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GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

इलेक्ट्रिक लोकोमोटिव के कर्षण गियर हेतु
तकनीकी विशिष्टि
***TECHNICAL SPECIFICATION FOR TRACTION GEARS
OF ELECTRIC LOCOMOTIVES***

विशिष्टि संख्या चा०श०. ०.२८००.०९ (संशोधन - ०२)
जून २००५
SPECIFICATION NO. MP. 0. 2800.09 (REV.-02)
JUNE, 2005

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TECHNICAL SPECIFICATION FOR CASE CARBURISED GEARS AND PINIONS FOR ELECTRIC LOCOMOTIVES.

0. FOREWARD

Traction gears constitute vital part of the power transmission system of locomotives and call for sophisticated techniques in manufacture, with special material, equipment and quality control requirements.

1.0 SCOPE

This specification is applicable for traction gears and pinions used in electric locomotives listed at Annexure 'A'. It covers technical requirements of manufacture and supply from raw material to finished stage.

2.0 MATERIAL

2.1 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.

2.2 Chemical Composition & Mechanical Properties:

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

2.3 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.

2.4 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.**

2.4.1 **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%

2.4.2 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%

2.5 case of steel to any other composition, prior approval of RDSO shall be obtained.

3.0 MANUFACTURING OF FORGED BLANK

3.1 The gear and pinion shall be manufactured by rolling/forging ingots in to blooms / billets / bars (made from adequately rolled / forged cropped ingots) to the blank stage, followed by closed die or upset forging, or peripheral forging. The ratio of reduction at different stages shall be as follows:

- a) The minimum-reduction ratio from the minimum section of the ingot to maximum section of the round bloom / billet by forging shall be 4:1.
- b) The gear blanks shall be made by a process of upset forging, followed by peripheral forging under a power hammer or press. The reduction ratio in height by upset forging from round bloom/bar to the gears blank shall be at least 4:1.
- c) The forging and rolling processes shall be performed in such a manner, that the central axis coincides with the axis of the gear wheel.
- d) The semi-product (bloom) intended for the manufacture of forged blanks of gears/pinions shall be obtained from cropped ingots, without any pipe.
- e) 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 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 grain size of forging when tested in accordance with IS/2853/ Latest Version shall be in the range of 5 to 8 inherently fine-grained structure. 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.

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 1.8mm 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 S330 hard shot to obtain 200% minimum coverage in root area. Peening intensity should be between 0.007 to 0.010 C.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.

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, shall be first forged down to 1/4 of the original section 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.

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 takes 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 sample fail to meet the requirement as mentioned in relevant material specification, the entire lot shall be rejected.

In the events 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-penetrate 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.

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 72 months (**six 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.

ANNEXURE-A

CASE CARBURISED GEARS AND PINIONS USED IN ELECTRIC LOCOMOTIVES

SR. NO.	DESCRIPTION	NO. OF TEETH	DRAWING NO.	CLASS OF LOCOS
1	INTERMEDIATE PINION	35	DDO-254	

2	INTERMEDIATE GEAR RIM	66	DDO-256	WAG1 WAG3 WAG4
3	INTERMEDIATE GEAR	64	DDO-257	
4	FINAL DRIVE GEAR	65	DDO-258	
5	MOTOR PINION	31	DDO-259	
6	MOTOR PINION	22	DDO-265	
7	INTERMEDIATE PINION	29	DDO-265	WAG2
8	INTERMEDIATE GEAR	42	DDO-267	
9	IDLER GEAR	48	DDO-268	
10	FINAL DRIVE GEAR	59	DDO-269	
11	FINAL DRIVE GEAR	65	DDO-270	
12	INTERMEDIATE GEAR WHEEL	35	DDO-272	WAM1
13	MOTOR PINION	16	DDO-273	
14	GEAR WHEEL	66	DDO-275	
15	PINION	17	DDO-276	WAM2 WAM3 WAP2
16	GEAR WHEEL	63	DDO-288	
17	PINION	20	DDO-289	

SR. NO.	DESCRIPTION	NO. OF TEETH	DRAWING NO.	CLASS OF LOCOS
18	GEAR RIM	59	DDO-279	WCM1 WCM5
19	PINION	16	DDO-280	
20	GEAR WHEEL RIM	73	DDO-281	

21	PINION	16	DDO-282	WCM4
22	GEAR RIM	62	DDO-283	WCM2
23	PINION	16	DDO-284	
24	SOLID GEAR	62	DDO-290	
25	SOLID GEAR WHEEL	74	DDO-291	WCG2
26	PINION	18	DDO-292	
27	GEAR WHEEL	61	DDO-293	WCAM1
28	MOTOR PINION	16	DDO-294	
29	GEAR WHEEL	62	DDO-295	WAM4 WAG5 WCAM2
30	GEAR WHEEL (WITH ROLLERSUSP. BRG.)	62	SKDL-4455	
31	MOTOR PINION	15	DDO-296	
32	GEAR WHEEL	58	DDO-297	WAP1 WAM4
33	PINION	21	DDO-298	
34	GEAR WHEEL (ROLLERSUSP. BRG.)	58	SKDL-4456	

SR. NO.	DESCRIPTION	NO. OF TEETH	DRAWING NO.	CLASS OF LOCOS
35	PINION	16	DDO-285	WCM3
36	GEAR RIM	51	DDO-286	
37	GEAR WHEEL	77	DDO-299	WAG5B
38	PINION	17	DDO-300	
39	GEAR WHEEL	64	SKDP-3459	WAG5H WAG7 WCM6
40	PINION	18	SKDP-3460	
41	GEAR WHEEL	58	SKDL-4355	WAP3 WAP4
42	PINION	23	SKDL-4356	
43	GEAR WHEEL	65	SKDL-4372	WCG3 & WAG7
44	PINION	16	SKDL-4373	
45	GEAR WHEEL	60	SKDP-3381	WCAM3
46	PINION	21	SKDP-3382	

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