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डीजल इलेक्ट्रिक लोकोमोटिव के कर्षण अल्टरनेटर/ जनरेटर
में प्रयुक्त गियर और पिनियन हेतु तकनीकी विशिष्टि
***TECHNICAL SPECIFICATION FOR GEARS AND PINIONS USED ON
TRACTION ALTERNATOR / GENERATOR OF DIESEL ELECTRIC LOCOMOTIVES***

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TECHNICAL SPECIFICATION FOR GEARS AND PINIONS USED ON TRACTION ALTERNATOR/GENERATOR OF DIESEL ELECTRIC LOCOMOTIVES.

1.0 SCOPE

This specification is applicable for the traction generator / alternator bull gears and pinions of diesel electric locomotives listed at Appendix "B". It covers the technical requirements of their manufacture and supply from raw material to the finished stage.

2.0 MATERIAL

2.1 Chemical Composition & Mechanical Properties:

2.1.1 The pinions and gears shall be manufactured from steel grade 15Ni7Cr4Mo2 TO IS: 4432-1988 (Indian Standard Specification, First Revision for Case Hardening Steel.)

2.2 The inclusion rating of the steel shall not exceed 2.0 A, 2.0 B, 2.0 C & 2.0 D for both thick and thin series. The field of each type of inclusion shall be determined in accordance with IS: 4163 and shall be taken as the rating.

2.3 Chemical composition and Mechanical properties of the steel used shall conform to the relevant material specification **or as per the given table of 1 and 2.**

2.4 **Chemical Composition:** The chemical composition of the gear/ pinion steel shall be as given in table 1

TABLE-1

Sr.no.	Element	15Ni7Cr4Mo2 TO IS: 4432-1988	
		Minimum	Maximum
1	Carbon	0.12%	0.18%
2	Manganese	0.60%	1.00%
3	Phosphorus	0.035 Maximum	
4	Sulphur	0.035 Maximum	
5	Silicon	0.15%	0.35%
6	Nickel	1.50%	2.00%
7	Chromium	0.75%	1.25%
8	Molybdenum	0.10%	0.20%

2.5 Mechanical properties: -

The mechanical properties of the gear/ pinion steel shall be as given in table 2
TABLE-2

MATERIAL	(With 16mm dia. Test piece)			
	Tensile strength (Mpa) minimum	Yield Strength (Mpa) minimum	%Elongation (mm) Minimum	Reduction area(mm ²) minimum
15Ni7Cr4Mo2	1100 to 1400	>750	9%	40%

2.6 Case of steel to any other composition or any other deviation is felt necessary, prior approval of RDSO shall be obtained.

3.0 MANUFACTURE AT STEEL WORKS AND FORGED SHOPS

3.1 Gears and pinions shall be manufactured from forging quality steel made by open hearth , electric, duplex basic oxygen or a combination of these processes. The steel shall be fully killed and homogeneous. The steel shall also be subjected to secondary refining including vacuum degassing. Sufficient discard shall be made from each ingot to ensure freedom from pipe, harmful segregation and other defects. The material shall be fine grained so that the grain size called for in clause 5.2 is met.

3.1.1 The semi-product intended for the manufacture of forged blanks of gears / pinions shall be obtained from adequately rolled / forged cropped ingots, without any pipe and segregation . The forging ratio shall be 1:4 minimum from ingot to bloom / billet / bar.

3.1.2 Forged Blanks :

No welding shall be permitted on the rough shapes. The outside surfaces of the forged blanks shall not show any flaw, cracks, folds or other injurious defects. The forged blanks shall be provided with adequate allowance for machining all over and shall be suitably annealed to facilitate subsequent machining.

3.2 Forging of Gears and Pinions :

The gear blanks shall be made by process of upset forging, followed by peripheral forging under a power hammer or press with a minimum forging ratio of 1 : 4 from bloom/billet/bar. The forging and rolling processes shall be performed in such a manner, that the central axis coincides with the axis of the gear wheel.

3.3 The pinion blanks shall be made by process of upset forging with a minimum forging ratio of 1 : 2.5.

3.4 The manufacturer of blanks shall submit the details of manufacture indicating the method of forging with stage wise sketches, dimensions, forging ratios etc.. The manufacturer shall also submit a certificate that the bar stock used

by him has been made from an ingot having at least 4 times cross sectional area and the source of supply.

3.5 In case only forged blanks are purchased, the manufacturer shall ensure free access of the inspecting authority at his works for the satisfaction of the latter that the material is being supplied in accordance with this specification.

4.0 FORGED BLANKS FREE FROM DEFECTS:

4.1 Billets, blooms, slabs and bars shall be free from cracks, surface flaws, laps, rough, jagged and imperfect edges and all other surface defects which may result in defects in the forging made there from.

4.2 The pre machined gears and pinions shall be free from cracks, lap or any other harmful surface or internal defects.

4.3 No welding shall be permitted on the forged blank. The outside surfaces of the forged blanks shall not show any flaw, cracks, fold or other injurious defects. The forged blanks shall be provided with adequate allowance for machining all over, and shall suitably be annealed to facilitate subsequent machining.

4.4 Forging supplier shall furnish test report showing the Mill source, Chemical composition, inclusion rating of material, forging ratio indicating the method of forging with stage wise sketches and dimensions for preparing forging blanks and grain flow pattern of gear and pinion blanks supplied to the gears manufacturer.

4.5 A photograph of grain flow pattern of forging blank of pinion and gear should be submitted prior to prototype inspection by RDSO.

5.0 TESTS ON ROUGH FORGED GEAR BLANKS:

5.1 Macro etch test: The macroetch examination shall be done as per ASTM-E381 (method of Macroetch testing & inspection of steel forging). The macroetched section shall reveal satisfactory flow line pattern right up to the centre of the forged blank.

5.2 Grain size: The microstructure shall be uniform without any carbon segregation. ASTM grain size 5 to 7 should be obtained. Grain size of forging should be tested in accordance with IS/2853/ Latest Version This is as per IS 4432 -1988.

5.3 Ultrasonic Test: All forged blanks, before and after machining is performed on them, shall be tested ultrasonically for ensuring freedom from casting and forging defects. A tentative standard for Ultrasonic Testing and criteria for acceptance/ rejection of the gear/ gear blanks is given at Appendix A.

5.4 Hardness Test: The forging when tested in accordance with IS- 1500 shall show a hardness value of 170 – 220 HB.

6.0 PRE-MACHINING HEAT TREATMENT OF FORGED BLANKS

6.1 To relieve the residual, forging stresses, the forging shall be normalised at 840°C - 870°C .The soaking time shall be given according to ruling thickness forged blank.

7.0 MACHINING: - as per clause 9.0.

8.0 HEAT TREATMENT**8.1 Case Hardening:**

The active tooth surface of the gear/pinion shall be suitably case carburised, hardened and tempered to obtain the specified case depth, case hardness and physical properties of core as specified in clause 8.2.2.

8.2 Effective Case Depth:**8.2.1 Definition and Measurement:**

The effective case depth is defined as that at which a hardness of 500 HV 30 (50 RC) is obtained. The depth is measured perpendicularly inwards from the surface. The available case depth after finish grinding shall be 1.2 mm minimum or as mentioned in relevant drawing.

8.2.1.1 Case Depth of Carburised and Hardened Gears:

For checking the case depth, one spy-piece shall be provided per container when box carburising and, at least, one but preferably two (towards top and bottom of furnace) when gas carburising. The spy-piece shall be of a section, which adequately simulates that of the teeth, which it represents and shall be placed near to but not on the gear teeth. The spy-piece shall be of the same material from which the gears are made.

After carburising, the spy-piece shall be hardened and tempered along with the gears it represents, and then broken. Hardness survey of the case shall be carried out after grinding and polishing as per IS: 6416 (Method of measuring case depth of steel). The results shall be as specified in Clause 8.2.1

Alternatively, the end of the teeth remote from the traction motor side may be ground back at an angle to reveal the case for visual examination or hardness testing.

8.2.2 Hardness of Case-hardened Layer:

Surface hardness of the gear after grinding measured at tip, flank or root shall not be less than 650 HV 30 or 58 RC (620 HB). For the position where the effective case depth is measured on either spy-piece or gear the hardness shall not be less than 500 HV 30 (50 RC).

8.2.3 Micro Examination:

At least one spy-piece per carburising batch shall be microscopically examined for establishing absence of cementite network and free cementite. Retained austenite content of 15% - 30% may be permitted in the carburised zone. This is as per IS 4432 - 1988.

9.0 GENERAL GUIDE LINES FOR MACHINING OF ALL TYPES OF GEARS AND PINIONS

- 9.1** Bore of the pinions / gears is referred to as the fitting surface.
- 9.2** Fitting surfaces of the gear and pinion shall be ground finished before finish grinding the teeth.
- 9.3** The surface texture of the fitting surfaces of gear and pinion shall not be coarser than the values specified in the relevant drawings.
- 9.4** The gear teeth shall be of involute profile, cut and ground on gear generating machines. Protuberance cutter shall be used for generating the teeth for automatically producing the most suitable stock allowance for grinding and generating simultaneously the largest possible tooth fillet of semi-circular shape with absolute uniform transition for the involute tooth flank to the tooth root after grinding. No discontinuity/ Step formation from the ground tooth flank and the machined root fillet shall be permitted.
- 9.5** The tooth profile shall be given the 'tip' and 'root' relief in accordance with the specification mentioned in the relevant drawings. The longitudinal crowning shall be provided as specified in the relevant drawings.
- 9.6** The dimensions, tolerances and surface finish specified in the relevant drawings shall be strictly adhered to. The following errors/ deviations shall be measured as per gear/pinion relevant drawings.
- a) Over all dimensions.
 - b) Individual error of pitch.
 - b) Consecutive error of pitch.
 - c) Cumulative error of pitch.
 - d) Profile error.
 - e) Alignment error.
 - f) Radial Run out.
- 9.7** The gear / pinion should be free from sharp edges.
- 9.8** The working face of the teeth shall be free from defects such as heterogeneity in metal and forging / cutting / grinding imperfections. Any repair of these surface defects shall be prohibited.
- 9.9** The end faces of the teeth shall also not show defects similar to Clause 9.8 particularly near the root circle.

10.0 SHOT PEENING:

Shot peening should be done on fillet radius and root of gears before grinding, to impart compressive stress. All tooth surfaces should be protected against peening or should be as per relevant drawings requirements. Use shot size S.A.E.- 170, intensity 0.010-0.012A and coverage area 90% minimum .or shall conform to the relevant drawings.

11.0 TESTS

11.1 Physical Testing on Material:

11.1.1 The following tests shall be conducted at the works of the gear manufacturer or in an approved test house at the cost of manufacturer on the test samples selected as per Clause 11.1.2. At least, one sample per cast shall be subjected to the following tests:

- i) Ultimate tensile strength.
- ii) Yield stress.
- iii) Elongation percentage.

The test result shall confirm to the Table-2 of this specification.

11.1.2 Test Sample:

The test sample shall be made in the form of a bar from a bloom of relevant cast selected at random, having the same reduction forging ratio and heat treatment as the forging it represents and then a test bar of diameter as per relevant material specification shall be turned from the forging.

This test bar shall then be heat treated (blank carburising, hardening and tempering) along with the gear / pinions of the same cast as indicated in Clause 11.1.1 and then the test piece machined .It shall carry the following markings for identifications:

- (a) Steel used
- (b) The cast number / Heat no.

Tests on bar stock:

One bar stock shall be cut in the presence of the inspecting authority and macro list shall be carried out to determined , if sufficient working as defined in this specification has been done on the ingot to obtain the bar stock.

NOTE: (i) Blank carburising means the thermal treatment associated with carburising as applied to a test piece without using any carburising medium.

- (II) Tests on bar stock: - one bar stock shall be cut in the presence of the inspecting authority and macro list shall be carried out to determine if sufficient working as defined in this specification has been done as the ingot to obtain the bar stock.
- (iii) Test sample shall be repeated at an interval of every three years and also whenever the failures of gear and pinion take place.

11.1.3 Chemical composition & Physical properties:

One test sample per cast shall be chosen for chemical composition. The analysis of steel shall be carried out either by method specified in IS: 228 "Method of chemical analysis of steel and its relevant parts of any other established instrumental method (Spectrometer)". The chemical composition and physical test results shall conform to the relevant material specification.

The chemical composition and physical test result shall conform to the relevant material specification. If any one of the test samples fail to meet the requirement as mentioned in relevant material specification, the entire lot shall be rejected.

In the event of rejection of entire lot, the lot offered shall be made unusable in presence of purchasing / inspecting authority. However, approving / purchasing authority reserves the right to repeat the tests at their discretion at certain time interval.

11.2 TESTS ON FINISHED GEARS: -

(a) Type Tests: - These will be conducted by RDSO on prototype gears whenever a new source is to be approved. The lot offered for prototype tests should not have less than 6 gears. These shall also be conducted once in every three years after approval of prototype at any instance and deemed necessary by RDSO. The following tests shall be conducted in addition to acceptance tests mentioned at Para 11.2(b) and other tests laid down in relevant specifications.

- (i) **Material test:** Confirmation of the properties of material as mentioned in material relevant specification are mandatory for product approval or approval of manufacturer. It will be carried out in presence of RDSO representative.
- (ii) **Hardness Check:** The hardened teeth of all gears, after appropriate heat treatment, shall be tested for surface hardness. The hardness shall be measured at four equidistant points in the proximity of the root circle of the teeth. The average value of four readings shall conform to the values specified in Clause 8.2.2. The variation between the maximum and minimum values shall not exceed 20 points HV.

- (iii) **Crack Detection check:** All the finished gears/pinions should be subjected to crack detection by suitable method such as magnetic particle test, die-penetrant test or fluorescent test. On the discretion of inspection authority. Ultrasonic testing on rim & hub portion can also be employed to check any internal cracks in the forged & finished gears / pinions.
- (iv) **Dimensional & Tolerance checks:** The finished gears shall be checked for dimensional accuracies, tolerance, surface finish and tooth errors / deviations as per clause 9.6.

If any one of the gears fails to meet the requirement as mentioned in relevant material specification and dimension of drawing, the entire lot shall be rejected.

- (b) **Acceptance Tests (During Routine inspection):** - These are the tests to be conducted, during routine inspection by purchaser / RITES against individual orders:

- a) Overall dimensions check.
- b) Hardness check.
- c) Crack detection test.
- d) Tooth error/ deviations as per gear/ pinion relevant drgs.

During Routine inspection, inspection authorities shall check 30% of gears & pinions from the lot offered.

12.0 MARKING

Following information shall be etched or punched at the free side of the gears, which shall be indelible and clearly legible.

- i) Name of the supplier.
- ii) Date of manufacture e.g. 05/2005.
- iii) No. of teeth & gear ratio.
- iv) Drawing no.
- v) Manufacturer Job Sr.No.
- vi) Designation of Material.

13.0 Quality Assurance Plan

- 13.1 QAP shall be submitted by manufacturer before undertaking manufacture of prototype and got approved by RDSO. The QAP should be framed in such a manner so as to ensure inherent protection against the use of incorrect machine parameters for case hardened gears. QAP shall also have the following information.

- 13.2 The Q.A. plan should incorporate quality assurance activities planned for manufacturing & supply of bull gear and pinion in order to fulfil

specification quality, requirements given in relevant gear/pinion drawings, specification, standards & other applicable documents for it. It shall include detailed stage inspection plan, agency carrying out the check, sampling lot and acceptance limits. Frequency of various checks, details of nature of work involved in the checks and records maintained regarding these checks shall be indicated.

13.3 Manufacturer shall on demand by the purchaser, make the records of checks carried out during internal quality assurance available for scrutiny.

14.0 ACCEPTANCE OF FINISHED GEARS AND GUARANTEE

14.1 Unless otherwise agreed between the supplier and the purchaser, a minimum 36 months (**Three years**) guarantee of reliable service, shall be ensured by the supplier. The supplier shall undertake to replace, as quickly as possible, the defective gear/pinion on account of faulty material or workmanship. If failure of a particular gear involves the failure of the other mating gear/gears, the supplier shall also be responsible for the replacement of the damaged gear/gears.

14.2 The Inspecting Officer shall inspect the gears at various stages of manufacture for conformity with specifications as well as the finished condition before authorising for delivery. However, this authorisation does not relieve the supplier of his liability with respect to any imperfections, which may appear subsequently.

15.0 PROTECTIONS AND PACKING

The gears/pinions shall be suitably protected against oxidation and corrosion by three coats of ready mixed paint, brushing Bituminous black, to IS: 158 (Specification for ready mixed paint, brushing, bituminous black, lead free, acid, alkali, water and heat resisting for general purpose) or with any other approved anti-rust compound capable of being removed easily by white spirit or kerosene oil, allowing sufficient drying time between each coat. After the last coat has dried, the gear shall be covered with waterproof paper. The gears / pinions shall then suitably be placed to prevent any damage during transport and handling.

APPENDIX-A

**TENTATIVE STANDARD FOR ULTRASONIC TESTING AND
ACCEPTANCE OF TRACTION GEARS AND PINIONS**

1. Gears/pinions forgings shall be tested ultrasonically for soundness from one of the two side (flat) faces. In case of gears the scanning could be restricted to the rim portion. The scanning shall be done with a 2/2.5 MHz, 25 mm dia probe. The ultrasonic test unit used shall be either Krautkramer 'USIP 10' or any other instrument of similar or improved characteristics
2. The range shall be so adjusted that the back echo from the opposite face for a particular size of gear/pinion under test shall occur at the extreme end of the screen and its amplitude shall be approximately 75% of the full screen height. With this setting, the scanning shall be done by moving the probe circumferentially. In case the radial thickness of the rim of the gear and that of the pinion is considerable, the scanning may be done following multiple concentric paths separated by one probe position.

Criteria for Acceptance/Rejection:

- 1 Any flaw indication, the amplitude of which is greater than 25% of that of back echo obtained from an adjacent location, shall be rejected.
- 2 Flaw indications, the amplitude of which are less than 25% of back echo obtained from adjacent location may be accepted provided the back echo at that location is not less than 80% of the original and the total number of such flaw indications obtained on that gear/pinion is less than 5 and each flaw is separated from the other by more 25mm distance. Where there is a continuous flaw indication, the spread of the flaw shall not cover more than one probe position in any direction. Where such indications are obtained, scanning should be done in all radial directions at that location to verify the spread of flaw.
- 3 Where there is a flaw indication in the first quarter of the usable length of the trace, the same shall be confirmed by a scan from the opposite face.
- 4 Where the back echoes is reduced to less than 80% of the original, the gear shall be rejected.

APPENDIX-B

DRAWING LIST OF GEARS AND PINIONS USED IN GENERATOR AND TRACTIONALTERNATOR OF DIESEL ELECTRIC LOCOMOTIVES

SR. NO.	MACHINE DESCRIPTION	NO. OF TEETH	DRAWING NO.	CLASS OF LOCOS
1	GENERATOR BHEL 10931 AND GE GT-586 BULL GEAR	102	SKDP-3114	WDM2
2	PINION FOR AUX. MACHINES AG 351, GY27 & PTUS- PT241Y	43	SKDP-3115	WDM2
2	ALTERNATOR BHEL 10102	102	SKDP-3116	WDM2 , WDM3A , WDM3D, WDG3A & WDP3A
4	PINION FOR AUX. MACHINES AG 3101 & MODIFIED –PT 70 AZ	43	SKDP-3117	WDM2 , WDM3A , WDM3D, WDG3A & WDP3A

NOTE : The drawings with latest alterations available with RDSO shall only be referred to.