INDIAN RAILWAYS

SPECIFICATION

FOR

STANDARDIZATION OF BRAKE DISC

USED IN LHB COACHES

OF

INDIAN RAILWAYS

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RESEARCH DESIGNS AND STANDARDS ORGANISATION
(MINISTRY OF RAILWAYS)
MANAK NAGAR
LUCKNOW - 226011

Signature

Name & Designation | Prepared by: | Checked by: | Approved by:
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Signature

Name & Designation | Prepared by: SSE/Carriage | Checked by: SSE/Carriage | Approved by: Director/Carriage
1.0 FOREWORD

1.1 LHB type coaches of Indian Railways have been provided with Axle Mounted Disc Brake System wherein Brake Disc is that part of vehicle brake system that serves to convert kinetic energy into heat by means of friction. Axle mounted brake disc are ring-shaped castings made from cast steel or grey cast iron with crosswise cooling ribs. Presently, LHB Coaches have two types of Brake Discs i.e. 9 Bolt & 12 Bolt Design supplied by two renowned suppliers.

1.2 Following standards as applicable may be referred to in conjunction with this Specification:
   a. UIC 541-3
   b. EN 14535-1
   c. EN 14535-3
   d. DIN 27205-3

2.0 SCOPE

2.1 This specification is intended to standardize the Brake Disc for LHB Coaches so as to achieve the ease of interchangeability & maintenance and does not include all the necessary provisions of the contracts.

3.0 PARTICULAR REQUIREMENTS

3.1 The firm seeking registration for Brake Disc of LHB Coaches shall register online on RDSO websites. All relevant documents like Vendor Approval guidelines & Application form, latest version of all specifications and drawings shall be provided on websites. The firm shall follow the latest vendor approval guidelines for registration with RDSO.

3.2 The firm should possess ISO: 9001 certificate issued by International Accreditation Forum (IAF) under Multilateral Recognition Arrangement (MLA) for his works address, covering the items for which he seeks registration with RDSO.

3.3 The firm along with their principals/foreign collaborator shall have adequate infrastructures for manufacturing, testing and quality control requirements of Brake Disc. This will be verified by the RDSO at the time of registration of the firm.

3.4 The firm shall submit their design of brake disc for approval of RDSO.

4.0 FUNCTIONAL REQUIREMENT

4.1 The Brake Disc of Axle Mounted Disc Brake system shall fulfil the following requirement, under Indian Railway service conditions without crack, damage over permitted under DIN27205-3, damage or degradation other than normal wear of the friction face beyond permissible limits.

4.1.1 Brake Disc shall permit a braking moment or torque to be generated, supported and transmitted to the rail vehicle axle.

4.1.2 Brake Disc shall permit, by frictional engagement of a brake pad or pads, the conversion into heat of the kinetic and potential energy involved in retarding the vehicles which is attributed to the use of the disc brake.

4.1.3 Brake disc shall absorb part or all of the kinetic and potential energy arising from the braking of coaches.

4.1.4 Brake disc shall dissipate the absorbed energy by radiation, convection and conduction.

5.0 DESIGN REQUIREMENT

5.1 The axle mounted brake disc shall consist of the friction ring with cooling ribs and the hub. The friction ring of Brake Disc shall have to be cast as a single piece followed by its machining on...
required surfaces as per EN 14535-1. The thickness of the friction ring and the size of the cooling ribs are related to prevent overheating during brake application.

5.2 The brake disc (including friction ring and spokes) shall have adequate mechanical and thermal capacity for service on and off the Indian Railways, under the environmental and operating conditions identified in Annexure-III.

5.3 Brake Disc shall be of 12 bolt design.

5.4 All parts of the brake disc shall be designed for fatigue strength.

5.5 In the design of axle mounted discs, the fatigue life of the connection between the hub and friction ring must take into account cyclic loading from thermal and shock environments that are separately considered and are encountered in normal service.

5.6 The fatigue life at the most highly stressed location in the connection between the hub and spoke, due to combined strains from thermal load and shock load, shall be equal to or greater than the projected service life of the friction ring or 20,00,000 km, whichever is greater.

5.7 Brake disc shall be designed and constructed in such a way that in case of hitting of flying stones raised from ballast track, it does not affect the functional efficiency or cause failure of disc.

5.8 The connections between brake discs and wheel set axle must satisfy the following requirements:

5.8.1 Transmission of brake power.

5.8.2 Largely unrestricted thermal expansion of friction faces and friction segments.

5.9 A minimum true specific weight shall be of great importance.

5.10 The friction ring shall be designed additionally with a view to minimizing their overall weight.

5.11 The friction ring of brake disc shall have a groove around their outside circumference to indicate the condemning limit and when they have to be exchanged.

5.12 The crosswise cooling ribs carry off the heat and serve simultaneously to maintain a thermal balance within the friction rings.

5.13 Cooling fins that are arranged radially between the friction surfaces provides for sufficient cooling at the friction ring. They convey a stream of cooling air from the hub through the interior of the friction ring to the outside, using a centrifugal force that is controlled by speed.

5.14 Low-noise behaviour by the brake disc under all operational conditions shall be of great importance.

5.15 The replacement of worn, damaged brake discs/sections without dismounting of the wheels should be possible.

5.16 Ventilation grids of the brake disc to be so designed to avoid entrapping of debris like paper, polythenes etc. may get trapped in service which may choke them. The design of the ventilation grids of the brake disc shall be suitably modified/ redesigned to get self-cleaning properly.

5.17 Supplier should also offer split disc design so that replacement for damaged or worn out friction rings can be achieved with ease without the necessity of dismounting of wheels from the axles and also the same can be mounted on hub of standard interface having 12 bolts design of any make.
5.18 Unless the purchaser requests otherwise, a suitable hole and groove feature shall be incorporated to facilitate pressurized liquid assisted assembly and/or disassembly of hub and axle. The threaded hole connection is to be closed with a locking bolt G1/4A x 8 DIN 910 and sealing ring A14 x 20 x 1.5 DIN 7603.

6.0 PERFORMANCE REQUIREMENTS

6.1 The brake disc is to be so designed that it provides faultless operation under the conditions of use mentioned at Annexure – III for a period of at least 6 years from the date of commission.

6.2 Brake disc should be designed in such a way that it has minimum wear and tear and maintenance possibility. The goal for the wear limit on friction faces and friction segments shall be 2 million kilometers.

6.3 Design of the brake disc shall be such that the performance is not adversely affected under extreme positions of wheel and suspension movements under maximum wear conditions.

6.4 Brake Disc shall be able to expand during the braking process to avoid crack formation on the disc. The expansion shall be in such a dimension that vibrations are minimised.

6.5 Brake Discs shall have a higher strength against external dynamic loads (shocks upto 100g).

6.6 The maximum thermal heating of brake disc in no case exceeds the permissible value of chosen material.

6.7 The brake disc offered shall be suitable to work with any UIC/RDSO approved Organic Brake Pads suitable for speeds upto 200 Kmph and must qualify frictional and thermal characteristics as stipulated in UIC 541-3.

7.0 GENERAL TECHNICAL REQUIREMENTS

7.1 The general technical requirements for manufacture of Standardized Brake Disc are mentioned in Annexure-I.

7.2 The general design and drawing of the brake disc shall be got approved from RDSO.

7.3 QAP for the manufacture and inspection of the brake discs should be prepared by the FIRM and submitted to RDSO for approval.

7.4 Routine and Functional tests on the brake disc shall be done as indicated in Clause 15.

7.5 The prototype testing of any new design brake disc (which is being used by IR for the first time) shall be witness by the RDSO at the firm premises. All the inspection and testing charges including logistics/air fare etc. shall be borne by the FIRM.

8.0 SUBMISSION OF TECHNICAL DOCUMENTS

8.1 The following technical documents/details in triplicate shall be submitted by the Firm along with application:

8.1.1 The clause by clause comments on this specification, confirming compliance with all the clauses and elaborating, wherever necessary shall be enclosed.

8.1.2 Detailed drawing in A1/A2 size of Brake Disc which shall contain details regarding material specification, dimensions, estimated weight, testing parameters, marking particulars, reference to manufacturing / original collaborator’s drawing etc.

8.1.3 Material data sheet for all components i.e. friction ring, hub, bolts etc. shall be made available for verification to the visiting inspection agency.
8.1.4 FEA report of brake disc offered to Indian Railways. The maximum stress from the FEA at the specified load, with a factor of safety of at least 1.50, shall be less than the allowable fatigue limit. The FEA report must include an analysis for fatigue life showing the damage factor due to loads imposed by vertical and lateral axle box acceleration and thermal loads resulting from friction between disc and brake pads. The FEA report shall include but not limited to, the following:

a) Introduction
b) Table of contents
c) Summary
d) Physical properties of each material used for the disc. This table shall include but not limited to:
   - Yield strength
   - Ultimate strength
   - Elongation
   - Tension modulus
   - Compression modulus
   - Shear modulus
   Minimum values shall be used and shall be selected from material specification

e) Views of key structural areas (spoke, hub-friction ring connections, etc.) showing member locations and geometry, and indicating the material and thickness of each. Other FEA views may be required where critical stresses are identified.

f) A tabulation or fatigue curve justifying the contractor’s selection of allowable fatigue stresses for the disc material for each transition or joint, and the fatigue-critical stress ranges. The FEA report shall include a description of how this process is carried out.

g) The complete test report must be submitted including procedure, raw and induced data, and summary of results, including:
   - Structural sketches and/or layouts of the critically stressed locations showing locations and shapes depicted in scale, thickness, section properties and material.
   - Diagrams displaying externally applied loads and boundary conditions.
   - Colour plots of the stress under each loads and boundary conditions.
   - Natural frequencies of the disc.

8.1.5 Hub & Friction ring connecting Bolt calculation report.

8.1.6 The corresponding wear calculations and/or tests at the testing bench.

8.1.7 Details of testing facilities available at manufacturers.

8.1.8 For a new entrant or in case of any design changes of the existing approved suppliers the type and routine test specification and test reports shall be submitted.

8.1.9 The firm shall enclose the supply details along with performance reports issued by various International Railways for their brake disc.

8.1.10 Operation & maintenance manual and service instructions.

8.2 In addition to the above, further information, if required by the RDSO/Indian Railways, shall be promptly provided by the Firm.

9.0 APPROVAL OF DRAWING

9.1 The design/drawing of the Brake disc shall be developed based on the technical and performance requirements given in this specification and sound engineering practice. The
entire drawing shall be submitted by the firm with technical data and calculations to RDSO for approval.

9.2 The drawing shall be developed in SI units.

9.3 Material grade/ specifications for each component shall be indicated on the relevant drawings of the firm and the firm shall supply copies of translation in English of such specifications/drawings other than Indian Standard Specifications to purchaser/RDSO.

9.4 Approval of the design means the approval of the general design features. Notwithstanding the approval, the contractor will be wholly responsible for the performance of the Brake disc offered.

10.0 DIMENSIONS AND TOLERANCES

10.1 Brake discs are intended to be mounted on the axle to RCF Drg No. LW02100 alt ‘Nil’. It shall be ensured by the firm that disc/discs offered by him are suitable to be fitted on to the axle as per this drawing.

10.2 Broad specification of the brake disc shall be as under:

a) Dimensions 640 x 110 mm
b) Outer Diameter of friction ring 640 +0/-1 mm
c) Inner Diameter of friction ring 350 mm
d) Width of friction ring 110 +0/-0.3 mm
e) Inner bore 199 mm (H6)
f) Width of hub 150 mm
g) Pitch Circle dia of hub/friction ring 276 mm connecting bolt
h) No. of connecting bolts 12 nos.
i) Size of connecting bolts M12

10.3 The imbalance of new discs shall be equal to or less than 16gm.

11.0 MANUFACTURE

11.1 Brake Disc shall be manufactured as per drawing approved by the RDSO.

11.2 Brake Disc shall be free from casting defects.

11.3 No sharp corners or edges shall be present.

11.4 The surface roughness on friction faces shall be \( \leq 16 \mu m \), except where otherwise specified by the IR or purchaser.

11.5 The surface roughness on hub bore shall be between 0.8\( \mu m \) to 3.2\( \mu m \), except where otherwise specified by the IR or purchaser.

11.6 Hub connection to the friction ring shall be made properly. The connecting bolts shall be tightened with the specified torque wrench.

11.7 The brake disc shall be carefully protected against corrosion.

11.8 The friction faces, friction segments and surfaces which are exposed to high temperature shall not be provided with surface protection.

11.9 The remaining surfaces shall be provided with either an appropriate lacquer structure or galvanic coating or phosphating.

11.10 Surface protection shall be evident on the drawing.
12.0 PROTOTYPE INSPECTION

12.1 The manufacturer shall offer at least 3 Nos. Prototype discs of a new or modified brake disc, the necessary testing according to Para 14 of this specification shall be carried out on test piece.

12.2 The Prototype inspection of brake disc shall be carried out by Carriage Directorate of RDSO or their nominee at manufacturer's premises. The manufacturer shall provide, without extra charges material, tools and any other assistance, which may consider necessary for any test examination and dimensional checking.

12.3 After prototype clearance, the brake disc shall be subjected to field trial as per Para 16.0 of this specification.

13.0 PURCHASE INSPECTION

13.1 The purchase inspection shall be carried out at the premises of the manufacturer who are registered with RDSO. The following procedure shall be followed:

13.2 The Inspecting Authority shall make audit checks of the manufacturing procedure 'Internal Quality Assurance System' to ensure that the Brake Disc offered for inspection is manufactured strictly as per 'Internal Quality Assurance System' and the manufacturer has carried out all the tests/inspections during manufacturing stage to ensure that the Brake Disc as well as their components are manufactured strictly to the specification/drawing and quality standard of the collaborator. During audit checks the inspection Authority shall see from the records of 'Internal Quality Assurance' that the Raw material used for the manufacture of Brake Disc is as per specification laid down.

13.3 Manufacturer shall have to maintain the internal tests record and submit to the Inspection Authority.

13.4 The Inspection Authority shall conduct the following checks/tests of the Brake Disc from a lot of 250 Nos. or part thereof.

13.4.1 2% or minimum three number Brake Discs picked up at random shall be checked for dimensions and tolerances, general workmanship and surface finish as per RDSO approved drawings.

13.4.2 1% or minimum two disc picked up at random shall be verified for tests mentioned in clause 14.2.1 (a), (b), (c) & (d) of specification during prototype inspection. The supplier shall produce relevant test reports of the test done on the test bars/chilled samples used for the manufacture of particular batch/lot/heat of disc for the tests mentioned in clause 14.2.1 (a), (b), (c) & (d) during purchase inspection.

13.4.3 Test reports for 2% or minimum three numbers Disc picked up at random shall be verified for tests mentioned in clause 14.2.1 (e) & (f) of specification.

13.5 In case the samples picked up fails in any of the tests/checks indicated at clause 13.4.1 to 13.4.3, the entire lot of the Brake Disc shall be rejected by the Inspecting Authority.

13.6 Inspecting authority shall have access to all detailed manufacturing/original collaborator's drawings for all items of equipment. The firm shall be obliged to show these drawings as and when called for.

13.7 The inspecting authority may deviate from the agreed procedure if and when found necessary to re-assure that the material is being furnished in accordance with this specification. In this
regard the manufacturer shall not be entitled to object on any ground whatsoever on the nature and procedure of testing that may be followed by the inspecting authority.

14.0 TESTS

14.1 Type Test

14.1.1 The following test shall constitute type test and shall be carried out in accordance to EN 14535-3 (draft) at the time of Product approval of new entrant or at the time of design change of existing design:

a) Performance and Endurance Test
b) Centrifugal Test
c) Ventilation Test
d) Heat dissipation test

14.2 Routine Test

14.2.1 The following test shall constitute routine test and shall be verified against value specified in manufacturer's specification/QAP:

a) Chemical characteristics
b) Hardness
c) Tensile Testing
d) Microstructure
e) Magnetic Particle Testing
f) Residual imbalance

15.0 FIELD TRIAL

15.1 The brake disc offered by the supplier shall be subjected to field trials on minimum 18 coaches (Preferably 1 rake) for a period of minimum 2 years or 4,00,000 Km whichever is later.

15.2 After the satisfactory performance of the field trials, the disc offered may be considered for regular service on Indian Railways and firm may be approved. The existing suppliers who have been successfully supplying Brake Disc for LHB coaches to Indian Railways will be exempted from the field trial.

16.0 GUARANTEE

16.1 The firm shall, at their cost, replace the Brake Disc failing prematurely or proving unsatisfactory in service for reasons attributed to defective/faulty design, defective material or poor workmanship within a period of 72 months from the date of delivery or 66 months from the date of fitment, whichever is earlier. This warranty shall survive, notwithstanding the fact that the brake disc may have been inspected, accepted and payment thereof made by the firm.

16.2 Brake Disc shall be subjected to detailed trials as discussed in Clause 15 of the specification. Any modifications found necessary as a result of these tests or further service trials shall be carried out by the contractor at his own cost in the coaches in a manner approved by the purchaser. All schematic layout and installation drawings incorporating the modifications shall be submitted to RDSO for final approval.

17.0 AFTER SALES SERVICE

17.1 Firm may be required to send their technical expert during the installation and commissioning of their brake disc on coach/coaches. The charges for this service shall be quoted separately.

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<td>SSE/Carriage</td>
<td>Director/Carriage</td>
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17.2 Firm shall also depute its technical expert on request by the Purchaser/RDSO to investigate and attend to specific problems that may come up during actual operation of Brake Disc.

17.3 Firm shall supply at least 3 copies (Soft & hard copy both) of the Operation & Maintenance Manuals and Servicing Instructions to each coaching depot where LHB coach maintenance is done:

17.3.1 Brief Details of brake disc.

17.3.2 Details of attention to be given during IOH/POH or any other schedule examination.

17.3.3 Details of tools & machinery for maintenance of brake disc.

17.3.4 Typical defects and their remedial measures.

17.3.5 Maintenance standards including clearances and tolerances at various locations and permissible limits of wear for good service performance of equipments.

17.3.6 Firm shall submit the frequency and detailed work content of various inspection / maintenance schedules necessary for maintenance of brake disc offered by them. Whether these requirements are time based or distance travelled based shall be indicated for each schedule.

18.0 MARKING

18.1 The detailed form of the marking shall be defined on the drawing. The following data shall be applied to the part in a clearly recognized way:

a) Manufacturer’s data (manufacturer’s name / trade mark), month & year of manufacture and serial number.

b) Residual imbalance in gm (Data regarding residual brake disc imbalance shall be located directly in the place where the imbalance occurs).

The above data shall be stamped/engraved, clearly legible, in an appropriate location.

19.0 PACKING

19.1 Supplier shall ensure that Brake Discs in an assembled condition are adequately packed before dispatch to prevent damage in transporting, handling and storage. The safe transportation shall be the responsibility of manufacturer.
ANNEXURE-I

INFRASTRUCTURE & TESTING FACILITIES REQUIRED FOR MANUFACTURE OF STANDARDIZED BRAKE DISC USED IN LHB COACHES OF INDIAN RAILWAYS

1.0 SCOPE

1.1. This Section covers the infrastructural requirements for manufacture of standardized brake disc used in LHB Coaches of Indian Railways.

2.0. REQUIREMENTS

1.1. All vendors seeking registration with RDSO/Railways as decided by Ministry of Railways must fulfill the requirements of this schedule.

1.2. The FIRM should have adequate plant, machinery and manufacturing capacity for manufacture and supply the brake disc within the delivery schedule.

1.3. The FIRM should have a well-established quality control system and testing facility to ensure adequate quality, at all stages of manufacture.

3.0 PLANT, MACHINERY AND INFRASTRUCTURE REQUIREMENTS

3.1. The Manufacturer shall have adequate space and covered area with cemented floor to accommodate the following and for smooth logistics:

a) Damp-free place for storage of raw materials.

b) Adequate manufacturing area.

c) Finishing, Assembly and Inspection area.

d) Storing and dispatch of finished products.

3.2. The Manufacturer shall have following machines/facility:

a) Suitable precision machining facility for hub and friction ring which includes operations Turning, Facing, Drilling, Tapping, Phosphating & Grinding etc.

b) Suitable jigs & fixtures for assembling friction ring, hub and other associated parts.

c) Suitable automated torqueing tool for M12 bolts of brake disc.

d) Balancing machine for complete Brake Disc.

4.0 TESTING FACILITIES

The Manufacturer shall have the following testing and other equipments to test the product as per the relevant requirements of the specification, installed in a workstation with controlled temperature and humidity.

a) Magnetic particle testing facility.

b) 3-D CMM for checking geometrical dimensions.

5.0 QUALITY CONTROL REQUIREMENTS

5.1. The firm should have acquired ISO:9000 series certification for the product for which an approval is sought.

5.2. Quality manual of the firm for ISO:9000 should clearly indicate at any stage the control over manufacturing and testing of the railway product.

Signature

Name & Designation | Prepared by: | Checked by: | Approved by:
--- | --- | --- | ---
SSE/Carriage | SSE/Carriage | Director/Carriage
5.3 The firm should submit the Quality Assurance Plan (QAP) as per RDSO ISO doc no. CG-G-7.1-2.

5.4 The firm must ensure that proper analysis is being done on monthly basis to study the rejections at various internal stages and it is documented.

5.5 The firm should ensure that latest version all the relevant specifications, IS Standards are available with the firm.

5.6 Traceability of product/parts thereof should be ensured from raw material upto finished stage.

5.7 There should exist a quality manual of the firm indicating the extent of control for production and testing.

5.8 System for calibration of testing & measuring equipment.

6.0 DOCUMENTATION

Firm shall maintain the following documents/ records:

6.1 A well-documented Quality Plan.

6.2 Incoming raw material register with Test Certificates references of suppliers and internal test results.

6.3 Stage inspection results including finished products results.

6.4 Records of internal rejection and its analysis vis-à-vis action plan.

6.5 Records of final products inspection by external agencies (like RDSO/Railways), Non-Conformity Reports and case analysis as well as action taken thereof.

6.6 There should exist a system of documentation in respect of rejection at customer end, warranty replacement and in service performance.

6.7 Records of raw material received and supplies made to Railways against the raw material. Incoming raw material with TC reference of supplier as well as internal test/audit checking from outside agency.

6.8 The details regarding Stage inspection and test result.
ANNEXURE-II

DESIGN DATA AND LOAD CASES FOR BRAKE DISC

a) THERMAL LOAD AND BRAKING SCENARIO

<table>
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<th>S. No.</th>
<th>Description</th>
<th>Unit</th>
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<th>Service Braking</th>
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<td>Mean Braking Radius (m)</td>
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<td>Wheel diameter (New) (m)</td>
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<td>Mean Co-efficient of friction of Brake Pads</td>
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<td>10.</td>
<td>Deceleration rate</td>
<td>m/sec²</td>
<td>1.2</td>
<td>0.80</td>
</tr>
<tr>
<td>11.</td>
<td>Clamping force per disc</td>
<td>kN</td>
<td>42</td>
<td>25</td>
</tr>
<tr>
<td>12.</td>
<td>Kinetic energy</td>
<td>MJ</td>
<td>7.9</td>
<td>7.9</td>
</tr>
<tr>
<td>13.</td>
<td>Load cycles</td>
<td>-</td>
<td>6000</td>
<td>62500</td>
</tr>
</tbody>
</table>

b) IMPACT LOAD

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Description</th>
<th>Vertical</th>
<th>Axial</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.</td>
<td>Standard Impact</td>
<td>25g</td>
<td>3g</td>
</tr>
<tr>
<td>3.</td>
<td>Extraordinary Impact</td>
<td>100g</td>
<td>100g</td>
</tr>
</tbody>
</table>
OPERATING CONDITIONS FOR BRAKE DISC

1. Coach Type: LHB Type BG Passenger Coaches
2. Axle Load: 16.25t (max.)
3. Gross Load (Coach): 65t (max.)
4. Gross Load (Train): 1700t (max. without loco)
5. Operating speed (max): 160 Km/h
6. Maximum deceleration: 1.3 m/sec²
7. Emergency Braking distance: 1200 meter
8. Wheel diameter: 915 (New); 845 (Worn)
9. Wheel base: 2560mm
10. Minimum clearance above rail level: 102 mm under loaded and worn Condition
11. Maximum bogie rotation and swing: 3.5°, 82mm
12. Track Parameters
   a) Steepest Gradient: 1 in 37
   b) Sharpest curvature: 175 m radius
   c) Super elevation (max): 1765 mm max.
13. Environmental condition
   a) Maximum temperature under sun: 70 °C
   b) Maximum temperature under shade: 45 °C
   c) Minimum temperature at Night: -5 °C
   d) Altitude: Sea level to 652 meters
   e) Humidity: 100% saturation during rainy Season
   f) Rain falls: Fairly heavy
   g) Atmosphere during hot weather: Dusty

   Environment: Coaches shall be working in coastal area with saline and corrosive atmosphere.
14. The vibrations and shocks normally to be encountered in service.
   a) Maximum vertical acceleration = 3.0 g
   b) Maximum longitudinal acceleration = 5.0 g
   c) Maximum transverse acceleration = 2.0 g