BRITISH STANDARD

BS EN 13261:2009

Railway applications — Wheelsets and bogies — Axles — Product requirements

ICS 45.040

BSI
British Standards

National foreword

This British Standard is the UK implementation of EN 13261:2009. It supersedes BS EN 13261:2003 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee RAE/3/-/1, Wheels and wheelsets.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Foreword

This document (EN 13261:2009) has been prepared by Technical Committee CEN/TC 256 “Railway applications”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by September 2009, and conflicting national standards shall be withdrawn at the latest by September 2009.

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This document supersedes EN 13261:2003.

This document has been prepared under a mandate given to CEN/CENELEC/ETSI by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directives 96/48/EC and 2001/16/EC, amended by Directive 2004/50/EC.

For relationship with EU Directives 96/48/EC and 2001/16/EC, see informative Annex ZA and ZB, which are integral parts of this document.

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Introduction

Normative documents which have been used until now in Europe for axle delivery (UIC leaflets, national standards) had, for the main purpose, a complete definition of delivery procedures and axle characteristics that were to be measured.

Product qualification was sometimes mentioned, but the procedures and the characteristics that had to be verified for the qualification were not given.

This standard addresses these issues by:

a) definition of all axle characteristics; these are verified either during qualification or delivery of the product (see clause 3);

b) definition of qualification procedures (see Annex I);

c) definition of delivery conditions (see Annex J); here, a choice is given to the supplier of either:

   1) a traditional delivery procedure with a control by batch sampling as in existing documents (see J.5), or;

   2) a delivery procedure using quality assurance concepts (see J.6).

1 Scope

This European Standard specifies the characteristics of axles for use on European networks.

It defines characteristics of forged or rolled solid and hollow axles, made from vacuum-degassed steel grade EA1N[1] that is the most commonly used grade on European networks. For hollow axles, this standard applies only to those that are manufactured by machining of a hole in a forged or rolled solid axle

In addition, the particular characteristics for axles in grade EA1T[1] and EA4T[1] are given in Annex A.

Two categories of axle are defined, category 1 and category 2. Generally, category 1 is chosen when the operational speed is higher than 200 km/h.

This standard is applicable to axles that are designed in accordance with the requirements of EN 13103 and EN 13104.

NOTE Different values for some characteristics may be agreed if a particular process of fabrication (e.g. cold rolling, shot peening) has an influence on them.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 10002-1, *Metallic materials – Tensile testing – Part 1: Method of test at ambient temperature*

EN 10045-1, *Metallic materials – Charpy impact test – Part 1: Test method*

EN 13103, *Railway applications – Wheelsets and bogies – Non-powered axles – Design method*

EN 13104, *Railway applications – Wheelsets and bogies – Powered axles – Design method*

EN 13260, *Railway applications – Wheelsets and bogies – Wheelsets – Product requirements*

EN 20898-2:1993, *Mechanical properties of fasteners – Part 2: Nuts with specified proof load values – Coarse thread (ISO 898-2:1992)*

EN 22768-1, *General tolerances – Part 1: Tolerances for linear and angular dimensions without individual tolerance indications (ISO 2768-1:1989)*

EN 22768-2, *General tolerances – Part 2: Geometrical tolerances for features without individual tolerance indications (ISO 2768-2:1989)*

EN ISO 643:2003, *Steels – Micrographic determination of the apparent grain size (ISO 643:2003)*

EN ISO 2409:2007, *Paints and varnishes – Cross-cut test (ISO 2409:2007)*

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[1] N for a normalized metallurgical condition
T for a quenched and tempered metallurgical condition

EN ISO 2808:2007, *Paints and varnishes – Determination of film thickness (ISO 2808:2007)*

EN ISO 9227:2006, *Corrosion tests in artificial atmospheres – Salt spray tests (ISO 9227:2006)*

EN ISO 14284:2002, *Steel and iron – Sampling and preparation of samples for the determination of chemical composition (ISO 14284:1996)*

ISO 4967:1998, *Steel – Determination of content of non-metallic inclusions – Micrographic method using standard diagrams*

ISO 5948:1994, *Railway rolling stock material – Ultrasonic acceptance testing*

ISO 6933:1986, *Railway rolling stock material – Magnetic particle acceptance testing*

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ISO/TR 9769[2] *Steel and iron – Review of available methods of analysis*.

3 Product definition

3.1 Chemical composition

3.1.1 Values to be achieved

The maximum percentage contents of the various elements are given in Table 1.

Table 1 — Limit values by product analysis (%)

C	Si	Mn	P [a]	S [ab]	Cr	Cu	Mo	Ni	V
0,40	0,50	1,20	0,020	0,020	0,30	0,30	0,08	0,30	0,06

[a] A maximum content of 0,025 % may be agreed at the time of enquiry and the order.
[b] A minimum sulfur content may be agreed at the time of enquiry and the order according to the steelmaking process, in order to safeguard against hydrogen embrittlement.

3.1.2 Location of sample

The test sample shall be taken at mid-radius of solid axles or at mid-distance between external and internal surfaces of hollow axles.

3.1.3 Chemical analysis

The chemical composition analysis shall be performed according to the methods and definitions described in ISO/TR 9769.

[2] See also CEN/TR 10261.

3.2 Mechanical characteristics

3.2.1 Characteristics from tensile test

3.2.1.1 Values to be achieved

The values to be achieved at mid-radius of solid axles or at mid-distance between external and internal surfaces of hollow axles are given in Table 2.

The values to be achieved near the external surface shall be greater than or equal to 0,95 times the values measured at mid-radius of solid axles or at the mid-distance between external and internal surfaces of hollow axles.

The values to be achieved in the centre of solid axles or near the internal surface of hollow axles shall be greater than or equal to 0,8 times the values measured at mid-radius or at mid-distance between external and internal surfaces.

Table 2 — Values to be achieved at mid-radius of solid axles or at mid-distance between external and internal surfaces of hollow axles

R_{eH}(N/mm²)[a]	R_m (N/mm²)	A_5%
≥ 320	550-650	≥ 22
[a] If no distinctive yield strength is present, the proof stress $R_{p0,2}$ shall be determined.		

3.2.1.2 Location of test pieces

The test pieces shall be taken from three levels in the largest axle section:

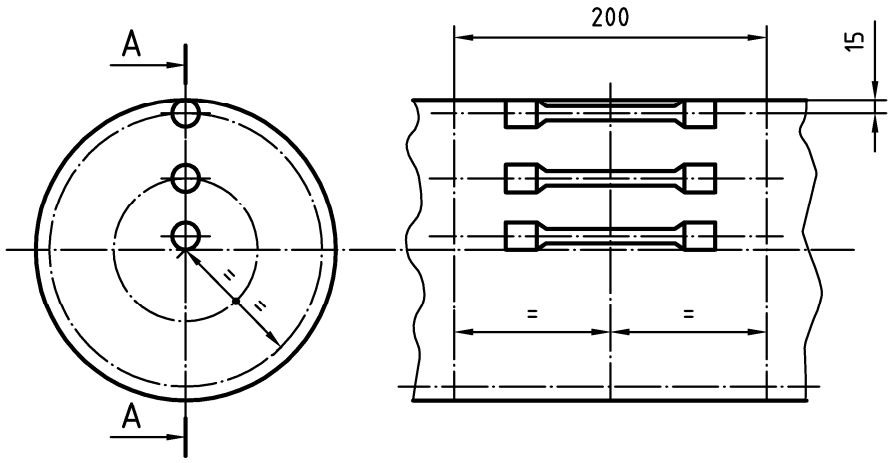
1) as near as possible to the external surface for all the axles;

2) at mid-radius and in the centre of solid axles;

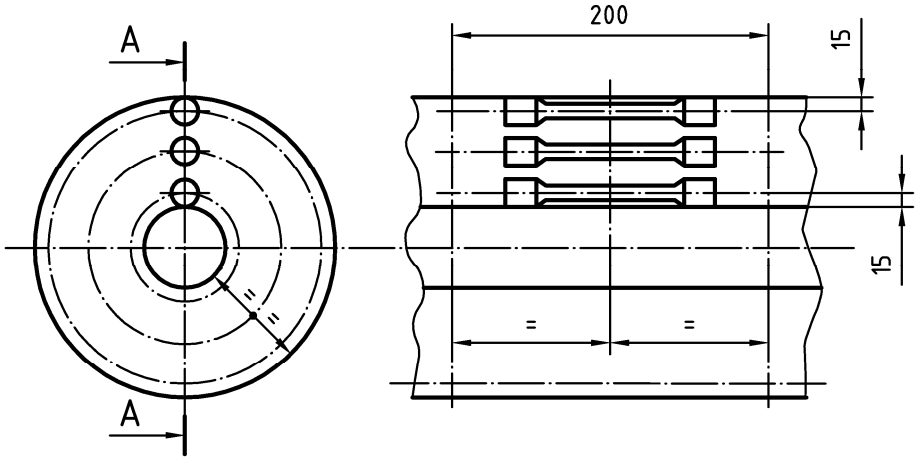
3) at mid-distance between external and internal surfaces, and near the internal surface of hollow axles

as shown in Figure 1 a) and b).

Dimensions in millimetres



1a) — Solid axle



1b) — Hollow axle

Figure 1 — Location of test pieces

3.2.1.3 Test method

The test shall be carried out in accordance with EN 10002-1. The test piece diameter shall be at least 10 mm in the machined-down portion. The gauge length shall be five times the diameter.

3.2.2 Impact test characteristics

3.2.2.1 Values to be achieved

Impact test characteristics shall be determined at 20 °C in the longitudinal and the transverse directions. Values to be achieved at mid-radius of solid axles, or at mid-distance between external and internal surfaces of hollow axles, are given in Table 3.

Near the surface, they shall be greater than or equal to 0,95 times the values measured at mid-radius or at

mid-distance between external and internal surfaces of hollow axles.

In the centre of solid axles or near the internal surface of hollow axles, they shall be greater than 0,8 times the values measured at mid-radius or at mid-distance between external and internal surfaces.

For each level (surface, mid-radius, centre), the average value of the 3 test pieces (see 3.2.2.2) is defined in Table 3.

No individual value shall be less than 70 % of the values in Table 3.

Table 3 — Values to be achieved at mid-radius or at mid-distance between external and internal surfaces of hollow axles

KU **longitudinal (J)**	***KU*** **transverse (J)**
≥ 30	≥ 20

3.2.2.2 Location of test pieces

The test pieces shall be taken from three levels in the largest axle section:

1) as near as possible to the external surface for all the axles;

2) at mid-radius and in the centre of solid axles;

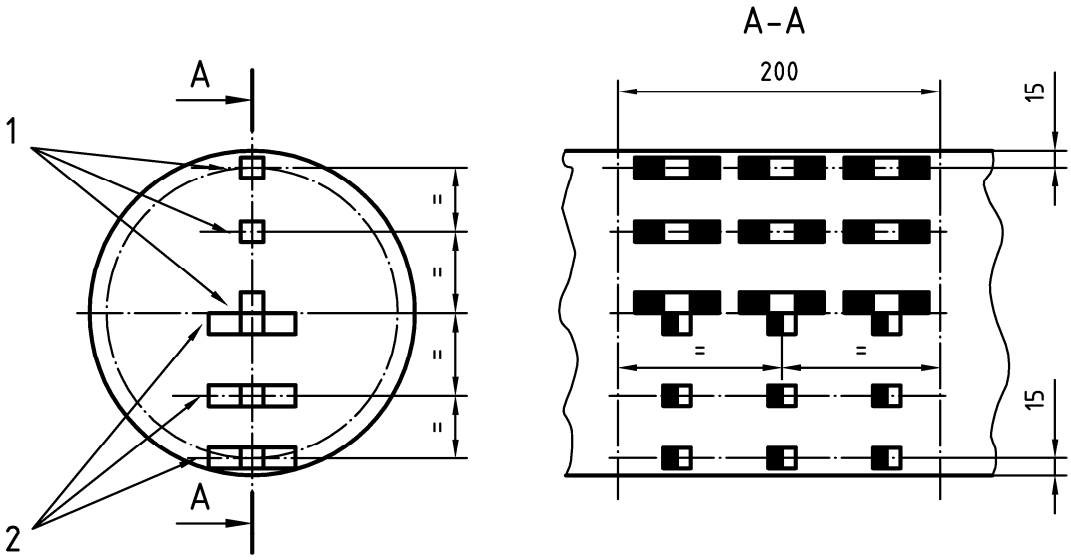
3) at mid-distance between external and internal surfaces, and near the internal surface of hollow axles

as shown in Figure 2a) and 2b).

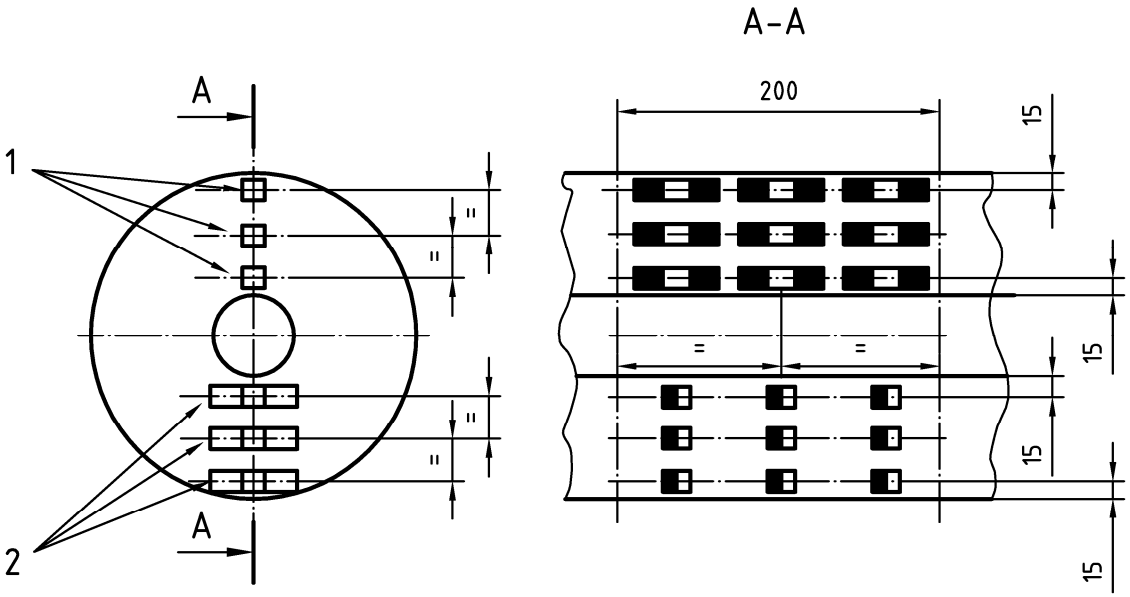
3.2.2.3 Test method

The test shall be carried out in accordance with EN 10045-1.

Dimensions in millimetres



2a) — Solid axle



2b) — Hollow axle

Key

1 longitudinal test piece

2 transverse test piece

Figure 2 — Location of test pieces

3.2.3 Fatigue characteristics

3.2.3.1 General

3.2.3.1.1 Introduction

Verification of the fatigue characteristics is essential in order to have a correctly dimensioned axle. The satisfactory performance of an axle in service depends upon these characteristics. The values defined in this subclause are used for the calculation of the maximum permissible stresses that are referred to in the design rules in EN 13103 and EN 13104.

It is necessary to estimate the fatigue limits in the following two areas, in order to predict the behaviour of the axle under in-service stresses:

1) for the material, tests are made on reduced test pieces, for which the shapes do not depend upon the product geometry;

2) for the product, tests are made on full size test pieces, for which the dimensions and manufacture are similar to the final product and its associated permissible fabrication defects.

3.2.3.1.2 Fatigue limits on reduced test pieces

The fatigue limits defined with reduced test pieces are used to verify that the notch effect of the material used for the fabrication of the axle is in accordance with the security coefficient "*S*" defined in design standards EN 13103 and EN 13104. They are determined from:

— unnotched surface test pieces (fatigue limit R_{fL});

— notched test pieces (fatigue limit R_{fE}).

3.2.3.1.3 Fatigue limits on full size test pieces

The limits determined on full size test pieces are used to verify that the axle fatigue characteristics are in accordance with those that are used to calculate the maximum permissible stresses referred to in design standards EN 13103 and EN 13104.

These fatigue limits apply to different axle areas. Only the fatigue limits applying to the axle body are taken into account in this standard. The limits applying to the wheelset depend mostly on the assembly and are referred to in EN 13260.

It is necessary to define two fatigue limits:

— on the body surface, limit F_1;

— on the bore surface in the case of a hollow axle, limit F_2.

3.2.3.2 Values to be achieved

The values to be achieved are given in Table 4.

Table 4 — Fatigue limit values

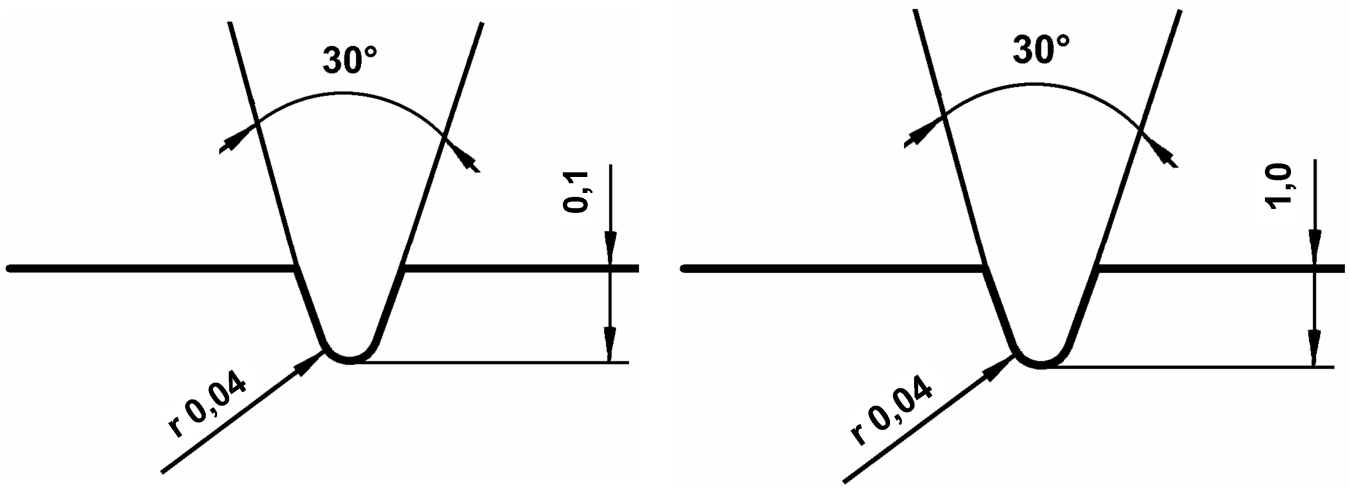
Limit	F_1	F_2	R_{fL}	R_{fE}	$q=R_{fL}/R_{fE}$
Value	≥ 200 N/mm²	≥ 80 N/mm²	≥ 250 N/mm²	≥ 170 N/mm²	≤ 1,47

3.2.3.3 Fatigue test pieces

For F_1 and F_2 determination, the test piece areas where the cracks initiate shall have a similar geometry and surface roughness to those of the axle areas that have to be analysed. For F_2 determination, the test piece surface shall have a 1 mm deep notch as shown in Figure 3b. All of these test pieces shall come from the same fabrication process as that for the axle.

For R_{fL} and R_{fE} determination, the test piece diameter is around 10 mm in the area where the crack initiates. The roughness (R_a) of the test piece for R_{fL} determination is less than or equal to 0,4 µm. The notch for R_{fE} determination is shown in Figure 3a. These test pieces are located as near as possible to the surface of the axle body.

Dimensions in millimetres



3 a) — Notch for determination of R_{fE}

3 b) — Notch for determination of F_2

Figure 3 — Fatigue test piece notches

Examples of drawings of full-size and reduced dimension test pieces are given in Annex H.

3.2.3.4 Test method

The tests shall be performed with machines that induce rotating bending stresses in the area where it is required to initiate a fatigue crack.

For each limit, F_1 and F_2, it shall be verified that for three test pieces there is no crack after 10^7 cycles of load that generates a surface stress level equal to F_1 and F_2. The values of the stresses are calculated by classical beam theory where it may be applied. If not, the stresses shall be measured by strain gauges in the areas where the fatigue cracks initiate.

R_{fL} and R_{fE} shall be determined for 10^7 cycles for a non-fracture probability of 50 %, which requires the use of at least 15 test pieces for each limit and a statistical method for the interpretation of the results.

3.3 Microstructure characteristics

3.3.1 Values to be achieved

The microstructure shall be one of ferrite and pearlite. The grain size shall not be greater than that defined by the reference diagram 5 in Annex B of EN ISO 643:2003.

3.3.2 Location of the test piece

The test pieces shall be taken from the largest axle section in a 200 mm^2 plane, perpendicular to arrow F, at mid-radius of solid axles, or at mid-distance between external and internal surface of hollow axles, as shown in Figure 4.

3.3.3 Test method

Tests shall be performed in accordance with EN ISO 643.

3.4 Material cleanliness

3.4.1 Micrographic cleanliness

3.4.1.1 Cleanliness level to be achieved

The level of cleanliness shall be measured by micrographic examination as defined in 3.4.1.2 and 3.4.1.3. The maximum values of inclusions to be obtained are given in Table 5.

Table 5 — Maximum values of inclusions in thin and thick series

Type of inclusions	Category 1		Category 2	
	Thick series (maximum)	Thin series (maximum)	Thick series (maximum)	Thin series (maximum)
A (Sulfur)	1,5	1,5	1,5	2
B (Aluminate)	1	1,5	1,5	2
C (Silicate)	1	1,5	1,5	2
D (Globular oxide)	1	1,5	1,5	2
B + C + D	2	3	3	4

3.4.1.2 Location of the micrographic sample

The examination field is given in Figure 4.

The examination shall be made in a 200 mm^2 plane, perpendicular to arrow F, at mid-radius of the solid axles, or at mid-distance between external and internal surface of hollow axles. The test pieces shall be taken from the largest axle section.

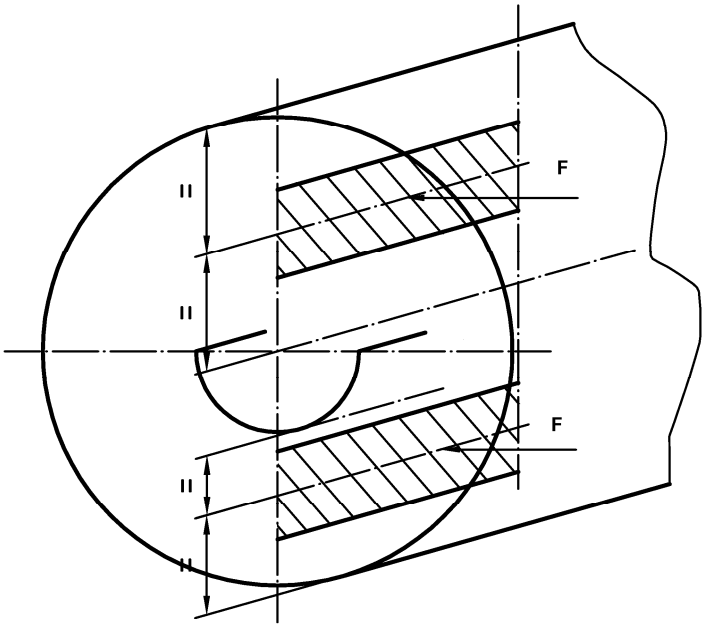


Figure 4 — Location of sample for micrographic examination

3.4.1.3 Test method

Cleanliness level determination shall be carried out in accordance with ISO 4967:1998, method A.

3.4.2 Internal integrity

3.4.2.1 General

Internal integrity shall be determined by ultrasonic examination. Standard defects shall be flat bottom holes at different depths.

3.4.2.2 Level to be achieved

The axles shall have no internal defects that give echo magnitudes equal to or greater than those obtained for a standard defect situated at the same depth. The diameter of this standard defect shall be 3 mm. No attenuation of the back echo higher than 4 dB due to non-homogenates or internal defects shall be accepted.

3.4.2.3 Test piece

The examination shall be made on the axle itself after heat treatment and in the delivery condition before the final protection is applied.

3.4.2.4 Method of examination

The axle internal integrity is verified by ultrasonic diametral examination according to method Da of ISO 5948:1994. The whole axle shall be examined, except certain parts (fillets, grooves, etc.) after agreement between the customer and the supplier.

3.5 Permeability to ultrasound

3.5.1 General

The permeability shall ensure the feasibility of ultrasonic testing during service and is verified by producing a record for the axle after a preliminary calibration of the testing apparatus.

3.5.2 Level to be achieved

The echo obtained on the axles being checked shall have an amplitude equal to or greater than 50 % of full screen height, after preliminary calibration of the apparatus on the standard wedge described in Annex B. The height of the background noise shall be less than 10 % of the screen height.

3.5.3 Test piece

The test piece to be examined shall be the axle, after full heat treatment.

The condition of the journal ends, at the moment of inspection, shall be the same as that required for delivery, without protection.

3.5.4 Test method

The ultrasonic permeability examination shall be performed by longitudinal checking of the axle according to method T of ISO 5948:1994.

If the tests are not performed by an automated process, the measurement shall be performed at a minimum of 6 points, equally distributed around the axle journal section.

The probes used are the piezoelectric type, transmitter and receiver, in quartz or barium titrate BaTi with round or rectangular sections (between 80 mm^2 and 450 mm^2). Their frequency and the height of the echo obtained in front of the flat bottom of diameter 1 mm are described in Table 6 for each category of axle. The noise during the calibration shall not exceed 5 % of the full screen height.

For this test, the instrument shall operate with narrow frequency bands centred on the nominal frequencies "F_n" so that the band is between F_n - 20% and F_n + 20%, for an attenuation of 3 dB in relation to the frequency signal F_n.

Table 6 — Calibration for permeability examination

	Category 1	**Category 2**
Frequency *F*n	5 MHz	2 MHz to 3 MHz
Conditions for calibration (% of full screen height)	90 %	40 %

For other types of probes, an agreement between the customer and the supplier is required in order to define the calibration and results to be achieved.

3.6 Residual stresses

3.6.1 General

The different fabrication phases shall not create residual stresses that can cause in-service deformations of axles or facilitate fatigue crack initiation.

3.6.2 Values to be achieved

On the axle surface, residual stresses shall be less than or equal to +100 N/mm^2.

The difference between residual stress values measured at two different points 2 mm under the surface shall be ≤ 40 N/mm^2.

3.6.3 Test piece and position of measurement points

The test piece shall be the axle in the delivery condition. The position of measurement points is given in Figure 5.

Dimensions in millimetres

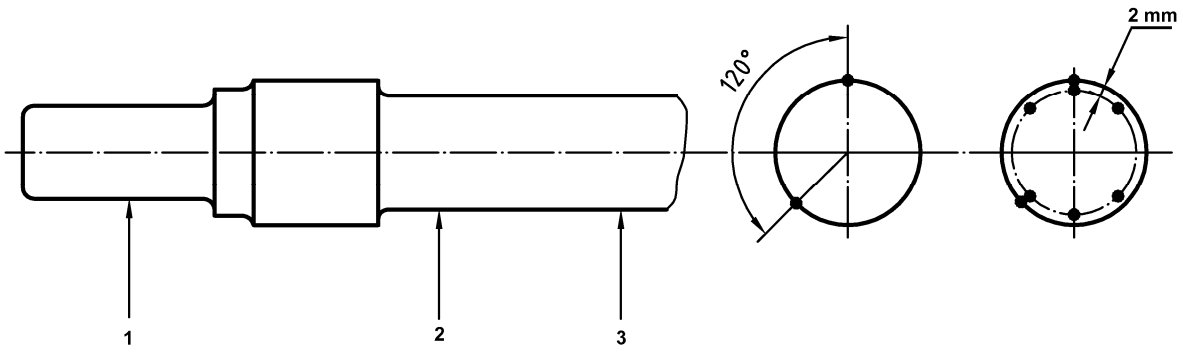


Figure 5 — Position of measurement points

3.6.4 Measurement method

The measurements shall be made either with strain gauges or by X-ray diffraction. The method shall be agreed between the customer and the supplier.

3.7 Surface characteristics

3.7.1 Surface finish

3.7.1.1 Characteristics to be achieved

The axle surface shall not show any other marks than those stipulated in this standard.

The surface roughness (*R*a) is given in Table 7. The symbols are those defined in Figure 6.

Table 7 — Surface finish

Designation	Symbol (see Figure 6)	Surface roughness [a] *Ra* (µm)	
		Rough-machined	Finished or ready for assembly
End of the axle			
- axle end and chamfer	a	-	6,3
- axle centre face (solid and hollow axle)	See details R1 and R2	-	3,2
Journal			
- journal diameter	b	12,5	0,8
- stress relieving grooves	c (detail V)		0,8
Abutment			
- abutment diameter	d	12,5	1,6
Wheelseat			
- wheelseat diameter	e	12,5	Minimum 0,8 Maximum 1,6 [c]
- lead in taper	f (detail U)		1,6
Body			
- inner transitional radii to wheelseat	g (detail T)	-	1,6
- axle body diameter	l		3,2 [b]
- gearwheel, seat and brake disc seat diameter	h	12,5	Minimum 0,8 Maximum 1,6 [c]
- bearing seat and seal seat diameter	j	12,5	0,8
- transitional radii between two seats	k (detail S)		1,6
Bore			
- bore diameter	m (detail R1)		3,2 [c]

[a] For old axle types with plain bearing journals, the requirements are in the standards that deal with these products.

[b] 6,3 may be agreed if fatigue limits F_1 and F_2 defined in 3.2.3.2 and the sensitivity required for the in-service ultrasonic control are achieved.

[c] In-service Non-Destructive Examination may require smaller values of surface finish, e.g. Ra 2 µm for the bore.

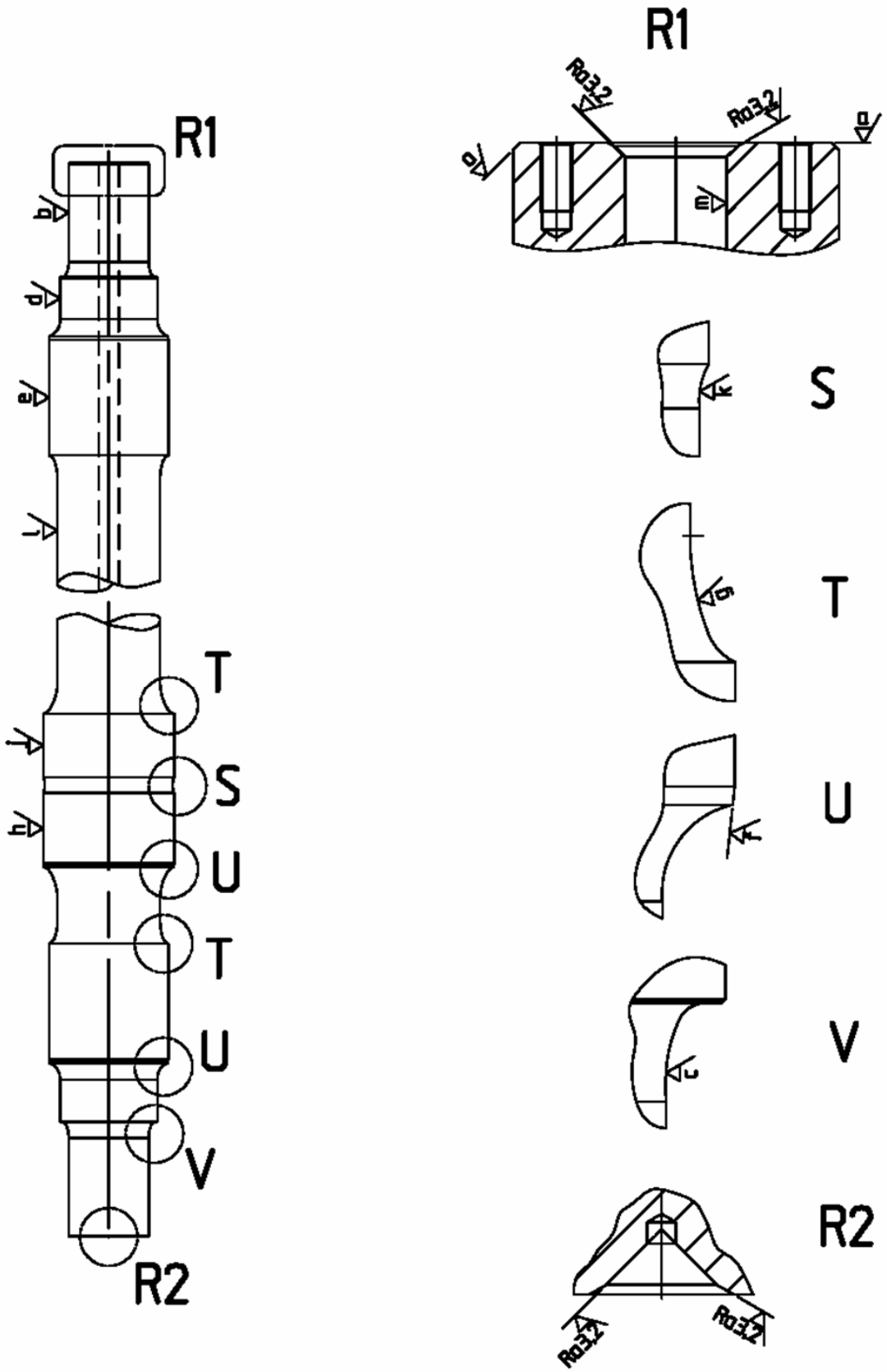


Figure 6 — Symbols for surface finish

3.7.1.2 Measurement method

The mean roughness of the axle surfaces (*R*a) in their delivery condition, given in Table 7, shall be measured with a roughness test apparatus. In fillet radii, the roughness may be evaluated by comparison with tactile and visual specimens agreed between the customer and the supplier.

3.7.2 Surface integrity

3.7.2.1 General

Surface integrity of the axles shall be determined by a magnetic particle test for the external surfaces and by an ultrasonic examination or an equivalent method, agreed between the customer and the supplier, for the bore surface of hollow axles.

3.7.2.2 Level to be achieved

On the external surface of the axle:

— transverse defects are not permissible;

— longitudinal defects are acceptable outside z_0 zones (see Figure 7), provided they are within the limits given in Table 8 (see also J.7).

A defect shall be considered as a longitudinal defect if its inclination with the axle centreline is less than 10°.

Dimensions in millimetres

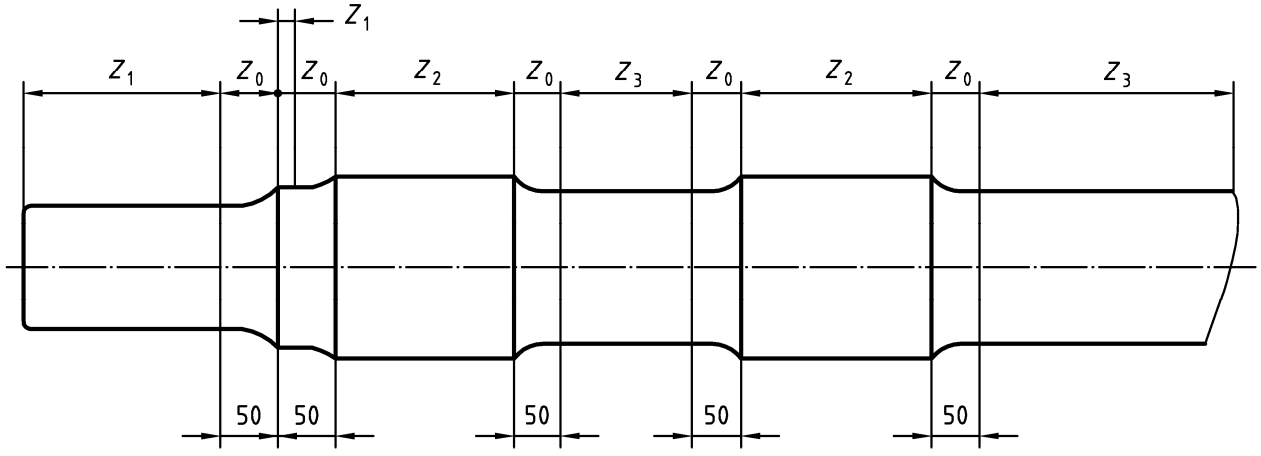


Figure 7 — Zones

On the bore surface of the hollow axles, transverse defects are permitted if they are no more than 0,5 mm deep and if there is not more than one per metre of axle length.

Table 8 — Longitudinal defect limits

Zones	Category 1		Category 2	
	Maximum length of an isolated defect[a]	**Maximum cumulative length of isolated defects**	**Maximum length of an isolated defect[a]**	**Maximum cumulative length of isolated defects**
z_0	0	0	0	0
z_1	≤ 6 mm	≤ 6 mm	≤ 6 mm	≤ 6 mm
z_2	≤ 6 mm	≤ 15 mm	≤ 6 mm	≤ 15 mm
z_3	≤ 6 mm	≤ 15 mm	≤ 10 mm	≤ 30 mm
[a] Defects are to be considered as isolated when the space between two of them, located on the same circumferential line, is more than 10 mm.				

3.7.2.3 Test piece

The test piece shall be the axle itself, after heat treatment, in the finish-machined condition defined by the purchase order and before the application of the protection.

3.7.2.4 Methods of examination

3.7.2.4.1 External surface of the axle

The general conditions of the magnetic particle test are given in ISO 6933, except for:

— the surface magnetic flux, which shall be greater than 4 mT;

— the lighting energy of ultra-violet light, which shall be greater than 15 W/m².

The magnetization methods are those described in ISO 6933:

— circumferential magnetization for longitudinal defect investigation (see Figure "a" of ISO 6933:1986);

— axial magnetization for transverse defect investigation (see Figure "b" of ISO 6933:1986).

3.7.2.4.2 Bore surface of the axle

The method shall be agreed between the customer and the supplier. Unless otherwise specified, 45°-incidence ultrasonic examination from the external surface is to be undertaken.

3.8 Geometrical and dimensional tolerances

Geometrical tolerances are given in Table 9. The symbols used are defined in Figure 8.

Dimensional tolerances are given in Table 10. The symbols used are defined in Figure 9.

Table 9 — Geometrical tolerances

Designation	**Symbol (see Figure 8)**	**Geometrical tolerances [ab] (mm)**	
		Rough-machined	**Ready for assembly**
Journal and abutment Cylindricity Run out of the vertical face of the abutment relative to the reference Y-Z Run out of the abutment relative to the reference Y-Z	n		0,015 0,03 0,03
Wheelseat Run out relative to the reference Y-Z[c] Cylindricity	p	1,5 0,1	0,03 0,015
Gearwheel seat Run out relative to the reference Y-Z[c] Cylindricity	q	1,5 0,1	0,03 0,015
Motor bearing seats Run out relative to the reference Y-Z[c] Cylindricity	r	1,5 0,1	0,02 0,015
Disk brake seat Run out relative to the reference Y-Z[c] Cylindricity	s	0,15 0,1	0,03 0,015
Axle body Run out relative to the reference Y-Z[c]	t		0,5 [d]
Bore Concentricity relative to the reference Y-Z [c]	u		0,5
Holes for fixing axle end caps Concentricity relative to the reference Y-Z [c]	v		0,5
Machining centre run out relative to the reference Y-Z [c]	w_1 w_2 (details R1/R2)		0,02 0,03

[a] For parameters which do not have a tolerance in this table, the general tolerances of EN 22768-2 shall be applied.
[b] For old axle types with plain bearing journals, the requirements are in the standards that deal with these products.
[c] Reference axis: the reference axis is taken from the axle journals, identified as Y-Z in Figure 8.
[d] 0,3 mm for category 1 axles.

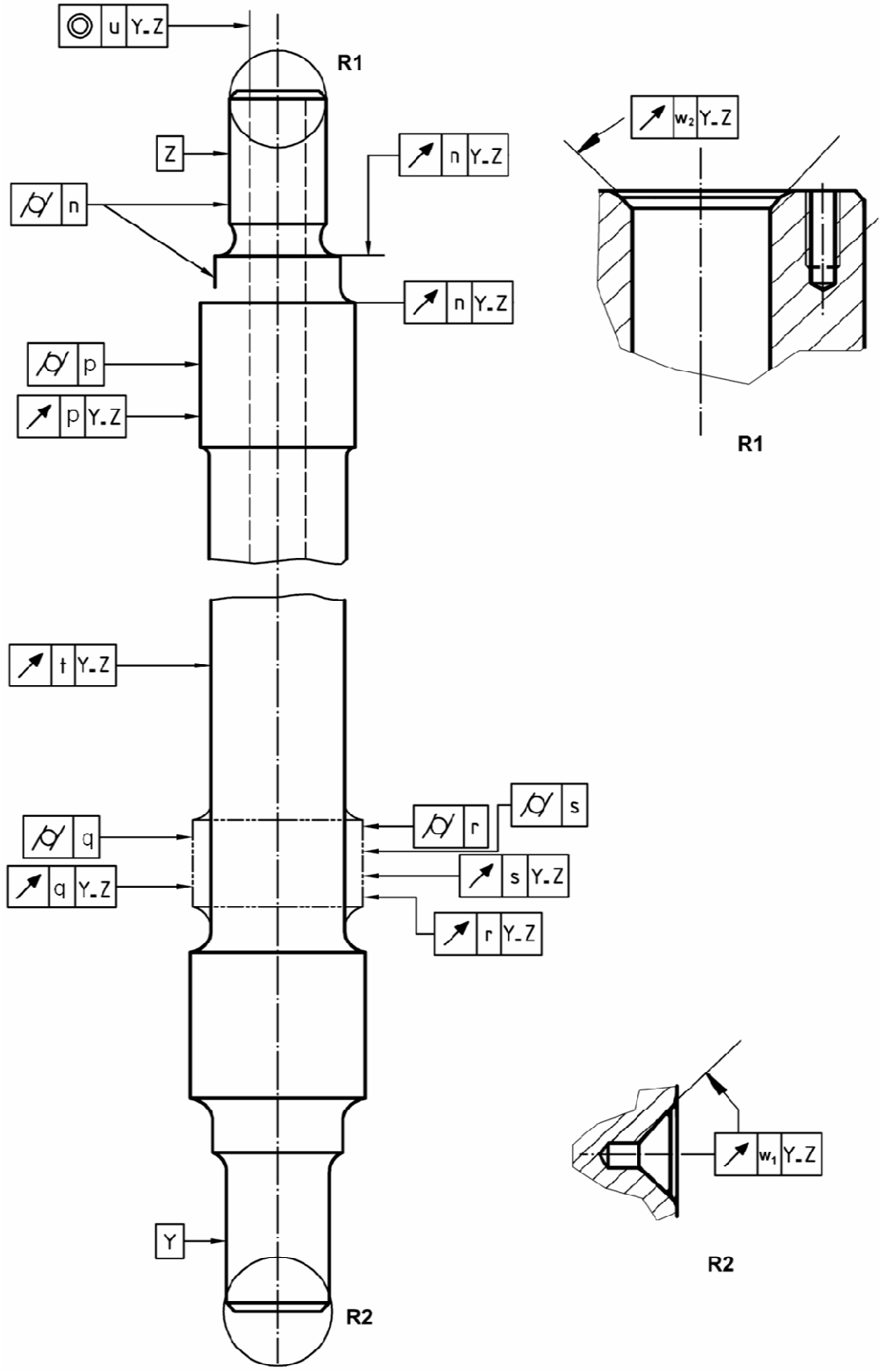


Figure 8 — Geometrical tolerance symbols

Table 10 — Dimensional tolerances

Designation	Symbol (see Figure 9)	Dimensional tolerances[a] (mm)	
		Rough-machined	Ready for assembly
Longitudinal sizes			
- Length of axle[b]	A	+2 / 0	± 1
- Length of wheelseat (including collar)	B	+2 / 0	0 /- 0,5
- Length over abutments (between reference planes)	C	+2 / 0	± 0,5[d]
- Journal bearing seat length	D	0 / -2	+1 / 0
Diameters			
- Diameter of journal	H	+2 / 0	[c]
- Wheelseat diameter	K	+2 / 0	[c]
- Diameter of seats of gear wheel, or brake disc, or plain seal spacer, or bearing seat for motor suspension or motor drive roller bearing seat	J	+2 / 0	[c]
- Abutment diameter	N	+2 / 0	± 0,25
- Diameter of body	P	+4 / 0	+2/ 0
- Diameter of bore	O	-	± 1

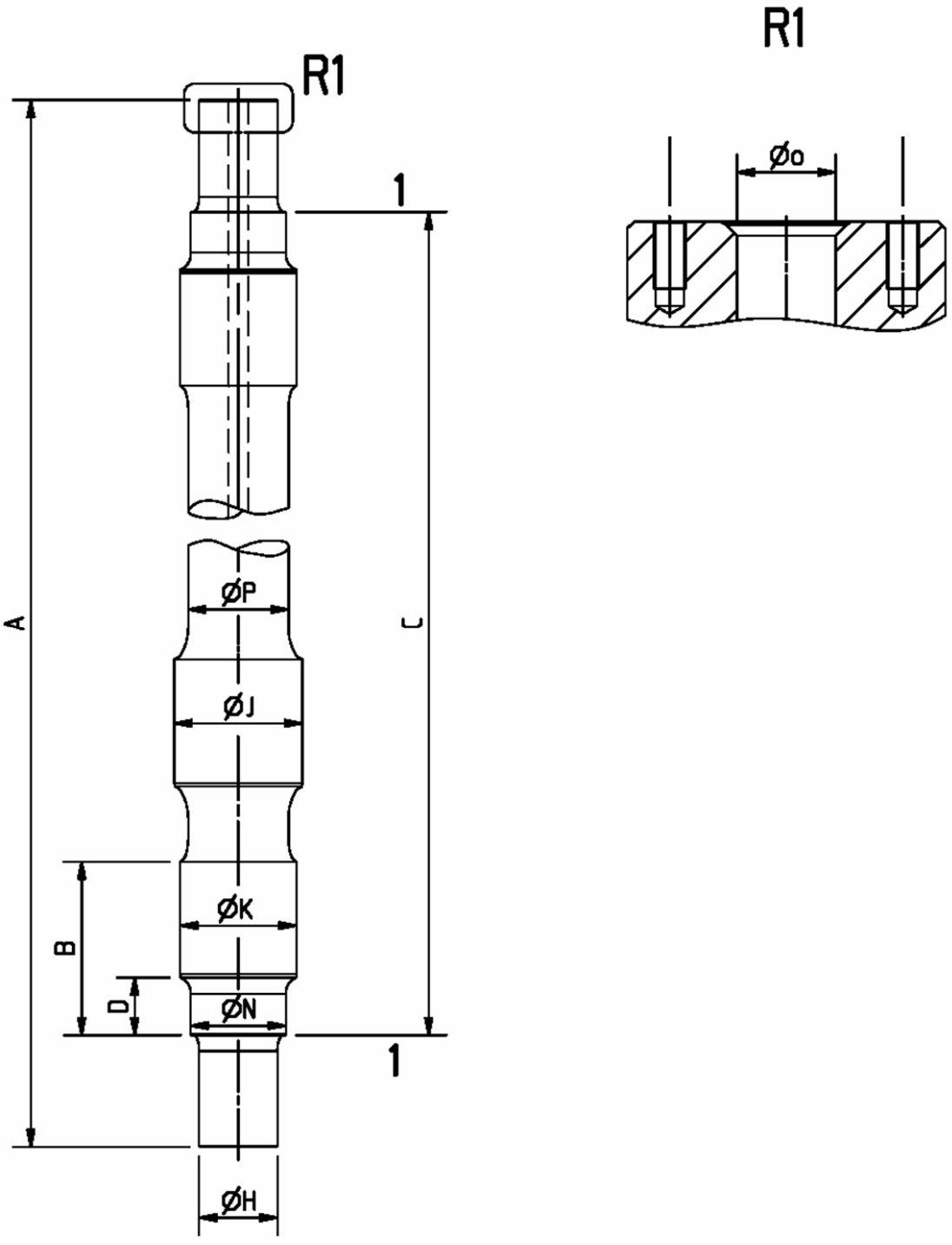
[a] For parameters that do not have a tolerance defined in this table, the general tolerances of EN 22768-1 shall be applied.

[b] Attention is drawn to the fact that compliance with tolerances over the total length "A" does not allow all the individual tolerances to be cumulatively applied to the particular dimensions.

[c] According to the requirements of the drawing or documents accompanying the order.

[d] Other geometries may be proposed and defined in the order.

Dimensions in millimetres



Key

1 reference surfaces

Figure 9 — Dimensional tolerance symbols

3.9 Protection against corrosion and against mechanical aggression

3.9.1 Final protection

3.9.1.1 General

All axles in service shall be protected against corrosion for the areas where there are no fitted components. For some axles, it is necessary to have protection against mechanical aggression (impacts, gritting, etc.).

Four classes of protection are defined, according to the use of the axle and the maintenance policy that is applied to the axle:

— class 1: sections of axles that are subject to atmospheric corrosion and to mechanical impacts;

— class 2: sections of axles that are subject to the action of specific corrosive products;

— class 3: sections of axles that are subject to atmospheric corrosion;

— class 4: axles that are subject to atmospheric corrosion when the stresses calculated according to EN 13103 and EN 13104 in the sections that are subject to atmospheric corrosion are less than 60 % of the permissible stresses;

— different classes are permitted on the same axle.

The choice between these four classes shall be defined in the order unless other requirements are defined. Some areas of an axle protected by a class 1 or class 3 coating can be requested with a class 2 coating.

The protective coatings for each class are, as a minimum, defined by the following characteristics given in Table 11. Other characteristics may also be required in the order according to particular conditions of utilization of the axles. The tests shall be carried out several days after the application of the coating, depending on the paint system and the recommendations of the paint supplier. In the absence of any information, a period of 14 days after the application of the coating may be adopted.

The bore surface of hollow axles shall be protected against corrosion using a product whose properties are specified by the customer and the supplier.

Table 11 — Protective coatings

	Class 1	Class 2	Class 3	Class 4
Coating thickness	X	X	X	-
Coating adhesion	X	X	X	-
Resistance to impacts	X	-	-	-
Resistance to gritting	X	X	X	-
Resistance to salt spray	X	X	X	-
Resistance to specific corrosive products	-	X	-	-
Coating resistance to cyclic mechanical stresses	X	X	X	-

NOTE Particular attention should be paid to the environmental impact of the paint system used. In order to avoid the emission of volatile organic components (VOC), water-based paints are recommended. In this case, the surface preparation and specific application requirements should be defined by the customer and supplier in order to meet the requirements of this standard.

3.9.1.2 Coating thickness

3.9.1.2.1 Values to be achieved

Unless the order includes special requirements, the minimum coating thickness shall be that which was recorded and found satisfactory during the "axle" product qualification.

3.9.1.2.2 Test piece

The test piece shall be the axle covered with its coating.

3.9.1.2.3 Method of measurement

The measurement shall be carried out by the 6 Ba method of EN ISO 2808:2007, provided that the thickness of the coating permits this. If not, it is to be agreed between the customer and the supplier.

3.9.1.3 Coating adhesion

3.9.1.3.1 General

The adhesion is a characteristic of all adhesive forces applied between the coating and the axle surface.

3.9.1.3.2 Characteristics to be achieved

For a coating thickness of up to 250 µm, the appearance shall comply with classification 1 of EN ISO 2409:2007, after incisions and coating wrench tests.

For a coating thickness greater than 250 µm, the adhesion characteristic shall be agreed between the customer and the supplier.

3.9.1.3.3 Test piece

The test piece shall be the axle or an axle section covered with the coating to be evaluated.

3.9.1.3.4 Test method

For a coating thickness of up to 250 µm, the test method shall be that recommended by EN ISO 2409.

For a coating thickness greater than 250 µm, EN ISO 2409 cannot be applied, therefore the test method shall be agreed between the customer and the supplier.

3.9.1.4 Resistance to impacts

3.9.1.4.1 General

This characteristic defines the ability of the coating to protect the axle from damage due to impacts from projectiles, e.g. ballast. This characteristic applies only to class 1.

3.9.1.4.2 Characteristics to be achieved

After the test defined in 3.9.1.4.4, no hole shall be found in the coating, nor shall there be any alteration to the test piece surface.

3.9.1.4.3 Test piece

The test piece shall be the axle or an axle section covered with the coating to be evaluated.

3.9.1.4.4 Test method

The test piece shall be tested by firing a projectile onto the protected surface in accordance with Annex C.

3.9.1.5 Resistance to gritting

3.9.1.5.1 General

This characteristic defines the ability of the coating to protect the axle from damage due to repeated sand or grit blasting.

3.9.1.5.2 Characteristics to be achieved

After the test defined in 3.9.1.5.4, the coating surface shall comply with:

— coating loss level 3 for the protection of classes 1 and 2;

— coating loss level 4 for the protection of class 3

as described in Annex D.

3.9.1.5.3 Test piece

The test piece shall be the axle or an axle section covered with the coating to be evaluated.

3.9.1.5.4 Test method

The method to assess the resistance to gritting is given in Annex D.

3.9.1.6 Resistance to salt spray

3.9.1.6.1 General

This characteristic defines the ability of the axle surface, when protected by its coating, to resist corrosion accelerated by an artificial salt spray.

3.9.1.6.2 Characteristics to be achieved

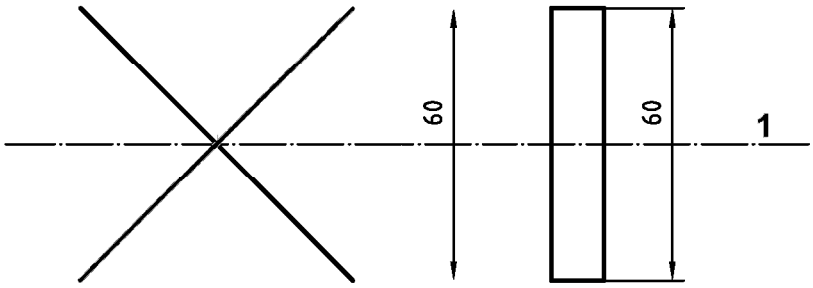
After the test defined in 3.9.1.6.4, no corrosion shall be found under the coating, nor shall there be any corrosion present at a distance of more than 2 mm from the edges or from the incisions in the coating.

The length of the incision is divided into successive 10 mm sections. The maximum width of the corrosion is noted for each of these sections. The average of these measurements constitutes the increase in corrosion.

3.9.1.6.3 Test piece

The test piece shall consist of an axle section covered with the coating to be evaluated in which cross-shaped incisions (for coating thickness ≤ 250 µm) or an aperture (for coating thickness > 250 µm) have been made (see Figure 10).

Dimensions in millimetres



Key

1 generating line

Figure 10 — Salt spray test pieces

3.9.1.6.4 Test method

The assessment of resistance to salt spray is carried out in accordance with EN ISO 9227:2006; the solution used is that of the NSS test of that standard.

3.9.1.7 Resistance to specific corrosive products

3.9.1.7.1 General

This characteristic, which only affects the class 2 coating, assesses its resistance to specific corrosive products that might affect it (corrosive environments, products transported, etc.).

3.9.1.7.2 Characteristics to be achieved

After the test defined in 3.9.1.7.4, no alteration of the coating shall be found, nor of the surface. Furthermore, compliance with an adhesion test carried out according to EN ISO 2409 shall allow this coating to be classified as class 1 also.

3.9.1.7.3 Test piece

The test piece shall consist of an axle section covered with the coating to be evaluated.

3.9.1.7.4 Test method

The resistance to specific chemicals is determined by means of a test that includes repeated submergence and emergence. This test is described in Annex E (normative). It shall be followed by the adhesion test defined in EN ISO 2409, performed 24 h after the end of the corrosion test phase.

3.9.1.8 Coating resistance to cyclic mechanical stresses

3.9.1.8.1 General

This characteristic, which defines the ability of the coating to resist cyclic mechanical stresses, shall be verified by means of test pieces. They shall be stressed in rotary bending by increasing the stress levels up to the failure point of the coating. The level reached before this point defines the resistance of the coating.

3.9.1.8.2 Characteristic to be achieved

In the test conditions defined in 3.9.1.8.4,

— level 5 shall be reached with class 1 and class 3 coatings,

— level 10 shall be reached with class 2 coating.

3.9.1.8.3 Test piece

The rotary bending test piece (with a diameter of 8,5 mm at its active part) shall be made of steel grade EA1N, protected by the coating to be evaluated.

An example of a drawing of the test piece is given in Annex H.

3.9.1.8.4 Test method

The test method and conditions are defined in Annex F.

3.9.2 Temporary protection

Before assembly, the parts of the axle that have been prepared to receive the other components shall have been given temporary protection against corrosion and impact, in accordance with the delivery condition.

The characteristics of the protection are to be agreed between the customer and the supplier according to the transportation conditions and storage conditions (handling, environment, etc.).

This protection shall remain effective for at least 3 months in normal atmospheric conditions, unless otherwise specified.

3.10 Marking

Each axle shall be identified, as a minimum, with the following stamped marks:

— manufacturer's mark;

— cast number;

— steel grade;

— month and two last figures of the year of production;

— number of the axle in the batch, following heat treatment.

These marks shall be located on one journal end only and shall be limited to one half of the surface of this journal end. The other half of the surface shall be dedicated to the wheelset manufacturer’s marking.

On the other journal end, half of the surface shall be free of any marks. This shall be dedicated to the operator’s marks.

The configuration of this marking shall be defined in the order. Any burrs resulting from the stamping shall be levelled in order to permit in-service ultrasonic examination.

Annex A
(normative)

Particular characteristics for axles of steel grade EA1T and EA4T

A.1 Chemical composition

The chemical composition shall be as given in Table A.1.

Table A.1 — Maximum limit by product analysis (%)

Grade	C	Si	Mn	P [a]	S	Cr	Cu	Mo	Ni	V
EA1T	0,40	0,50	1,20	0,020	0,020 [a b]	0,30	0,30	0,08	0,30	0,06
EA4T	0,22 0,29	0,15 0,40	0,50 0,80	 0,020	 0,015 [b]	0,90 1,20	 0,30	0,15 0,30	 0,30	 0,06

[a] A maximum content of 0,025% may be agreed at the time of enquiry and the order.

[b] A minimum sulfur content may be agreed at the time of enquiry and the order according to the steelmaking process, in order to safeguard against hydrogen embrittlement.

A.2 Mechanical characteristics

A.2.1 Characteristics from tensile test

The values of R_{eH}, R_m and A_5 shall be as defined in Table A.2.

Table A.2 — Values to be achieved at mid-radius of solid axles or at mid-distance between external and internal surfaces of hollow axles

Grade	R_{eH} (N/mm²) [a]	R_m (N/mm²)	A_5 %
EA1T	≥ 350	550 - 700	≥ 24
EA4T	≥ 420	650 - 800	≥ 18

[a] If no distinctive yield strength is present, the proof stress $R_{p0,2}$ shall be determined .

A.2.2 Impact test characteristics

The values of absorbed energy with U-notch specimens (KU) shall be as defined in Table A.3.

Table A.3 — Values to be achieved at mid-radius of solid axles or at mid-distance between external and internal surfaces of hollow axles

Grade	*KU* longitudinal (J) at 20 °C	*KU* transverse (J) at 20 °C
EA1T	≥ 40	≥ 25
EA4T	≥ 40	≥ 25

A.2.3 Fatigue characteristics

The limiting stresses shall be as defined in Table A.4.

Table A.4 — Fatigue limit values

Grade	F_1 ≥	F_2 ≥	R_{fL} ≥	R_{fE} ≥	R_{fL}/R_{fE} ≤
EA1T	200 N/mm^2	80 N/mm^2	250 N/mm^2	170 N/mm^2	1,47
EA4T	240 N/mm^2	96 N/mm^2	350 N/mm^2	215 N/mm^2	1,63

A.3 Metallographic characteristics

For EA1T, the micrographic structure shall be of ferrite and pearlite. The grain size shall not be greater or finer than that defined by standard chart 5 in Annex B of EN ISO 643.

Steel grade EA4T consists of a micrographic structure of bainite/annealed martensite. The grain size shall not be greater or finer than that defined by standard chart 5 in Annex B of EN ISO 643.

Annex B
(normative)

Standard wedge for measurement of permeability to ultrasound

B.1 Test piece

The longitudinal test piece is taken from an axle that has been examined by ultrasound in order to ensure that there are no defects.

B.2 Tolerances of the wedge

Length and diameter	≤ 0,1 if values are ≤ 100 mm
	≤ 0,2 if values are > 100 mm
Perpendicularity between faces	≤ 5°
Roughness	1,6 ≤ Ra ≤ 3,2

B.3 Steel grade

EA1N with double normalization and a chemical composition and mechanical characteristics conforming to this standard. The grain size shall not exceed that defined by standard chart 8 in Annex B of EN ISO 643:2003.

Annex C
(normative)

Method to assess resistance to impact of the coating

C.1 Principle

The test method is to fire a projectile perpendicular to the protected surface and then to study the change to the coating and that of the test piece surface.

C.2 Test piece

The test piece shall be a coated axle or coated axle section representative of the finished product.

C.3 Apparatus

A machine that allows a treated steel projectile to be fired (diameter: 32 mm; top angle:105°; mass: 60 g). Its Vickers hardness shall be 400.

C.4 Procedure

It shall be fired by the expansion of a volume of air compressed at 8 bar in order to ensure an exit speed of 19,4 m/s.

The resistance to the impact is assessed at – 25 °C and at ambient temperature.

C.5 Expression of results

After the impact, the appearance of the coating surface shall be examined with the naked eye, as well as the appearance of the test piece surface, once the coating has been removed. Changes shall be recorded and compared to the criteria given by this standard.

Annex D
(normative)

Method to assess resistance to gritting of the coating

D.1 Principle

A known quantity of grit is dropped onto the protected surface and the coating is then examined for any change.

D.2 Test piece

The test piece shall be a coated axle or coated axle section representative of the finished product.

D.3 Apparatus

Straight tube (inside diameter: 38 mm; height: 5 m) in the upright position, with a funnel at the top to receive the grit and closed by a trapdoor at the bottom.

The grit is represented by a kilogram of HM6 steel nuts, of class 8.8, as defined by EN 20898-2:1993.

D.4 Procedure

Place the test piece with its coating 30 mm beneath the tube so that the falling direction of the grit makes an average angle of 45° with the tangent to the test surface.

Open the trap door and drop the grit all at once.

Examine the impacted surface and record the results.

D.5 Expression of results

Use the following table to note the percentage P of surface[3] where the coating has come off in flakes.

Table D.1 — Results

Level	P%	Level	P%
1	10	6	60
2	20	7	70
3	30	8	80
4	40	9	90
5	50	10	100

3 Inner surface of the closed convex polygonal line passing through the outside points of impact.

Annex E
(normative)

Method to assess the resistance of the coating to specific corrosive products

E.1 Principle

The test piece is repeatedly submerged in a test solution and the coating and the protected surface of the test piece is examined for possible changes.

E.2 Test piece

The test piece shall be a coated axle or a coated axle section representative of the finished product.

E.3 Apparatus

A watertight enclosure, which is kept at constant temperature, and in which a system allows for a test piece to be submitted to alternate submergence/emergence cycles.

E.4 Corrosive products

The corrosive products into which the specimen is dipped shall be selected according to the specific aggressive elements that the axle shall be submitted to during its lifetime.

The three following solutions:

1) 3% water solution, by volume, with (95-97)% sulfuric acid, in demineralized water with a resistivity of more than 10 MΩ.m;

2) 10% water solution, by mass, with potassium chloride, in demineralized water with a resistivity of more than 10 MΩ.m;

3) 10% water solution, by mass, with sodium hydroxide, in demineralized water with a resistivity of more than 10 MΩ.m

are representative of the majority of the corrosive agents the axles are subjected to in service.

NOTE Other products, such as oils, fuels, etc. may be considered.

E.5 Procedure

The tests shall be performed on the test piece for each specific corrosive product and in the following conditions:

— temperature of the enclosure and solution: 23 ± 2 °C;

— duration of a submergence period: 4 h;

— duration of an emergence period: 4 h;

— number of submergence/emergence cycles: 32

The customer and the supplier may agree on different test conditions, according to the specific corrosive product under examination.

After testing, the test pieces shall be rinsed out with clear water and dried by ambient air for a period of 1 h.

E.6 Expression of results

After the test piece has been submitted to the tests, rinsed out and dried, possible changes shall be examined with the naked eye; an adhesion test shall also be carried out, according to EN ISO 2409.

Annex F
(normative)

Method to assess the resistance of the coating to cyclic mechanical stresses

F.1 Purpose

The purpose of this test is to assess the resistance of the coating to cyclic mechanical stresses.

F.2 Principle

The test comprises the stressing of a steel test piece, covered with the coating to be evaluated, in rotary bending, by increasing stress levels up to failure point of the coating.

A corrosive product is used to initiate a crack in the test piece when the coating is torn.

F.3 Test piece

The test pieces are those defined in Figure H.2. Their diameter is 8,5 mm over their active part.

The test pieces are made of steel grade EA1N as defined in this standard. They are covered over their active parts with the coating to be evaluated.

F.4 Apparatus

The apparatus shall allow rotary bending tests to be carried out on the test pieces in which the stresses applied to active parts vary according to the level.

The apparatus shall also allow for the application to the test pieces of a corrosive product during testing.

F.5 Procedure

The tests shall be performed on four test pieces, at successive level numbers, for which the maximum value of the stresses applied to the test piece surfaces is given by the following relation:

$$\sigma_n = 160 + n \times 10 \text{ N/mm}^2$$

where:

σ is the maximum stress on the test piece surface, over its active part
n is the level number ($n > 0$).

The test begins with n equal to 1

Each level comprises 13×10^6 cycles under the simultaneous action of the mechanical stress and the specified corrosive product. A 96-h non-testing time shall be allowed after each level, with no stress and no action from the corrosive product.

Demineralized water shall be used as the corrosive product, with a resistivity of more than 100 MΩ.m, which is distributed "drop by drop", one drop every (15 ± 2) s being applied to the active part of the test piece.

F.6 Expression of results

Three of the four test pieces shall reach the indicated level without failure.

Annex G
(normative)

Measurement of the hydrogen content in the steel for axles at the melting stage

G.1 Sampling

In order to meet the specified requirements, samples are taken from the molten bath using one of the following 4 methods:

1) copper mould;

2) silica dip tubes;

3) quartz bubbling tube (translucent quartz is prohibited because of its hygroscopic ability);

4) immersion probe method (carrier gas method with thermal conductivity detector).

G.2 Analysis methods

Two methods only are accepted:

— vacuum extraction in a temperature range of 650 °C to 1050 °C;

— injecting a carrier gas into the liquid steel at (650 ± 20) °C. The resulting diffused gas containing hydrogen is recovered for re-circulation and analysis.

G.3 Precautions

See 6.5 of EN ISO 14284:2002.

NOTE The operators should be specifically trained for performing this analysis.

Annex H
(informative)

Drawings of test pieces

Dimensions in millimetres

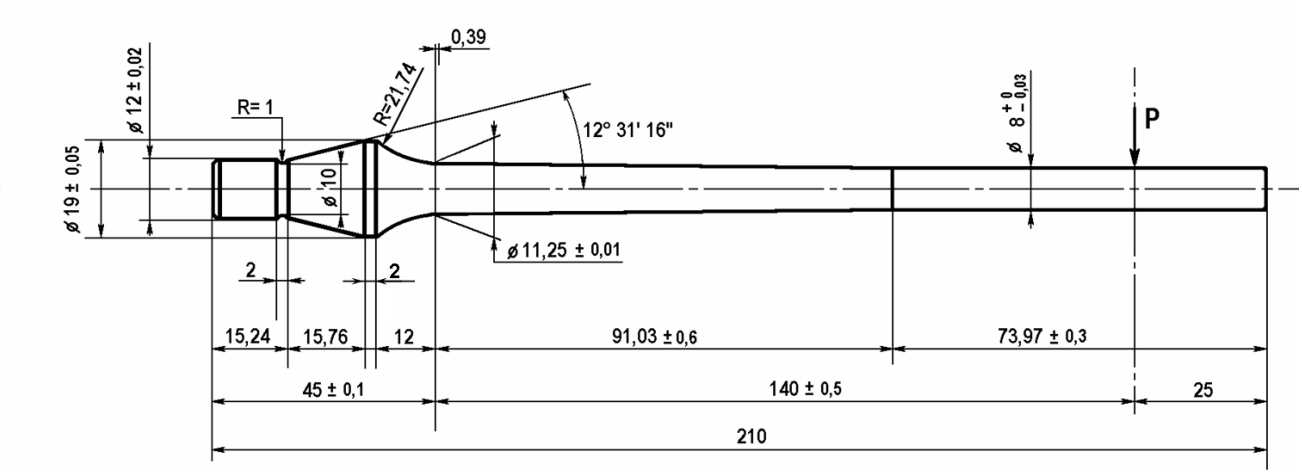


Figure H.1 — Small-scale test piece for steel fatigue limit determination

Dimensions in millimetres

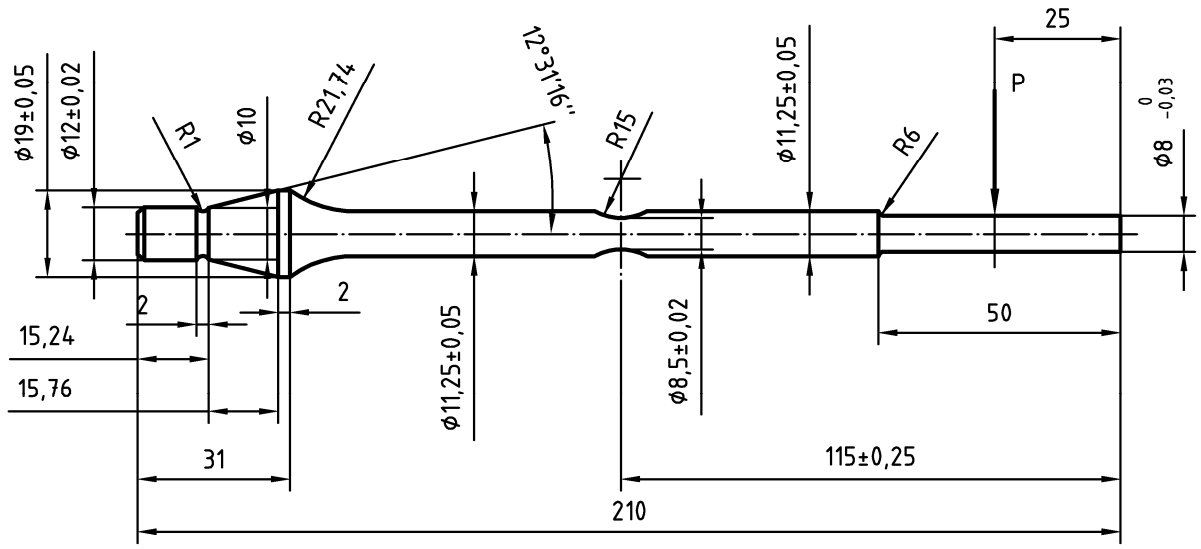
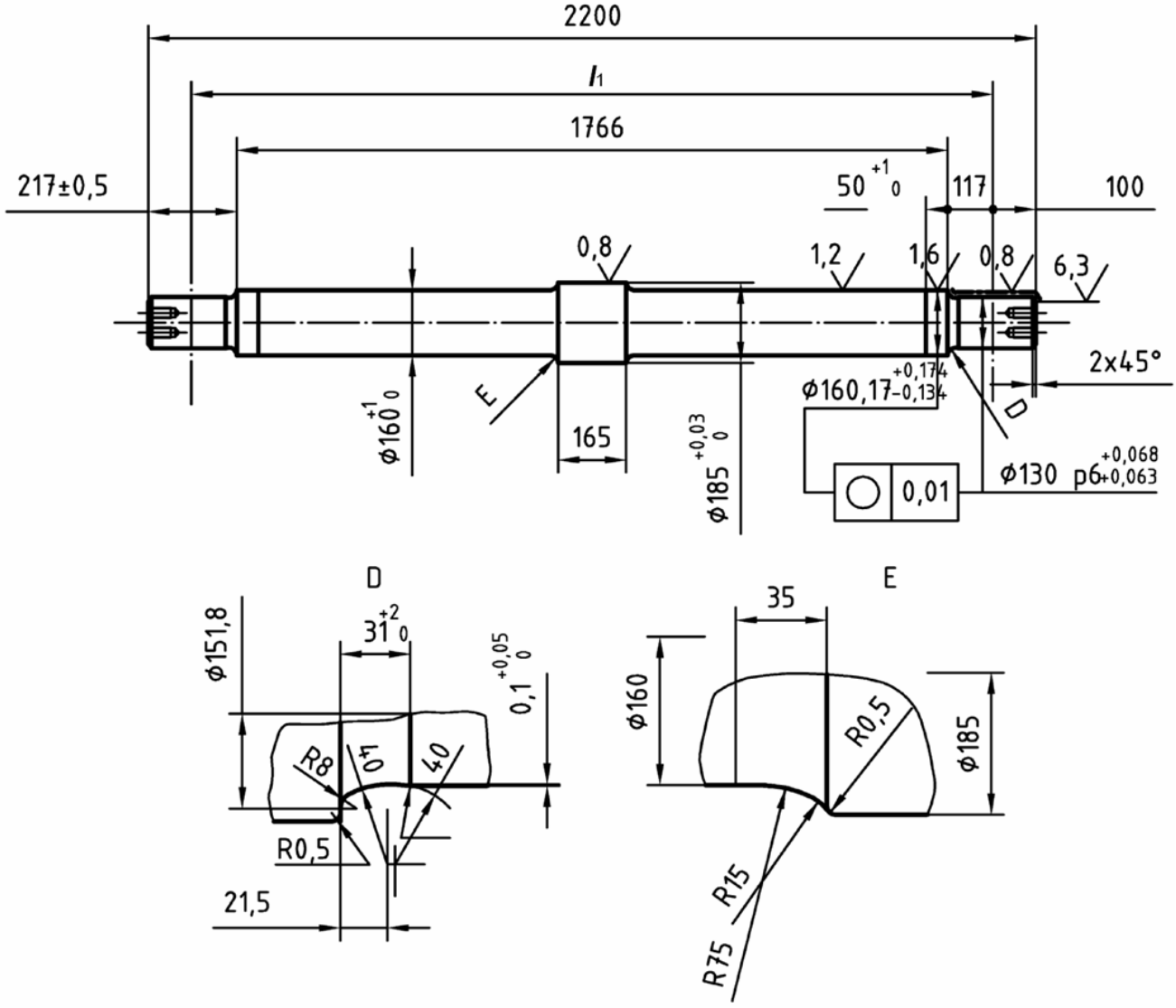


Figure H.2 — Small-scale test piece to assess coating resistance under cyclic mechanical stresses

Dimensions in millimetres



Key

1 centre to centre distance of journals 2000

Figure H.3 — Full-size test piece for fatigue test

Annex I
(informative)

Product qualification

I.1 Introduction

CEN/TC 256 considers that the following clauses represent the best means of assessing conformity of a range of products to this standard. However, a quality system other than the one specified in EN ISO 9001 may be applied.

I.2 General

An axle shall be qualified before being used on a European network.

This clause specifies the requirements and procedures to be applied for product qualification.

Qualification of an axle is directly linked to the supplier and an axle can only be qualified if the supplier meets the requirements specified in I.3.

These requirements and procedures apply only to axles for which the design has already been approved:

— either by previous use on European networks;

— or by application of EN 13103 and EN 13104.

The requirements are to be applied in the following cases:

— any axle to be provided by a new supplier;

— any non-qualified axle to be provided by a supplier, when its diameter is appreciably different to qualified axles from this supplier;

— any change in the manufacturing process of a qualified axle from a supplier.

I.3 Requirements

I.3.1 Requirements to be met by the supplier

I.3.1.1 General

Where manufacture of an axle involves more than one supplier, the following requirements shall be met by all concerned.

I.3.1.2 Quality organization

The supplier should operate a quality assurance system conforming to EN ISO 9001.

I.3.1.3 Staff qualification

Staff trained in non-destructive testing shall be qualified in accordance with EN 473.

I.3.1.4 Equipment

The equipment used by the supplier for manufacture, control and monitoring shall allow the requirements of this standard to be met.

For ultrasonic testing, an automatic method should be used. For non-automatic methods, the reproducibility shall be demonstrated.

I.3.2 Requirements to be met by the product

The product shall meet the product requirements specified in clause 3.

The traceability of each axle shall be established after its heat treatment.

I.4 Qualification procedure

I.4.1 General

The qualification procedure for the product comprises three successive stages:

— provision of documents by the supplier;

— evaluation of the manufacturing equipment and production processes;

— laboratory tests.

I.4.2 Documentation required

When a request for qualification is submitted, the supplier shall provide a file comprising:

a) a description of the products that are the subject of the request;

b) a description of the company stating:

c) company size (number of employees, defining the proportion between production, control and quality assurance),

   1) annual production of all the products;

   2) a list of all the means of production and control;

d) data about the company organization, with the relevant organization charts;

e) a description of the manufacturing processes with explanations of the different stages of manufacture, including the reduction ratio of the rolling or forging process;

f) data about raw materials with the list of suppliers;

g) results of tests on the products that are the subject of the request;

h) qualification certificates if the product has been previously qualified.

If a file has already been provided by a supplier for the qualification of a different axle, the file to be provided by this supplier for the qualification of a new axle shall include only data specific to this new axle or new to the company

I.4.3 Evaluation of the manufacturing plant and of the production processes

This evaluation comprises:

— an inspection of the manufacturing plant and examination of the production processes;

— an inspection of the raw material manufacturing plant and examination of its production processes;

— auditing of the data provided by the supplier to confirm whether the requirements of I.3.1 have been fully met;

— auditing of the information provided in the documents referred to in I.4.2.

At the end of this stage, a report shall be produced. It shall identify all the production processes including those of the raw material which are essential for product quality for which qualification is requested. It shall give an assurance that the evaluation satisfies the requirements of I.3.1 for the qualification procedure to continue.

I.4.4 Laboratory tests

All characteristics defined in clause 3, except fatigue characteristics, shall be proven for two axles taken from one production process.

For the fatigue characteristics defined in 3.2.3, the verifications shall be carried out on axles to be qualified or on test pieces taken from products from the same fabrication process.

The method for verifying the level of residual stresses shall be defined following agreement between the customer and the supplier (see 3.6.4).
.
For better identification of the product to be qualified, there may be a need for further tests (metallographic, etc.) to be conducted at this stage, in addition to those mentioned in clause 3. The results of these tests have no influence on the final decision on qualification.

A report shall be produced. It shall describe the test pieces and the different tests. It shall also indicate the thickness of the final protective coating measured of the test pieces tested. It shall give the results and specify whether the product satisfies the requirements.

I.5 Qualification certificate

I.5.1 Condition of validity

The certificate of qualification shall specify the limits of validity at least for:

— the steel grades;

— the axle diameters;

— the availability of fatigue data;

— the class and thickness of the final protection.

I.5.2 Modification and extension

At the request of the supplier, the scope of the certification validity may be modified or extended if:

— other products are to be considered;

— the main parameters have been modified (manufacturing processes, quality organization, etc.).

I.5.3 Transference

In the case of a change in ownership, an existing qualification may, if requested, be transferred to another company if the relevant content and conditions prior to the qualification have not been modified.

I.5.4 Lapsed certification

The manufacturing equipment and processes described in I.4.3 shall be re-assessed if, in a period of 2 years, no products have been supplied within the scope of the product that was the subject of the qualification.

I.5.5 Cancellation

If the customer registers significant defects in the product, the parts of the qualification procedure concerned shall be repeated.

If the supplier has not ensured that important conditions of the qualification were met, it may be cancelled.

I.6 Qualification file

A qualification file shall be prepared for each qualified product. It shall contain the following documents:

— the application request from the supplier;

— the documents provided by the supplier (see I.4.2);

— the assessment reports (see I.4.3);

— the laboratory test reports (see I.4.4);

— the qualification certificate (see I.5).

Annex J
(informative)

Product delivery

J.1 Introduction

CEN/TC 256 considers that the following clauses represent the best means of assessing conformity of the products delivered to this standard.

J.2 General

The customer shall define the following in the order:

1) the geometry and the dimensions of the axle (drawings);

2) the steel grade if it is not grade EA1N;

3) the category of the axle according to its utilization;;

4) the delivery condition (see J.3);

5) the class of the final protection against corrosion and mechanical aggression and if it has to be on the axle before the assembly of the wheelset (see 3.9.1);

6) the nature and characteristics of the temporary protection for finished parts (see 3.9.2);

7) the configuration of the marking on the axle ends (see 3.10).

In the offer, the supplier shall make a proposal for the fabrication quality supervision of the products:

8) either by batch control as described in J.5.1,

9) or by a quality plan approved by the customer, as indicated in J.6.

The customer and the supplier shall agree on the following points:

10) internal integrity: parts which it is not possible to examine (see 3.4.2.4);

11) permeability to ultrasound: type of probes (see 3.5.4);

12) residual stresses: measurement method (see 3.6.4);

13) surface integrity: examination method of the bore surface (see 3.7.2.4);

14) protection against corrosion of the bore (see 3.9.1.1);

15) coating thickness: method of measurement (see 3.9.1.3);

16) coating adhesion: test method (see 3.9.1.3.4);

17) choice of controls (Table J.1).

The customer and the supplier shall agree on the following point:

18) roughness condition of the fillet radii: measurement method by comparison with tactile and visual specimens (see 3.7.1.2).

J.3 Delivery condition

The degree of finish of the different parts of an axle on delivery shall be any one of the following:

— unmachined (as-forged or as-rolled condition) where the specific area has not been machined except for what the manufacturer has to do to make the axle compatible with the requirements of this standard;

— rough-machined, where the specific part has been machined and requires subsequent machining;

— finished, where the specific part has undergone final machining (not applicable to seats);

— ready to assemble, where a seat has received final machining for assembly.

J.4 Controls on each axle

Whether the fabrication quality supervision is made with controls by batch sampling (see J.5), or with a quality plan (see J.6), controls are required to ensure that the special characteristics, which are defined in clause 3, are achieved. These controls shall be made on each delivered axle and are:

— internal integrity (see 3.4.2);

— permeability to ultrasound (see 3.5 or J.5.2);

— surface integrity (see 3.7.2).

J.5 Batch control

J.5.1 Controls

The nature and number of controls are defined in Table J.1. A batch comprises axles from the same cast and heat treated under the same conditions.

Table J.1 — Nature and number of controls to be carried out

Characteristics to be verified	Number of axles per batch to control		References
Maximum size of the batch	≤ 100	> 100	
- Chemical composition [e]	1	1	3.1
- Hydrogen content	[a]	[a]	[b]
- Tensile characteristics (mid-radius) [e]	1	2	3.2.1
- Impact test 3) [c e]			3.2.2
- longitudinal (mid-radius)	1	2	
- transverse (mid-radius)	1	2	
- Micrographic cleanliness [e]	1	2	3.4.1
- Permeability to ultrasound	100 %	100 %	3.5 or J.5.2
- Internal integrity [f]	100 %	100 %	3.4.2
- Surface integrity [d g]	100 %	100 %	3.7.2
- Surface appearance	100 %	100 %	3.7.1 or J.5.3
- Geometry and dimensions	100 %	100 %	3.8
- Final protection:			
- film thickness	10 %	10 %	3.9.1.1

[a] One analysis per cast. Care should be taken to ensure that the reported maximum hydrogen content value is representative of the whole cast.

[b] The hydrogen content is determined according to the methods described in Annex G (normative). It shall be < 2 ppm for category 1 axles and < 2,5 ppm for category 2 axles.

[c] Three test pieces are used for each test.

[d] By agreement between the customer and the supplier, the magnetic particle test for determining longitudinal defects may be replaced by a visual examination as defined in J.5.4.

[e] By agreement between the customer and the supplier, the test pieces may be taken from a journal extension. In this case, the values to be achieved shall be agreed between the customer and the supplier.

[f] By agreement between the customer and the supplier, the AVG method may be used.

[g] Depending on the magnetization process, demagnetization may be necessary. The method shall be agreed between the customer and the supplier.

J.5.2 Permeability to ultrasound

J.5.2.1 General

Comparison shall be made with the permeability of a reference axle that is agreed between the customer and the supplier.

J.5.2.2 Level to be obtained

The back echo obtained on inspected axles shall have an amplitude greater than or equal to the back echo amplitude recorded on the reference axle.

J.5.2.3 Test piece

Every axle shall be examined after heat treatment and in the finish-machined condition, before the application of the final protection.

J.5.2.4 Test method

Ultrasonic permeability shall be verified by examination in a direction parallel to the axle, according to method T of ISO 5948:1994. The probe frequency shall be 5 MHz for category 1 axles and equal to or higher than 2,5 MHz for category 2 axles.

J.5.3 Surface finish

The surface finish characteristics shall be in accordance with 3.7.1.1.

They may be estimated by comparison with the roughness specimens that are the subject of an agreement between the customer and the supplier.

J.5.4 Visual examination

The visual examination shall be made under normal conditions of vision.

The acceptability criteria shall be established on the basis of the reference images used by agreement between the customer and the supplier.

J.6 Quality plan

J.6.1 General

In the case of quality control by a quality plan (according to the definition in EN ISO 9000) of the products to be delivered, it shall be established by the supplier and shall be agreed with customer.

This quality plan shall refer to the quality manual of the supplier; it shall contain specific elements for the product.

J.6.2 Purpose

This plan shall be drawn up with the offer with the objective of:

— describing the processes and quality control of the producer in order to achieve the required quality of the product to be delivered; the reasons for their selection shall be given;

— the quality plan shall provide at least the same confidence as that from batch control.

This quality plan shall define the controls that are made during the manufacturing process and those for product delivery. These controls may be collated in the control plan of the fabrication process.

J.6.3 Application of the quality plan

Any modification to the quality plan shall only be made with the agreement of the customer.

If a non-conformity is discovered by the customer in the products to be delivered, the applicable clauses of the quality plan shall be discussed and if the result is unsatisfactory the quality plan can be cancelled.

In this case, the controls and tests defined by the "control by sampling of batches" mode shall be applied in their entirety until a new agreement is reached between the customer and the supplier.

J.7 Allowable rectification

With the exception of wheelseats, journals ready for assembly, stress relieving grooves and fillets, on which retouching work is not authorized, surface defects may be eliminated by metal removal. This may be achieved by machining or fine grinding, on the condition that these processes do not result in excessive heating or the formation of cracks and do maintain dimensional tolerances. The resultant surface shall be carefully blended into the adjacent material.

In z_0 zones (see Figure 7) of powered axles, such rectification is allowed if the depth of the defect to be repaired is less than 0,25 mm.

Each rectification is followed by inspection to determine that the requirements given in 3.7.2 have been met.

Annex ZA
(informative)

Relationship between this European Standard and the Essential Requirements of Council Directive 96/48/EC of 23 July 1996 on the interoperability of the trans-European high-speed rail system amended by Directive 2004/50/EC of 29 April 2004

This European Standard has been prepared under a mandate given to CEN/CENELEC/ETSI by the European Commission and the European Free Trade Association to provide one means of conforming to Essential Requirements of the New Approach Directive 96/48/EC, amended by Directive 2004/50/EC.

Once this standard is cited in the Official Journal of the European Communities under that Directive and has been implemented as a national standard in at least one Member State, compliance with the normative clauses of this standard indicated in Table ZA.1 confers, within the limits of the scope of this standard, a presumption of conformity with the relevant Essential Requirements of that Directive and associated EFTA regulations.

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Table ZA.1 — Correspondence between this European Standard and Directive 96/48/EC

Clause(s)/sub-clause(s) of this EN	Clauses/subclauses/points and annexes of the June 2006 TSI adopted by the Council on 21 February 2008	Corresponding text, clauses/subclauses/annexes of Directive 96/48/EC
The whole standard is applicable	4.2.3.4.1 Dynamic rolling stock behaviour. General	Annex III, Essential requirements, General requirements – 1.1.1, 1.1.3 Safety Annex III, Essential requirements, General requirements – 1.5 Technical compatibility Annex III, Essential requirements, Requirements specific to each subsystem "Control and Command and Signalling" – 2.3.2 Technical compatibility Annex III, Essential requirements, Requirements specific to each subsystem "Rolling stock" – 2.4.2 Reliability and availability

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

Annex ZB
(informative)

Relationship between this European Standard and the Essential Requirements of Directive 2001/16/EC of the European Parliament and of the Council of 19 March 2001 on the interoperability of the trans-European conventional rail system amended by Directive 2004/50/EC of 29 April 2004

This European Standard has been prepared under a mandate given to CEN/CENELEC/ETSI by the European Commission and the European Free Trade Association to provide one means of conforming to Essential Requirements of the New Approach Directive 2001/16/EC, amended by Directive 2004/50/EC.

Once this standard is cited in the Official Journal of the European Communities under that Directive and has been implemented as a national standard in at least one Member State, compliance with the normative clauses of this standard indicated in Table ZB.1 confers, within the limits of the scope of this standard, a presumption of conformity with the relevant Essential Requirements of that Directive and associated EFTA regulations.

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Table ZB.1 — Correspondence between this European Standard and Directive 2001/16/EC

Clause(s)/sub-clause(s) of this EN	Clauses/subclauses/points and annexes of the January 2005 rolling stock – freight wagon TSI and approved by the committee on the interoperability and safety of the European rail system	Corresponding text, clauses/subclauses/annexes of Directive 2001/16/EC
The whole standard is applicable	4.2.3.4.1 Vehicle dynamic behaviour. General 5.3.2.4 Vehicle track interaction and gauging. Axle 5.4.2.4 Vehicle track interaction and gauging. Axle 6.1.3.2.4 Vehicle track interaction and gauging. Axle Annex E: Vehicle track interaction and gauging, Wheelset dimensions and tolerances for standard gauge Annex M: Vehicle track interaction and gauging, Axle Annex Q: Assessment procedures, interoperability constituents Annex Y: Constituents, bogies and running gear	Annex III, Essential requirements, General requirements – 1.1.1, 1.1.3 Safety Annex III, Essential requirements, General requirements – 1.5 Technical compatibility Annex III, Essential requirements, Requirements specific to each subsystem "Control and Command and Signalling" – 2.3.2 Technical compatibility Annex III, Essential requirements, Requirements specific to each subsystem "Rolling stock" – 2.4.2 Reliability and availability

	Clauses/subclauses/points and annexes of the Conventional Rail Rolling Stock TSI for Locomotives and Traction Units (draft submitted to the committee on the interoperability and safety of the European rail system in September 2008)	
	3.10.1.1.1 *4.2.3.5.2 Wheelsets*	

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within the scope of this standard.

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[2] EN ISO 9000, *Quality management systems – Fundamentals and vocabulary (ISO 9000:2005)*

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[4] CEN/TR 10261, *Iron and steel – Review of available methods of chemical analysis.*

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