GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

TECHNICAL SPECIFICATION FOR ROOF MOUNTED FORCED COOLED DYNAMIC BRAKING RESISTORS WITH D.C. MOTOR DRIVEN COOLING BLOWERS FOR A.C. ELECTRIC LOCOMOTIVES

SPECIFICATION No: RDSO/2008/EL/SPEC/0069, Rev. '1'

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1	----	All	0 Draft	First Issue
2		03-15, 17-23, 25, 27, 29 & 45 -53	'1	Review of hot spot temperature and blower motor rating

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SECTION 1: GENERAL

0. FOREWORD

0.1 DYNAMIC BRAKING RESISTORS

Dynamic braking resistors are used to dissipate energy that is produced in the motor as the drive provides braking torque to stop the train. The resistors are either used alone for decelerating or in conjunction with compressed-air brakes for stopping the train.

Resistors integrated into the power unit dissipate electrical energy created by electric braking systems. The dynamic braking resistor is connected across the Armature of the traction motor.

0.2 DYNAMIC BRAKING TECHNOLOGY

The drive manufacturer normally determines the power rating (watts) needed to prevent overheating during braking duty.

The peak braking current is determined by the specified resistance value. Each drive manufacturer specifies a resistance range with a minimum to prevent over current and damage to the drive and a maximum value to give adequate lower dissipation capability.

REQUIREMENT

The specification covers requirement of forced cooled roof mounted high capacity Rheostatic Braking Resistors complete with blower motor set for provision on the roof of electric locomotives to control speed of the train.

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 wear and tear of mechanical brakes and time to release brakes after each operation. However, this brake is not effective at low speeds or for stopping the trains for which mechanical brakes are to be used.

This specification consists of the following Sections:

- Section 1 – General.
- Section 2 - Resistor Grid Unit.
- Section 3- Cooling Blower Motor.
- Section 4 - Blower set.
- Section 5 – High Tension Cable
- Section 6 - Annexure and Drawings

1.0 GOVERNING SPECIFICATIONS

The specification is based on the following standards as well as standards referred elsewhere in this specification:

S. N.	Specification	Details
1.	IEC:60349–1, 2002	Rules for rotating machines for rail road vehicles
2.	IEC:60322–2001-03	Railway application rules for power resistors of open construction
3.	IEC 61373 Ed.2.0 - 2010	Railway application rolling stock equipment– Shock and Vibration tests
4.	IS:3588-1987	Specification for electric axial flow fans.
5.	IS: 3394:1985. (Reaffirmed 2006)	Method for accelerated life test of electrical resistance alloy for heating element
6.	IS:12075-1987	Mechanical vibration of rotating electrical Machines.
7.	IS: 4691-1985	Degree of protection provided by enclosures for rotating electric machinery.
8.	BS: 6195-1993	Insulated flexible cables and cords for coil leads.
9.	IS: 5 – 1994	Colours for ready mixed paints and enamels.
10.	IS: 10192-1982	Synthetic resin bonded glass fibre (SRBGF) sheets for electrical purposes
11	IEC:60626-3 2002	Combined flexible materials for Electrical Insulation-Specifications for individual materials

1.1 Other relevant IEC, IS and BS specifications quoted in the appropriate clause of the specification will also apply except where modified/ amended by the provisions of this specification.

1.2 Latest version/revision of the standards and specifications etc shall be followed, unless specifically mentioned otherwise.

2.0 SCOPE OF SUPPLY:

2.1 The Specification covers the manufacture and testing of forced cooled roof mounted high capacity Rheostatic braking resistors units duly assembled in a steel frame. Rheostatic braking resistor unit shall be mounted on the roof of 25 kV AC Locomotives type WAM-4, WAG-5 & WAG-7 Class of Electric Locomotives on the Indian Railways.

2.2 The deliverables include complete DBR along with all its components including blower motor, blower, air flow relay, terminal block, copper bus bars, hardware, cable lug etc. The details of scope of supply will be as follows :-

a) Terminal block/terminal bushing to be supplied as per CLW's drawing no CLW/ES/SK-3/R-36

b) Long bolt size (14 mm dia X 50mm) and necessary hardware of grade AISI 316 (A-4) for connecting copper bars and cables are also to be supplied along with DBR.

c) Cable lugs for connection 120 mm^2 cable for DBR as per requirement.

d) Tin plated copper bar of 40 X 7 mm of suitable length for interconnection between DBR and Roof Bar are also to be supplied along with DBR.

e) Mounting bracket along with necessary hardware for mounting of DBR on Roof, are to be supplied with DBR. However, design of mounting / fixing bracket are to be supplied in consultation with consignee.

2.3 With the provision of force cooled roof mounted DBR, some of the existing roof bars inter connecting between the Pantographs and VCB shall have to be removed and these connections will be replaced with 45 KV XLPE cable to restore continuity of power supply to locomotive. Supplier shall also supply 45 KV, XLPE cable along with complete set of accessories required for connection.

2.4 DBR units shall be so designed that each of the two forced cooled DBR units are mounted on roof and the interconnection between the pantographs and VCB shall be by 45 KV, XLPE cable. It shall be possible, for the purpose of maintenance, to remove and fit the forced cooled DBR unit along with roof with minimum disturbance to other roof equipment. The complete scheme shall be submitted by supplier.

2.5 Provision of each DBR with motor blower unit weighing approximately 1200kg shall require strengthening of the roofs. The roof may require for strengthening at the loading point of DBR with the application of MS angle.

2.6 Operating and maintenance manual containing essential technical information for understanding the principle of operation of the forced cooled roof mounted DBR as well as for carrying out inspection, maintenance and overhaul shall be

supplied by supplier in hard as well as soft version. The manual shall be in English and one set of such manual shall be supplied with supply of every lot of 5 loco set of the equipment.

The manual shall be in A4 size sheet printed on one side in suitable folder. All drawings/sketches / Photographs shall be in A4 /A3 size sheets only. The supplier may follow his standard practices in regard to the preparation of such a manual, but the following information should be necessarily included:

- Principle of operation and precautions before use.
- General Assembly drawing including mounting details and overall dimensions.
- Diagrams of electrical connections.
- Drawings of resistance arrangement, copper bars, cables, main frame, mounting insulators and other important components.
- The bill of material indicating drawing no, sub contractor etc.
- Detailed instructions for inspection, maintenance and over haul.
- Dimensional drawings and key drawings of such other parts which will be required for proper appreciation of the forced cooled roof mounted DBR.
- Spare part list with reference numbers. This may also include items which may be required only in emergencies i.e. due to breakages, damages etc.
- Tests reports of critical component such as resistance, insulators, XLPE cable etc.

2.7 If TOT with the firm outside India is involved, then the supply experience of collaborator shall be furnished.

2.8 The supplier shall list out the special tools, recording and testing instruments/kits if any which will be required for inspection/ testing and maintenance of the forced cooled roof mounted DBR.

2.9 Supplier shall furnish technical information for resistor, blower and motor as laid down in Annexure I, II and III.

3.0 SERVICE CONDITIONS

3.1 Ambient Temperature: The ambient temperature of the air at the inlet to the blower will be 0°C to 55°C (maximum).

3.2 Relative Humidity: Varying up to 100%.

3.3 Maximum Altitude: 1760 meters above Mean Sea Level.

3.4 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, as Per IEC 61373-2010 Category-1, Class 'A'.

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

3.6 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.

4.0 GENERAL CONDITIONS:

4.1 This specification is for development of Forced cooled Roof Mounted DBR within the existing MMD for Electric Locomotives.

4.2 Supplier should have experience of manufacturing and supplying DBR for Electric Locomotive application at least for last three years.

4.3 Supplier is advised to familiarize them with complete layout of equipment including the roof equipment layout of the existing locomotives.

4.4 Once a prototype is approved, no supplier shall change his source of supply or sub-contractor for purchase of components and sub-assemblies without RDSO approval.

4.5 Supplier shall engrave/emboss identification marks indicating their monogram/brand names and the month and year of manufacture at a conspicuous place on all the major component of the forced cooled roof mounted DBR.

4.6 Technical guidance and assistance for proper operation and maintenance, trouble shooting, investigation and generally all aspects of technical liaison that may be required during the service trials period of one year shall also be organized by the Supplier.

4.7 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 Forced Cooled Roof Mounted DBR and any other factor which may cause such dispute. The responsibility to settle any issue lies with the supplier.

5.0 APPROVAL OF DRAWINGS

The successful supplier shall be asked to submit and finalise the detailed component drawings of the equipment offered in association with CLW and RDSO. The supplier shall, as far as possible, incorporate such features of the equipment/subsystems, which have been proven in service on similar applications on Indian Railway.

6.0 HARDWARE

All the hardware used shall be of metric threads only. High tensile fasteners shall only from RDSO's / CLW's approved sources. Use of Stainless Steel Grade A2-70 is preferable.

7.0 NAME-PLATE

Each resistor box unit/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.

8.0 INSPECTION & TESTS ON DBR UNIT

8.1 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. Routine Tests are those made on all 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 asked.

8.2 SCHEDULE OF TESTS:

The supplier shall submit detailed test plan to RDSO for review and approval, before commencing the tests. The supplier shall make arrangement in his works to carry out complete Type

Tests on one unit, simulating the actual loco conditions as far as possible. If it is not possible to conduct certain tests at the works of the supplier, the same shall be conducted in electric loco shed/workshop. The supplier shall clearly bring out in his offer the tests to be carried out at the works of the supplier or in the electric loco shed/workshop. Complete set of Type Tests and Routine Tests to be carried out on Resistors boxes, blower motors and blower described in Section 2, 3 and 4 are listed in the following section. The tests report on the XLPE cable shall be submitted to RDSO.

S. N	Tests	Type Test (Clause No.)	Routine Test (Clause No.)
A.	**Resistors**		
1.	General Inspection and Dimension measurement.	16.3	16.3
2.	Measurement of Resistance Value.	16.5	16.5
3.	Temperature rise test. (Stationary condition)	18.0 A	-
4.	Temperature rise test. (Actual Working condition)	18.0 B	-
5.	Test for withstanding vibration and shock.	19.0	-
6.	Hygroscopic Test.	20.0	-
7.	Test for performance in rain.	21.0	-
8.	Di Electric Test.	22.0	22.0
9.	Insulation resistance test.	23.0	23.0
10.	Condition of resistor after test.	25.0	25.0
B.	**Cooling Blower Motor**		
1.	Measurement of motor Resistance. (in cold condition)	27.2	27.2
2.	Direction of rotation.	27.3	27.3
3.	No-load test.	27.4	-
4.	Temperature rise test.	27.5	-
5.	Max. & Min. voltage operation test.	27.6	-
6.	Over speed test.	27.7	-
7.	Starting test.	27.8	-
8.	Commutation test.	27.9	-
9.	Interruption test.	27.10	-
10.	Voltage jump test.	27.11	-

11.	Dielectric test.	27.12	27.12
12.	Insulation Resistance test.	27.13	27.13
13.	Enclosure Protection tests.	27.14	-
14.	Weight Measurement.	27.15	-
C.	**Blowers :**		
1.	Air Delivery Test.	29.2	29.2
2.	Starting time test.	29.3	-
3.	Starting duty test.	29.4	-
4.	Endurance test.	29.5	-
5.	Checking of critical dimensions, fixing and locking arrangement.	29.6	-
6.	Weight Measurement.	29.7	-

9.0 MEASUREMENT OF DIMENSIONS AND WEIGHT OF COMPLETE UNIT:

All dimensions, overall mounting arrangements, terminal, terminal blocks, cable, bus-bar arrangement etc. shall be checked with the drawings. The overall dimensions of the assembly shall not exceed the limits indicated in the Annexure 'VI' (Including the lifting hook). Weight of the complete unit including all accessories is to be weighted. The weight should not be more than 1200 Kg.

10.0 APPROVAL OF PROTOTYPE:

Prototype unit manufactured as per RDSO's approved drawing shall be offered for Type Test at firm's premises. After successful completion of all tests mentioned in Clause 8.2, prototype unit shall be approved.

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.

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

11.0 TECHNICAL SPECIFICATION OF RESISTOR ELEMENTS

11.1 RATING OF THE RESISTORS:

1.	Continuous rated current of the resistance	900 A
2.	Value of resistance per traction motor at Operating temperature of 20°C	0.5 Ω +7% / - 5%
3.	Total Number of Traction Motors	06 (six)
4.	Hot spot temperature.	500°C Max. at Continuous rated current of 900 Amps.
5.	Peak over load rating	1.25 times the rated Power for 10 min.
6.	Total heat dissipated in the resistors Corresponding to 900A braking current.	2430 kW
7.	Average temperature of resistor element	350°C Max. at Continuous rated current of 900 Amps.
8.	Average exit air temperature.	150°C Max. at Continuous rated current of 900 Amps.

11.2. 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 900A for each traction motor.

12.0 DESIGN OF THE RESISTORS

12.1 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 500°C continuously. The resistor bank enclosure shall be provided with screwed covers and shall consist of temperature resistant insulating material of suitable design if required.

12.2 The material for the resistor grids shall be Nickel, Chromium, Iron alloy with 60% Ni, 15% Cr and rest iron with trace elements (may or may not be disclosed by the manufacturer for improving the property of resistance material) of M/s. Krupp VDM Gmbh or M/s. Kanthal Sweden. Complete details of the Resistance material including Chemical composition shall be submitted to RDSO. If resistance material proposed to be used is from well-known resistor manufacturer worldwide having 60% Ni, 15% Cr and rest iron with trace element if any, and is in use for Railway application, its complete details including chemical composition test report shall be submitted to RDSO/CLW for seeking prior approval. Resistance material should have a minimum lifetime of 100 hours as per accelerated life test as specified in IS: 3394:1985. The melting point of the grid material should not be less than 1390°C. Resistance value of all boxes should be same. The resistance grids shall be so designed as to be accommodated in the mounting dimensions which shall be within the dimensions as per Annexure VI. Each resistor box shall be designed such that there is uniform heat flow over the entire surface of the resistor elements.

12.3 The resistor elements shall be held in such a way that the thermal expansion at high temperature i.e. of the order of 500°C, does not result in the deterioration/sagging of the grids elements. Suppliers shall furnish details of the arrangement for supporting the elements and allowance for thermal expansion at high temperature.

12.4 The resistor elements in each box 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.

12.5 The insulators with which the resistor elements will be in contact directly or through metallic connectors shall be made of temperature-resistant, non hygroscopic, shock proof material capable of withstanding 250°C continuously without any adverse effect on its electrical and mechanical properties.

12.6 The maximum weight of the each unit shall not exceed 1200 kg. Supplier shall mention the actual weight of the assembly and the individual sub-assemblies.

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. Flexible Copper cables for internal connections shall be only from RDSO/CLW approved sources. Alternatively in place of insulated cable copper bus bars can be used for internal connections.

13.0 ENCLOSURE:

13.1 Main framework of the enclosure shall be of welded steel construction

13.2 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.

14.0. COOLING OF THE RESISTOR:

14.1 Resistor boxes shall be forced cooled by motor blower set. The blower shall draw air from the side of the locomotive and after cooling the resistor elements the hot air shall be discharged from the top. Proper and uniform distribution of air over entire area of resistor box shall be ensured. The specification of the motor are covered in Section-3 (Motors).

14.2 The resistors and their cooling system shall be so designed that the heat radiated is restricted to the minimum to prevent excessive temperature rise of the equipment inside fitted on the roof of the locomotive. The average exit air temperature shall not be more than 150°C.

15.0 COLOUR SCHEME:

Colour of main framework of enclosure shall be of high temperature grade of colour No. 631 Light grey of IS 5-1994. In case stainless steel sheets are used for main frame assembly painting is not required.

16.0 TEST PROGRAMME FOR RESISTORS

16.1 Type Tests and Routine Tests shall be carried out on the DBR units as detailed in Clause 16.2. 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.

16.2 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. N	Tests	Type Test (Clause No)	Routine Test (Clause No)
1.	General Inspection • Physical Condition • Dimension measurement Mounting Bracket/Legs as per CLW's Drg. No. CLW/ES/SK-1/0069 Dated 16.07.2011.	16.3	16.3
2.	Resistance measurement • Initial in cold condition • At the end of temperature rise test in hot condition • At the ends of temperature rise test in cold condition at ambient temperature.	16.5	16.5
3	Temperature rise test.	18.0	-
4.	Test for withstanding vibration and shock.	19.0	-
5.	Hygroscopic Test.	20.0	-
6.	Test for performance in rain.	21.0	-
7.	Di Electric Test.	22.0	22.0
8.	Insulation resistance test.	23.0	23.0
9.	Condition of resistor after test.	25.0	25.0

16.3 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, especially contact surfaces.

Dimension measurement as per Manufacture Drawing duly approved by RDSO/CLW.

Mounting legs should be as per CLW's Drawing No. CLW/ES/SK-1/0069 Dated 16.07.2011.

16.4 Check on Chemical composition of resistor element material:
Supplier shall submit the original purchase document of the material and chemical composition test results from the manufacturer of the resistor element or from Government approved test laboratories. Special test result for verifying lifetime shall also be submitted by supplier.

In case joints are used in the resistor element, suitable tests shall be carried out to verify the electrical resistance of the joint shall not be more than the equal length of the parent element, and the mechanical strength of the joint shall not be less than the parent element.

16.5 Measurement of Resistance

16.5.1 Check on the rated value of resistance for each resistance box carried out by using voltmeter and ammeter or digital micro ohm meter. Readings are taken at ambient Temperature and corrected to the reference temperature of 20°C and 500°C. The allowable tolerance on resistance values in relation to the rated values shall be limited to +7% and –5%.

16.5.2 Resistance measurements shall be repeated at the end of temperature rise test.

16.5.3 After the temperature rise test, the resistance shall be measured again at the ambient temperature. The value obtained as corrected to 20°C and 500°C shall not exceed by more than 3% the value measured before temperature rise test.

17.0 AIR FLOW MEASUREMENT

17.1 Type test:
Perform the following set of tests on complete DBR Unit with blower by giving external voltage supply equal to rated voltage, 70% & 125% of rated voltage respectively to the motor.

17.1.1 Measure the in let air velocities at minimum 32 points of air suction mesh guard. Calculate the average air velocity and volume flow rate.

The volume flow rate of the inlet air should not be less than 11.0 m^3/sec. at rated voltage

17.2 Routine Test:

Perform the set of tests similar to Clause 17.1.1 on Complete DBR units with by giving rated voltage supply to the motor.

18.0 TEMPERATURE RISE TEST

A. STATIONARY CONDITION

The temperature rise tests shall be 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 cables, the resistor position etc. The cooling conditions shall be so arranged as to reproduce the normal service conditions, as closely as possible.

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

200 A, 400 A, 560 A, 750 A, 800 A, 900 A & 1006 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 as prescribed.

18.2 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.

18.3 During the temperature rise tests, the temperature of the terminals shall also be measured and it shall not exceed the limits 70°C.

18.4 Temperature rise test shall also be conducted to verify the over load rating of the resistor, i.e., 1.25 times the rated Power (1006 Amp. approx) for 10 minutes. Average temperature of the resistor, exit air temperature and hot spot temperature should be within specified limit.

18.5 After temperature rise tests, the elements shall be physically examined to check for any distortion or sag.

18.6 The test results for verifying the electrical and mechanical properties of the element supporting insulating material used in the resister assembly before and after subjecting them to continuous temperature of 250°C shall be submitted by manufacturer. The

manufacturer shall also submit results of shock proof ness tests of element supporting insulating material.

B DYNAMIC TEST (ACTUAL WORKING CONDITION)

After successfully completion of above mentioned tests, temperature rise test also to be repeated on forced cooled roof mounted DBR actually mounted on the locomotive and in Dynamic Braking mode.

The followings are procedure of testing:-

a) Locomotive should be connected with fully loaded train.

b) Check the setting of QF-1, QF-2 and QE relays. (QE-900Amp., QF-1 & QF-2 -950Amps.)

c) The loco pilot of the loco should be responsible for caution and signal aspect.

d) Testing should be done preferably at a stretch where there is long span without speed reduction.

e) Loco pilot of the locomotive will notch up/down or apply the air brake to maintain the speed of train at constant and desired level. The start speed should be maintained at 30 kmph and should in the next attempt go at 50 kmph, 60 kmph, 70 kmph, 90 kmph so on.

f) Loco pilot of test locomotive should apply the Dynamic brake only. Notch up-down should be made to maintain the desired current level. During trial notch up, to achieve the desired braking current of 900 Amps.

g) From the data logger, maximum temperature level should be recorded. Also Record locomotive speed, braking current, Notch position, and time consumed during trial.

NOTE : i) Locomotive and crew will be arranged by Indian Railways while instrumentation will be arranged by suppliers for both the static and Dynamic tests.

ii) Minimum points on the grid elements for measurement of temperature rise with the provision of thermocouple should be at least 18 nos. per unit.

19.0 TESTS FOR WITHSTANDING SHOCK & VIBRATION

19.1 The complete unit shall be fixed in a suitable position on to a machine producing sinusoidal vibrations of adjustable amplitude and frequency, as specified in IEC 61373-2010 Category-1, Class 'A'.

19.2 After Shock and Vibration tests, the resistor box or frame must be able to withstand successfully the electrical tests including Di-electric strength tests.

20.0 HYGROSCOPIC TEST

The resistor box or complete unit shall be placed in a humid enclosure at a temperature of 20°C to 25°C and a relative humidity (RH) of at least 95% for 24 hrs. As soon as possible, and in any case, not more than 5 minutes after removal from the humid enclosure and wiping off extraneous surface moisture with a clean cloth. Di-electric test shall be carried out, using test voltages of values 75% given in Clause 22.0.

21.0 TESTS FOR PERFORMANCE IN RAIN

21.1 The resistance unit shall be brought to maximum temperature by the application of appropriate current.

21.2 Isolate the power to resistor and blower unit. Then spray with water at ambient temperature in a direction in the vertical plane from an angle 45° with the direction of motion and with an output of 3 mm/min for 5 minutes. Repeat the test at least three times without producing any adverse effect of DBR unit.

21.3 At the end of test carry out Di-electric test at 50 Hz for one minute duration in each case, using test voltages of 75% as give in clause no. 22.0

21.4 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.

22.0 DI-ELECTRIC TEST

These tests shall be carried out with the power frequency 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 frequency of 50 Hz shall be as nearly as possible sinusoidal.

The test voltage is applied progressively in 10s, maintained at the prescribed value during 60 sec. ± 5 sec., and then decreased progressively to zero.

i) In case of single insulation level
- Between Resistance Element to Earth – 4.0 KV.

ii) In case with three insulation level
- Between resistance element to tie rod- 1.5 KV
- Between resistance element to intermediate frame- 3.0 KV
- Between resistance element to Earth- 4.0 KV

23.0 INSULATION RESISTANCE

Measure the Insulation Resistance before and after the dielectric test with 1000V Megger the value should be more then 100 MΩ.

24.0 TESTS FOR AIR FLOW RELAY FUNCTION

To ensure the working of MVRF, air flow indication to be provided for loco pilot. Disconnect the motor connection from the terminals, connect indication lamp across the contacts of Air flow Relay. Connect external DC source to Motor (MVRF). Run the blower by gradually increasing the DC voltage till the air flow relay picks up within and indication lamp glows. Record MVRF voltage and current at which air flow relay picks up. QVRF Relay should pick up at 50 V. Ensure that air flow relay should not pick up in reverse direction rotation of blower motor.

25.0 CONDITION OF RESISTOR AFTER TEST

After completion of tests specified, check shall be made that:-
- No screw and nut are loose.
- There is no distortion or corrosion or scaling of any components.
- The resistor elements are not deformed, cracked or broken.
- The insulators have suffered no damage.

SECTION 3
BLOWER MOTOR

26.0 D.C. MOTOR

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

1.	Type	DC Series Motor
2.	Power	27 kW (Approx.) 02 nos.
3.	No of Poles	04 (four)
4.	Rated Speed	1750 RPM
5.	Cooling	Surface cooled by DBR fan
6.	Mounting	Vertically mounted
7.	No of Brush Holders	4
8.	Insulation	Class H
9.	Temperature rise limit	Field : TI - 80 °C Armature : TI - 80 °C Commutator : 85 °C
10.	Absolute Bearing Temp	90 °C (max)

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

The motor shall able to be accommodated in the roof cut out of diameter 500 mm. One metallic seal ring shall be welded in the cut out to provide sealing of the roof to stop rain water ingress.

Carbon brush shall be only from RDSO's approved sources. Prior approval shall be mandatory for the proposed grade of Carbon brush.

26.2 Terminal Plate:

Epoxy moulded terminal block/plate should be used.

26.3 Terminal Leads:

i) Terminal leads should be flexible, insulated, fibre glass copper connecting lead wire with fire retardant silicon elastomer suitable for temperature –50°C to +180°C

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

26.4 Bearings:

- Either deep groove ball bearings or roller bearings of adequate design should be used to withstand the vibration encountered on the locomotive.
- Minimum L10 life shall be 100,000 hours.
- Sealed bearings should not be used.

- Bearing should have C3 class of clearance
- Manufacturer should supply the lubrication schedule and the quantity during maintenance.
- Label for lubricating instructions shall be provided adjacent to the nipples.
- 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.
- Tolerances on boundary dimension shall be adopted as per IS specification.
- Maximum temperature of bearing cap should be restricted to 90°C.

27.0 TEST PROGRAMME FOR D.C. MOTOR

27.1 All motors shall be generally tested in accordance with IEC 60349-1:2002. The type tests and routine tests to be carried out on motor are given below:

S. N	Tests	Clause of Type Test	Clause of Routine Test.
1.	Measurement of resistance (cold)	27.2	27.2
2.	Direction of rotation	27.3	27.3
3.	No Load Test	27.4	-
4.	Temperature Rise Test	27.5	-
5.	Maximum & Minimum Voltage Operation Test	27.6	-
6.	Over speed test	27.7	-
7.	Starting Test	27.8	-
8.	Commutation Test	27.9	-
9.	Interruption Test	27.10	-
10.	Voltage Jump Test	27.11	-
11.	Dielectric Test	27.12	-
12.	Insulation Resistance Test	27.13	-
13.	Enclosure Protection Test	27.14	-
14.	Weight Measurement Test	27.15	-

27.2 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 or by milliohm meter. Record the method of test, winding temperature, voltage, current and resistance.

27.3 Direction of Rotation:

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

27.4 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.

27.5 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:

- One hour temperature rise test at rated voltage and current.
- Steady state temperature rise test at rated voltage and current.

Measure voltage, current, input power, speed, temperature of frame, bearing and air inlet and outlet,

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

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 60349-1: 2002. (Latest version)

Record the method of tests and measurements and various measured and calculated values. The efficiency of the motor shall also be calculated and recorded.

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

- 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.

- 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.

27.5.1 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. 27.5).

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.

27.6 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 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 27.5.

Immediately after the above test, increase the voltage to 125% of rated voltage 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 27.5.

27.7 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 of Shock Pulse Meter.

27.8 Starting Test:

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 of 70% of the rated voltage and five successive starts at 125% of rated voltage against full load torque. No mechanical distortion, flashover, or permanent damage should occur.

completion of the test. The commutation test shall be carried out at following points:

- At maximum speed, maximum voltage.
- At rated current and speed.
- At maximum current (1.5 times rated current).

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

27.10 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

27.11 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 (125% rated voltage). The test shall be carried out five times in succession, the minimum voltage conditions being restored between each voltage jump.

27.12 Dielectric Test:

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

27.13 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. The value should not be less than 50MΩ.

27.14 Enclosure Protection Test:

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.

27.15 Weight Measurement:

Measure and record the weight of the motor

SECTION 4
BLOWER SET

28.0 BLOWER SET

28.1 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.

28.2 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.

- Air quantity - Not less than 11 m^3/sec.
- Rated RPM - 1750
- Fan diameter – 1315 mm max.

The impeller shall be rated for continuous operation at the rated output. The standard air density of 1.2 kg/m^3 shall be considered while designing airflow.

The impeller shall be so designed that it can deliver minimum rated air quantity and total head.

28.3 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.

28.4 Special Constructional Features:

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

28.5 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. It should be of double side axial intake direction and axial discharge direction. All welds of the housing should be welded continuously.

28.6 Direction of Rotation:

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

28.7 Inspection Cover on Casing:

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

28.8 Balancing:

Impeller shall be dynamically balanced individually and with motor.

28.9 Vibration:

Vibration level at blower casing shall not exceed 25 Micron Peak to Peak when blower is running at rated voltage.

28.10 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.

28.11 Lifting Arrangement:

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

28.12 Inter-changeability:

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

28.13 Name Plate:

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

- Manufacturer's name.
- Type and Serial Number
- Air delivery (m^3/s)
- Rated speed.
- Make of the motor
- Power consumption in kW
- Impeller diameter (mm).
- Weight of blower unit (kg)
- Manufacturing date and year.
- Manufacturers' name and DBR serial number should be engraved on impellers also.

28.14 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. This relay should pick up at MVRF speed, corresponding to 50 volt DC supply to MVRF.

29.0 TESTS ON BLOWER MOTOR SET :

29.1 Type Tests and Routine Tests shall be carried out on the Blower Motor sets as detailed below. 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. N.	Tests	Clause of Type Test	Clause of Routine Test.
1.	Air Delivery Test	29.2	29.2
2.	Starting time test	29.3	-
3.	Starting Duty Test	29.4	-
4.	Endurance test	29.5	-
6.	Checking of dimensions, fixing and locking arrangement of impeller and workmanship.	29.6	29.6
7.	Weight measurement	29.7	-

29.2 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 125% of the rated voltage. 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 of observed and calculated values.

Plot curves between total head (mm WG), Static head (mm WG) 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.

29.3 Starting Time Test:

With supply equal to 70% , 110% of the rated voltage and at 125% rated 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.

29.4 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.

29.5 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.

29.6 Dimensions Measurement:

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

29.7 Weight Measurement:

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

SECTION- 5

HT CABLE FOR INTERCONNECTING PANTOGRAPH AND VCB

5.1 With the provision of force cooled Roof mounted DBR, some of the existing roof bars inter connecting the Pantographs and VCB shall have to be removed and this connection shall be provided using 45 kV XLPE cable. Supplier shall supply 45 KV, XLPE cable only from RDSO approved sources along with complete set of accessories required for connection.

5.2 The cable shall be laid on the roof of the locomotive and shall pass over resistor bank enclosures. Detailed layout of the HT cable as well as the forced cooled DBR units shall be provided by the supplier for review and finalisation. Alternative arrangement of laying down the DBR units and the HT cable, establishing its merit, may also be offered by the supplier.

5.3 XLPE CABLE:

XLPE sheathed cable size 120 mm² of 45 KV rating, with stranded copper conductor confirming to class 2 of IEC 60228-2004 constructed in accordance with IS 7098 Part 2 1985.
Metallic tape and wire screen of the XLPE cable is required to be earthed at both the ends.

5.4 TERMINATION:

Outdoor type termination arrangement with pre moulded stress control device in conjunction with suitable numbers of skirts or any other proven design shall be used over the XLPE insulation to provide adequate creepage distance on both the ends. The termination shall be class I type of IEEE-48 (latest version)

Termination shall have a suitable size of copper lug crimp to 120mm² copper conductors and provided with earth stress cone, leakage current collector and water sealing arrangement.

5.5 TAPE:

Sealing of termination should be done by self bonding tape and silicon tape.

The self bonding tape shall be Okoprene- Neoprene rubber or its equivalent having operating temperature not less then 130°C. The dielectric strength of the tape shall not be less than 5

KV/mm. The elongation during stretching shall not be less than 40%. The tape shall be suitable for outdoor application and shall not be affected by heat, water, dust and other air contamination.

Silicon tape shall have class 'H' insulation made up of silicon rubber. The tape shall be of anti tracking property. Tape shall withstand 2.5 KV, with resistance of 10 KΩ and current of 0.25 Amps. for 1000Min. No tracking should occur.

5.6 TESTS ON XLPE CABLE:

The XLPE cable, to be provided in lieu of the roof bars, shall be tested as stipulated in RDSO specification no. ELRS/SPEC/BL/0003 (Rev. 1). The successful Supplier shall submit detailed test plan and get it approved by RDSO prior to commencement of the tests.

5.7 DESIGN DATA OF THE XLPE CABLE:

Complete technical details shall be submitted by the Supplier meeting the requirements of the RDSO specification no. ELRS/SPEC/BL/0003 (Rev. 1):

SECTION- 6

Following annexure form part of the specification:

Annexure I : Design data of braking resistors

Annexure II : Design data of blower

Annexure III : Design data of d.c. motors

Annexure IV : Maximum moving dimension of WAG-5 locomotive

Annexure V : Maximum moving dimension of WAG-7 locomotive

Annexure VI : Envelop size for force cooled roof mounted DBR

ANNEXURE- I

DESIGN DATA OF BRAKING RESISTORS

1.	Resistors
2.	Resistance Material Chemical composition
3.	Specific Resistance at 20 °C
4.	Temperature Co-efficient -- At 20 °C, 300 °C & 500 °C
5.	Maximum permissible service temperature
6.	Specific heat
7.	Melting point
8.	Co-efficient of linear expansion
9.	Heat conduction
10.	Density
11.	Average outlet temp. of cooling air at rated output
12.	Ohmic value of Resistor at 20 °C
13.	Ohmic value of each resistor box at 500°C
14.	Effective Ohmic value of resistance box with Blower Motor connected in parallel At 20 °C, 300°C & At 500 °C
15.	Size of Element Strip
16.	Developed length of element per turn
17.	No. of turns per element
18.	No. of elements per box • Series • Parallel
19.	Weight of active material per box
20.	Weight of resistor box
21.	Total weight of assembly with blower and motor
22.	Temperature of the elements • Average working temperature of element • Hot spot temperature • Temperature time constant

Insulation

- Insulation in between resistor element and support
  i) Primary
  ii) Secondary
- Type of separators between resistor elements, if any.

Drawings

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

ANNEXURE-II

DESIGN DATA OF BLOWER

Type, model and make.

Air delivered in cubic meter per minute at static and total pressure head in mm WG corrected to 20°C and 760 mm barometric pressure.

- At rated voltage
- At lowest voltage of the driving motor.

Design Data –

- Impeller
- Type of impeller blades
- Number of blades
- Method of fixing of the blades
- Clearance between inlet cone and impeller Maximum shaft speed of the impeller
- Motor shaft and impeller bore diameter (max. and min.)
- Method of fixing of impeller on motor shaft and locking arrangement.
- GD2 value of the impeller (indicate the maximum variation in manufacture)

Note:

GD2 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.

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

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

The Supplier shall enclose the following characteristic curves at 20°C and 55°C.

- Total and static head vs air delivery
- Total and static efficiency vs air delivery
- Air horse power vs air delivery
- Power absorbed vs air delivery
- Speed vs air quantity in m^3/sec.

Necessary dimensioned drawings of the blowers and its component showing the constructional and assembly details, along with material specification, Separate drawing of impeller and total weight of blower including motor.

ANNEXURE – III

DESIGN DATA OF D.C. MOTORS

A. GENERAL DATA

1. Type, model and make.
2. Nominal voltage
3. Rated speed (rpm.)
4. Continuous rating (HP/kW)
5. Rated current –
   - At rated voltage.
   - At minimum voltage
6. Class of insulation –
   - Armature
   - Field
   - Commutator
   - 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
    - Rated voltage.
    - Minimum voltage.
    - Maximum voltage.
13. Starting torque and current at –
    - Rated voltage.
    - Minimum voltage.
    - Maximum voltage.
14. Full load current and torque voltage in item 13.
15. GD2 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 °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.

(iii) 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

(iv) 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.

(v) 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.

(vi) Banding:

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

(vii) Terminal Box :

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

(vii) 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/m^2)
4. Ratio Field AT /Armature AT at full field.
5. Specific power ($Watts/cm^3$)
6. Frequency of flux reversal.

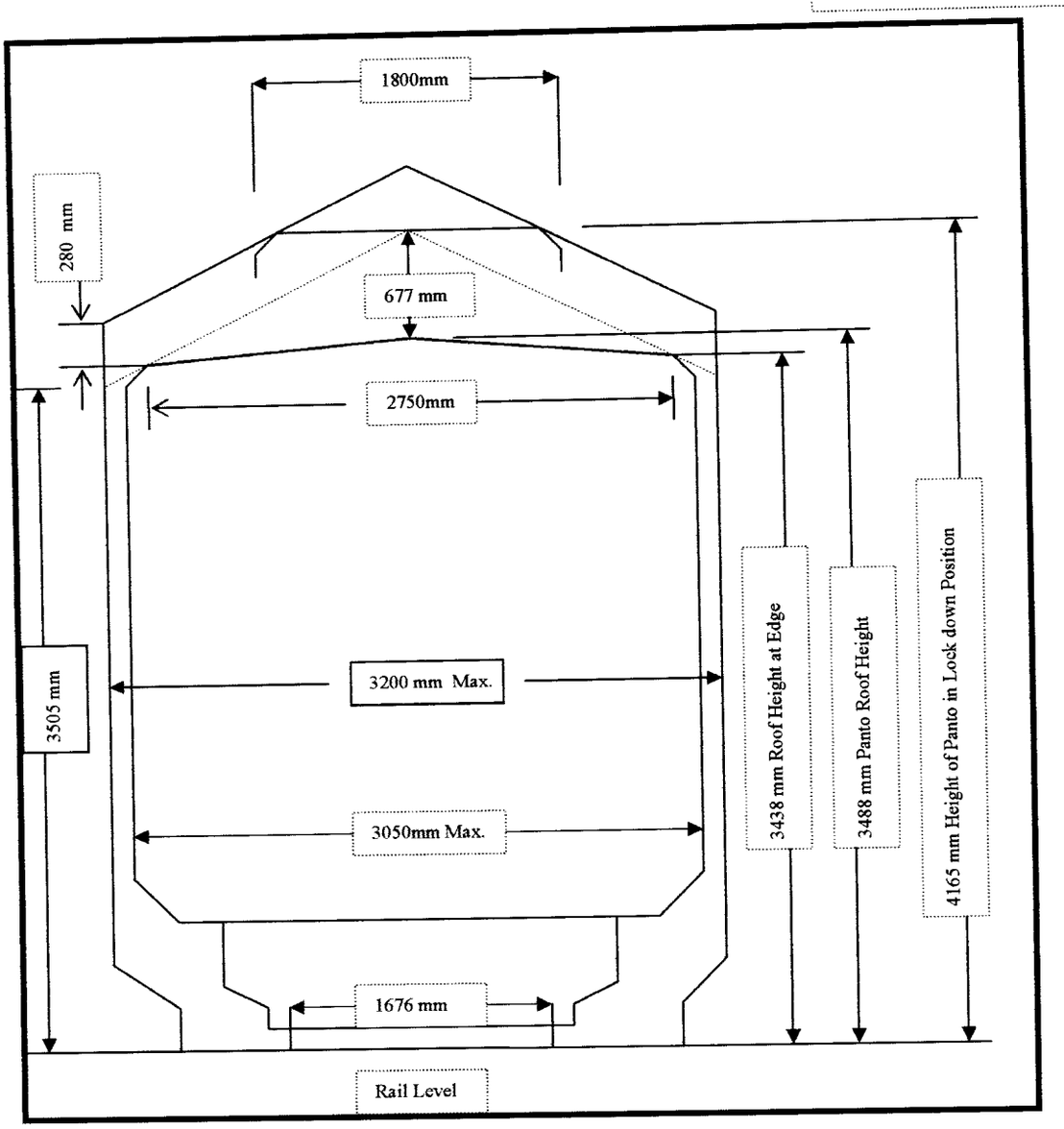
D. DRAWING

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:

Drawings at Sl .Nos. 1, 2, 6 & 7 shall be submitted by all Suppliers.

ANNEXURE- IV

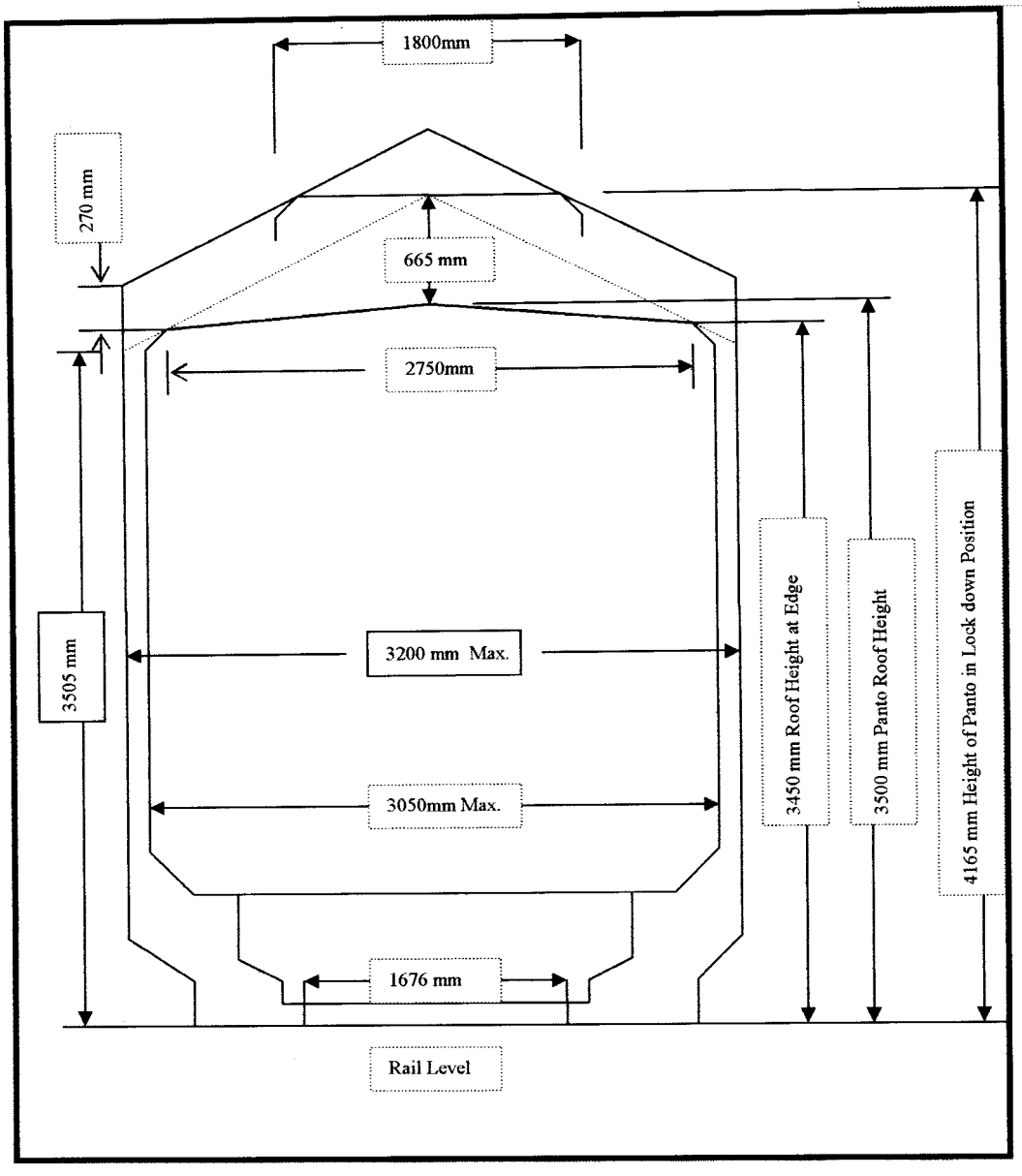


MAXIMUM MOVING DIMENSION OF WAG-5 LOCOMOTIVE

WAG -5 / CLW / DRG.05/1/47/485
SKDL-4089

Prepared By	Checked By	Issued By
V.K.Gupta	R. Dasgupta	A.K.Goswami

ANNEXURE V



MAXIMUM MOVING DIMENSION OF WAG-7 LOCOMOTIVE

WAG -7 / CLW / DRG.05/1/47/4-----
SKDL-4089

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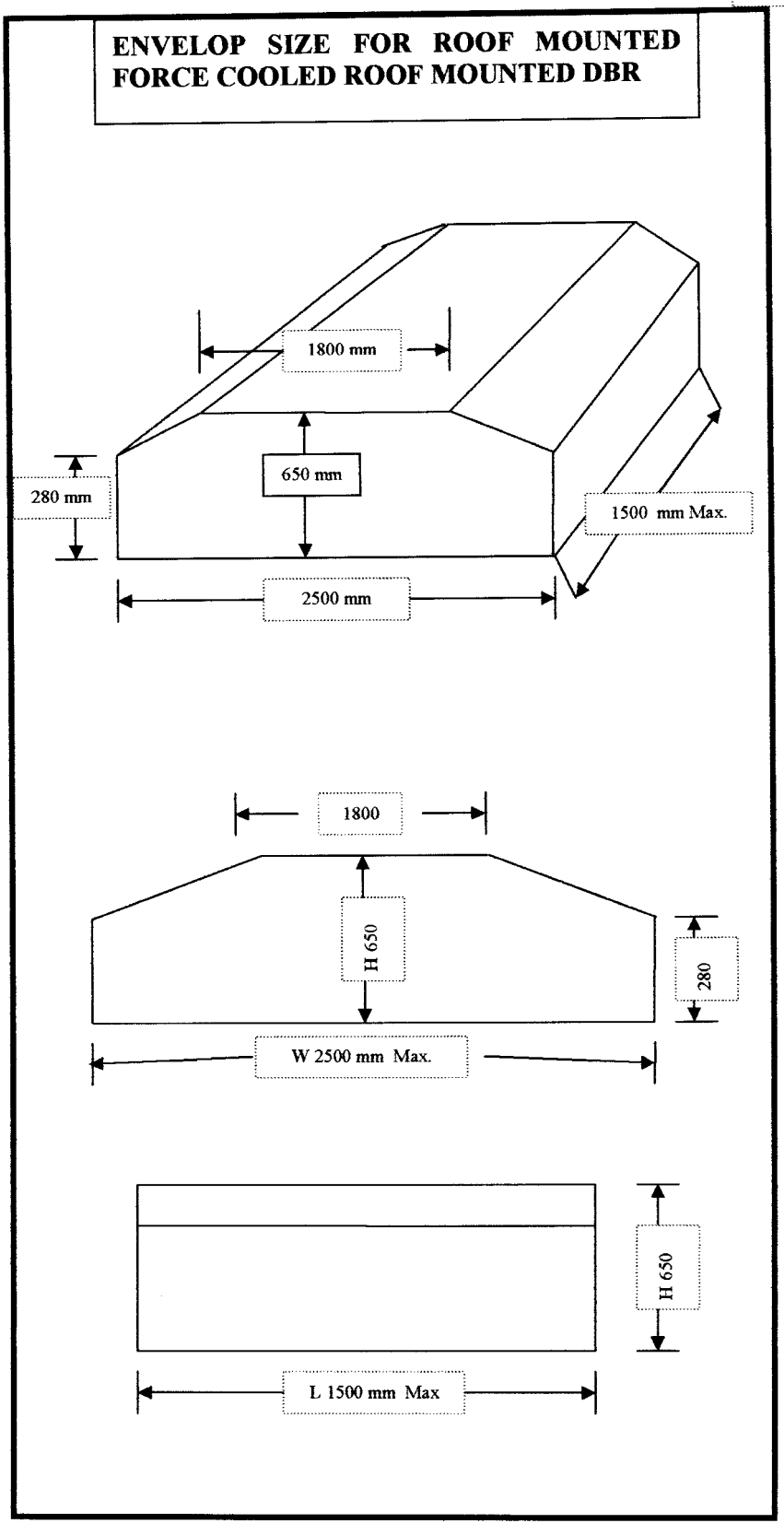
ANNEXURE VI



ENVELOP SIZE FOR ROOF MOUNTED FORCE COOLED ROOF MOUNTED DBR

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