



भारत सरकारए रेल मन्त्रालय

**GOVERNMENT OF INDIA**  
**MINISTRY OF RAILWAYS**

डीज़ल एवं विद्युत रेल इंजनों के ठोस रोल्ड मल्टिपल – घिसाव वाले पहियों  
के लिए भारतीय रेल मानक विष्टिठ

सभी गेजों के लिए लागू

**INDIAN RAILWAY STANDARD SPECIFICATION FOR SOLID  
ROLLED MULTIPLE WEAR WHEELS  
OF DIESEL AND ELECTRIC LOCOMOTIVES  
(Applicable to all Gauges)**

**Serial No. R-34-15**

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अनुसंधान अभिकल्प और मानक संगठन

लखनऊ—226 011

**RESEARCH DESIGNS & STANDARDS ORGANISATION**

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## **FOREWORD**

This IRS specification was first adopted in 1969. It has been improved and revised in 1981, 1996, 1999, 2003, and 2009 to meet the enhanced performance requirements of locomotives. The current revision of 2015 incorporates revisions arising out of further advancements in technology of wheel manufacture, particularly those adopted by established OEMs.

This specification is issued under the fixed serial no. R-34 and the final number indicates the year of original adoption as standard or in case of revision, the year of latest revision.

## CONTENTS

Sr. No.	DESCRIPTION	Page No.
1.	SCOPE	1
2.	MANUFACTURE	1
3.	QUALITY OF MATERIAL	4
4.	DIMENSIONS AND TOLERANCES	4
5.	BRANDING	4
6.	SAMPLING AND ORDER OF TESTS FOR ACCEPTANCE	4
7.	BRINNEL HARDNESS TEST	5
8.	VERIFICATION OF RESIDUAL STRESS	5
9.	TENSILE TEST	6
10.	CHEMICAL ANALYSIS OF PRODUCT	6
11.	IMPACT TEST (U-NOTCH)	6
12.	NON-METALLIC INCLUSIONS AND MICRO-STRUCTURE	6
13.	RE-TEST	7
14.	NORMAL AND TIGHTENED INSPECTION	8
15.	ULTRASONIC TESTS	8
16.	MAGNETIC PARTICLE TESTS	8
17.	ADDITIONAL TESTS	9
18.	INSPECTION	9
19.	TESTING FACILITIES	9
20.	PROTECTION	9

<b>APPENDIX / FIGURES / DRAWINGS</b>		
A.	METHOD OF ULTRASONIC TESTING & ACCEPTANCE STANDARD FOR LOCOMOTIVE WHEELS (Clause 15)	10
B.	METHOD OF MAGNETIC PARTICLE TESTING & ACCEPTANCE STANDARD FOR LOCOMOTIVE WHEELS (Clause 16)	13
Fig.1	SKETCH SHOWING THE HARDENED ZONE FOR MONO-BLOCK WHEELS TO IRS R-34	15
Fig.2	POSITION OF TENSILE, IMPACT AND INCLUSION TEST PIECES	16
Fig.3	LOCATION OF SAMPLE FOR FRACTURE TOUGHNESS TEST	17
Fig.4	ALTERNATE REFERENCE STANDARD	18
Fig.5	REFERENCE STANDARD FOR RADIAL PROBING	19
DDO-208	WHEEL MARKINGS	20

**INDIAN RAILWAY STANDARD SPECIFICATION FOR SOLID  
ROLLED MULTIPLE WEAR WHEELS  
OF DIESEL AND ELECTRIC LOCOMOTIVES  
(Applicable to all Gauges)**

**1. SCOPE**

- 1.1 This standard covers the requirements of heat treated solid rolled multiple-wear wheels for Diesel and Electric locomotives of all gauges.
- 1.2 Any special requirements given in the relevant drawings will override this specification.

**2. MANUFACTURE**

**2.1 Process of steel manufacture**

The wheels shall be manufactured from steel made by Electric, Basic Oxygen or any other process recognized as equivalent by the purchaser. The steel shall be of killed quality.

**.1 Hydrogen Content**

The steel shall be vacuum degassed and hydrogen content in liquid steel shall not be more than 2.5 PPM. Hydrogen analysis shall be done as given in Para 2.1.2 & 2.1.3.

**.2 Sampling for Hydrogen Analysis**

The sample of liquid steel shall be taken from ladle by plunging the sampler 300 mm below the molten metal-slag interface. The sample shall be held 2-3 seconds and then quenched in cold water so that the sample temperature falls below 150°C within 5 seconds.

The sample shall be removed from cold water and immediately packed in dry ice or liquid Nitrogen. The sample shall be analyzed within 48 hours and till the time of analysis, the sample shall continuously be fully covered by dry ice / liquid Nitrogen.

Sampling shall be done by 6 mm diameter tube of Pyrex glass or ceramic which does not react with steel. General wall thickness of the tube shall be 1.5 mm and at the fill end 0.5 mm approx. The tube should be under vacuum of  $10^{-3}$  bar (0.76 mm of Hg).

Any other method of sampling shall have a prior approval of the purchaser.

**.3 Hydrogen Analysis**

The analysis of sample shall be done by Inert Gas Fusion technique in which sample is fused at around 1900°C in induction heating crucible. A Nitrogen carrier gas transports the released Hydrogen to a thermal conductivity cell. The amplified and integrated output of the cell is to be calibrated for Hydrogen in PPM.

A Leco-RH-3 Hydrogen analyzer or similar precision equipment may be used for Hydrogen determination. Hydrys system may be used for online / instantaneous measurement of Hydrogen content in liquid steel.

Any other method for Hydrogen Analysis shall have a prior approval of the purchaser.

## 2.2 Chemical composition

- .1 **Ladle Analysis:** The ladle analysis of steel, when carried out by the method specified in relevant parts of IS: 228<sup>1</sup> (latest versions) or any other established instrumental / chemical method, shall be as follows:

Elements	Permissible Percent	
Carbon	0.57 to 0.67 or as specifically mentioned in the drawing	
Manganese	0.60 to 0.85	
Silicon (Min.)	0.15	
Phosphorus (Max.)	0.03	
Sulphur (Max.)	0.03	
Chromium (Max.)	0.25	} Combined 0.50% (Maximum)
Nickel (Max.)	0.25	
Copper (Max.)	0.28	
Molybdenum (Max.)	0.06	
Vanadium (Max.)	0.10	
Aluminum (Max.)	0.02 * (preferable)	* Aluminum upto 0.04% (max.) is permitted provided that the manufacturer ensures Al inclusions (non-metallic) to not worse than 1.5 for both thick and thin series.

In case of dispute, the procedure given in IS: 228<sup>1</sup> and its relevant parts shall be the reference method. However, where the method is not given in IS: 228 and its relevant parts, the reference method shall be as agreed between the purchaser and the manufacturer.

## .2 Product Analysis:

The product analysis is to be carried out as laid down in Clause 11. The permissible variation from the limits specified in Clause 2.2.1 shall be as follows:

Elements	Variation Percent	
Carbon	+ 0.03 / - 0.02	
Manganese	± 0.03	
Silicon	- 0.03	
Phosphorus	+ 0.005	
Sulphur	+ 0.005	
Chromium, Nickel & Copper	+ 0.05	
Molybdenum & Vanadium	+ 0.02	
Aluminum	+ 0.002 **	** Aluminium content in product analysis upto 0.04% (max.) is permissible including this variation

<sup>1</sup> Method for chemical analysis of steel

## 2.3 Manufacturing of wheel

- .1 The wheels shall be manufactured by forging and rolling process from cropped ingots or from cheeses of steel blooms of suitable section, length and weight, manufactured by the continuous casting method, in such a manner that the central axis of the ingot or the bloom coincides with the axis of the wheel. Sufficient discard shall be made from both ends of each ingot to ensure freedom from piping and undesirable segregations. Each ingot shall be of suitable section and length to produce two or more wheel blanks after top & bottom discards have been made to eliminate the defective portion completely.
- .2 The steel shall be refined in the ladle furnace and vacuum de-gassed. Suitable shrouding arrangements from the ladle to tundish and from tundish to mould shall be made. The continuous casting machine shall have the facility of electromagnetic stirring.
- .3 The minimum cross section of the cropped ingot or continuously cast bloom shall be such that a minimum reduction ratio of 4:1 is obtained with the maximum wheel section at rim portion. That is, the original height of cropped ingot piece should be at least 4 times the height of rough wheel at rim.

Or

The minimum cross section of the cropped bloom manufacture from ingot rolled down to bloom size shall be such that a minimum reduction ratio of 3:1 is obtained with the maximum wheel section at rim portion. That is, the original height of cropped bloom piece should be at least 3 times the height of rough wheel at rim.

## 2.4 Cooling

- .1 During manufacture, necessary care shall be exercised in regulation of temperature to obtain the best physical properties, expected from the chemical composition & mechanical work and to achieve the desired microstructure.
- .2 After the last hot forming operation i.e. dishing and coning, all wheels shall be slowly cooled, protected from draft of air or handled in such a manner so as to prevent injury by rapid cooling below the critical range.
- .3 Optimised cooling regime should form part of a documented Quality Assurance Plan (QAP).

## 2.5 Heat treatment

The heat treatment shall consist treatment of only rim by way of rim quenching and subsequent wheel tempering. While employing water spraying during rim quenching, care should be taken to prevent access of cooling medium to the web.

- .1 **Rim Quenching treatment:** This treatment entails heating the wheel for a sufficient time to bring it uniformly to a temperature of at least 825°C and then hardening the rim with jets of water under pressure the wheel must rotate during the rim quenching process followed by wheel tempering to a temperature of 480°C to 520°C. The wheel is then left to cool in still air preferably in a covered cooling pit or under cover. However, this heat treatment schedule is indicative only meant for guidance. The firm shall determine their heat treatment schedule on the basis of chemical composition of the metal and their laid down heat treatment process approval plan. The firm shall clearly bring out their heat treatment schedule in the QAP.

### 3. QUALITY OF MATERIAL

The wheel shall be free from cracks, surface flaws, laminations, inclusions, laps, hydrogen flakes and all other harmful defects.

### 4. DIMENSIONS AND TOLERANCES

4.1 The wheels shall be accurately machined to the dimensions and tolerances shown in the relevant drawings. When maximum weight of the finished wheel is shown in the drawing, the tolerances indicated should be worked to close limits so as not to exceed the specified weight. Any wheel not cleaning up perfectly true in the lathe shall be rejected.

4.2 The radii at junction of the web with rim and web with hub on both sides shall be machined without leaving black spots so as to blend smoothly with the web, as shown in the relevant drawings. Any hole indicated in the drawing shall also be machined and flame cutting shall not be resorted to.

4.3 Permissible variation in the dimensions where tolerances are not given in the individual drawing(s) shall be as follows:

- .1 **Thickness of rim:** The radial thickness of the rim shall not vary more than 3mm around the wheel circumference.
- .2 **Plane of back / inside face:** When wheels are gauged with a straight edge applied to back face of the rim, no point on back face of rim shall be more than 1mm from the straight edge.
- .3 **Hub wall thickness:** The thickness of the hub wall measured at any two points, equidistant from the face of the hub, shall not vary by more than 2 mm.
- .4 **Rotundity:** Tread when gauged with a ring gauge, must not have opening over 0.5mm between the tread and the gauge at any point.
- .5 **Diameter of bore:** The diameter of rough finished bore shall not vary by more than 2mm from the dimension shown in the relevant drawing.
- .6 **Eccentricity:** Eccentricity between the rough bore and tread, measured in the plane of tapping line shall not exceed 3 mm.
- .7 The difference between the minimum and maximum thickness of web at any given radius shall not be more than 1.5 mm.

### 5. BRANDING

Each wheel shall be legibly stamped on the outside face of hub as indicated in DDO-208 (latest alteration). Care shall be taken to ensure that the impressions do not have sharp corners/edges and the entire preparation is suitably rounded to remove sharp corners.

5.1 Manufacturer shall maintain and preserve the record co-relating every individual wheel with the cast number, drawing number of the wheel and heat treatment given, and produce the same on demand by the purchaser /inspecting officer.

### 6. SAMPLING AND ORDER OF TESTS FOR ACCEPTANCE

100% wheels shall be checked for appearance, dimensions, branding particulars, hardness at outside face of the rim, ultrasonic testing and magnetic particle test. For other tests i.e. destructive tests, following provisions shall be applicable.

## 6.1 Lot Size

Lot size will be 250 or less. All the wheels of a lot shall be from the same heat and heat treatment batch.

## 6.2 Sample for destructive tests

Random sampling shall be followed with the sample size as given below:

- .1 Sample size will be 1. The selected wheels shall pass the outside hardness test as specified in Clause 7.1. Wheels selected for destructive testing may be in un-machined or machined condition at the discretion of the manufacturer. If the selected wheels are in un-machined condition, the surface should be prepared by grinding or other suitable method for hardness measurement.

## 6.3 Order of the tests

Wheel of the above sample shall be subjected to the tests stipulated in Clause 7.1. On compliance to the clause 7.1, the same wheel shall be subjected to tests stipulated in clause 8 followed by tests mentioned in clauses 7.2, 9, 10, 11 and 12.

Preferably, the destructive tests should be conducted in un-machined condition of the lot, after duly preparing the surface of the sample wheels for hardness test as per Clause 7.1. This is to avoid any likely damage to the surface if reheat treatment is required

## 7. BRINELL HARDNESS TEST

Brinell Hardness test shall be conducted with 10 mm diameter ball & 29.42 kN force (3000 kg load) combination as per IS:1500<sup>2</sup> (latest version). Any other method shall require purchaser's or his inspecting officer's prior approval.

- 7.1 **Hardness on outside face of the rim:** This test shall be conducted on all wheels after machining to the size as per the drawing. The hardness of the rim when measured on its outside face, with the edge of impression not less than 12 mm from the chamfer joining the face and tread shall show Brinell Hardness number 300 to 341 and the hardening effect shall be to a depth of about 30 mm from the tread as measured on the out side face of the rim. The hardness number at a depth of 30mm from the tread shall not be less than 300BHN.

- (i) **Uniformity of hardness of batch:**

The extreme hardness values of the rim of wheels from the same batch shall not vary by more than 30 BHN.

- 7.2 **Hardness Test on Cut Section:** Hardness survey shall indicate a smooth transition from the radius face to the tread face. Any decarburised metal shall be removed from the outside face of the rim at a point chosen for measurement of hardness number. A cut section of wheel as shown in Fig.1 shall be prepared for the purpose of conducting hardness survey. The surface shall be properly prepared to permit accurate determination of hardness.

*Note: The test piece should preferably be saw cut. Should flame cutting be employed, sufficient discard shall be made during shaping so as to eliminate the heat-affected zone.*

- .1 The hardening effect shall be as shown in Fig.1 with Brinell hardness number showing a minimum of 300BHN at 30 mm from tread surface (end of shaded area). The hardness survey shall indicate a smooth transition from interior of the wheel to the tread surface (341 BHN maximum) in vertical direction.

## 8. VERIFICATION OF RESIDUAL STRESS

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2 Method for Brinell Hardness Test for metallic materials



- 8.1 The residual stresses occurring in rim quenched wheels shall be compressive in nature.
- 8.2 Two datum points 100 mm apart shall be marked in the centre of thickness of rim on the flat surface on the side opposite to the flange. A radial saw cut from the top of the flange to the bore shall then be made half way between the two datum marks. Flame cut may also be permitted. The distance between the datum marks shall then be measured.
- The reduction in distance between the datum marks should be greater than or equal to 1 mm.

## 9. TENSILE TEST

- 9.1 The test pieces shall comply with the specified test requirements. The tensile test shall be carried out in accordance with IS: 1608<sup>3</sup> (latest version) using standard proportional test piece having a gauge length equal to  $5.65 \sqrt{A}$  where  $A$  is the cross sectional area of the test piece. Two test pieces shall be taken from the test wheel from position 1 & 2 shown in Fig. 2.
- 9.2 **Tensile strength at rim:** It shall not be less than 980 MPa with an elongation of 8% minimum.
- 9.3 **Tensile strength at web:** It shall not be less than 775 MPa with an elongation of 13% minimum and shall not exceed 900 MPa with a minimum elongation of 11%.
- 9.4 Minimum yield strength or 0.2% proof stress at rim shall be 620 MPa.

## 10. CHEMICAL ANALYSIS OF PRODUCT

- 10.1 The sample shall be taken for analysis by the purchaser or his inspecting officer. These samples shall be drilled or cut from a location adjacent to the location from where tensile sample for rim is required to be taken.
- 10.2 The sample shall be subjected to complete chemical analysis in accordance with IS: 228 or any other established method. In case of dispute, the procedure given in the relevant part of IS: 228 shall be the reference method. In case, the method is not stipulated in IS: 228, the reference method shall be as agreed to between the purchaser and the manufacturer. The permissible variation of percentage of elements shall be within the specified values mentioned in Clause 2.2.2.

## 11. IMPACT TEST (U-NOTCH)

The impact test shall be carried out in accordance with the requirements of IS: 1499<sup>4</sup> (latest version). Three test pieces a, b and c shall be taken from the sample at the position specified in Fig.2. The average impact value of 3 samples when done with 5 mm deep U notch at + 20°C shall be 11 Joules with no individual value below 9 Joules.

## 12. NON-METALLIC INCLUSIONS AND MICRO-STRUCTURE

- 12.1 **Non-metallic inclusions at rim:** The specimen shall be from a portion of the tensile test piece at Fig.2 and taken from the position indicated in that figure. When checked as per IS: 4163<sup>5</sup> (latest version), inclusions shall not be worse than 1.5 for both the thick and thin series (A, B, C & D types).
- 12.2 **Non-metallic inclusions at web:** The specimen shall be from a portion of the tensile test piece at web. When checked as per IS: 4163 (latest version), inclusions shall not be worse than 1.5 for both the thick and thin series (A, B, C & D types).
- 12.3 **Microstructure:** The structure at the standard location of tensile testing piece taken from the rim as shown in figure.2 will consist of fine pearlite. ASTM grain size will be 6 or finer. Bainitic

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<sup>3</sup> Mechanical testing of metals-- Tensile testing

<sup>4</sup> Method for charpy impact test (U-notch) for metals

<sup>5</sup> Method for determination of inclusion content in steel by Macroscopic method

structure in the microstructure is not acceptable. However, since formation of ferrite is always associated with pearlitic structure in normal course depending on the carbon content, the microstructure at the location of tensile strength can consist of predominantly fine pearlite with finely dispersed ferrite.

### 13. RE-TEST

- 13.1 Should any wheel of the sample drawn for the purpose of destructive tests as indicated in Clause 6.2, fail in Brinell Hardness tests mentioned in Clause 7.1, the purchaser or the inspecting officer shall again randomly select wheel sample of the size as mentioned in Clause 6.2 from the same lot with or without re-heat treatment. Any re-heat treatment shall require purchaser or inspecting officer's prior permission. The sample wheels shall be accepted if the results of these further tests are satisfactory. Should any of the retested wheels fail to fulfill the conditions of Brinell Hardness test, the sample will be rejected. In such eventuality, the manufacturer may segregate good wheels after 100% hardness check and offer the good wheels for drawing sample for other subsequent tests.
- 13.2 Should the sample of the lot which has passed Brinell Hardness tests of Clause 7.1, fail in residual stress test, the manufacturer may, with the concurrence of the purchaser or inspecting officer, reheat treat the lot and present it again for Brinell Hardness tests of Clause 7.1 and residual tests with double the sample size as mentioned in Clause 6.2. Should the sample fail in any of the tests, the lot shall be rejected. Should the results of these repeat tests prove satisfactory, the lot from which the wheels were selected shall be accepted.
- 13.3 Should the sample of the lot which has passed Brinell Hardness tests of Clause 7.1, residual stress test, fail in cut-section Brinell Hardness tests mentioned in Clause 7.2, two more sets of cut-section hardness tests be made from two wheels of the same lot for repeat tests. The wheels shall be accepted if the results of these further tests are satisfactory. Should the repeat cut-section hardness tests not prove satisfactory, the manufacturer may, with the concurrence of the purchaser or inspecting officer, reheat treat the lot and present it again for Brinell Hardness test of Clauses 7.1, residual stress test and cut section Brinell Hardness tests with double the sample size as mentioned in Clause 6.2. Should the sample fail in any of these tests, the lot shall be rejected. Should the results of these repeat tests prove satisfactory, the lot from which the wheels were selected shall be accepted.
- 13.4 Should the sample of the lot which has passed Brinell Hardness tests of Clause 7.1, residual stress test and cut section Brinell Hardness test, fail in tensile tests, two more sets of tensile test pieces shall be taken from two wheels of the same lot for repeat test. The wheels shall be accepted if the results of these further tests are satisfactory. Should the repeat tensile tests not prove satisfactory, the manufacturer may, with concurrence of the purchaser or the inspecting officer, reheat treat the lot and present it again for Brinell Hardness test of Clause 7.1, residual stress test, cut section Brinell Hardness test and tensile tests with double the sample size as mentioned in Clause 6.2. Should the sample fail in any of the tests, the lot shall be rejected. Should the results of these repeat tests prove satisfactory, the lot from which the wheels were selected shall be accepted.
- 13.5 Should the sample of the lot which has passed Brinell Hardness tests of Clause 7.1, residual stress test, cut section Brinell Hardness test and tensile test, fail in impact test, two more sets of impact test pieces shall be taken from two wheels of the same lot which has given the defective impact test results for repeat tests. The lot shall be accepted if the results of these repeat tests are satisfactory on both the wheels. Should the repeat impact tests not prove satisfactory, the manufacturer may, with the concurrence of the purchaser or the inspecting officer, reheat treat the lot and present it again for Brinell Hardness tests of Clause 7.1, residual stress test, cut section Brinell Hardness test, tensile test and impact test

with double the sample size as mentioned in Clause 6.2. Should the sample fail in any of these tests, the lot shall be rejected. If the results of these repeat tests prove satisfactory, the lot from which the wheels were selected shall be accepted.

- 13.6** Should the sample of the lot which has passed Brinell Hardness tests of Clause 7.1, residual stress test, cut section Brinell Hardness test, tensile test, and impact test fail in microstructure, the manufacturer may, with the concurrence of the purchaser or the inspecting officer, reheat treat the lot and present it again for Brinell Hardness tests of Clause 7.1, residual stress test, cut section Brinell Hardness test, tensile test, impact test and microstructure with double the sample size as mentioned in Clause 6.2. Should the sample fail in any of these tests, the lot shall be rejected. If the results of these repeat tests prove satisfactory, the lot from which the wheels were selected shall be accepted.
- 13.7** In Para 13.1 to 13.6, reheat treatment has been allowed as a correction measure for getting correct values of any particular property in which wheels may have failed. However, any particular lot shall not be reheat treated more than twice to meet the full requirement of this specification.
- 13.8 Surface condition after reheat treatment subsequent to final machining:** It is preferable to conduct the destructive tests before machining of the lot so as to avoid damage to the machined surface if reheat treatment is done. Reheat treatment on machined wheel, if permitted, shall be carried in such a manner that there is no loose scale formation. Only adherent oxide film should form. With such adherent film formation, no machining or other mechanical operation is required, discoloration of machined surface notwithstanding.

#### **14. NORMAL AND TIGHTENED INSPECTION**

Tests on the wheels shall be carried out either in normal or in tightened manner.

- 14.1 Normal inspection:** In normal inspection, the sample size shall be as per Clause 6.2 and retests as per Clause 13 may be permitted.
- 14.2 Tightened inspection:** In tightened inspection, the sample size shall be double the size mentioned in Clause 6.2 and no retest shall be permitted.
- 14.3** The following criteria shall be applied for changing from normal to tightened inspection and vice versa.
- a. If, while on normal inspection, 2 out of 5 (or less) consecutive lots have been rejected or have been accepted after one or more retests as per Clause 13, change over to tightened inspection.
  - b. If, while on tightened inspection, 5 consecutive lots have been accepted, change over to normal inspection.

#### **15. ULTRASONIC TESTS**

All the wheels conforming to the stipulation of the above-mentioned clauses shall be subjected to ultrasonic testing and only those passing the test shall be accepted. Ultrasonic testing will be done after final heat treatment and machining operations. The method of testing and acceptance standard shall be as given in Appendix "A".

#### **16. MAGNETIC PARTICLE TESTS**

All the wheels shall be tested by magnetic particle method to ensure soundness of the wheels at web region. Magnetic particle testing shall be done after final heat treatment and machining operations. Both sides of the wheel web (plate) shall be inspected through this method. The method of testing and acceptance standard shall be as given in Appendix "B".

## 17. ADDITIONAL TESTS

- 17.1 The purchaser or inspecting authority may, in case of reasonable doubt, also resort to other forms of testing as mutually agreed to between the purchaser or inspecting authority and the manufacturer is to satisfy that the wheels are free from defects of any kind.
- 17.2 **Fracture toughness at rim:** The test shall be carried out in accordance with ASTM standard E: 399. Five test samples shall be taken from points evenly distributed over the whole rim and as shown in Fig. 3. The fracture toughness value at  $25 \pm 5^\circ\text{C}$  under consideration shall be the value  $K_Q$ . The average value calculated from the 5 measurements of  $K_Q$  shall be minimum  $60 \text{ MPa}\sqrt{\text{m}}$  with no individual value below  $50 \text{ MPa}\sqrt{\text{m}}$ .
- .1 The above test at Clause 17.2 shall be carried out, when a supplier is supplying this type of wheel for the first time to Indian Railway or when specifically mentioned in the contract by the purchaser and shall be generally applicable to the bulk suppliers each supplying more than 2,500 wheel discs in a contract. The fracture toughness test will be conducted for every 10,000 wheel discs. If the manufacturer does not have the requisite facility to carry out this test, the services of any reputed agency as agreed by the purchaser / inspecting authority can be availed of.
- 17.3 **Balancing Test:** The test specimen shall consist of the finished wheel. This test shall be applicable only in case it is specified in the drawing/ purchase order, and will require to be done in all such wheels.

## 18. INSPECTION

- 18.1 The inspecting officer or the purchaser shall have free access to the works of the manufacturer at all reasonable times; he shall be at liberty to inspect during any stage of manufacture and to reject any material not conforming to the terms of this specification. The inspecting officer or the purchaser shall have the authority to mark all the rejected wheels in an easily distinguishable manner so that such wheels cannot be recycled / re-offered for inspection in subsequent lots.
- 18.2 The purchaser or the inspecting officer reserves the right to be present at, and take part as he deems fit, in all analysis and other chemical and physical examinations / tests which the manufacturer may carry out, either for his own purpose or under the terms of this specification, on the wheels as well as on their materials, during all stages of manufacture.

## 19. TESTING FACILITIES

The manufacturer shall supply, free of charge, the material required for testing, and shall, at his own cost, furnish & prepare necessary test pieces and supply labour & appliances for such testing as may be carried out at his premises in accordance with this specification. In case the manufacturer fails to provide facilities for conducting the prescribed tests at his works, he shall bear the cost of carrying out the tests elsewhere.

## 20. PROTECTION

After inspection and approval, the wheels shall be carefully cleaned of all rust and protected with one coat of mineral oil to IS: 1154<sup>6</sup> (latest version) or red oxide primer or any other protective coating as agreed to between the purchaser and the supplier. Effective protection of finish machined parts of the wheels against impact damage during transit shall be ensured by the supplier before dispatch.

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<sup>6</sup> Temporary corrosion preventive, fluid, soft film, solvent deposited, water displacing

**METHOD OF ULTRASONIC TESTING & ACCEPTANCE STANDARD  
FOR LOCOMOTIVE WHEELS  
(Clause 15)**

For detecting internal discontinuities in the rim and hub of the wheel, ultrasonic inspection shall be carried out by following the procedure shown below and by using equipment which complies with the following requirements. Reference standard used for sensitivity setting shall be from wheels conforming to this standard. The surface finish of probing face shall be in accordance with the relevant wheel drawing. The ultrasonic inspection shall be performed after final thermal and machining operations.

#### **A-1 ULTRASONIC TESTING ON WHEEL RIM**

The rims of the wheels shall be checked through ultrasonic inspection to detect the defects at two orientations:

- i. Defect parallel to the rim face (axial testing)
- ii. Defect parallel to the running tread (radial testing)

##### **A-1.1 AXIAL TESTING**

All wheels shall be subjected to ultrasonic testing of rim through probing axially along the rim face to detect any flaw having orientation parallel to the rim face.

##### **.1 Equipment**

- .1 Automatic ultrasonic testing equipment shall be used. The instrument shall have a pulse echo transmitter & receiver and shall have an operating frequency range of 2 to 5 MHz. The manufacturer shall have on-line test facility to inspect 100% wheels. For determination of final rejection, manual ultrasonic equipments approved by the purchaser may be employed.
- .2 The transducers shall be of normal (0 degree) type comprising of high sensitivity Piezo electric ceramic crystal operating at 2 to 2.5 MHz frequency and of 18-20 mm diameter.
- .3 An automatic flaw alarm system shall be used in conjunction with the ultrasonic instrumentation to facilitate flaw indication beyond acceptable level.
- .4 An immersion or contact type testing technique shall be used in automatic on-line testing. For manual testing of suspect wheels, a suitable couplant shall be used between the test surface and the transducer. In case of dispute in respect of couplant, the decision of the inspecting officer shall be final and binding.
- .5 **Calibration block:** 50mm x 50mm x 50mm block of steel to grade 45C8 of IS:1875 <sup>7</sup> shall be used. Alternatively, this calibration block can be made of portion of the heat-treated wheel of steel grade conforming to the specification IRS R-34.
- .6 **Standard reference piece:** Standard reference piece shall be from a portion of the wheel having a 3mm diameter flat bottom hole drilled perpendicular to the rim face and to a depth of  $25 \pm 2$ mm at the mid thickness of the rim (Fig 4.1).
- .7 **Alternate reference piece:** Alternate reference piece shall be from a portion of the wheel having a small diameter hole of diameter 3mm drilled at a distance from the testing surface equal to the depth of the hole indicated in A-1.1.1.6 (Fig. 4.2). The instrument shall be adjusted to give an equal test value to that of a 3mm diameter flat bottom hole.

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<sup>7</sup> Carbon Steel billets, blooms, slabs and bars for forgings

## .2 Calibration

- .1 **Time base:** Set the time base of ultrasonic flaw detector using 0 degree longitudinal wave with the help of calibration block as mentioned in Para A-1.1.1.5. Three multiple echoes will be observed.
- .2 **Sensitivity setting:** Sensitivity setting shall be done with the help of standard wheel piece (Fig. 4.1). Gain level should be adjusted to produce 60% height from the reference standard as mentioned in Para A-1.1.1.6.
- .3 Alternatively, sensitivity setting shall be done with the help of an alternate reference piece as mentioned in Para A-1.1.1.7 (Fig. 4.2) and shall be used only with the specific approval of the purchaser.
- .4 Reference standard for the inspection of heat-treated wheels shall be fabricated from heat-treated wheels.

## .3 Scanning

- .1 Wheels shall be inspected axially from either the outside or inside rim face by automatic scanning (Fig. 4.1 and 4.2). For determining acceptance or otherwise, probing from both sides may be carried out.
- .2 The speed of scanning shall permit efficient detection of the reference standard discontinuities.

## .4 Rejection criteria

- .1 Any wheel with a flaw indication equal to or larger than 60% of the full-scale height shall be rejected. If more than 3 defects of amplitude 20% or above are observed, the wheel shall be rejected. If two defects of amplitude 20% or above are observed, and if these defects are closer than 50 mm, the wheel shall be rejected.
- .2 Ultrasonic indications that result from wheel geometry or spurious signal shall not be valid cause for rejection. The judgement of the inspecting officer shall be final and binding in this respect.
- .3 The final disposal of rejection of wheels may be determined by manual testing of disputed areas. The surface finish of rim of reference standard will be almost same as that of wheels tested manually by contact probing.

## A-1.2 RADIAL TESTING

All wheels will be subjected to ultrasonic testing of rim through probing circumferentially along the tread surface to detect any flaw having orientation parallel to the tread surface.

### .1 Equipment

- .1 Equipment shall be same as described in Clause A-1.1.1.
- .2 **Calibration Block:** 50x50x50mm block of steel to grade 45C8 of IS: 1875 shall be used. Alternatively, this calibration block can be made of portion of the heat-treated wheel of steel grade confirming to the specification IRS R-34.
- .3 **Standard reference piece:** Reference piece shall be from a portion of new wheel having 3mm diameter flat bottom hole drilled from opposite to tread surface (Fig. 5) to depth of 20mm.

### .2 Calibration

- .1 **Time Base:** Set the time base of ultrasonic flaw detector using 0 degree longitudinal wave with the help of calibration block as mentioned in Para A-1.2.1.2. Three multiple echoes shall be observed.

.2 **Sensitivity setting:** Sensitivity setting shall be done with the help of standard wheel piece as mentioned in Para A-1.2.1.3 (Fig.5). Probing shall be done from the tread opposite to flat bottom hole and the gain level shall be adjusted to produce an echo of 60% height of vertical scale of CRT. This gain level shall be reference gain for acceptance or otherwise for the wheel.

### .3 Scanning

Increase the gain level by 6dB over and above the gain level described at Para A-1.2.2.2. Apply couplant on the tread surface, place the probe on this face and scan entire circumference on the wheel in case of contact type automatic scanning equipment. For immersion type of equipment, the wave propagation shall be through the liquid used for immersing the wheel. No back echo will appear. Care shall be taken during probing to cover full width of the tread. In case a flaw signal is observed, reduce the gain by 6dB.

### .4 Rejection criteria

Any wheel with a flaw indication equal to or larger than 60% of the full-scale height shall be rejected. If more than 3 defects of amplitude 20% or above are observed, the wheel shall be rejected. If two defects of amplitude 20% or above are observed and if these defects are closer than 50 mm, the wheel shall be rejected.

.5 The final disposal of rejection of wheels may be determined by manual testing of disputed areas. The surface finish of tread of reference standard shall be almost same as that of wheels tested manually by contact probing.

## A-2 ULTRASONIC TESTING ON WHEEL HUB

Only such wheels, which pass ultrasonic test for the rim, shall be subjected to ultrasonic testing of hub.

### A-2.1 EQUIPMENT

Equipment shall be the same as used for ultrasonic testing of the rim portion of the wheels, suitably calibrated for hub thickness. However, manual testing of hub will be permitted.

For hub testing, the back wall echo shall be adjusted to full screen height using a wheel hub free from internal discontinuities.

Surface finish of reference piece shall be similar to wheels tested if manual testing is resorted to.

### A-2.2 REJECTION CRITERIA

1. Any wheel with a flaw indication equal to or larger than 60% of the full-scale height shall be rejected. If more than 2 defects of amplitude less than 60% and greater than 20% are observed, the wheel shall be rejected. If two defects of amplitude less than 60% and greater than 20% are observed, and if these defects are closer than 50 mm, the wheel shall be rejected.
2. Where there is a partial suppression of the back echo and flaw echo is also absent, the back echo shall not be less than 30% of the full screen height without change of testing parameters.

## A-3 MARKING

Wheel conforming to the above ultrasonic stipulations shall be stenciled "UT" on the back plate with red colour paint using characters at least 25 mm in height or at such locations as may be shown on the drawing or specified by the purchaser.

**METHOD OF MAGNETIC PARTICLE TESTING & ACCEPTANCE STANDARD  
FOR LOCOMOTIVE WHEELS**

(Clause 16)

**B. MAGNETIC PARTICLE TESTING**

**B.1 PURPOSE**

To supplement visual inspection of the surface of new wheels by detecting discontinuities which may be harmful to wheel in service.

**B.2 SCOPE**

This test method covers the wet fluorescent magnetic particle inspection of plates of the wheels ordered to this specification.

**B.3 EQUIPMENTS**

**.1 Magnetizing Apparatus**

The magnetizing apparatus shall be on line and shall be capable of inducing suitable magnetic fields within the entire plate area of the wheel to facilitate the disclosure of both circumferentially and radially oriented discontinuities. The magnetizing currents used shall be large enough to induce magnetic fields of sufficient intensity to disclose surface discontinuities 0.3 mm in depth. Any non-metallic entrapment on surface shall also get detected.

**.2 Lighting Apparatus**

The inspection shall be performed in a darkened booth with the area of the wheel to be inspected illuminated with properly filtered black light. The black light shall have a predominant wavelength of 4,000 to 3,400 angstrom units and the intensity of the black light, measured at the surface to be inspected, shall be a minimum of 75 foot-candles at point of inspection.

**.3 Inspection Medium**

.1 The bath or solution shall be prepared using a suitable carrier fluid & fluorescent magnetic particles and renewed monthly or more often if contamination is noted in weekly tests. Each time the bath is renewed, the bath container shall be cleaned out and the agitation & circulation system should be flushed with 5 to 8 litres of clean carrier. Filtering screens shall be removed and cleaned by blowing with air. In preparing the new bath, only recommended materials shall be used. The amount of powder shall be carefully weighed out in accordance with the material manufacturer's recommendation and the powder shall be directly added to the bath containing the correct amount of carrier. It is recommended that powder be added directly over the sump so that it shall be drawn quickly into the pump and circulated. The amount of carrier & powder used and the date of preparation shall be recorded on a regular form set up for this purpose, as outlined in paragraph B.3.3.6.

.2 Concentration and contamination of the bath solution shall be tested weekly as follows:

The pump and agitation system shall be operated for 20 minutes and then solution should be run through hose and nozzle for 30 seconds. Using a regular 100 ml centrifuge tube, fill the centrifuge tube with 100 ml of the solution. Allow bath solution to settle for the time recommended by the manufacturer of the type of powder used making sure that the tube is not subjected to excessive vibration during the settling



period. Each horizontal division represents 0.1 ml and correct reading in volume of particles shall be as stipulated by the powder manufacturer. Check shall also note contamination due to dirt, chips or other foreign matter settling with the powder. Contamination is also indicated when the carrier appears to acquire more than usual fluorescence or when the magnetic particles appear to have lost fluorescent qualities. This condition can be readily observed when the settling tube is exposed to ultraviolet light. The readings obtained are to be shown on the regular report form as outlined in paragraph B.3.3.6.

- .3 The ultraviolet light shall be tested weekly using a light meter, such as a type having foot candle scale with 10X multiplying disc or equivalent or a meter that responds specifically to the ultraviolet range of 3,650 angstrom units (365 nanometers). The latter type meters are calibrated in microwatts per square centimetre. The meter shall be held at a fixed distance of 380 mm from the light source (from black light filter surface to meter sensing element) and shall have a minimum meter reading of 525 microwatts per square centimetre.
- .4 The conversion factor from foot candles (for light meters) to microwatts per square centimetre is 5.7 times the foot candle reading (at 380 mm distance).
- .5 The maximum allowable foot candles shall be left to the discretion of the user depending on the degree of brilliance desired to obtain satisfactory inspection conditions. Before taking reading, it shall be ensured that the glass black light filters are clean. Reports of this test shall be shown on regular form as outlined in paragraph B.3.3.6.
- .6 A regular form shall be prepared embodying the information to be shown on monthly and weekly tests as outlined above and this form shall be on hand at the wheel shop and available to inspectors.

#### **.4 Preparation for Inspection**

The surface shall be scale free before magnetic particle inspection. The wheels shall be in machined condition.

#### **.5 Detection of Discontinuities**

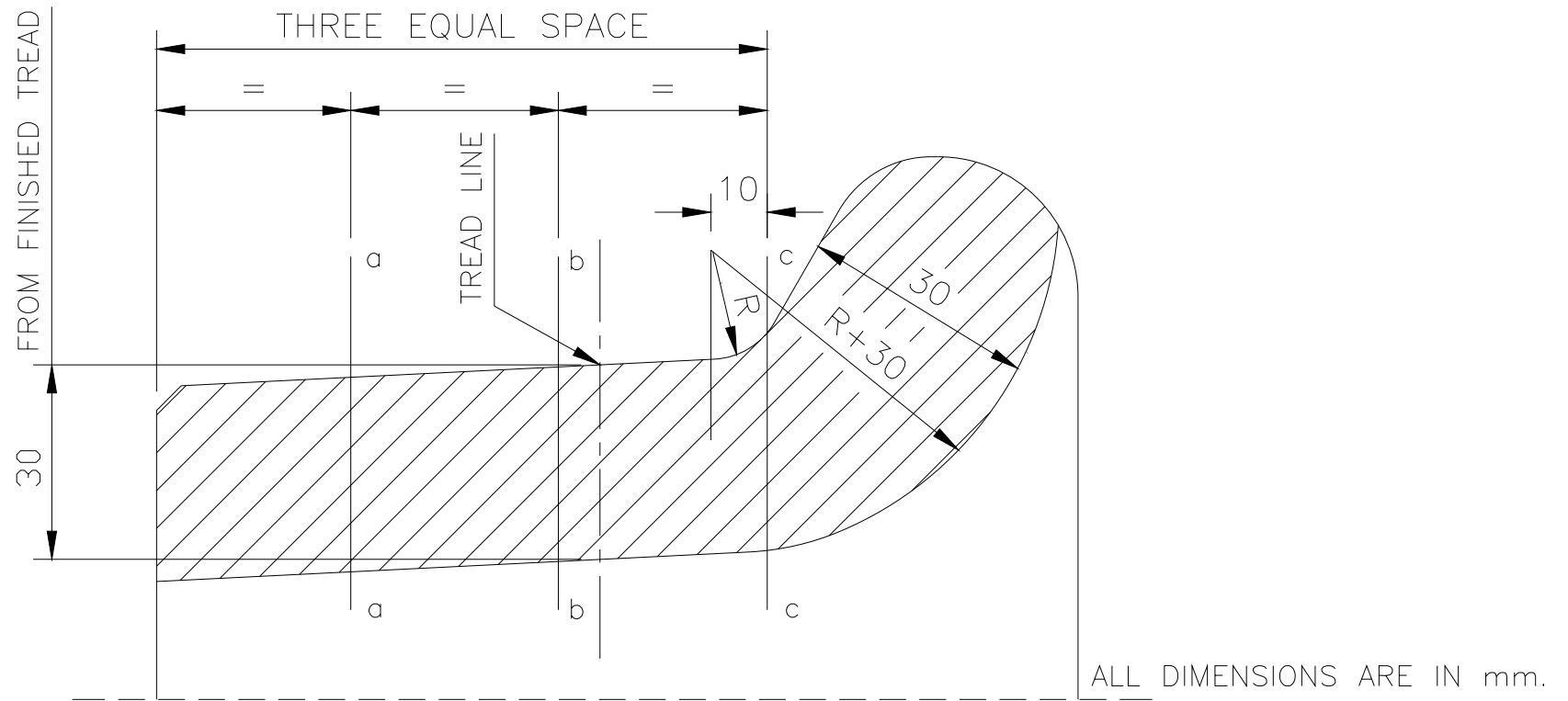
This inspection shall be performed to detect discontinuities whose axes may be in any direction. Continuous or residual magnetization shall be used with adequate coverage by the inspection medium.

#### **.6 Time of Inspection**

The magnetic particle inspection shall be performed following final machining. A wheel / wheels with standard defects will be run at start of the shift to see that detection system is functional.

#### **.7 Rejection**

Discontinuities may be removed by machining or grinding where sufficient stock remains. Such wheels shall be retested by magnetic particle inspection. Wheels where spot grinding has to be resorted to, shall be so ground that the area ground is at least 10 times the depth to avoid deep pit formation. The edges of the ground area shall be smooth and rounded. Maximum depth of grinding is 3mm. However, it shall be ensured that after grinding, the minimum dimensions at any spot are within the stipulated dimension in the wheel drawing. The wheel which has crack(s) which could not be removed even after grinding upto a depth of 3mm shall be rejected. If entrapment material is seen even after grinding to a depth of 3mm, wheel shall be rejected. If a crack is seen on bore, the wheel may be allowed to be bored upto allowable maximum bore and again put up for magnetic particle inspection.



The Brinell Hardness Number measured at a depth of 30 mm from tread surface (end of shaded area) shall not be less than 300 BHN. On lines a-a, b-b & c-c, the hardness should smoothly and proportionately increase in vertical direction upto 341 BHN from 300 BHN (minimum) measured at the depth of 30 mm from tread surface in the shaded zone.

**Fig. 1**

SKETCH SHOWING THE HARDENED ZONE FOR MONO-BLOCK WHEELS TO IRS R-34

(Refer Clause 7.2)

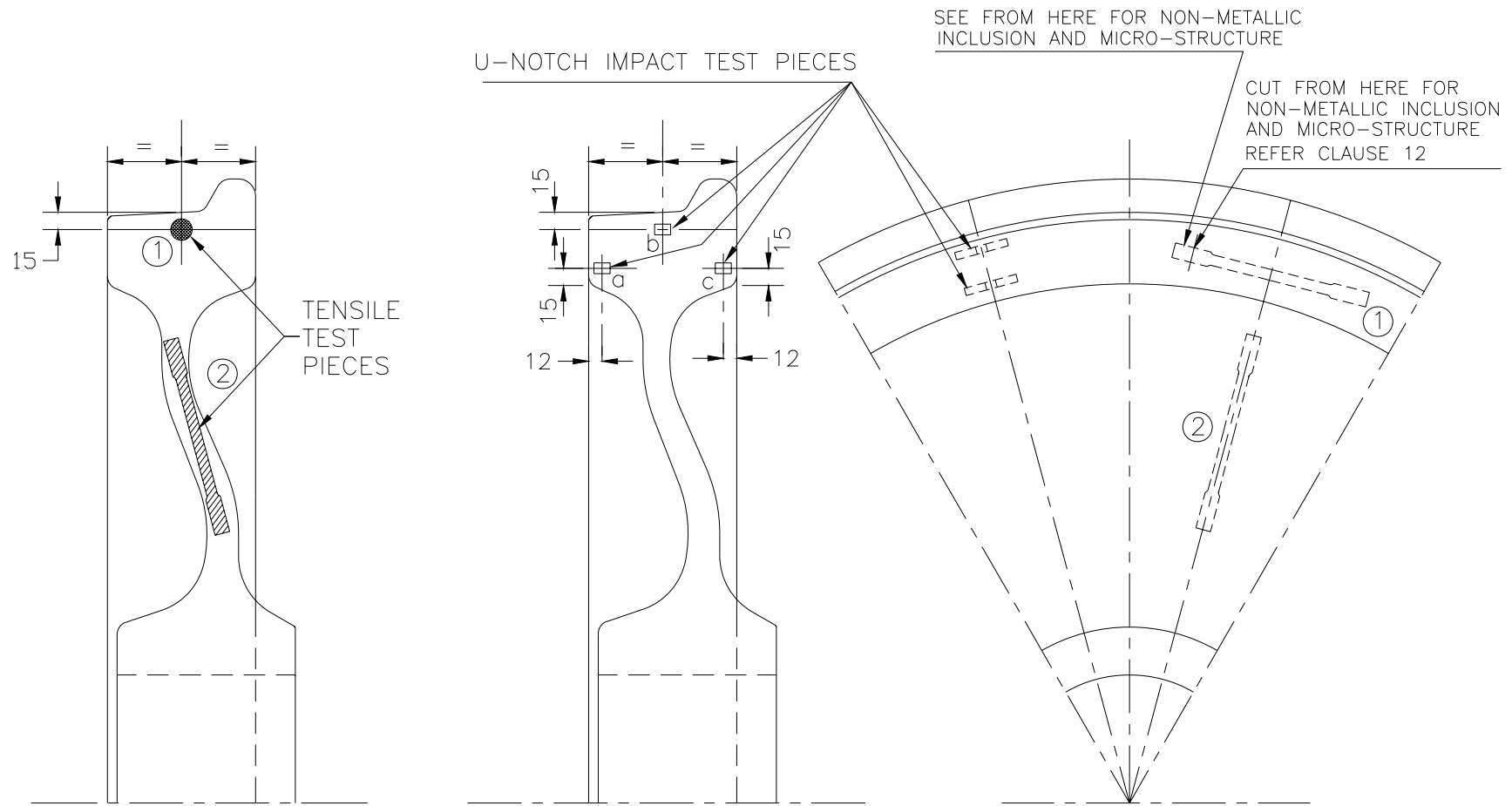
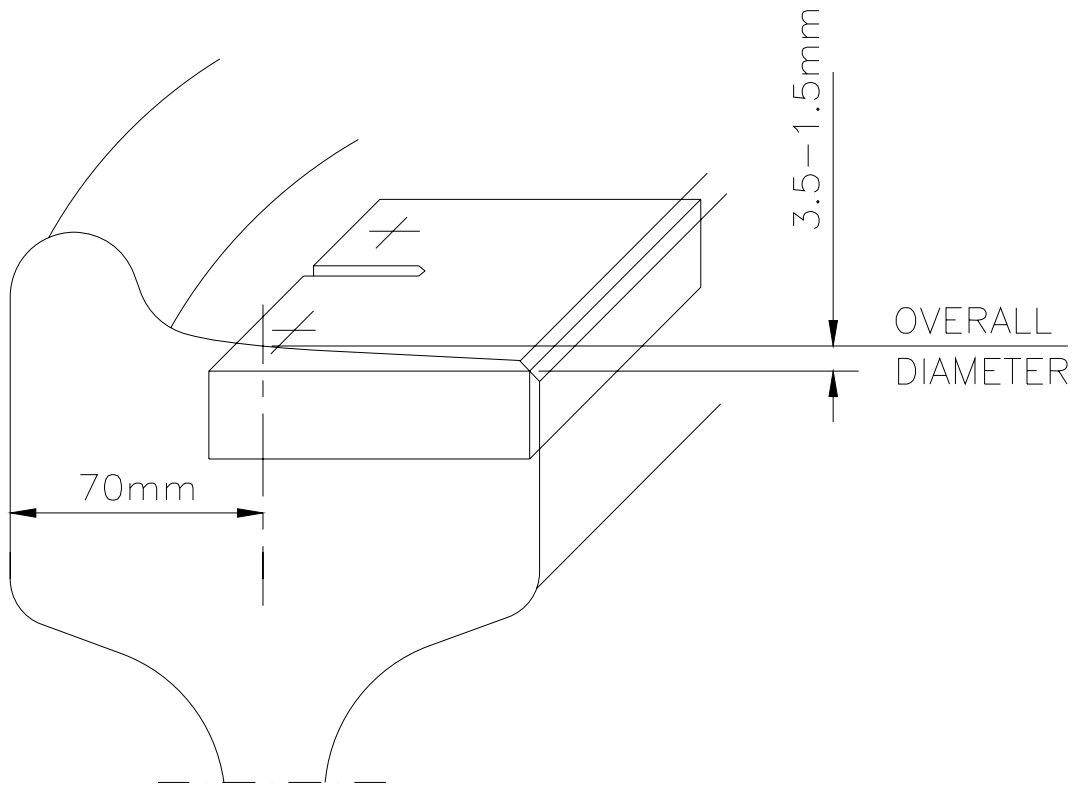


Fig. 2

POSITION OF TENSILE, IMPACT AND INCLUSION TEST PIECES

(Refer Clauses 9.1, 11 & 12)



**Fig. 3**

LOCATION OF SAMPLE FOR FRACTURE TOUGHNESS TEST

(Refer Clauses 17.2)

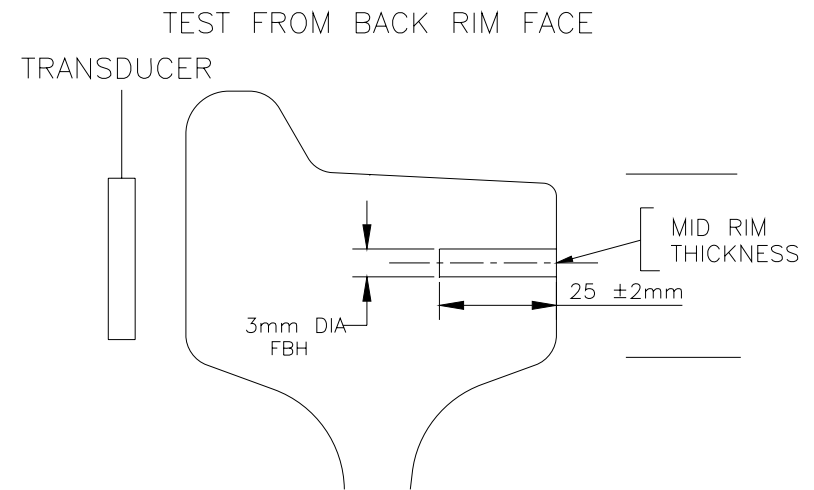
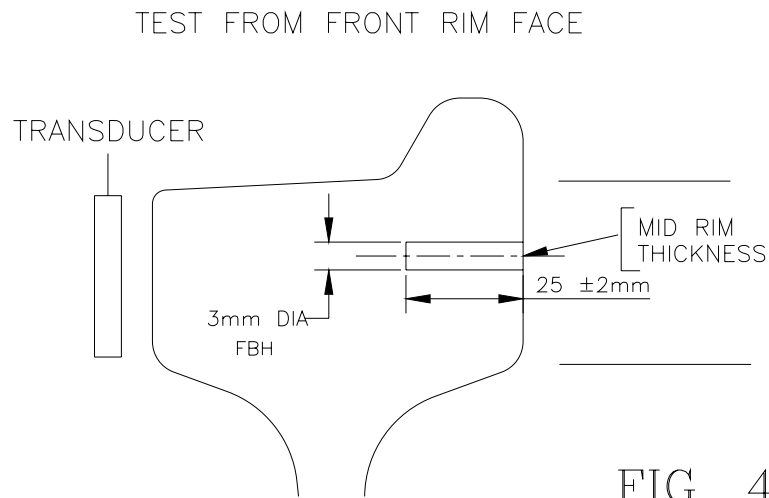


FIG. 4.1

REFERENCE STANDARD (REFER CLAUSE A-1.1.1.6)

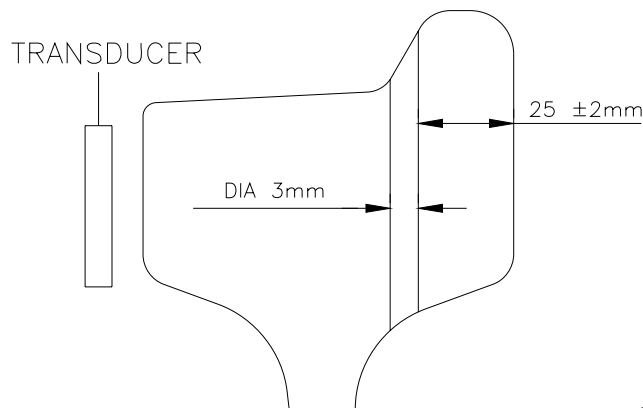


FIG. 4.2

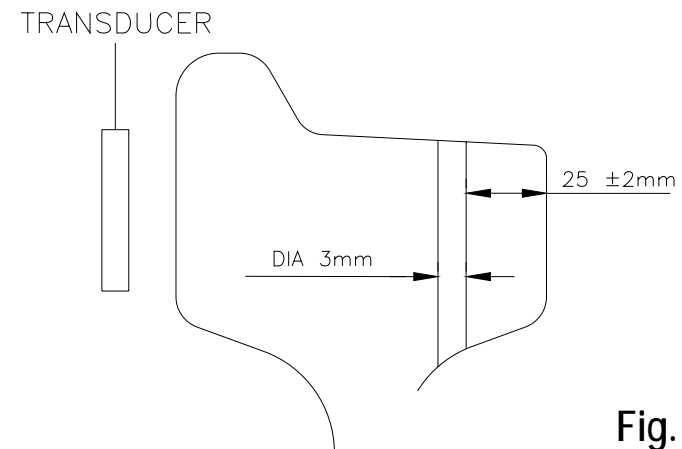
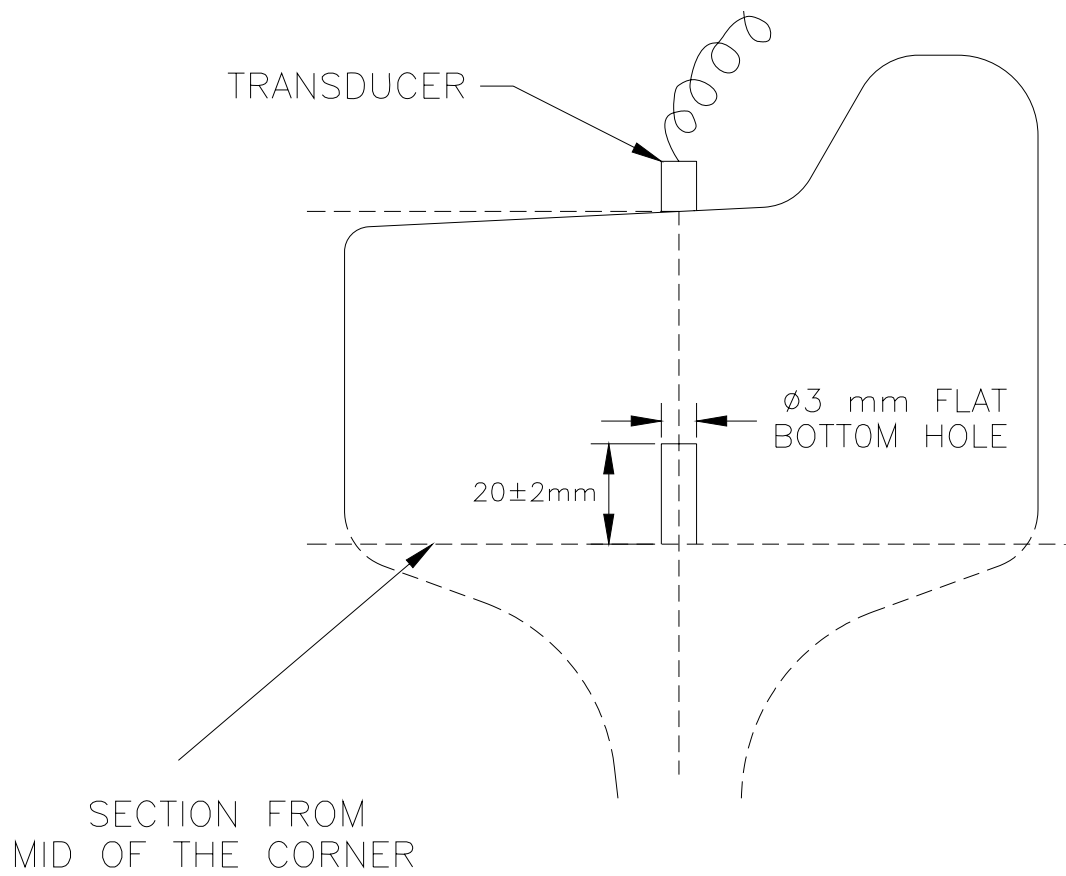


Fig. 4

ALTERNATE REFERENCE STANDARD  
(Refer Clauses A-1.1.1.7)



**Fig. 5**

REFERENCE STANDARD FOR RADIAL PROBING  
(Refer Clauses A-1.2.1.3)

DDO-208

MANUFACTURER'S NAME CODE  
(MAXIMUM 2 ALPHANUMERICAL CHARACTERS TO BE ALLOCATED BY THE AUTHORITY RELEASING PURCHASE ORDER.)

MANUFACTURER'S CAST NO. AND/OR SERIAL NO. TO UNIQUELY IDENTIFY THE WHEEL  
(MAXIMUM 8 DIGITS)

CODE FOR THE PARTICULAR CONTRACT TO BE ALLOCATED BY THE AUTHORITY RELEASING PURCHASE ORDER  
(MAXIMUM 4 ALPHANUMERICAL CHARACTERS)

ABBREVIATED DRG. NO.  
(MAXIMUM 5 CHARACTERS)  
(ABBREVIATED NUMBERS TO BE INDICATED OMITTING THE FIRST CLUSTER OF ALPHABETS AND ANY '/' & '-'. AS FOR EXAMPLE FOR DRG. NO. D/WL-4948/R MENTION ONLY '4948R')

**NOTE:-**

- 1) STAMP ON OUT SIDE HUB FACE OF WHEEL.
- 2) NOMINAL HEIGHT OF THE LETTERS TO BE 10mm.
- 3) DEPTH OF IMPRESSION SHOULD BE 2.0 mm(MAX.) WHEN HOT STAMPING IS DONE AND 1.0 mm (MAX) WHEN COLD STAMPING AFTER MACHINING IS DONE. BRANDING PARTICULARS SHALL BE CLEAR AND LEGIBLE.
- 4) ITALICISED CHARACTERS (SLOPING UPWARD TO RIGHT) SHALL BE USED.
- 5) STAMPING TO BE SPACED A MINIMUM OF 3.2mm BETWEEN CHARACTERS AND 35 mm BETWEEN GROUPS. STAMPING SHALL BE AT A DISTANCE OF 12<sup>±</sup> mm FROM THE OUTER EDGE OF HUB.
- 6) STAMP WITH ROUNDED EDGE LETTERS SHALL ONLY BE USED.
- 7) STAMPING MAY BE EITHER HOT STAMPING BEFORE HEAT-TREATMENT OR COLD STAMPING AFTER MACHINING. STAMPING BY LOCALISED HEATING IS PROHIBITED.
- 8) ANY OTHER INFORMATION AS DEEMED NECESSARY BY THE MANUFACTURER OR PURCHASER/INSPECTOR SHALL BE STENCILLED ON THE BACK PLATE WITH RED PAINT USING CHARACTERS AT LEAST 25 mm IN HEIGHT.

TOLEANCES ON UNTOLEANCED DIMENSION TO IS:2102 (COARSE) SURFACE ROUGHNESS VALUE TO IS:3073

GRADE NO.	N1	N2	N3	N4	N5	N6
Raum	0.25	.05	0.1	0.2	0.4	0.8
SYMBOL	VVVV			VVV		

GRADE NO.	N7	N8	N9	N10	N11	N12
Raum	1.6	3.2	6.3	12.5	25	50
SYMBOL	VV		V		S	

**WHEEL MARKINGS**

REFERENCE: SK.DL-46

(1)	L2-999	DRG. REVISED AND REDRAWN	04.05.09	RDSO
ALT. NO.	REF. LETT.	DESCRIPTION	DATE	AUTH.
			INDIAN RLYS RDSO (MP)	DRG. NO. <b>DDO-208</b>

D	Duty	APPD	B. Mandal	DI	SEPTEMBER, 08
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