazipur-844101.
- East Coast Railway, Chandrashekharpur, Bhubaneshwar-751016.
- Southern Railway, Park Town, Chennai-600 003.
- South Central Railway, Secunderabad-500 371.
- South Eastern Railway, Garden Reach, Kolkata -700 043.
- South Western Railway, 4th Floor, Laxmi Balakrishna Square Complex, Railway Station Road, Hubli- 580 020 (Karnataka).
- South East Central Railway, Bilaspur-495004
- Western Railway, Churchgate, Mumbai-400 020.
- West Central Railway, Jabalpur-482001.
- Chittaranjan Locomotive Works, Chittaranjan-713331 (WB)

## AMENDMENT No. 2

**Sub:** Amendment in Specification No. ELRS/SPEC/DBR/0028, Rev. '0' dated Sept. - 2003.

**Ref:** RDSO's Specification No. ELRS/ SPEC/ DBR/0028, Rev. '0' of Sept. 2003 issued vide letter No. EL/3.2.29 dated 15.10.2003.

***

With reference to the above, the following amendments may be incorporated in the specification.

Existing Clause No. 8.7 should be replaced with ***"The terminal of the resistor banks to which the external cables are to be connected shall be designed so that temperature at the joint of the cable sockets is less than 70°C to prevent damage to the cable insulation. The cable socket for external connection shall also be supplied duly secured on the terminals conforming to drawing no. CLW/ES/SK-5/R-29, Alt. M. For internal terminal connections only copper bus bars are to be used".***

( Kishore Kumar )
for Director General/Elect.

Encl: Nil

Copy to : As per standard Mailing List No. EL/M/0019.

_____
_____
_____
_____PIN:

14/07/06

( Kishore Kumar )
for Director General/Elect.

Encl: Nil

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Research Designs & Standards Organisation
LUCKNOW – 226011

सं. ईएल/3.2.29 दिनॉक 14.07.2006

मुख्य विद्युत अभियंता,

- मध्य रेलवे, मुम्बई सीएसटी –400 001
- उत्तर रेलवे, बड़ौदा हाऊस, नई दिल्ली–110 001
- उत्तर मध्य रेलवे, हेस्टिंग रोड, इलाहाबाद – 211 001
- पूर्व रेलवे, फेयर्ली प्लेस, कोलकाता–700 001
- पूर्व–मध्य रेलवे, हाजीपुर–844 101
- पूर्व तटीय रेलवे, चन्द्रशेखरपुर, भुबनेश्वर–751 016
- दक्षिण रेलवे, पार्क टाउन, चेन्नई–600 003
- दक्षिण मध्य रेलवे, रेल निलायम, सिकंदराबाद–500 371
- दक्षिण पूर्व रेलवे, गार्डेनरीच, कोलकाता–700 043
- दक्षिण पश्चिम रेलवे, चौथा तल, लक्ष्मी बालकृष्ण स्कवायर कामप्लेक्स,रेलवे स्टेशन रोड, हुबली (कर्नाटक)
- दक्षिण पूर्व मध्य रेलवे, बिलासपुर–495 004
- पश्चिम रेलवे, चर्चगेट, मुम्बई–400 020
- पश्चिम मध्य रेलवे, जबलपुर–482 001
- चित्तरंजन रेल इंजन कारखाना, चित्तरंजन–713 331

विषयः विशिभिट सं. ईएलआरएस/ स्पेक/डीबीआर/0028ए रिवी. '0' – सितम्बर – 2003
संदर्भः इस कार्यालय के दिनॉक 14.07.2006 का संशोधन सं. – 2

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उपरोक्त विषय पर इस कार्यालय के दिनॉक 14.07.2006 का संशोधन – 2 आपके सूचनार्थ एवं आवश्यक कार्रवाई हेतु संलग्न है ।

( एम.सी.महन्त )
कृते महा निदेशक/विद्युत

संलग्नक : यथोक्त ।

प्रति : मेलिंग लिस्ट सं. – ईएल/एम/0019 के अनुसार ।

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( एम.सी.महन्त ) 14/07/06
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Government of India - Ministry of Railways
Research Designs & Standards Organisation,
LUCKNOW - 226011

No. EL/3.2.29 Dated 16.08.2007

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- West Central Railway, Jabalpur-482001.
- Chittaranjan Locomotive Works, Chittaranjan-713 331 (WB)

**Amendment No. 3**
**(RDSO Specification No. ELRS/SPEC/DBR/0028, Rev '0' of Sept., 2003)**

**Sub:** Technical Specification for Dynamic Braking Resistors with AC/DC Motor Driven cooling blowers for Electric Locos – Amendment No.3.

**Ref:** RDSO Specification No. ELRS/SPEC/DBR/0028 Rev `0" of Sept. 2003, issued vide RDSO letter No.EL/3.2.29 dated 15.10.2003.

***

As per the Railway Board's guidelines, CLW have switched over to thin walled (electron beam irradiated cable) 120 mm² cable in place of 150 mm² elastomeric cables for external connection of Dynamic Braking Resistors (DBR).On Locos provided with 120 mm² cable, cable Socket should be provided as per CLW's Drg. No. CLW/ES/SK-10/R-29, Alt. 'O'

The clause 8.7 of the above referred specification is therefore, amended as follows :-

*" The terminal of the resister bank to which the external cables are to be connected shall be designed so that temperature at the joint of the cable sockets is less than 70° C to prevent damage to the cable insulation. The cable socket for the external connection shall also be supplied duly secured on the terminals conforming to CLW's Drg. No. CLW/ES/SK-10/R-29, Alt. 'O'. For internal terminal connections only copper bus bars are to be used."*

( Kishore Kumar )
for Director General/Elect.

Encl: As above

Copy to : As per standard Mailing List No. EL/M/0019

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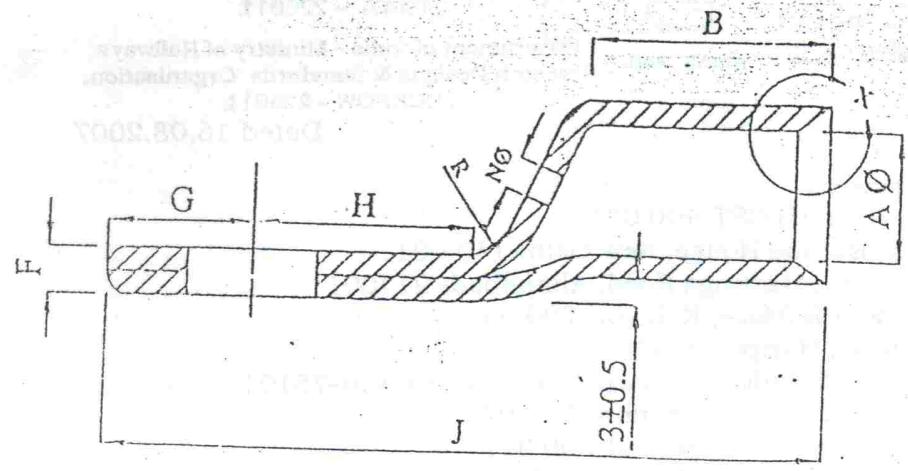
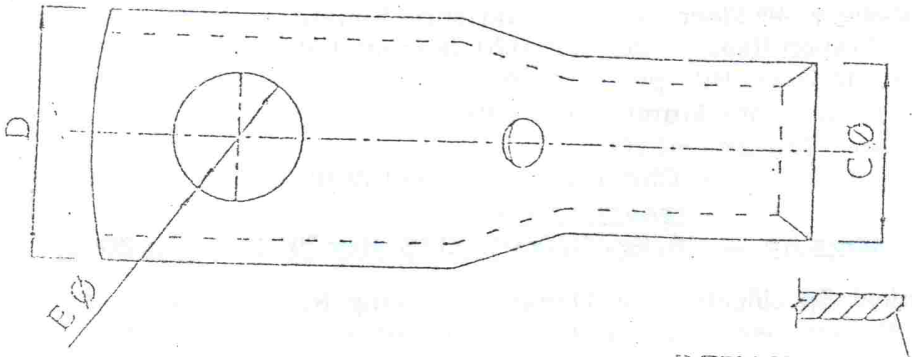
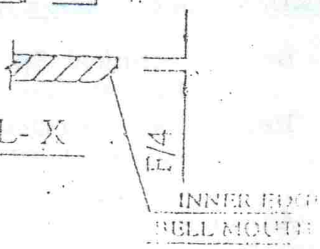
16/08/07

( Kishore Kumar )
for Director General/Elect.

Encl: As above




DETAIL- X

# CABLE TERMINALS TYPE : 6A

NOTE:
1. DIMENSION 'R' SHOULD BE GRATER THAN 3F
2. DIMENSION 'E' MAY BE SUITABLY INCREASED TO Ø 10 DIA TO SUIT M-10 BOLT USED IN DBR

DIMENSIONS IN MM

| SIZE SQ. MM. | TYPE | A ±0.15 | B ±0.5 | C ±0.15 | D ±0.5 | E ±0.5 | F | G ±0.5 | H ±0.5 | J ±1.0 | R |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 120 | 6A | 16 | 30 | 22 | 31.5 | 16 | 6 | 18 | 27 | 58 | 4 |

| | | | |
|---|---|---|---|
| '0' | NOTE 2 ADDED TO E & M-10 BOLT OF DBR | 13/07/07 | |
| ALT. | DESCRIPTION | DATE | INITIAL |

SPECIFICATION FOR CABLE TERMINALS TYPE 6A FOR [illegible]

CHITTARANJAN LOCOMOTIVE WORKS, WEST BENGAL

CLW/ES/[illegible]