TECHNOLOGY MANAGEMENT

PROCEDURE RS/ME/SP/021 REV 8

TRANSNET FREIGHT RAIL SPECIFICATION FOR THE SUPPLY OF WROUGHT WHEELS FOR TRACTIVE AND TRAILING STOCK

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Schedule of Amendments

Section amended	Description	Revision number	Date issued
5.1.1	Revised mechanical loading diagram, mechanical loading is to be done according to the latest UIC 510-5 standard.	7	07/2015
4.1.2	Added paragraph on the re-qualification of manufactures that have not supplied in 5 years.	8	01/2017
5.1.2	Changed Thermal loading requirements to be done in accordance with UIC 510-5. Both Drag braking and fracture tests are to be conducted.	8	01/2017
5.1.3	Added section on the combination of Drag braking and mechanical loading results.	8	01/2017
5.4	Addition of a section on the determination of fatigue characteristics by conducting an accelerated fatigue tests.	8	01/2017
8.3.3	Removed section on the range of hardness on rim adhering throughout the lifetime of the wheel.	8	01/2017
8.3.3	Changed minimum hardness value for class B wheels from 277 to 302 Brinell hardness	8	01/2017

1 SCOPE

This specification covers the requirements for the supply of wrought steel wheels for tractive and trailing stock manufactured from ingots or continuous cast blooms for both 34 and 36 inch wheels. The 34 inch wheel size will be restricted to a maximum of 22 ton axle load, whilst the 36 inch wheel size will be restricted to a maximum of 32.5 ton axle load.

2 REFERENCES

BS EN ISO 6892-1: (latest revision): Tensile testing of metallic materials-Method of test at ambient temperature.

BS EN ISO 148-1 (latest revision): Charpy impact test on metallic materials-Test method (V- and U-notches).

ASTM E112-88 (latest revision): Standard test method for determining average grain size.

ISO 643 (latest revision): Micrograph determination of the ferritic or austenitic grain size.

ASTM E837 (latest revision): Determining residual stresses by the hole drilling strain gage method.

ASTM E340 (latest revision): Standard test method for macro-etching metals and alloys.

BS EN ISO 6506-1(latest revision): metallic material Brinell hardness test method

BS EN ISO 6506-2 (latest revision): Metallic materials- Brinell hardness test- part 2: Verification and calibration of testing machines.

ASTM E45 and ISO4967 (latest revision): Standard practice for determining the inclusion content of steel.

RS/ME/PR/061(latest revision): Ultrasonic testing procedure for internal, surface and sub-surface defects in new wrought and solid cast steel wheels.

RS/ME/PR/062(latest revision): Magnetic particle inspection procedure new wrought and solid cast steel wheels.

ISO 1005-6 (latest revision): Solid wheels for tractive and trailing stock- Technical delivery conditions.

AAR M107/M208 adopted (latest revision): wheel and carbon steels

UIC 510 – 5 O, (latest revision): Technical approval of solid wheels

BS EN 13262 (latest revision): Railway applications Wheel sets and bogies — Wheels — Product requirements

3 DEFINITIONS

The following definitions apply for the purposes of this specification.

3.1 Manufacturer

Any persons, body corporate or body incorporate who have contracted to supply wheels to TRANSNET FREIGHT RAIL subject to the requirements of this specification.

3.2 Melt or heat

The product of a single furnace charge

3.3 Strand

The product of a single continuous casting operation

3.4 Bloom

A bloom is a continuous cast strand that has been cut into shorter lengths. Cylindrical shaped blooms are preferred.

3.5 Cast

A cast is the Ingots or blooms that are the product of a single ladle. If a melt or heat is tapped into 2 or more ladles, then the ingots or blooms that are the product of each ladle are to be considered as separate casts.

3.6 Heat treatment batch

The product of a single heat treatment cycle where batch heat treatment is applied

3.7 TRANSNET FREIGHT RAIL Quality Evaluation Committee

The committee will consist of at least the following members.

a) VIT (Wheels and Axles) member, TRANSNET FREIGHT RAIL, Rolling Stock.
b) A representative from Quality Assurance, TRANSNET FREIGHT RAIL, Engineering (Rolling Stock).
c) VIT (Non-destructive Testing) member, TRANSNET FREIGHT RAIL, Engineering (Rolling Stock)

4 QUALIFICATION AS A MANUFACTURER

4.1 Qualification as a manufacturer of wheels that are to be used by TRANSNET FREIGHT RAIL must be approved by the TRANSNET FREIGHT RAIL Quality Evaluation Committee. Qualification is effective until revoked by TRANSNET FREIGHT RAIL. The cause of revocation is the failure of the manufacturer to maintain the requirements of this specification. The manufacturer is unconditionally approved for a period of five years, thereafter Transnet reserves the right to re-audit the manufacture's facility or conduct tests on wheels prior to commencement of the new contract.

4.2 Manufacturers that have been previously approved by Transnet Freight Rail but have not supplied for 5 years or more must be re-qualified. The manufacturers have to conduct an accelerated fatigue test and the Transnet Freight quality evaluation committee will conduct a re-audit of the manufacturer facilities provided the wheel design has not changed.

5 WHEEL DESIGN

5.1 Requirements and objective

Technical approval of all designs not previously evaluated or utilised in TRANSNET FREIGHT RAIL service is required. It is required from the manufacturer to provide a detailed stress analysis of the proposed wheel design in accordance with the guidelines and requirements as laid out in the latest UIC 510-5 O code. The objective is that the TRANSNET FREIGHT RAIL Quality Evaluation Committee evaluates the analysis results so that the in-service behaviour of that wheel may be predicted. The computations must be accurate and reproducible, regardless of where and by whom they are made.

5.1.1 Mechanical loading conditions

All loading conditions must be done according to the latest UIC 510-5 standard. All stress analysis and loading conditions are to be reported

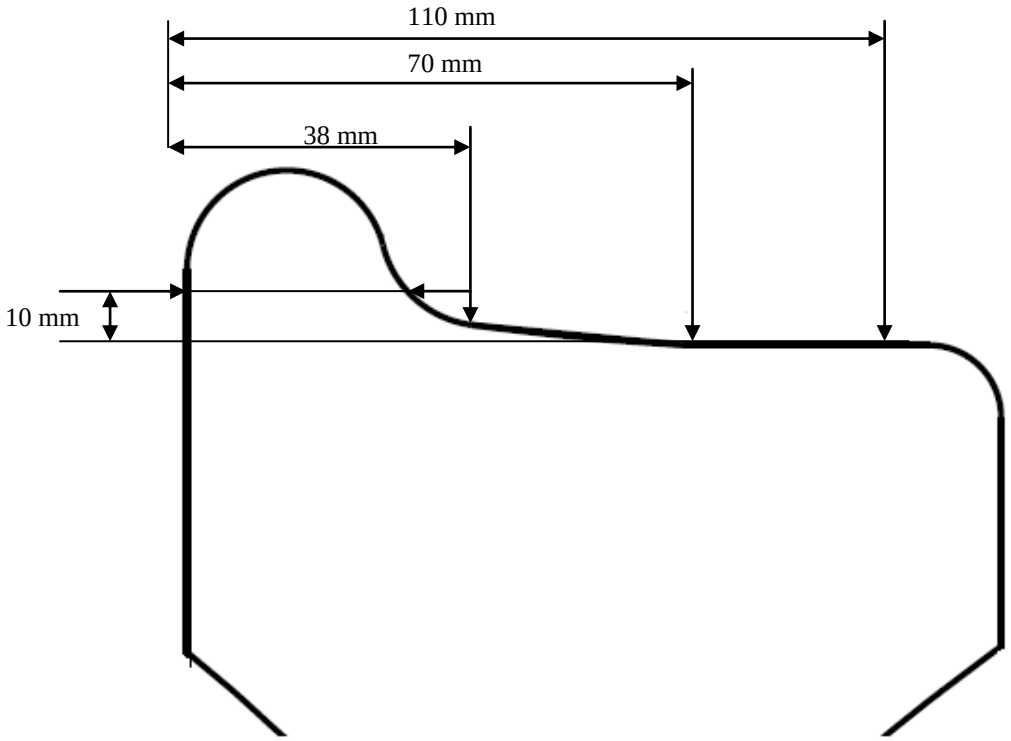

Figure 1: Loading positions on the tread and flange

5.1.2 Thermal loading condition

The influence of thermal input as a result of braking with composite brake blocks (tread braking) on the stress situation of the wheel must be measured. An isothermic contour plot must be provided with each thermal loading condition. The application of the thermal load must be centred on the taping line of the wheel tread and the width must be 80mm. The following thermal loading tests shall be conducted in accordance with the latest UIC 510-5/BS EN 13979-1 standard.

a) Drag braking on a rig

Ten identical thermal loads at a brake power of 50 KW for 45 minutes, at a speed of 60 km/h shall be accumulated for one wheel.

b) Should the wheel fail the drag braking test, a fracture test on a rig shall be conducted in accordance with the latest UIC 510-5 standard.

5.1.3 Combination of drag braking and mechanical loading results.

A combination of the drag braking results (residual stresses, displacements (hot and cold)) with the individual mechanical loading conditions shall be done to determine the combined effect.

5.1.4 Displacement of the rim

The displacement of the rim as shown by the example in Figure 2 must be calculated for each individual mechanical and thermal loading condition of the wheel.

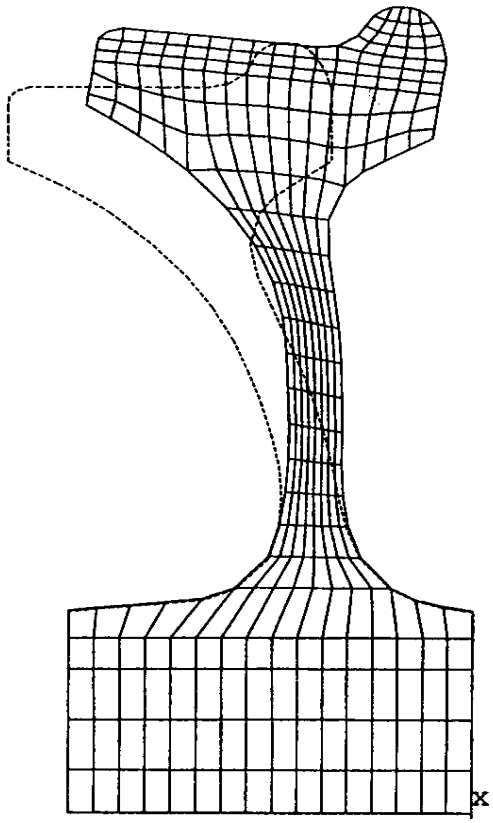

Figure 2 : Example of rim displacement as predicted by finite element analysis

5.1.5 Finite element analysis (FEA)

An FEA approach must be used for the analysis of the wheel design with respect to the mechanical loading, rim displacement, and thermal loading. All assumptions made, material properties used, and boundary conditions used must be stated with the results of the analysis. This includes but is not limited to the following;

- Modulus of elasticity as a function of temperature
- Post yield modulus as a function of temperature
- Yield strength of the rim, web and hub
- Thermal conductivity as a function of temperature
- Specific heat as a function of temperature.
- Thermal strain as a function of temperature.
- Convection coefficient as a function of temperature.
- Is radiation considered
- Is heat transfer to axle considered

5.1.6 Change in the residual stress magnitude and pattern in the rim

The expected change in the residual stress pattern in the wheel rim must be modelled with respect to the mechanical loading, rim displacement, and thermal loading.

5.2 Wheel design

5.2.1 New condition

The design of the wheel rim and wheel hub to be used for the FEA must conform to the requirements in the relevant drawings supplied by TRANSNET FREIGHT RAIL. The design of the wheel web to be used for the FEA must be provided by the manufacturer subject to the requirements of the relevant TRANSNET FREIGHT RAIL drawings for the hub and rim. Detailed drawings of the manufacturer's wheel web design coupled to the relevant TRANSNET FREIGHT RAIL drawings of the rim and hub must be supplied to the TRANSNET FREIGHT RAIL. A full analysis as described under 5.1 must be done for the wheel design in the new condition.

5.2.2 Worn condition

The same wheel design must also be evaluated fully in accordance with the requirements of 5.1 when the wheel rim has reached the condemning limit for rim thickness. The condemning limit for the rim thickness will be supplied by the TRANSNET FREIGHT RAIL Quality Evaluation Committee.

5.3 Responsibility

Once a FEA analysis has been approved by the TRANSNET FREIGHT RAIL Quality Evaluation Committee, then it is the responsibility of the manufacturer to inform TRANSNET FREIGHT RAIL of any change in the conditions used for the approval of the FEA. The manufacturer must demonstrate that the change in condition will remain acceptable. TRANSNET FREIGHT RAIL may require any manufacturer to repeat the FEA analysis in full or in part. Failure by the manufacturer to do so would result in the disqualification as an approved manufacturer. This would imply that wheels would not be accepted from the manufacturer until the requirements of TRANSNET FREIGHT RAIL are adhered to.

5.4 Fatigue characteristics

An accelerated fatigue tests shall be conducted on two as delivered wheels in accordance with BS EN 13262. The accelerated fatigue test shall be conducted prior to the factory audit and in-service/track tests. The radial stress to be used for the test is outlined in the table below.

Table 1: radial stresses for a machined and un-machined web

Symmetrical loading	Un-machined web	Machined web
Radial stress for verification	± 168 N/mm^2	± 240 N/mm^2

6 MANUFACTURE

6.1 Steelmaking process

The wheels must be made from steel produced by the open hearth, electric arc, or basic oxygen processes. The steel must be killed in the furnace or ladle. If the ingot route is to be used, then the steel must be poured into hot-topped ingot moulds. Continuous casting is permitted subject to the approval of the steelmaker that supplies the cast by the TRANSNET FREIGHT RAIL Quality Evaluation Committee.

6.2 Removal of defective sections (discard)

If the ingot route is used, then a sufficient discard must be made from each ingot to ensure freedom from primary and secondary piping, and undue segregation. If the continuous cast route is used, then a sufficient discard must be made from each end of a continuous cast strand to ensure freedom from primary and secondary piping, and undue segregation.

6.3 Reduction of the wheels

6.3.1 Rolling and forging

The wheels must be manufactured from ingots; continuously cast blooms, or rolled or forged ingots and blooms that are capable of producing two or more wheels after the removal of discards.

The sections of ingots or blooms must be forged, pierced, and rough shaped by a hammer or press. The wheels must be finally shaped by rolling or die forging. The final shaping may be supplemented by machining to the required dimensions as specified in the relevant drawings. The surface finish after machining may not exceed 12,5µm R_a.

Precautions must be taken during hot-working to avoid grain growth and defects caused by overheating. As a guideline, hot-working should not exceed 1280ºC and should end between 850ºC and 1000ºC.

6.4 Hydrogen cracking (flaking)

The steel must be vacuum degassed. Slow cooling to below the critical range of the steel following hot-working must be done.

The hydrogen content of the steel must not exceed 3.0 ppm.The supplier should take precaution to prevent hydrogen related cracking on wheels.

6.5 Traceability of the wheels during manufacture

All ingots and blooms must be marked at each manufacturing stage so that each wheel can be identified as specified in clause 7. Where stamped identification marks differ from the final identification marks of the wheel, then they must not be visible on the final wheel.

6.6 Heat treatment

The management of the required heat treatment operations must ensure the uniformity of structure and properties of comparable parts of the same wheel and in all wheels of the same heat treatment batch. Freedom from distortion must also be insured.

6.6.1 Rim quenching and tempering

The wheels must be uniformly re-heated to the proper temperature to refine the grain structure and then the wheel rims must be quenched. The wheels must be charged into a furnace after rim quenching for a tempering treatment. The wheels must be tempered so as to meet the requirements of this specification. The wheels must then be cooled under controlled conditions.

All temperatures must be recorded on correctly calibrated and continuously recording pyrometers. These pyrometers must be placed so as to reflect the true furnace temperatures. The cast numbers and the quantity of wheels must be identified with

the relevant chart. The charts must be retained by the manufacturer for a minimum period of 6 years

The manufacturer must keep records of the withdrawal and loading rates of the wheels for continuous heat treatment processes. These records must include the maximum and minimum furnace temperatures at the time of withdrawal or loading of wheels.

Temperature charts and records must be given to the TRANSNET FREIGHT RAIL Quality Assurance Inspector when the wheels are submitted for inspection.

6.7 Removal of surface defects

6.7.1 Permitted repairs

Surface defects may be removed by machining or grinding provided that no heat cracking is produced, that the dimensional tolerances as specified in the relevant drawings are maintained, that a depth of 3mm is not exceeded by the corrective action, and that the magnetic particle inspection method as specified in specification RS\ME\PR\061 is used to ensure the complete removal of the surface defect. The depression that results from the corrective action must be dressed out into the surrounding contour over an area of at least 8 times the length and width of the depth of the corrective action. The surface roughness of the dressed area must not exceed 12,5µm R_a. However repairs are not permitted on the following regions of the wheel.

- The wheel tread
- The wheel flange
- The field and flange sides of the wheel rim.
- The region on the wheel boss and web lying within 100mm measured from the wheel bore surface

6.7.2 Prohibited repairs

Deposition of any form of material that will conceal defects is not permitted. If concealment of defects is found to be present, then the entire batch submitted for inspection will be rejected.

6.8 Web/plate requirements

6.8.1 Shoot peening will be performed on the black webbed wheel. The web surface of wheels must be shot peened in accordance with the procedure in ISO 1005-6:1994, Annex A. The shot peening must be done on all wheels. If any surface defects have been repaired in accordance with clause 6.7, then the wheels must be shot-peened after the repairs.

Re-peening of areas of the web repaired by grinding may be done by portable methods such as needle gun designed for the task in accordance with the clause 7.2.6 of AAR M-107/M-208

6.8.2 Wheels excluded in clause 6.8.1 must be machined to a maximum surface roughness of 6.3 µm without formation of laps.

7 MARKING OF THE WHEELS

7.1 Required markings

The following must be legibly marked on each wheel by stamping to a depth of 2mm and a height of no less than 10mm.

- Manufacturer's mark
- Cast number or a serial number which can be identified with the specific cast
- Date of manufacture (month and last 2 figures of the year of manufacture)
- Consecutive wheel number
- Wheel class

The position of the hot stamping is shown in Figure 3. A space of 3mm must be left between the individual characters and at least 20mm between individual groups of characters. Wheels must be marked on the flange side boss face

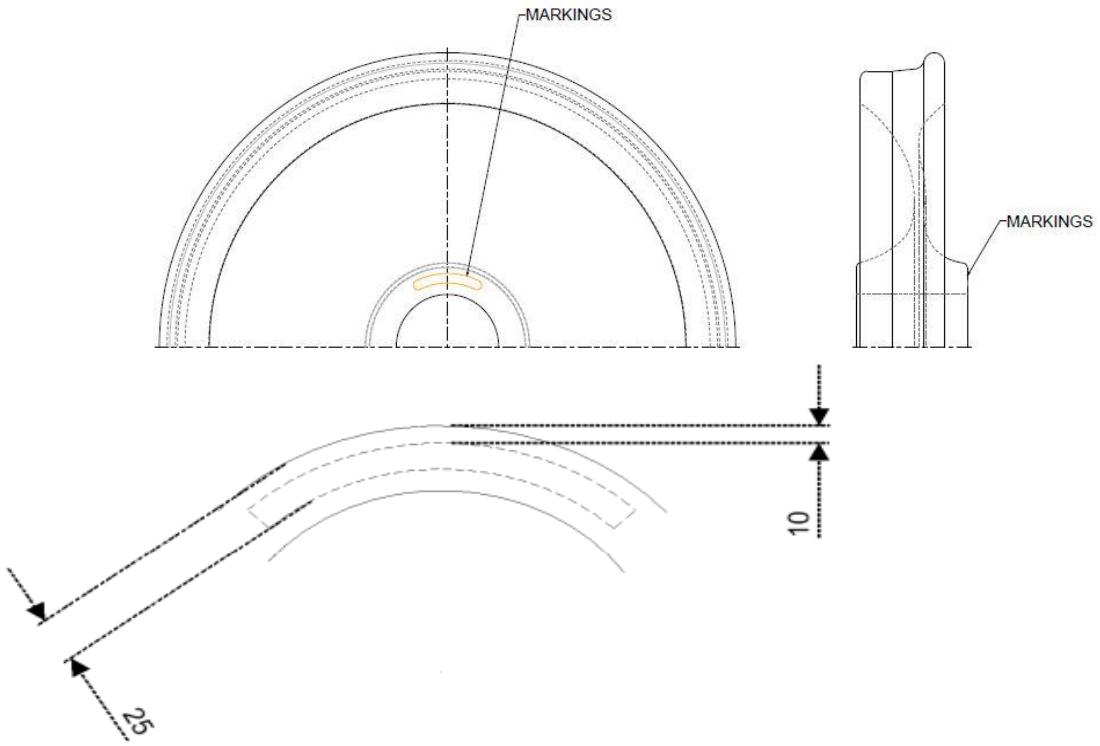

Figure 3: Position of markings

8 REQUIREMENTS

8.1 Chemical composition

8.1.1 Ladle analysis

The chemical composition of the wheels must be in accordance with the requirements in Table 3.

TABLE 2: CHEMICAL COMPOSITION

ELEMENT	CLASS B	CLASS C
% Carbon	0.57 – 0.67	0.67 – 0.77
% Manganese	0.60 – 0.90	0.60 – 0.90
% Phosphorus	0.03 maximum	0.03 maximum
% Sulphur	0.005 – 0.04	0.005- 0.04
% Silicon	0.15-1.00	0.15 – 1.00
% Aluminium	0.06 maximum	0.06 maximum

The chemical composition of the wheels must be in accordance with the requirements in table 3.
Elements that are not specified in table 3 must not be intentionally added to the steel other than for the purpose of finishing the heat. Precautions must be taken to prevent the addition of such elements from scrap or other sources. The presence of elements will be considered to be incidental up to the maximum amounts specified in table 4. The total percentages of these elements must not exceed 0.85%.

TABLE 3: RESIDUAL ELEMENTS

ELEMENT	CLASSES B AND C
% Titanium	0.03 maximum
% Chromium	0.25 maximum
% Nickel	0.25 maximum
% Copper	0.35 maximum
% Molybdenum	0.10 maximum
% Vanadium	0.04 maximum
% Colunbium (Niobium)	0.05 maximum

If the manufacturer chooses to vary from the above limits for nickel chromium, Molybdenum and Vanadium, the formula must me the following requirement; 930- (570×%carbon)-(80×%manganese)-(20×%silicon)-(50×%chromium)-(30×%nickel)-(20× (%molybdenum+ %Vanadium)) > 390

8.1.2 Check analysis

The chemical composition determined from the check analysis must be in accordance with the requirements in Tables 3 and 4. A variation on the specified range in Table 3 in the carbon content of the check analysis of -0.02/+0.03 is permitted. Specimens for a check analysis may be taken from any or all of the wheels submitted for testing at the discretion of the TRANSNET FREIGHT RAIL Quality Assurance Inspector.

8.1.3 Alternate materials

The manufacturer may propose alternate steel compositions in the micro-alloyed class

8.2 Physical properties

8.2.1 Appearance

The parts of the wheels remaining unmachined (if any) must be trimmed. These unmachined parts must blend smoothly into any machined part. The roughness of the machining must not exceed 12,5µm R_a.

8.2.2 Microstructure

The microstructure of the wheel must be pearlitic. The grain size must not be coarser than index 5 as determined in accordance with ISO 643.

8.2.3 Macrostructure

The macro-etch of a radial slice through the cross section of the wheel must not reveal any defects such as looseness in the structure or segregation in the region of the rim as shown by Figure 4. The macrostructure must be examined at a magnification of not less than 10X. A restriction of a 1mm internal defect size measured in any direction must be applied to the remainder of the wheel cross section.

8.2.4 Balancing requirements

If wheel balancing is required, then specifications ISO 1005/8 of 1986 and ISO 1005/6 of 1992 must be used for the checking of residual unbalance and for the correction of unbalance.

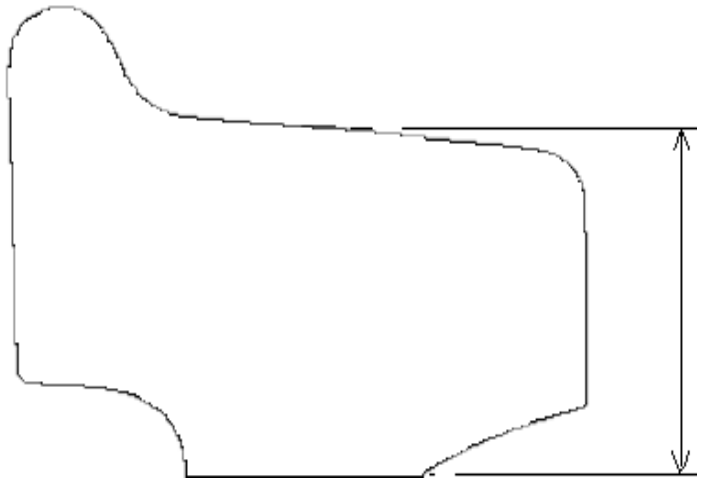

Figure 4: Position where no looseness or cracking in the structure is allowed

8.2.5 Non-destructive testing

a) Ultrasonic examination

The requirements for the ultrasonic examination are specified in specification RS/ME/PR/061.

b) Magnetic particle examination

Any surface defects revealed by magnetic particle examination must be treated in accordance with clause 6.7. The requirements for the magnetic particle examination are specified in specification RS/ME/PR/062.

8.3 Mechanical properties

8.3.1 Tensile properties

The tensile properties must be in accordance with the requirements specified in Table 5.

TABLE 4: TENSILE PROPERTIES

PROPERTY	CLASS B	CLASS C
Ultimate tensile strength of the rim (MPa)	900 minimum	1050 minimum
% Elongation of the rim	8 minimum	8 minimum
Ultimate tensile strength of the web (MPa)	650 minimum 950 maximum	800 minimum 1000 maximum
% Elongation of the web	8 minimum	8 minimum
Impact strength (J) (Charpy-V-Notch)	Information only	Information only

8.3.2 Uniformity of rim hardness in a wheel batch

The hardness values measured on the side of the wheel rims opposite the flange side of wheels from the same batch must not exceed the limits specified in Table 6 (See Figure 5). A variation of 30HB 10/3000 must not be exceeded for wheels from the same heat treatment batch and heat.

8.3.3 Hardness survey of the rim

The hardness survey must be done on a prepared section of a radial slice of the wheel cross-section. The hardness values thus determined must be in accordance with the requirements specified in Table 6.

TABLE 5: BRINELL HARDNESS REQUIREMENTS OF THE RIM

POSITION/ PROPETIES	BRINELL HARDNESS (HB 10/3000)	
	CLASS B	CLASS C
Position A	302- 341	321 - 363
Position B	302 - 341	321 - 363
Position C	Position B_{min} – Position C≥ 10HB	Position B_{min} – Position C≥ 10HB

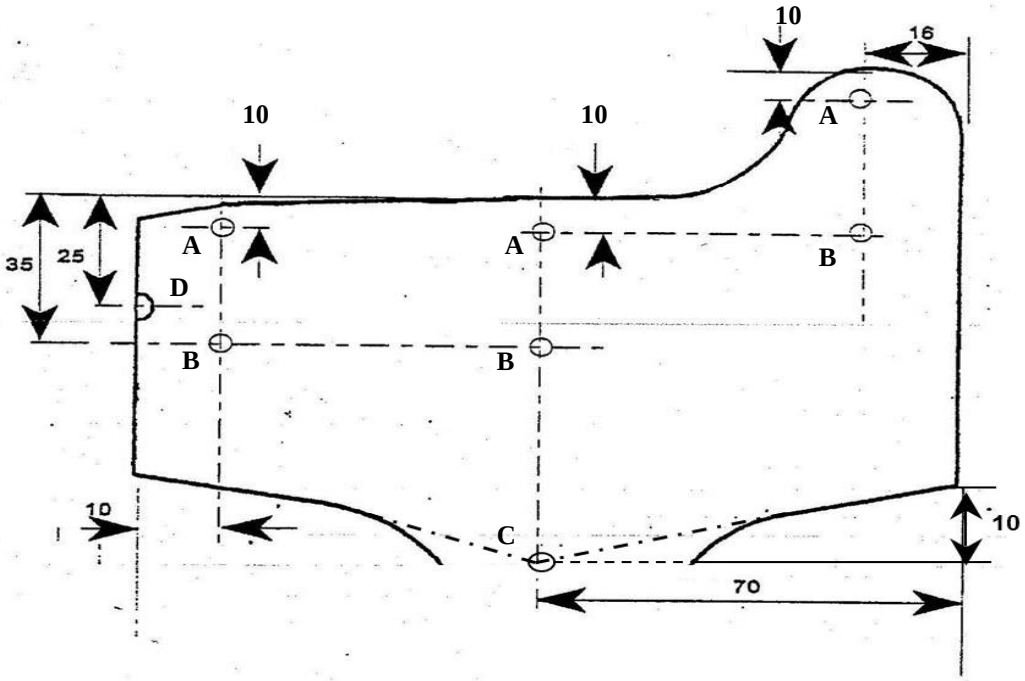

Figure 5: Position of Brinell hardness measurements (dimensions in mm)

8.3.4 Residual stress

A compressive stress is required in the rim of every wheel in the circumferential direction. The magnitude of the compressive residual stress must be agreed upon between the manufacturer and the Transnet Freight Rail Quality Evaluation Committee after consideration of the wheel design and stress measurements.

8.4 Dimensions and surface finish

All the dimensions of the wheels must be in accordance with the requirements of the relevant drawings. Any machining must not produce a roughness of greater than 12,5µm R_a.

8.5 Cleanliness of the steel

The inclusion content must conform to a quality that is not more severe than types A≤ 2.5, B≤2.5, C≤ 2.5, and D≤2.5 for both the thin and heavy series. The assessment must be performed in accordance with the requirements of ASTM E45-87 or ISO 4967 method A.

9 INSPECTION

9.1 Inspection of the characteristics of the wheels

Wheels for inspection must be provided by the manufacturer at the expense of the manufacturer. One wheel per batch must be selected by the TRANSNET FREIGHT RAIL Quality Assurance Inspector for inspection by the manufacturer. At least one (1) wheel per any consecutive batch will be selected by the TRANSNET FREIGHT RAIL

Quality Assurance Inspector for inspection by TRANSNET FREIGHT RAIL, Rolling Stock, Materials Engineering. The expense of the wheels inspected by TRANSNET FREIGHT RAIL will be covered by TRANSNET FREIGHT RAIL.

A wheel from every batch must be fully inspected by the manufacturer. Each wheel selected for inspection must comply with the requirements of this specification without any further manipulation. If it is established that the test wheel has been specially conditioned so that it no longer represents the wheel batch, then the wheel batch will be rejected. The test wheels that have been tested must be handed over to TRANSNET FREIGHT RAIL without any charge if requested.

Should any wheel fail to meet the requirements of this specification, then all other batches of wheels not yet despatched and wheels from the same batch as the rejected wheel will be subject to rejection. The TRANSNET FREIGHT RAIL Quality Assurance Inspector must have free entry at all times to the manufacturer's works while work on the contract is being performed. The manufacturer must give the TRANSNET FREIGHT RAIL Quality Assurance Inspector the necessary facilities and assistance so that he may be satisfied that the wheels presented for inspection are in accordance with the requirements of this specification.

9.2 Sampling and preparation of specimens and test pieces

9.2.1 Chemical analysis

The manufacturer must state the cast analysis of the steel. However, specimens may be taken at the discretion of the TRANSNET FREIGHT RAIL Quality Assurance Inspector from any or all of the test wheels that have been submitted for testing by the manufacturer.

The following specimens will be taken.

a) At least 50g of millings representing the average of a radial cross-section of the wheel;

OR

b) In the case of a spectrographic analysis, one specimen from the tensile test piece in position 1 of Figure 6.

9.2.2 Microstructure examination

A microstructure specimen must be taken from the head of the tensile test piece taken from position 1 of Figure 6 that has not been distorted. The specimen must be prepared in such a way as will give a representation of the cross-section of the wheel. The face to be prepared must be perpendicular to the axis of the tensile test piece. The examination of the microstructure must be done in accordance with the requirements of ISO 643.

9.2.3 Macrostructure examination

The macro-etch tests will be performed at a rate of one set per batch. The specimen must consist of a radial slice cut from the entire cross-section of the test wheel. One of the surfaces must be prepared for examination. The preparation and procedure of the macro-etch test must be done in accordance with the requirements of ASTM E 340-87.

9.2.4 Non-destructive testing

Every wheel of each batch must be tested ultrasonically and examined by magnetic particle inspection.

a) Ultrasonic examination

The test piece must consist of a wheel after full heat treatment and final machining of the side faces of the rim and the running tread.

b) Magnetic Particle examination

The test piece must be a wheel in the delivery condition as shown by the relevant drawings. However, the examination must be done before the wheel is subjected to a treatment that will protect it from oxidation.

9.2.5 Mechanical properties

a) Tensile test

Tensile test pieces must be taken from the wheel at positions 1 and 2 as shown in Figure 6. The tensile test pieces must be prepared in accordance with the requirements of BS EN ISO 6892-1. The diameter must not be less than 10mm.

b) Impact test (Information only)

Three test pieces must be taken from the wheel at the positions shown in Figure 6. The marking of the impact test pieces must enable the identification as shown in Figure 6. The test pieces must be prepared in accordance with the requirements of BS EN ISO 148-1. The axis of the bottom of the notch must be parallel with section A-A in Figure 6.

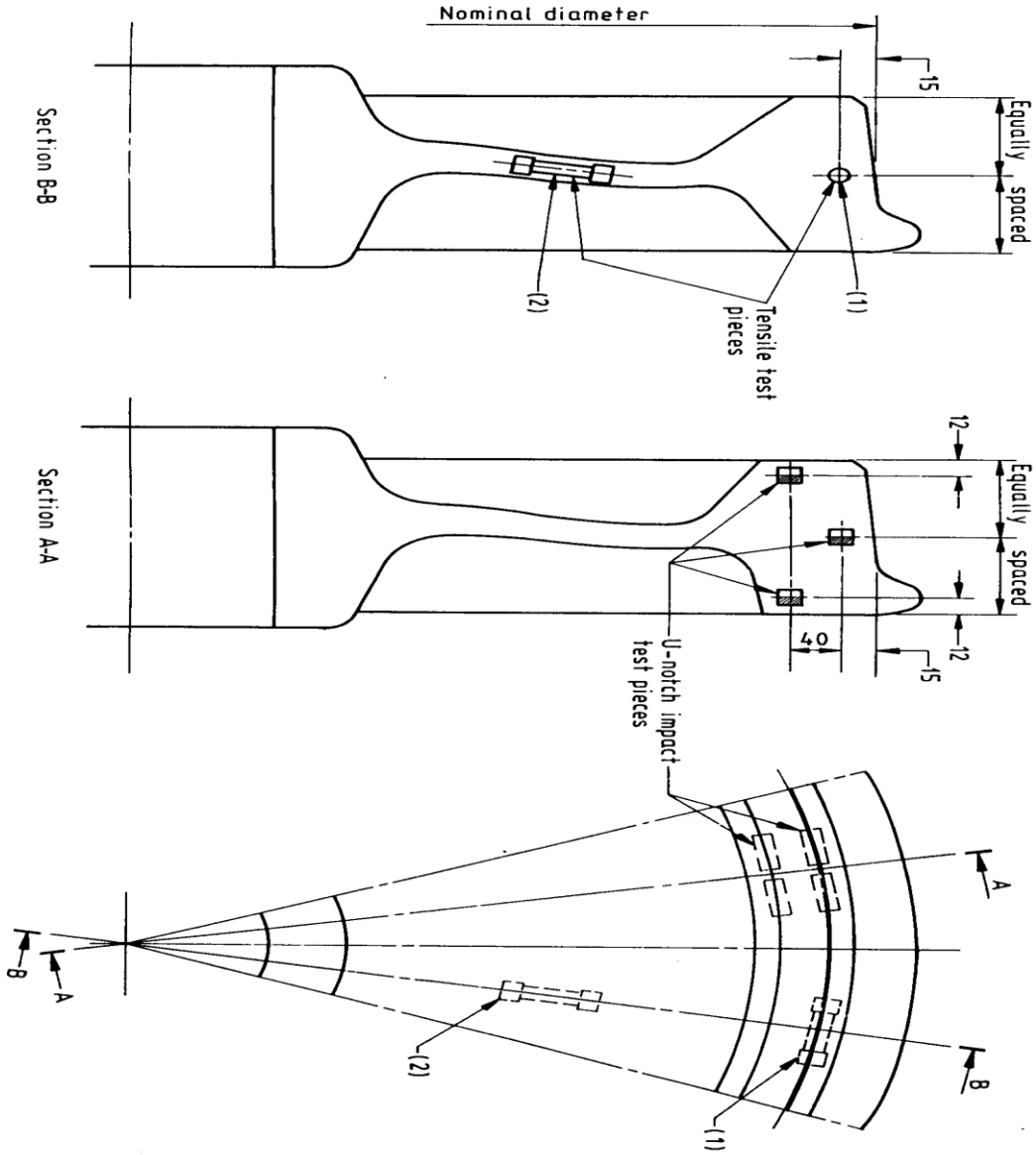

Figure 6: Position of tensile and impact test pieces (mm)

9.2.6 Uniformity of hardness in a wheel batch

Each wheel produced must be subjected to a Brinell hardness test in accordance with the requirements of BS EN ISO 6506. The indentation must be made on the plane face of the rim on the side opposite to the flange. The position for the indentation is shown in Figure 5. Where appropriate the position must be prepared by grinding or milling to remove any decarburized material.

9.2.7 Hardness survey

The test piece must consist of a plate comprising the complete radial section of the rim cross-section and it's joint with the web. The surface must be polished so as to facilitate the measurement of the indentation sizes. The indentations must be done in the positions shown in Figure 5.

9.2.8 Residual stress

The test piece must consist of the complete test wheel prior to the removal by machining of any material.

9.2.9 Cleanliness of the steel

The test piece must be taken from the wheel submitted for testing. The position must be 70mm from the flange face and 20mm below the tread. Four of these test pieces must be taken at 90^0 intervals around the wheel circumference for approval of the manufacturer by the TRANSNET FREIGHT RAIL Quality Evaluation Committee. The assessment must be done on the face that is parallel to the tread of the wheel.

One sample per test wheel may be taken for routine inspections.

9.3 Test methods

9.3.1 Chemical analysis

The analysis must be done according to the methods defined in the corresponding ISO standards or by any other method that is acceptable to the TRANSNET FREIGHT RAIL Quality Evaluation Committee.

9.3.2 Microstructure examination

The examination of the microstructure must be done in accordance with the requirements of ISO 643.

9.3.3 Macrostructure examination

The macro-etch test must be done in accordance with the requirements of ASTM E 340-87.

9.3.4 Non-destructive testing

a) Ultrasonic examination. The method for the ultrasonic examination of a wheel is specified in RS\ME\PR\061

b) Magnetic particle examination. The method for the magnetic particle examination of a wheel is specified in RS\ME\PR\062

9.3.5 Mechanical properties

a) Tensile test

The tensile test must be done in accordance with the requirements of BS EN ISO6892-1.

b) Impact test

The impact test must be done in accordance with the requirements of BS EN ISO 148-1.

9.3.6 Uniformity of hardness in a wheel batch and the hardness survey

The Brinell hardness test must performed according to the requirements of BS EN ISO 6506

9.3.7 Residual stress

a) Saw cut method

Two marks must be made at 100mm apart in the centre of the thickness of rim on the flat surface of the side opposite the flange. A radial saw cut must be made from the top of the flange through to the bore half-way between these marks. The distance between the marks must have at least reduced by 1mm after cutting.

OR

b) Ultrasonic bi-refringence technique

The ultrasonic bi-refringence stress measurement technique for assessing residual stresses may be used to measure the stress level in the wheel rim of every wheel produced. The measurement must be done on the flange side of the rim and at 15mm to 20mm below the tread.

9.3.8 Cleanliness of the steel

The assessment must be done in accordance with the requirements of ASTM E45-87 or ISO 4967 method A.

9.3.9 Visual appearance and dimensions

The wheels must be examined by visual inspection prior to delivery. The dimensions of every wheel must be checked by using regularly calibrated measuring instruments that have been approved by the TRANSNET FREIGHT RAIL Quality Evaluation Committee. These dimensions must comply with the dimensions specified in the relevant drawings. The roughness of the machined finish must be checked by a regularly calibrated measuring instrument approved by the TRANSNET FREIGHT RAIL Quality Evaluation Committee.

9.4 Conclusion of the inspection

9.4.1 Rejection

Any defects in appearance or dimensions will result in the rejection of the wheel. The same applies for the magnetic particle inspection that reveals marks or discontinuities that are not completely removed subject to clause 6.7. The ultrasonic indications must be in accordance with the requirements in the latest revision of procedure RS\ME\PR\061.

If an additional examination reveals that defects detected during the ultrasonic examination are hydrogen cracks (flakes), then all the wheels from that cast will be rejected. The additional examination will be done by TRANSNET FREIGHT RAIL Materials Engineering.

Any other testing result that does not comply with the requirements of this specification will result in the rejection of the batch subject to the requirements for repeated inspection.

9.4.2 Repeated inspections

Re-testing may be performed at the expense of the manufacturer. The following are the only re-tests that will be allowed.

a) Chemical analysis

If the check analysis does not comply with the requirements of Tables 3 and 4, then 2 further specimens must be taken from the same test wheel that was submitted for testing. Both of these specimens must conform to the requirements of Tables 3 and 4 or else the wheel batch will be rejected.

b) Mechanical properties

If the tensile test piece does not comply with the requirements of Table 5, then twice the number of original test pieces must be selected for re-testing and be tested in accordance with the requirements of this specification, at least one will be taken from the original test wheel. The mechanical properties obtained from these tensile test pieces must comply with the requirements of Table 5 or else the batch will be rejected.

c) Uniformity of hardness in a wheel batch, hardness survey, and residual stress

The manufacturer may re-heat treat a wheel batch up to a maximum of two times. For each re-heat treatment, a test wheel must be submitted from the batch for a complete inspection in accordance with the requirements of this specification.

The batch submitted for testing will be accepted by TRANSNET FREIGHT RAIL if the results of the re-tests and the remainder of the tests comply with the requirements of this specification.

10 CERTIFICATION

The manufacturer must provide a certificate of conformance to this specification. The certificate must certify that the wheel batch was manufactured and tested in accordance with the requirements of this specification. A report of all the test results must accompany the test certificate. The certificate and the report must be submitted to the TRANSNET FREIGHT RAIL Quality Assurance Inspector prior to delivery. The report of the test results must be traceable to the cast and heat treatment batch.

A list of the cast numbers, the consecutive wheel numbers for each batch of wheels, and the destination of the wheels must also be handed to the TRANSNET FREIGHT RAIL Quality Assurance Inspector prior to delivery.

The list of required test and examination results are as follows.

- Chemical analysis
- Microstructure examination
- Macrostructure examination
- Ultrasonic examination
- Magnetic particle examination
- Tensile test
- Impact test
- Uniformity of hardness
- Hardness survey of the wheel batch
- Residual stress level
- Steel cleanliness

11 DELIVERY

11.1 Protection against corrosion during transport

After inspection prior to storage or despatch, the finished machined wheels must be provided with protection against corrosion. The corrosion protection agent must be agreed between Transnet Freight Rail and the supplier.

11.2 Protection against mechanical damage during transport

Handling prior to dispatch and delivery packaging of the wheels must be in such a way that the wheels are protected against mechanical damages and the safety of the personnel is not compromised.

12 GUARANTEE

The manufacturer must guarantee the wheels for a period of n+6 years against any manufacturing defect that was not revealed during inspection where n is the year of manufacture. This period will be reckoned from the year marked on the wheel (n).

Wheels that prove to have manufacturing defects that do not conform to the requirements of this specification during the guarantee period will be rejected by TRANSNET FREIGHT RAIL. TRANSNET FREIGHT RAIL, on request, will undertake to supply the manufacturer with sample portions of the defective wheel for the purpose of a counter examination. The sample portions will be cut from the wheel at positions agreed to by TRANSNET FREIGHT RAIL and the manufacturer.

If the wheel is rejected, then the wheel or wheels must be replaced or refunded at their new replacement value. The defective wheel or wheels will remain as the property of TRANSNET FREIGHT RAIL.