


	<b>PRODUCT STANDARD</b> <b>TME DIVISION, BHOPAL</b>		<b>TM23620</b>		
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<p><b>TECHNICAL SPECIFICATION</b></p> <p><b>OF</b></p> <p><b>GEAR DRIVE ASSEMBLY</b></p> <p><b>(ALONG WITH ITS ASSEMBLY ON AXLE)</b></p> <p><b>FOR TRAIN SET APPLICATION</b></p>					
<p><b>Revision: 03</b>  <b>Date: 02/04/2025</b></p> <p><b>Revision: 02</b>  <b>Date: 24/03/2025</b></p> <p><b>Revision: 01</b>  <b>Date: 05/12/2023</b></p>					
Distribution		Qty.	Approved:  (M.Verma)		
TME TXM-Plg.		1 1	Prepared by:  (A.Shukla)	Checked by:  (B.Singh)	Date:  02/04/2025


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<b>COPYRIGHT AND CONFIDENTIAL</b> The information on this document is the property of <b>BHARAT HEAVY ELECTRICALS LIMITED</b> It must not be used directly or indirectly in any way detrimental to the interest of the company	<b>1. GENERAL</b> This specification governs the requirement for design, manufacturing and supply of gear drive assembly (mounted on axle) for use with BHEL traction motor for train set application in Indian Railways. The gear drive assembly should be reliable for operational speed of 160 kmph and should also be able to serve at a design speed of 180 kmph. Supplier shall clearly specify compliance of each clause of this specification in their offer. In case of any deviation w.r.t. any clause of this specification, supplier should also specify the same in their offer.																																	
	<b>2. SCOPE OF SUPPLY AND SERVICES</b> Scope of supply shall be gear drive assembly mounted on axle along with traction motor half coupling. Gear drive assembly components shall be as given below in Table-1. Gear drive assembly shall be in painted condition on un-machined surfaces & temporary rust preventive (TRP) applied on machined surfaces. [Paint and TRP should be sufficient to ensure minimum storage life as per clause 5.7 without any intervention] <p><b><u>Regarding axle to be used for gear drive mounting, for supply condition of Gear drive assembly (mounted on axle) and traction motor half coupling, complete sets of special tools, training etc. please refer enquiry condition.</u></b></p> <p style="text-align: center;"><b>Table-1</b></p> <table border="1"> <thead> <tr> <th>Sl. No.</th> <th>Component</th> <th>Qty. per gear drive assy.</th> <th>To be supplied as</th> </tr> </thead> <tbody> <tr> <td><b>A</b></td> <td><b>Gear drive assembly (mounted on axle)</b></td> <td></td> <td></td> </tr> <tr> <td>A.1</td> <td>Main driving gear along with pinion</td> <td>1 set</td> <td rowspan="8">Mounted on axle</td> </tr> <tr> <td>A.2</td> <td>Input Shaft (for pinion &amp; half coupling mounting)</td> <td>1 no.</td> </tr> <tr> <td>A.3</td> <td>Gear drive housing</td> <td>1 no.</td> </tr> <tr> <td>A.4</td> <td>Other gear drive assembly components viz. Bearings, Labyrinths, Seals, Fasteners, Rubber items, 'O' rings etc. required for complete gear drive assembly</td> <td>1 set</td> </tr> <tr> <td>A.5</td> <td>Half coupling (for Gear drive)</td> <td>1 no.</td> </tr> <tr> <td>A.6</td> <td>Reaction rod required for mounting gear drive housing on bogie.</td> <td>1 set</td> </tr> <tr> <td>A.7</td> <td>Fasteners required for mounting gear drive housing with reaction rod.</td> <td>1 set</td> </tr> <tr> <td>A.8</td> <td>Rubber item (elastomer) for mounting of Reaction rod on gear drive housing and bogie.</td> <td>1 set</td> </tr> </tbody> </table>		Sl. No.	Component	Qty. per gear drive assy.	To be supplied as	<b>A</b>	<b>Gear drive assembly (mounted on axle)</b>			A.1	Main driving gear along with pinion	1 set	Mounted on axle	A.2	Input Shaft (for pinion & half coupling mounting)	1 no.	A.3	Gear drive housing	1 no.	A.4	Other gear drive assembly components viz. Bearings, Labyrinths, Seals, Fasteners, Rubber items, 'O' rings etc. required for complete gear drive assembly	1 set	A.5	Half coupling (for Gear drive)	1 no.	A.6	Reaction rod required for mounting gear drive housing on bogie.	1 set	A.7	Fasteners required for mounting gear drive housing with reaction rod.	1 set	A.8	Rubber item (elastomer) for mounting of Reaction rod on gear drive housing and bogie.
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<b>3. INFORMATION TO BE PROVIDED BY SUPPLIER (WITHIN 3 WEEKS AFTER DATE OF PO PLACEMENT)</b>													
a. Tools required for assembly/disassembly, commissioning & maintenance:													
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<p>** 1) Any standard tool that is a catalogue item (i.e. available in open market) shall be excluded from the list of special tools.</p> <p><b>Note:</b> Special tools, special fixtures, special gauges, special templates, special equipment etc. along with standard tools shall be complete to carry out complete assembly, disassembly and maintenance of gear drive assembly (along with coupling).</p>													


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c. List of spares, must change items during scheduled maintenance (minor and major periodic overhauling) and consumables required for satisfactory maintenance and operation of gear drive assembly for a period of 35 years.																									
d. List of recommended spares for contingency repair (between scheduled maintenance) at depot.																									
<b>4. <u>OPERATING CLIMATIC AND ENVIRONMENTAL CONDITIONS</u></b> The gear drive assembly shall be designed suitably to ensure its normal working under following adverse climatic and environmental conditions:																									
<b>i. Relative Humidity:</b> up to 100% saturation during rainy season.																									
<b>ii. Ambient temperature</b> max.: 50° C min.: -10° C																									

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<p style="text-align: center;"><b>COPYRIGHT AND CONFIDENTIAL</b></p> <p style="text-align: center;">The information on this document is the property of BHARAT HEAVY ELECTRICALS LIMITED It must not be used directly or indirectly in any way detrimental to the interest of the company</p>	<p><b>iii. Altitude (Max):</b> 1000 meter above mean sea level</p> <p><b>iv. Rainfall:</b> Very heavy and continuous rainfall in certain areas (up to 2500mm during rainy season).</p> <p><b>v. Flooding:</b> The gear drive assembly shall be designed for train to run up to 8 km/h through water up to 203 mm above rail level. Allowance is to be made in addition for increase in the height of water level due to the wave effect. Even in case of flood levels more than the mentioned above, the gear drive assembly shall not get damaged and it should be possible to rejuvenate the gear drive assembly with minor attention without any adverse effect on its performance.</p> <p><b>vi. Atmosphere during hot weather:</b> Extremely dusty, humid and salty. The trainset shall be working in coastal area also and thus shall be continuously exposed to highly corrosive, salty atmosphere along with industrial pollutants.</p> <p><b>vii.</b> The gear drive assembly shall function in accordance with this specification when subjected continuously to an atmosphere containing dust in concentrations up to 1.6 mg / m<sup>3</sup>.</p> <p><b>viii.</b> The gear drive assembly shall function in accordance with this specification when subjected continuously to a humid and salt laden atmosphere with maximum pH value of 8.5, sulphate content of 7 mg per litre, maximum concentration of chlorine 6 mg per litres and maximum conductivity of 130 micro Siemens / cm.</p> <p><b>ix.</b> The gear drive assembly shall function in accordance with this specification when subjected to high wind speed in certain areas, with wind pressure reaching 216 kg/m<sup>2</sup> as per IS:875 Part 3(2015).</p> <p><b>x.</b> Gear drive assembly shall function in accordance with this specification when exposed to solar radiation in the range from 0 kW/m<sup>2</sup> to 1 kW/m<sup>2</sup>.</p> <p><b>xi.</b> Special care shall be taken to ensure no damage to gear drive assembly due to deposition of atmospheric salts and industrial pollutants. Supplier shall enclose the details of specific measures adopted to ensure the satisfactory working of gear drive assembly against the deposition of salts &amp; industrial pollution</p> <p><b>5. TECHNICAL REQUIREMENTS</b></p> <p><b>5.1 Gear Drive Assembly</b></p> <p><b>i.</b> The gear drive assembly shall be of proven design for same or higher traction/braking transmission.</p> <p><b>ii.</b> The gear drive assembly shall be free from lubricant leakage.</p> <p><b>iii.</b> The tractive/braking effort shall be directly transferred from the input pinion to wheel gear. The torque transmission arrangement of gear drive assembly shall be simple and suitable for both traction and braking forces.</p> <p><b>iv.</b> The gear drive assembly design shall be suitable for climatic and environmental conditions as specified in clause no. 4 of this specification. Special care shall be taken in design with respect to high track vibrations as mentioned in clause 5.2.</p> <p><b>v.</b> The gear drive assembly design documents as per clause 6.2 shall be furnished to BHEL. The suitability of gear drive assembly should be proved in a type test.</p>	

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<p style="writing-mode: vertical-rl; transform: rotate(180deg);"> <b>COPYRIGHT AND CONFIDENTIAL</b>            The information on this document is the property of BHARAT HEAVY ELECTRICALS LIMITED            It must not be used directly or indirectly in any way detrimental to the interest of the company         </p>	<p>iv. Gear drive housing and its sealing arrangement shall be designed in such a way that there should not be any ingress of water inside gear drive assembly upto a height of 203 mm from rail level. Allowance is to be made in addition for increase in the height of water level due to the wave effect.</p> <p>v. Oil level indicators/markers shall be provided to monitor oil level in housing.</p> <p>vi. Gear drive assembly shall be suitably painted (light grey colour) to prevent any deterioration of surface due to operation in extremely dusty, humid &amp; salty conditions for most part of the year.</p> <p><b>5.5 Bearings</b></p> <p>i. Details of the fits kept in the bearings of gear drive assembly should be furnished during submission of design documents to BHEL for further submission to BHEL's/customer's design approving agency.</p> <p>ii. L10 life calculation report for complete duty cycle shall be submitted. In the L10 life calculation, calculation of equivalent dynamic loading shall be also indicated.</p> <p>iii. Replacement schedule of bearing shall not be less than 9 years or 3.15 million kilometres of trainset operation (whatever comes first).</p> <p><b>5.6 Mounting and suspension arrangement</b></p> <p>i. Suitable reaction rod mounting bush (elastomer) shall be provided for suspension of gear drive housing.</p> <p>ii. The mounting bolts/nuts shall be accessible for easy mounting and dismounting during maintenance.</p> <p><b>5.7 Packaging and Storage</b></p> <p>Items covered in Table 1.A [Gear drive assembly (mounted on axle)], in Table 1.B [Half coupling (for traction motor), fasteners etc.], in Table 1.C [Complete set of special tools, special fixtures, special gauges, special templates, special equipment etc.], Spares for scheduled maintenance and Recommended spares shall be supported with suitable arrangement (i.e.; castor wheels for assembled gear drive assembly etc.) and packed suitably to avoid any damage during handling &amp; transit.</p> <p>✓ Packaging must be all weather-moisture proof and shall be such that items can be stored in as-it-is condition for minimum 18 months without any intervention. For further extension of storage duration, clear instructions shall be provided in maintenance manual/any other document.</p> <p>✓ Packaging of items (including assembled gear drive assembly) in storage container, shall be such that stacking of one container over another is permissible.</p>	
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	<p>TME/2023</p> <p><b>6. <u>DOCUMENTS SUBMISSION AND SUPPLIERS RESPONSIBILITY</u></b></p> <p><b>6.1</b> The supplier shall submit the following documents <u>along with their techno-commercial offer</u>:</p> <p><b>i. For gear drive assembly supply experience:</b></p> <p>Reference of projects executed for similar applications during the last 10 years wherein supplier has designed, manufactured and supplied at least 240 nos. of gear drive assembly (for using with fully suspended motor mounted on bogie) for Railway stock speed of 130 KPH or more. Experience shall be for gear drive assembly with similar configuration as shown in Annexure 3 of this specification; wherein gear drive assembly is in between the wheels and input shaft (of gear drive assembly) centre line/ coupling axis is parallel to axle centre line. Firm should submit necessary supporting credentials i.e. document in support of maximum operational speed of gear drive assembly and PO/Invoice/Contractual document/any other documentary proof in support of supply of 240 sets of gear drive assembly (if required, financial details may be hidden) along with OGA/photographs of supplied gear drive assembly indicating configuration of gear drive assembly.</p> <p><b>ii. For flexible coupling supply experience:</b></p> <p>a. Reference of projects executed for similar applications during the last 10 years wherein supplier/supplier's source of flexible coupling has designed, manufactured and supplied at least 240 no. of flexible coupling (both motor half &amp; gearbox half) for gear drive assembly for Railway stock speed of 130 KPH or more. Firm should submit necessary supporting credentials i.e. document in support of maximum operational speed of gear drive assembly and PO/Invoice/Contractual document/Any other documentary proof in support of supply of 240 nos. of flexible coupling (if required, financial details may be hidden).</p> <p>b. Supplier to confirm that coupling supplied shall be of same make for which experience details are submitted as clause 6.1 {ii (a)} above.</p> <p>c. OGA drawing of the offered gear drive assembly with all the necessary interface and mounting dimensions, coupling movement and relevant technical data, considered for offered gear drive assembly, meeting the requirement of Annexure 1 to 5 of this specification.</p>	

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<div>COPYRIGHT AND CONFIDENTIAL</div> <div>The information on this document is the property of BHARAT HEAVY ELECTRICALS LIMITED It must not be used directly or indirectly in any way detrimental to the interest of the company</div>	<div>6.2 Supplier shall start submission of design documents of gear drive assembly along with required technical data and calculations to BHEL Bhopal (for further submission to BHEL's/customer's design approving agency for approval) <u>within 4 weeks</u> after date of PO placement and shall be completed within 5 months of PO placement. Design documents shall comprise following:</div> <div><div>i. Technical write up and data sheet.</div><div>ii. Detailed outline drawing indicating weight and centre of gravity.</div></div> <div>Note: Outline drawing shall be reviewed for fitment clearance of gear drive assembly on bogie. Based on scrutiny, modification in fitment dimensions may be required to be done. Supplier to carry out the modifications accordingly.</div> <div><div>iii. General assembly/long section drawing with exploded view and complete bill of material.</div><div>iv. 3D model of external envelope of complete gear drive assembly.</div><div>v. Type of gear and pinion, grade of steel used and particulars of heat treatment.</div><div>vi. Outline drawing of gear &amp; pinion with relevant data required from fitment and maintenance point of view and deciding the usability/condemning limit like chord over teeth ('k' value) etc. Also, details of pitch circle diameter (PCD) of gear and pinion to be provided for design validation of bogie axle.</div><div>vii. Drawing of all items along with dimensions required from maintenance point of view.</div><div>viii. Material and type of construction of gear drive housing.</div><div>ix. Strength calculation for gear and pinion.</div><div>x. Calculation report (bearing, gearing, safety nose, reaction rod, shrink fit of gear axle, suitability of elastomers, all type of fasteners, shrink fit advancement of half coupling on motor and gear drive, coupling movement calculation etc.).</div><div>xi. Details of fits used in assembly of all different components of gear drive assembly including gear, pinion, bearings etc. in tabular form.</div><div>xii. The supplier shall submit finite element analysis (FEA) report in all 3-axis which includes stress analysis, fatigue analysis, modal analysis and transient analysis of complete gear drive assembly including sub-components considering boundary conditions for vibration &amp; shocks as per IEC-61373 (for axle mounted condition). For IEC:61373, acceleration values shall be as per clause 8.1, clause 9.1 and clause 10.5 of IEC:61373 for axle mounted condition.</div><div>The vibration and shock levels recorded on various Subsystems in existing Trains of Indian Railways (IR) are generally more than the limits given in IEC 61373.</div><div>Sufficient factor of safety shall be kept, considering above working/operating conditions.</div></div> <div>Note: Any other additional boundary conditions for FEA desired by BHEL's/customer's design approving agency shall be suitably incorporated in the FE analysis.</div> <div><div>xiii. Make &amp; type of bearings, L-10 life calculation of bearings for complete duty cycle and life span of bearing while considering the axle deflection.</div></div>	




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<p style="writing-mode: vertical-rl; transform: rotate(180deg); text-align: center;"><b>COPYRIGHT AND CONFIDENTIAL</b></p> <p style="writing-mode: vertical-rl; transform: rotate(180deg); text-align: center;">The information on this document is the property of BHARAT HEAVY ELECTRICALS LIMITED It must not be used directly or indirectly in any way detrimental to the interest of the company</p>	<p>TME/2023</p> <p><b>xiv.</b> Make &amp; type of lubrication compound of gear drive assembly, coupling grease and bearing lubricant along with their technical datasheet. Quantity for initial fill of lubricant and refill along with periodicity of refilling shall also be indicated.</p> <p><b>Note:</b> The lubricant recommended for use in gear drive assembly shall be made in India.</p> <p><b>xv.</b> Quality Assurance Plan of complete gear drive assembly including gear &amp; pinion, coupling.</p> <p><b>xvi.</b> Reliability prediction calculations (RAMS, FMECA, LCC etc.) as per clause 8 of this specification.</p> <p><b>xvii.</b> Source for flexible coupling.</p> <p><b>Note:</b> The flexible coupling selected shall be such that vibration coming on motor from gear drive shall not adversely affect the performance of the complete system (motor &amp; gear drive).</p> <p><b>xviii.</b> Motor shaft dimensions (length, taper, diameter etc.) for sitting of half coupling are as shown in Annexure 2. The half coupling mounted on motor shaft shall be suitable designed suiting to shaft dimensions. Threads on input shaft for fitment/dismantling of half coupling (for gear drive) shall be G ¾" BSP.</p> <p><b>xix.</b> Test schedule for type test and routine test (with acceptance limit of each parameter for every test) along with test formats.</p> <p><b>xx.</b> Supplier to furnish reports of type test carried out by supplier.</p> <p><b>xxi.</b> Supplier to furnish reports of routine test of each gear drive assembly (mounted on axle) carried out by supplier.</p> <p><b>xxii.</b> Documents detailing assembly and disassembly procedure of gear drive assembly complete on axle with suitable and sufficient photographs/views. Procedure shall also include assembly &amp; disassembly procedure of components on input shaft and assembly &amp; disassembly procedure of elastomers into reaction rod.</p> <p><b>xxiii.</b> Documents detailing assembly and disassembly procedure of reaction rod on gear drive housing &amp; bogie with suitable and sufficient photographs/views.</p> <p><b>xxiv.</b> Documents detailing assembly and disassembly procedure of half coupling on traction motor &amp; gear drive with suitable and sufficient photographs/views.</p> <p><b>xxv.</b> Documents detailing procedure for alignment of coupling halves with suitable and sufficient photographs/views.</p> <p><b>xxvi.</b> Maintenance manual of gear drive assembly along with operating manual. (as per clause 6.3 below)</p> <p><b>xxvii.</b> The supplier shall provide the certificate (along with test reports) for items of gear drive assembly complying with standard EN 45545 HL-3 for fire safety.</p> <p><b>Note:</b></p> <ol style="list-style-type: none"> <li>i) The approval/clearance of design documents of gear drive assembly shall be given by BHEL's/customer's design approving agency.</li> <li>ii) All the documents submitted by the supplier shall be in English language.</li> <li>iii) Any other documents besides above, if desired by BHEL's/customer's design approving agency during design documents approval, shall also be submitted.</li> <li>iv) Supplier shall be required to depute its technical experts to BHEL's/customer's design approving agency for discussions, finalization and approval of design documents of gear drive assembly.</li> </ol>	

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<b>COPYRIGHT AND CONFIDENTIAL</b> The information on this document is the property of BHARAT HEAVY ELECTRICALS LIMITED It must not be used directly or indirectly in any way detrimental to the interest of the company	<b>6.3 Maintenance:</b>		
	<p>i. The maintenance intervals as per the customer requirement (IR) for trainset, at depot, are as following:</p> <ol style="list-style-type: none"> <li>1) Monthly</li> <li>2) 9 Monthly</li> <li>3) 18 Monthly</li> <li>4) Intermediate Overhauling (3 years)</li> <li>5) Periodic Overhauling (6 years)</li> <li>6) 1st Major overhauling of gear drive assembly (9 years) and subsequent major overhauling after every 9 years.</li> </ol> <p>Note: Maintenance activities of gear drive assembly shall be aligned accordingly and mentioned in maintenance manual.</p> <p>ii. The supplier shall submit maintenance manual for the gear drive assembly containing following details:</p> <ol style="list-style-type: none"> <li>a. Write up on the working of gear drive assembly.</li> <li>b. The dimensional drawing of complete gear drive assembly (including flexible coupling) with technical data.</li> <li>c. The detail functioning of each item and its sub-assembly.</li> <li>d. Part list of components used in gear drive assembly.</li> <li>e. <u>Procedure of Assembly and Disassembly of Gear Drive Assembly:</u> <ol style="list-style-type: none"> <li>i. <u>For assembly of Gear drive Assembly on axle:</u> Assembly &amp; disassembly procedure of gear drive assembly (including all drive assembly components; i.e. reaction rod, gear drive half coupling etc.). Also including assembly &amp; disassembly procedure of components on input shaft and assembly &amp; disassembly procedure of elastomers into reaction rod.</li> <li>ii. <u>For alignment of gear drive assembly with motor on bogie:</u> Mounting and dismounting procedure of gear drive assembly with motor on bogie along with alignment procedure, after coach lowering.</li> <li>iii. <u>For coupling of Gear drive Assembly and traction motor:</u> Fitment procedure of half couplings on traction motor &amp; half coupling.</li> </ol> </li> <li>f. Testing procedure of gear drive assembly after mounting on bogie (including routine test or test that may be carried out at depot to check suitability of gear drive assembly).</li> <li>g. Maintenance instructions for inspection, troubleshooting and recommended maintenance schedule (minor and major periodic overhauling).</li> <li>h. List of standard tools, equipment and facilities required for assembly, disassembly &amp; maintenance along with tentative images/photographs, tentative weight and tentative floor sitting area.</li> </ol>		

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<b>COPYRIGHT AND CONFIDENTIAL</b> The information on this document is the property of BHARAT HEAVY ELECTRICALS LIMITED It must not be used directly or indirectly in any way detrimental to the interest of the company	<p>i. List of complete set of special tools, special fixtures, special gauges, special templates, special equipment etc. required for assembly, disassembly &amp; maintenance along with tentative images/photographs, tentative weight and tentative floor sitting area for procedures as mentioned in point 6.3 (ii.e) above.</p> <p>j. List of spares, must change items during scheduled maintenance. Along with catalogue number, tentative lead time for delivery from date of Purchase order and shelf life (Shelf life must comply clause 5.7).</p> <p>k. List of recommended spares for contingency repair at depot. Along with catalogue number, tentative lead time for delivery from date of Purchase order and shelf life (Shelf life must comply clause 5.7).</p> <p>l. List of consumables for assembly, disassembly &amp; maintenance of complete gear drive assembly. Also including the make, type and quantity of consumables required for assembly of each gear drive assembly on axle. Details of Indian OEM shall be included.</p> <p>m. Storage and Transportation instructions. Storage life of items shall be as per clause 5.7.</p> <p>n. Storage and transportation instruction for spares for scheduled maintenance and recommended spares (for contingency repair) shall be part of manual. Storage life of items shall be as per clause 5.7.</p> <p>iii. The supplier shall be responsible for carrying out improvements and modifications on the gear drive assembly supplied, in case any repetitive issues are observed during service (provided such modifications/ improvements are necessary for meeting the requirements of reliability, performance and safety etc.).</p> <p><b>6.4 Obsolescence Management:</b> Supplier is required to manage obsolescence of all equipment, spares and consumables to enable the gear drive assembly to continue in service for 35 years. In case of obsolescence of part/product, the supplier shall agree to provide manufacturing drawings, technical and supplier details to purchaser.</p>		

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**7. FUNCTIONAL AND TYPE TEST**


The type test (dimensional, material and other necessary tests) of individual items of gear drive assembly (gear, pinion, housing etc.) and complete gear drive assembly shall be in the scope of supplier. The supplier shall have in-house testing facility for the same. During testing, designed load and working conditions shall be simulated. The product shall conform to the designed parameters with respect to its application, efficacy and effectiveness. Axle & other test equipment for type testing by supplier, shall be in the scope of supplier.

Following tests shall be done as a part of type test of gear drive assembly:


- i. Dimensional, material & other necessary inspection of gear drive assembly items viz. gear, pinion, housing etc.
- ii. Inspection of interference fit details of components of gear drive system.
- iii. Name plate verification
- iv. Weight measurement of complete gear drive assembly including coupling half and without axle, traction motor & oil in gear drive housing.
- v. Dimensional inspection of gear drive assembly including axial & radial clearances of bearings, backlash, push on length gear coupling half gear drive side and other dimensions.
- vi. Supplier to provide confirmation that procedures and standard & special tools defined in manual are used during initial assembly (for type test) and are easy to use for correct assembly. Supplier to provide photographs of different stages wherein standard & special tools are used during assembly.
- vii. Water tightness test.
- viii. Immersion test as per clause 5.1.3.
- ix. Vibration, sound level measurement, temperature rise test (bearing temperature, oil sump temperature etc.), oil splashing verification, oil level verification, seal integrity and efficiency test, in both clockwise & counter clockwise directions, as per following (Refer Annexure 1 for motor ratings):
  - a) In no-load condition in horizontal position (without tilted position) of gear drive assembly.
  - b) In no-load condition in extreme tilted position of gear drive assembly with minimum oil level (excluding efficiency test).
  - c) In load condition, at starting torque.
  - d) In load condition, at braking torque.
  - e) In load condition, at continuous rating.
  - f) In load condition, at one- hour rating.
  - g) In load condition, at maximum operating motor speed.
  - h) In load condition, at maximum design speed.

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	<p>TME/2023</p> <p><b>x. Load cycle test for long hours:</b> Vibration, sound level measurement, temperature rise test (bearing temperature, oil sump temperature etc.), oil splashing verification, oil level verification, seal integrity and efficiency test in load condition, both clockwise &amp; counter clockwise directions)</p> <p><b>xi.</b> Contact pattern test of gear &amp; pinion.</p> <p><b>xii.</b> Supplier to provide confirmation that procedures and standard &amp; special tools defined in manual are used and are suitable for carrying out disassembly (after type test). Supplier to provide photographs of different stages wherein standard &amp; special tools are used during disassembly.</p> <p><b>xiii.</b> Gear drive oil analysis after load test.</p> <p><b>xiv.</b> Visual inspection of components after type test and disassembly for any damage.</p> <p><b>8. ROUTINE TEST:</b> The routine test of each gear drive assembly (mounted on axle) shall be in the scope of supplier. The supplier shall have in-house testing facility for the same. Test equipment for routine testing shall be in the scope of supplier.</p> <p>Indicative list of parameters for Routine test are as given below:</p> <ul style="list-style-type: none"> <li>a) Visual</li> <li>b) Bearing clearances (Axial/Radial)</li> <li>c) Testing of gearboxes at the maximum service operating speed under no-load with motor torque in both directions.</li> <li>d) Record of Vibration</li> <li>e) Record the temperature of Bearings and Gearbox oil.</li> </ul>	

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	<p>TME/2023</p> <p><b>9. <u>RELIABILITY AVAILABILITY MAINTAINABILITY AND SAFETY (RAMS):</u></b></p> <p>1) Vendor shall agree to submit following documents pertaining to RAMS analysis. Vendor shall submit RAMS documentation in the specified format/template as per attached Annexure 6.</p> <ul style="list-style-type: none"> <li>✓ Functional breakdown + inherent failure analysis</li> <li>✓ Mission critical failures Analysis (Fault Tree Analysis)</li> <li>✓ FMECA (Failure Mode Effects and Criticality Analysis)</li> <li>✓ System/Sub-Systems Hazard Analysis</li> <li>✓ Hazard Log + SIL data (if applicable)</li> <li>✓ List of critical components</li> <li>✓ Preventive Maintenance Analysis</li> <li>✓ Corrective Maintenance Analysis</li> </ul> <p>2) RAMS and LCC target for gear drive assembly (including coupling) shall be as following:</p> <ul style="list-style-type: none"> <li>a) Failure rate: Less than 0.015 FPMK (Failure per million Km)</li> <li>b) Life cycle cost (LCC) for 35 years- Cost material (Preventive maintenance+ Corrective maintenance): Less than 0.1 INR/km</li> <li>c) LCC for 35 years- Man hour (Preventive maintenance+ Corrective maintenance): Less than 2.2 hours/year</li> </ul>	

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<p><b>10. COST FOR SPARE ITEM</b></p> <p>Supplier to agree to provide price break-up/ percentage of quoted value (for unit quantity) for following components to allow separate procurement as spares. Supplier to provide price break-up after placement of purchase order and prior to supply of 1<sup>st</sup> consignment:</p> <p><b>10.1 Items covered in Table 1 (A) and Table 1 (B)</b></p> <table> <tr> <th>Sl. No.</th><th>Sub-assembly components/ Sub-assemblies</th><th>Items</th></tr> <tr> <td>1</td><td>Coupling</td><td>Half coupling (Motor side) &amp; Half coupling (Gear drive side)</td></tr> <tr> <td>2</td><td rowspan="2">Gear box housing and miscellaneous kit</td><td>Housing (Top and Bottom)</td></tr> <tr> <td>3</td><td>Other complete miscellaneous kit consisting of Oil filler plug, oil drain plug, oil level gauge, inspection plug, Name plate etc.</td></tr> <tr> <td>4</td><td>Main gear</td><td>Main gear</td></tr> <tr> <td>5</td><td>Input shaft</td><td>Input shaft (pinion)</td></tr> <tr> <td>6</td><td rowspan="2">Bearings</td><td>All type of bearings (on input shaft)</td></tr> <tr> <td>7</td><td>All type of bearings (on output shaft)</td></tr> <tr> <td>8</td><td></td><td>All other complete bearing assembly components on input and output shaft (consisting of labyrinth sealing unit, covers, rings, end plates, O-rings etc.)</td></tr> <tr> <td>9</td><td>Reaction rod</td><td>Reaction rod without elastomers</td></tr> <tr> <td>10</td><td>Elastomers</td><td>All type of elastomers</td></tr> <tr> <td>11</td><td rowspan="3">All type of fasteners</td><td>Fasteners adjoining half couplings.</td></tr> <tr> <td>12</td><td>Fasteners connecting reaction rod &amp; housing</td></tr> <tr> <td>13</td><td>All type of fasteners including pins, plugs etc. except half coupling fasteners and fasteners connecting reaction rod &amp; housing</td></tr> <tr> <td>14</td><td rowspan="2">Total assembly of gear drive</td><td>Assembly of gear drive assembly components on input shaft</td></tr> <tr> <td>15</td><td>Complete assembly of gear drive assembly on axle</td></tr> <tr> <td>16</td><td rowspan="2">Shims &amp; Height adjustment gauge</td><td>Shims</td></tr> <tr> <td>17</td><td>Height adjustment gauge</td></tr> <tr> <td>18</td><td>Other items</td><td>Any other items not covered in above table</td></tr> </table> <p><b>10.2 Items covered in Table 1 (C)</b></p> <p>Price break-up/ percentage of quoted value for individual tools specified for Table 1 (C); i.e. Complete set of special tools, special fixtures, special gauges, special templates, special equipment etc.</p>			Sl. No.	Sub-assembly components/ Sub-assemblies	Items	1	Coupling	Half coupling (Motor side) & Half coupling (Gear drive side)	2	Gear box housing and miscellaneous kit	Housing (Top and Bottom)	3	Other complete miscellaneous kit consisting of Oil filler plug, oil drain plug, oil level gauge, inspection plug, Name plate etc.	4	Main gear	Main gear	5	Input shaft	Input shaft (pinion)	6	Bearings	All type of bearings (on input shaft)	7	All type of bearings (on output shaft)	8		All other complete bearing assembly components on input and output shaft (consisting of labyrinth sealing unit, covers, rings, end plates, O-rings etc.)	9	Reaction rod	Reaction rod without elastomers	10	Elastomers	All type of elastomers	11	All type of fasteners	Fasteners adjoining half couplings.	12	Fasteners connecting reaction rod & housing	13	All type of fasteners including pins, plugs etc. except half coupling fasteners and fasteners connecting reaction rod & housing	14	Total assembly of gear drive	Assembly of gear drive assembly components on input shaft	15	Complete assembly of gear drive assembly on axle	16	Shims & Height adjustment gauge	Shims	17	Height adjustment gauge	18	Other items	Any other items not covered in above table
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	 <div>PRODUCT STANDARD TME DIVISION, BHOPAL</div> <div>TME/2023</div>	TM23620
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	<div>11. <u>ENCLOSURES</u></div> <div><div>i. Annexure-1: Input datasheet required for design of gear drive assembly.</div><div>ii. Annexure-2: Motor shaft details for half coupling fitment.</div><div>iii. Annexure-3: BHEL drawing no. 14450005052 rev.03 indicating external envelope of gear drive assembly.</div><div>iv. Annexure-4: Sketch of axle.</div><div>v. Annexure-5: Duty cycle for bearing life calculation.</div><div>vi. Annexure-6: RAMS documentation formats/templates.</div></div>	

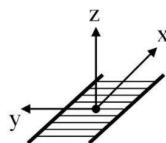
## Annexure-1

Input datasheet for design of Gear drive assembly		
<b>General Data:</b>		
1	End Customer	Indian Railways
2	Application	Electric Train set
<b>Vehicle:</b>		
1	Type of rail vehicle	Train set
2	Electrical drive type	IGBT based 3 phase drive
3	Bogie configuration (e.g. Fully, partly etc.)	BO-BO
4	Axle or Wheel drive	Axle drive
5	Allowable sound power level [dB(A)] for gear drive assembly	Clause 5.1.1
6	Vehicle life (year)	35 years
7	Environment temperature (°C)	-10°C (Minimum)
8	Environment temperature (°C)	50°C (Maximum)
9	Service speed (worn wheels) (km/h)	160 Km/h (Maximum)
10	Design speed (new wheels) (km/h)	180 Km/h (Maximum)
11	Number of bogies	32
12	Number of motor bogies	16
13	Axle load (kg)	17000 kg (Maximum)
14	Wheel diameter new (mm)	952 mm
15	Wheel diameter worn (mm)	877 mm
16	Track gauge (mm)	1676 mm (Broad gauge)
17	Truck wheel base (mm)	2700 mm
18	Daily running (km)	2000 km per day (Approx. 300 to 330 days per year)
<b>Drive gear assembly:</b>		
1	Drive concept	Traction motor fully suspended in bogie frame
2	Final drive gear type	Preferably helical
3	Number of Gear drive assembly per Bogie	2
4	Number of Gear drive assembly per Motor	1
5	Overall gear ratio	5.158
6	First stage gear ratio	5.158
7	Efficiency	98% (min.)
8	Weight (kg)	420±7% kg (Light weight is preferable)
9	Rail clearance at fully worn wheel	91 mm (Minimum)
10	Gear drive suspension type (fully or partially)	Partially
11	Axle diameter (between wheels)	179 mm (Refer annexure-4)
12	Axle diameter for Gearwheel sitting (mm)	217.5 mm (Refer annexure-4)
13	Axle diameter for bearings sitting (mm)	216.5 mm (Refer annexure-4)
14	Range of centre distance between axle C/L & motor shaft C/L	372 mm (Refer annexure-3)
15	Pinion offset (Position of motor shaft C/L above axle C/L)	20 mm above axle C/L (Refer annexure-3)
16	Distance between C/L of gear drive & bogie (mm)	513 mm (Refer annexure-3)
17	Distance to bottom of gear drive from axle C/L	347.5 (Maximum) (Refer annexure-3)

	(mm)	
18	Distance to top of gear drive from axle C/L (mm)	350 mm (Maximum) (Refer annexure-3)
19	Distance between end of flexible coupling (face towards motor side) and gear drive assembly pinion side (including all possible movements) (mm)	590 mm (Maximum) (Refer annexure-3)
20	Width of Gear drive assembly sitting on axle	350 mm (Maximum) (Refer annexure-3)
21	Length of Gear drive assembly up to safety catch from axle C/L (mm)	600 mm (Refer annexure-3)
22	Horizontal distance of bogie connection point of reaction rod (in relation to wheel axle center) (mm)	545 mm (Refer annexure-5)

**Traction motor:**

1	Motor manufacturer	BHEL
2	Motor type	AC
3	Motor weight (kg)	950±5% kg
4	Motor shaft end	Enclosed as annexure-2
5	Motor maximum power (motoring) (kW)	322
6	Motor maximum power (braking) (kW)	406.2
7	Motor continuous power (kW)	255
8	Motor continuous torque (Nm)	781
9	Motor continuous speed ( $\text{min}^{-1}$ )	3120
10	Motor maximum speed ( $\text{min}^{-1}$ )	5174
11	Maximum starting torque (Nm)	2486
12	Maximum braking torque (Nm)	2425
13	Root mean square torque (Nm)	1156
14	Motor short circuit torque (Nm)	12000
15	One-hour power rating (kW)	280
16	One-hour torque (Nm)	857

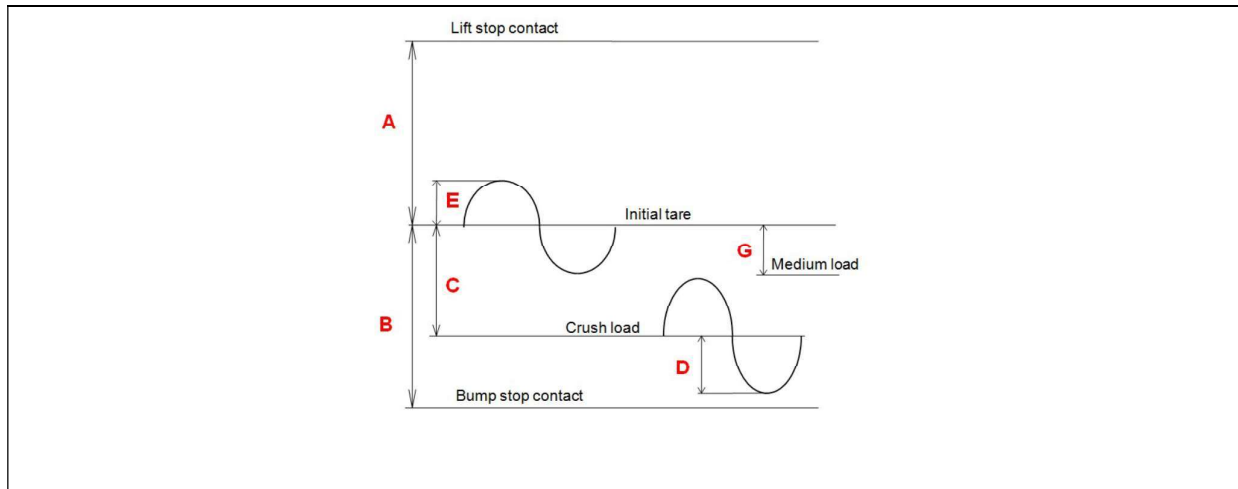
**Bogie primary suspension movement (TENTATIVE)**

X (longitudinal) to mechanical stop + tolerances [mm]

Y (lateral) to mechanical stop + tolerances [mm]

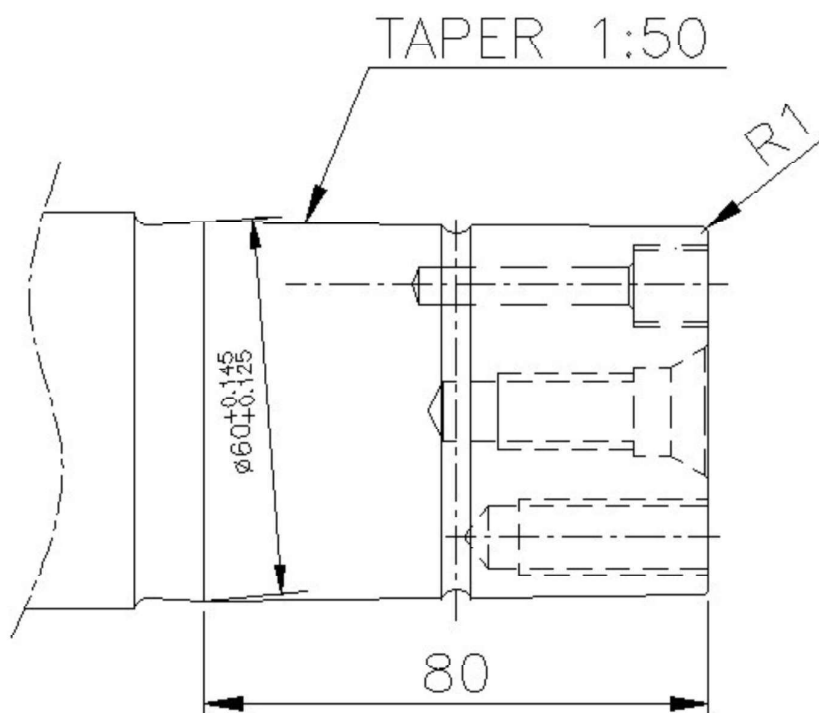
Maximum dynamic and continuous dynamic movement values for X and Y directions.

Z (vertical) [mm] – distances A, B to mechanical stops + tolerance of stop position along with E, C and D.

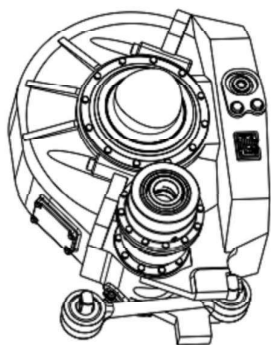
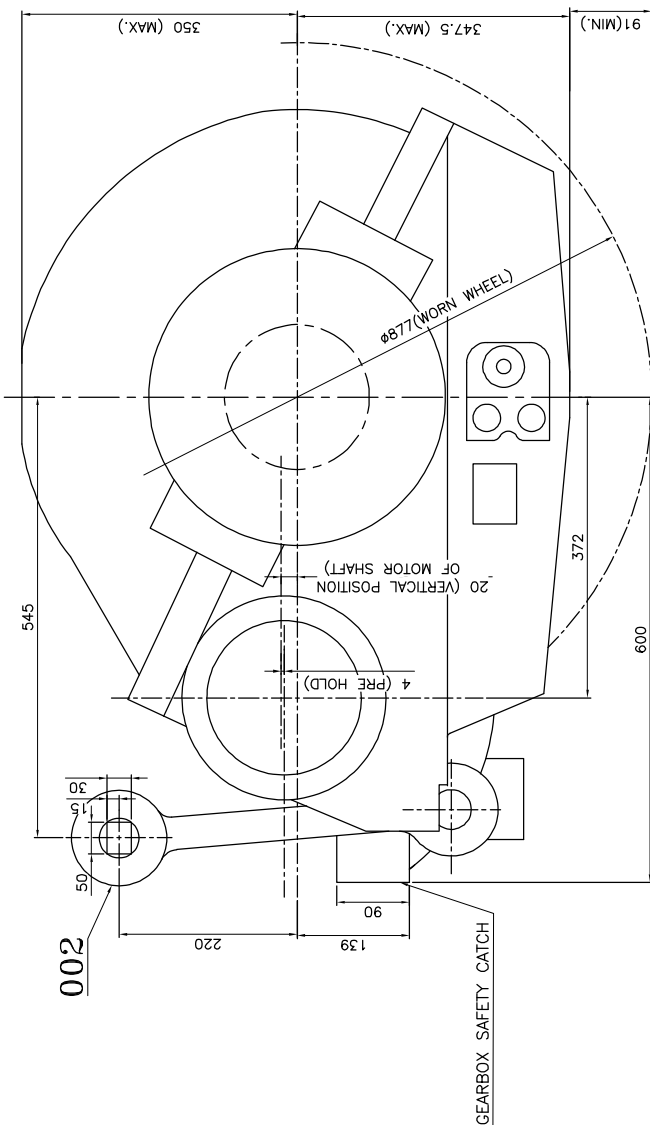

**Primary suspension (bogie tolerances  $\pm 2$  mm in all directions)**

Drives shown in position		Z = tare	
Prehold		4 mm at Z = 0	
X	Max.	$\pm 10$ mm	
Y	Max.	$\pm 8$ mm	
Z (bump stop)	Max.	- 45 mm	
Z (lift stop)	Max.	+ 25 mm	
Tare AWO	10%	Z = 0 mm	Dyn.: X $\pm 5$ ; Y $\pm 4$ ; Z $\pm 13$
Nominal AW3	80%	Z = -12.5 mm	Dyn.: X $\pm 9$ ; Y $\pm 4.5$ ; Z $\pm 14$
Full load AW4	10%	Z = - 15 mm	Dyn.: X $\pm 9.5$ ; Y $\pm 5$ ; Z $\pm 14$

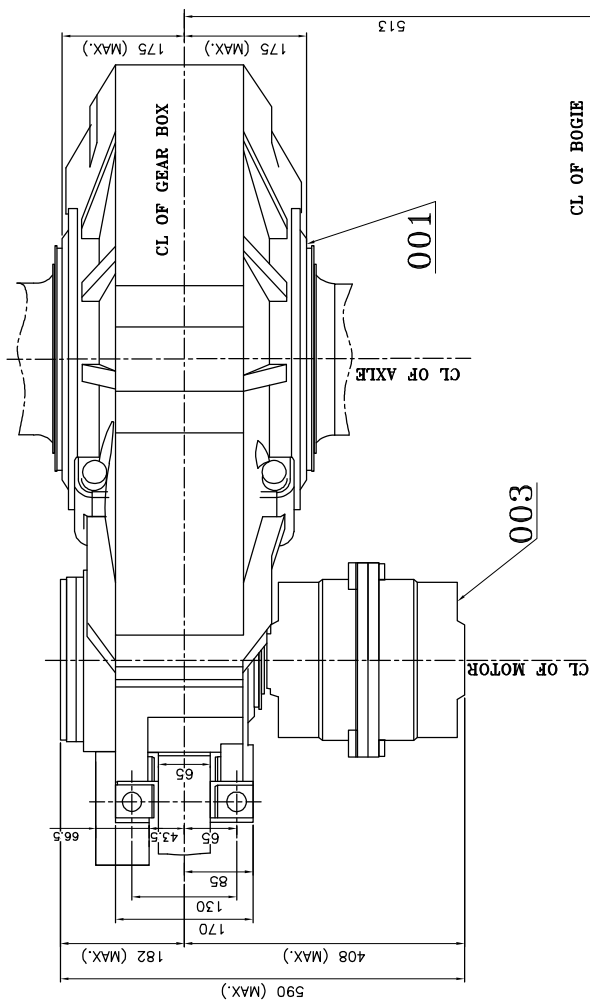
## Annexure-2



## SHAFT TAPER DETAILS

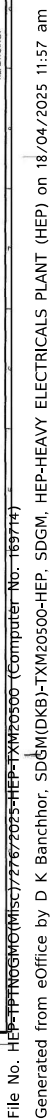


**3D VIEW FOR REF.**



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[illegible]



	Load cycle and speed time relation for L10 life calculation		
	Speed [km/h]	Motor Torque [Nm]	Time (%)
<b>Traction</b>	40	2486	7
	80	1410	8
	100	1170	15
	130	950	25
	160	346	30
<b>Braking</b>	120	-1230	9
	50	-2425	6



## Breakdown + Inherent Failure Reliability Prediction

[illegible]

$\lambda$	0.00	FPMH
MTBF	#DIV/0!	h
FPMK	0.00	failure
MKBf	#DIV/0!	km
$V_{conv}$	54	km/h

[illegible]

[illegible]

[illegible]

## Hazard Log + SIL

[illegible]

## Hazard List EMU (example for information only)

<b>1</b>	<b>ASPHYXIE, SUFFOCATION, ENVIRONMENT BAD CONDITION</b>
1.1	Biohazards
1.2	Dense or toxic fume
1.3	Hypothermia / Hyperthermia
1.4	No air change on board
1.5	Gas emission
<b>2</b>	<b>BURNS ELECTROCUTION</b>
2.1	Underframe Fire
2.2	Contact with hot object or chemical liquid or gas
2.3	Electrocution
2.4	Fire inside the train
2.5	HV Box – Electrical shock
2.6	Lightning
<b>3</b>	<b>COLLISION</b>
3.1	Collision between train and infrastructure (fixed equipment)
3.2	Collision with human people or animals
3.3	Collision with a train or an external object
3.4	Pressure wave
3.5	Side-on Collision with other trains / infrastructure
<b>4</b>	<b>DELAY DURING EVACUATION</b>
4.1	Delay during evacuation
4.2	Safety instruction
<b>5</b>	<b>DERAILMENT</b>
5.1	Lack of vehicle stability during train movement
5.2	Vehicle climbing
<b>6</b>	<b>EXPLOSION</b>
6.1	Explosion in traction / auxiliary converter case
6.2	Explosion of HV discharger
6.3	Explosion of pipe containing cooling fluid
6.4	Staff or passengers near pressurised equipment
<b>7</b>	<b>LOSS OF BALANCE AND FALLS</b>
7.1	Falls between train and platform
7.2	Fall from train onto the track
7.3	Falls inside the vehicle
7.4	Passenger loss of balance whilst in a train
7.5	Passenger loss of balance on the ground
<b>8</b>	<b>FALL AND CATAPULTING, CONTACT OF/WITH OBJECTS</b>
8.1	Bad fixation
8.2	Bodyshell fall during lifting procedure
8.3	Contacts with sharp or prominent objects inside a vehicle
8.4	Object falling from height
8.5	Slipping/ Fall of personnel
8.6	Passenger protruding beyond train gauge during movement
<b>9</b>	<b>ENTRAPMENT</b>
9.1	Entrapment (door leaf)
9.2	Entrapment (gangway passage)
<b>10</b>	<b>ABNORMAL ACCELERATION/DECELERATION/JERK</b>
10.1	Abnormal Acceleration
10.2	Abnormal Deceleration

SAFETY CRITICALITY CLASSIFICATION

Table 1 :Hazard Severity Level

Category	Severity level	Consequence to Person or Environment	Consequence to Service
I	Catastrophic	Fatalities and/or multiple severe injuries and/or major damage to the environment	System Loss
II	Critical	Single fatality and /or severe injury and/or significant damage to the environment	Loss of a major system
III	Marginal	Minor injury and/or significant threat to the environment	Severe system(s) damage
IV	Insignificant	Possible minor injury.	Minor system damage

Table 2:Frequency of Occurrence of Hazardous Events

Category	Frequency Level	Explanation	Frequency
A	Frequent	Likely to occur frequently. The hazard will be continually experienced.	More than once within a period of approximately 6 weeks
B	Probable	Will occur several times. The hazard can be expected to occur often.	Approximately once per 6 weeks to once per year
C	Occasional	Likely to occur several times. The hazard can be expected to occur several times.	Approximately once per 1 year to once per 10 years
D	Rare	Likely to occur sometime in the system life cycle. The hazard can be reasonably expected to occur.	Approximately once per 10 years to once per 1000 years
E	Improbable	Unlikely to occur but possible. It can be assumed that the hazard may exceptionally occur.	Approximately once per 1000 years to once per 10000years
F	Highly Improbable	Extremely unlikely to occur. It can be assumed that the hazard may not occur.	Once in a period of approximately 100000 years or more

Table 3 :Risk Evaluation and Acceptance

Frequency of occurrence of a hazardous event		Hazard Severity Level			
		I Catastrophic	II Critical	III Marginal	IV Insignificant
A	Frequent	Intolerable	Intolerable	Intolerable	Undesirable
B	Probable	Intolerable	Intolerable	Undesirable	Tolerable
C	Occasional	Intolerable	Undesirable	Undesirable	Tolerable
D	Rare	Undesirable	Undesirable	Tolerable	Negligible
E	Improbable	Undesirable	Tolerable	Negligible	Negligible
F	Highly Improbable	Tolerable	Negligible	Negligible	Negligible
		Severity Levels of Hazard Consequences			

Table 4 : Risk Acceptance Categories

Risk Evaluation	Risk reduction/control
Intolerable	Shall be eliminated
Undesirable	Shall only be accepted when risk reductions impracticable and with the agreement of the Authority as appropriate
Tolerable	Acceptance with adequate control and with the agreement of the Authority
Negligible	Acceptable with/without the agreement of the Authority

## Reliability table

<b>CRITICAL RELIABILITY CLASSIFICATION</b> <b>Service Affecting Failures</b>	
<b>Classification Level</b>	<b>Description</b>
<b>A</b>	Cumulative loss of 15 (fifteen) minutes or more, due to a malfunction in a train, causing a delay exceeding 15 minutes in reaching the destination of a scheduled service
<b>B</b>	Delay of more than 15 (fifteen) minutes in commencing the scheduled service of a train, due to a malfunction therein.
<b>C</b>	Inability to achieve at least 75% of the maximum speed it is ordinarily required to achieve during a scheduled service in accordance with Specifications and Standards
<b>D</b>	Detention of a train at any railway station for more than 15 (fifteen) minutes on account of a malfunction
<b>E</b>	Detention of a train at any place, not being a railway station, for more than 15 (fifteen) minutes on account of a malfunction
<b>F</b>	Cancellation of a scheduled service of a train due to malfunction



## Failure effect probability

These Beta values assigned in the criticality analysis are quantified from MIL-STD-1629A

Failure Effect	$\beta$ Value	Justification
Actual loss	1	System fails to perform the main functions.
Probable loss	$>0.10$ to $< 1.00$	Degradation of system performance in particular subsystem functions.
Possible loss	$>0$ to $= 0.10$	Degradation of subsystem functions but system works normally on the redundant path.
No effect	0	No impact on immediate effect.

### LCC Preventive Maintenance Analysis (Annex-2)

Doc. No		Rev No.	
Date:	12 March 2025		
Project	Vande Bharat Trains Project		
Equipment:			
Supplier:			
Compiled by:			

			REMARKS
Conversion speed	54.0	km/hrs	
Manpower cost	300.0	₹ /hrs	
Yearly distance run	3,50,000	km	
Running days per year	345	days	
LCC considered period	35	years	
Basic maintenance frequency	40,000	km	
Distance covered in the considered period	1,22,50,000	km	
Train-sets number in the fleet	80	Trains	



Insert data



LCC Corrective Maintenance Analysis (Annex-3)

Doc. No		Rev No.	
Date:	12 March 2025		
Project	Vande Bharat Trains Project		
Equipment:			
Supplier:			
Compiled by:			

			REMARKS
Conversion speed	54.0	km/hrs	
Manpower cost	300,00	₹ /hrs	
Yearly distance run	3,50,000	km	
LCC period	35	Years	
Fleet (nr. of trains)	80	Trains	

Insert data

**Note-2**  
Supplier must fill the columns that are highlighted with this colour.

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