APTU Uniform Rules (Appendix F to COTIF 1999)

Uniform Technical Prescriptions (UTP) applicable to Rolling Stock, subsystem

FREIGHT WAGONS - (UTP WAG) - ANNEX L

VEHICLE TRACK INTERACTION AND GAUGING

WHEELS

Explanatory note:

The texts of this UTP which appear across two columns are identical to corresponding texts of the European Union regulations. Texts which appear in two columns differ; the left-hand column contains the UTP regulations, the right-hand column shows the text in the corresponding EU regulations. The text in the right-hand column is for information only and is not part of the OTIF regulations.

OTIF UTP	*Corresponding text in EU regulations* [1]	*EU ref.* [2]

L.1 DESIGN ASSESSMENT

For wagons subject to section 7.6.4 of this UTP WAG, cast steel wheels are not authorised pending the publication of a European standard.		2009/107/EC JJ.2, 1.6

L.1.1 GENERAL

This chapter describes the assessment methods for wheel design in order to meet the performance requirements. There are three main aspects of a wheel's performance, each of which has different aims:

- Geometrical
  - to ensure compatibility with the track
  - to ensure compatibility with the axle
- Thermo mechanical:
  - to manage wheel deformation
  - to ensure that braking does not induce broken wheels
- Mechanical:
  - to ensure compatibility with the intended axle load
  - to ensure that wheels do not fail due to fatigue.

L.1.2 DESIGN PARAMETERS

L.1.2.1 Parameters for geometrical compatibility

There are three sets of parameters that are linked to functional, assembly or maintenance purposes.

[1] TSI Freight Wagons – The Annex to the Commission Decision 2006/861/EC published in the EU Official Journal L344 on 08.12.2006 as amended by Commission Decision 2009/107/EC published in EU Official Journal L45 on 14.02.2009.

[2] If no EU reference is indicated, it means that the chapter/section number is the same as in the OTIF text.

- Functional purposes
  - Nominal tread diameter: it affects buffer height and the loading gauge.
  - Rim width: it interfaces with Switches and Crossings.
  - Cone angle of the tread: it influences the stability of the vehicle
  - Tread profile outside of conical part of the tread
  - Flange height, thickness and angle
  - Transition between the flange and the active part of the tread
  - Rim position with reference to the wheel seat position on the axle
  - Parallelism of bore diameter
- Assembly purposes
  - Bore diameter
  - Hub length in order to ensure an adequate overhang of the wheel hub on the axle wheel seat.
- Maintenance purposes
  - Wear limit diameter of the tread
  - Wear groove shape
  - Geometry of the area for wheel clamping on reprofiling machines
  - Position of the hole for oil injection of dismantling
  - General rim shape in order to allow ultrasonic residual stress measurement for tread braked wheels.

L.1.2.2 Parameters for thermo mechanical Compatibility

Wheels shall be capable of absorbing the heat energy that is dissipated during service. This amount of energy generated is dependent upon:

- The energy created by the friction of the brake blocks on the tread .
- Type of brake blocks (nature, dimensions and number).

L.1.2.3 Parameters for mechanical assessment

Maximum axle load of wheelset

- Nature of the duty cycle
  - description of the lines: geometrical quality of track, curve parameters, maximum speed ...
  - proportion of time travelling on these differing lines
- Distance travelled during the whole life of the wheel.

L.1.3 ASSESSMENT OF GEOMETRICAL COMPATIBILITY

The drawing of the wheel shall be in conformity with the requirements that are defined according to the paragraph above: parameters for geometrical compatibility.

L.1.4 ASSESSMENT OF THERMO MECHANICAL COMPATIBILITY

L.1.4.1 General procedure

All new designs of wheels shall be fully assessed using methods that are appropriate to the application to demonstrate that they satisfy the requirements set out in this Annex.

This assessment shall be composed of three steps. If step 1 is passed, no further assessment is necessary. If step 1 is failed, step 2 shall be applied. If step 2 is passed, no further assessment is necessary. Step 3 assesses a marginal failure of steps 1 and 2. If step 3, is failed the wheel shall be considered to be non-compliant. For each step, tests shall be made on a wheel with a new rim (tread at its nominal diameter) and on a wheel

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with a worn rim (tread at its wear limit diameter).

In each case, the wheel selected for test shall have the worst case rim geometry for thermo mechanical behaviour; a validated numerical simulation shall confirm the selection. Where it is not possible to test the worst case wheel, the results shall be extrapolated to the worst case by the same numerical simulation.

L.1.4.2 First step: Braking bench test.

L.1.4.2.1 Test procedure

The power to be applied for 45 minutes during this test shall be equal to 1,2 P_a.

$P_a = m \cdot g \cdot V_a \cdot slope + m \cdot \gamma \cdot V_a$

where
m = vehicle mass on rail per wheel (kg)
g = gravitational acceleration (m/s^2)
$slope$ = average slope of the line (slope in ‰/1 000)
γ = deceleration of the train (m/s^2)
V_a = vehicle velocity (m/s)

When monobloc wheels are fitted to wagons that are 100 % tread braked, the following parameters should be taken into account: 2009/107/EC 3)

Wheel diameter range (in mm)	1 000 to 920 and 920 to 840	840 to 760	760 to 680
Power	50 kW	42,5 kW	38 kW
Application time	45 min	45 min	45 min
Running speed	60 km/h	60 km/h	60 km/h

Note: For specific types of freight traffic, the values for power and/or application time and/or running speed and/or axle loads and/or wheel diameters can be modified to check on the thermo-mechanical behaviour of these wheels in the context of a limited utilisation.

L.1.4.2.2 Decision criteria

Three criteria shall be satisfied simultaneously for the new wheel and for the worn wheel.

For the new wheel:

1. maximum lateral displacement of the rim during braking + 3/-1 mm

2. residual stresses in the rim after cooling:
   — $\sigma_{rn} \leq +\Sigma_r$ N/mm^2 as an average over three measurements
   — $\sigma_{in} \leq +(\Sigma_r + 50)$ N/mm^2 for each measurement

3. maximum lateral displacement of the rim after cooling + 1,5/-0,5 mm.

Lateral displacement is considered to be positive when the distance between the flange backs increases.

For the worn wheel:

1. maximum lateral displacement of the rim during braking + 3/-1mm

2. residual stresses in the rim after cooling:
   — $\sigma_{rw} \leq +\Sigma_r + 75)$ N/mm^2 as an average over three measurements
   — $\sigma_{iw} \leq +(\Sigma_r + 100)$ N/mm^2 for each measurement

3. maximum lateral displacement of the rim after cooling + 1,5/-0,5mm

The value of Σ_r shall be determined according to the steel grade requirements of the wheel rim. For ER6 and ER7 grades of EN13262, Σ_r = 200 N/mm^2.

For other steel grades, another value for Σ_r shall be agreed.

L.1.4.3 Second step: Wheel fracture bench test.

L.1.4.3.1 General

This second step shall take place if the residual stresses measured in the first step exceed the decision criteria.

L.1.4.3.2 Wheel fracture bench test procedure

The test procedure for the wheel fracture bench test shall comply with Annex A.3 of EN13979-1.

L.1.4.3.3 Decision criteria

The tested wheel shall remain unfractured.

L.1.4.4 Third step: Field braking test.

L.1.4.4.1 General

This third step shall take place if one of the results of the first step exceeds a decision criterion and if the wheel is not rejected after the second step.

L.1.4.4.2 Test procedure

The power to be applied during this test shall be as defined in Step 1 of this assessment.

L.1.4.4.3 Decision criteria

Three criteria shall be satisfied simultaneously for the new wheel and for the worn wheel.

For the new wheel:

1. maximum lateral displacement of the rim during braking + 3/-1 mm
2. residual stresses in the rim after cooling:
   - $\sigma_{rn} \leq +(\Sigma_r - 50)$ N/mm^2 as an average over three measurements
   - $\sigma_{in} \leq +\Sigma_r$ N/mm^2 for each measurement
3. maximum lateral displacement of the rim after cooling + 1,5/-0,5 mm.

Lateral displacement is considered to be positive when the distance between the flange backs increases.

For the worn wheel:

1. maximum lateral displacement of the rim during braking + 3/-1mm
2. residual stresses in the rim after cooling:
   - $\sigma_{rw} \leq +\Sigma_r$ N/mm^2 as an average over three measurements
   - $\sigma_{iw} \leq +(\Sigma_r + 50)$ N/mm^2 for each measurement
3. maximum lateral displacement of the rim after cooling + 1,5/-0,5mm

The value of Σ_r shall be fixed according to the steel grade requirements of the wheel rim. For ER6 and ER7 grades of EN13262, Σ_r = 200 N/mm^2.

For other steel grades, another value for Σ_r shall be agreed.

L.1.5 ASSESSMENT OF MECHANICAL COMPATIBILITY

L.1.5.1 General procedure.

This assessment shall be composed of two steps. If step 1 is passed no further assessment is necessary. If step 1 is failed step 2 shall be applied. If step 2 is failed the wheel

shall be considered to be non-compliant. The purpose of this assessment is to verify that no fatigue cracks initiate in the web during the whole life of the wheel.

The worst case wheel geometry for mechanical behaviour shall be assessed. Where the bench test wheel is not the worst case, test parameters shall be extrapolated to the worst case by a validated numerical simulation.

L.1.5.2 First step : calculation

L.1.5.2.1 Applied forces

The forces to be applied shall use the force P as a basis.

P is half the vertical force per wheelset on rail.

Three load cases shall be considered (see fig. L1):

– Case 1: straight track

F_z = 1,25 P

F_{y1} = 0

– Case 2: full curves

F_z = 1,25 P

F_{y2} = 0,6 P P for non-guiding wheelsets

F_{y2} = 0,7 P P for guiding wheelsets

– Case 3: negotiation of points and crossings

F_z =1,25 P

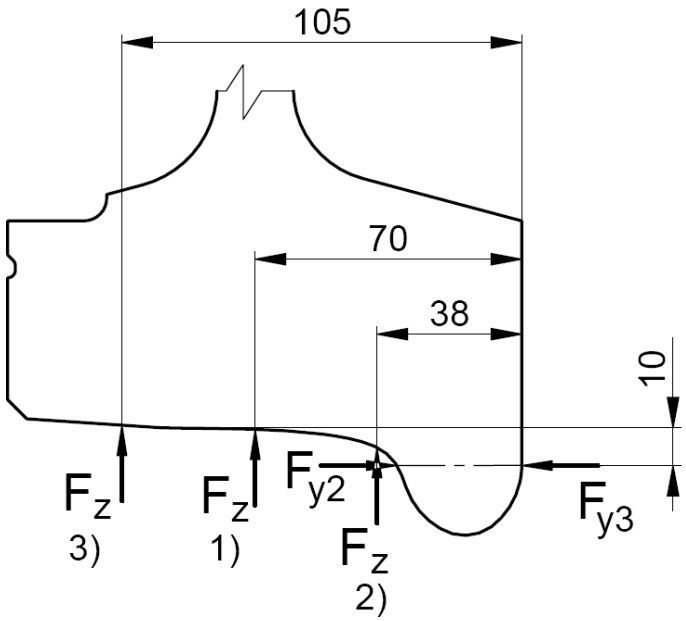
For non-guiding wheelsets

F_{y2} = 0,36 P F_{y3} = 0,6

For guiding wheelsets

F_{y2} = 0,42 P F_{y3} = 0,6

Figure L1



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L.1.5.2.2 Calculation procedure

A validated finite element analysis program shall be used to calculate the stresses in the wheel.

L.1.5.2.3 Decision criteria

The range of the dynamic stresses $\Delta\sigma$ shall be lower than the permissible stresses at all points on the web.

The permissible range of dynamic stresses, A, are as follows:

- for wheels with a machined web, A = 360 N/mm^2
- for wheels with a non-machined web, A = 290 N/mm^2

L.1.5.3 Second step: Bench test

L.1.5.3.1 General

This second step shall take place if the result of the first step exceeds a decision criterion.

L.1.5.3.2 Definitions of the bench loading and test procedure.

They shall be agreed between the designer of the wheel and the assessing entity. | Notified Body.

L.1.5.3.3 Decision criteria

Four wheels shall be tested.

No fatigue cracks ≥ 1 mm shall exist after the test.

L.2 PRODUCT ASSESSMENT

L.2.1 MECHANICAL CHARACTERISTICS LINKED TO WEAR:

L.2.1.1 Tensile test characteristics

Rim and web characteristics shall be as listed in table L1.

Table L1

Steel Grade	Rim			Web	
	R_{eH}(N/mm^2) (1)	R_m (N/mm^2)	A_5 %	R_m reduction ≥ (N/mm^2) (2)	A_5 %
ER6	≥ 500	780/900	≥ 15	≥ 100	≥ 16
ER7	≥ 520	820/940	≥ 14	≥ 110	≥ 16
ER8	≥ 540	860/980	≥ 13	≥ 120	≥ 16
(1) If no distinctive yield strength is present, the proof stress $R_{p0,2}$ shall be determined. (2) Reduction of tensile strength as compared with tensile strength of the rim on the same wheel.					

Locations of test specimens are given in figure. L2.

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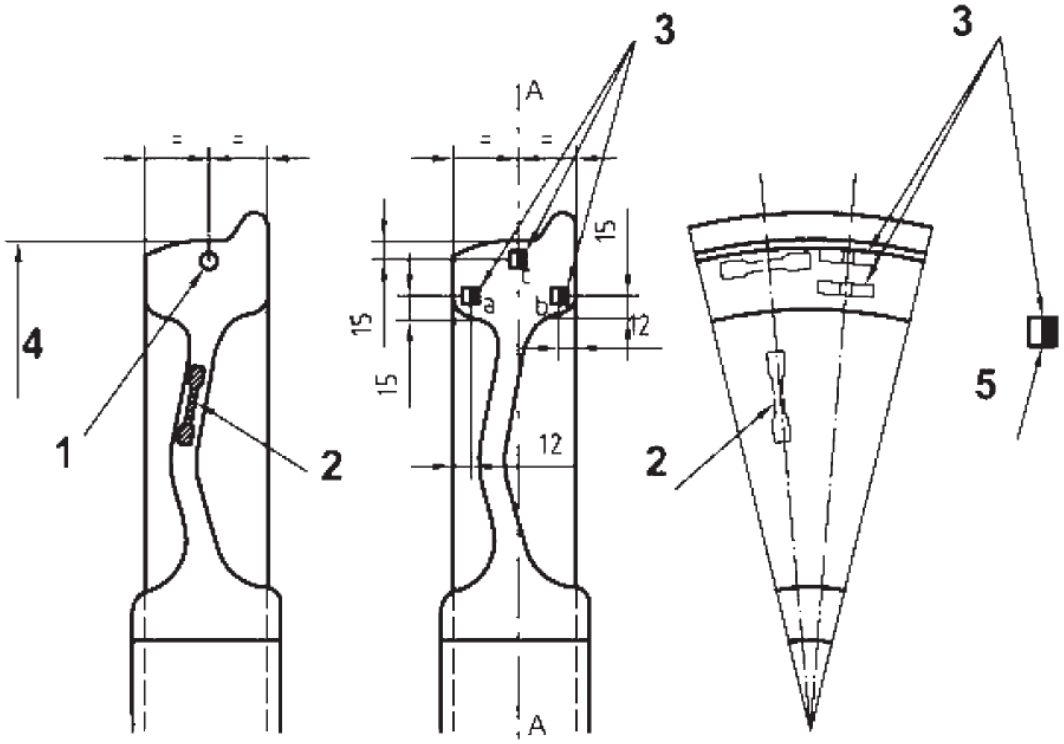
Figure L2

Locations of test specimens



Legend:
1 Tensile test specimen
2 Tensile test specimen
3 Impact test specimen
4 Wear limit diameter
5 Notch

L.2.1.2 Hardness characteristics in the rim

The minimum values of Brinell hardness in the whole wear zone of the rim shall be ≥ the values in table L3 for each reading.
These values shall be achieved up to a maximum depth of 35 mm below the nominal tread, even if the wear-depth is greater than 35 mm.

Hardness values in the rim/web transition shall be at least 10 points lower than the wear limit values.

Table L3

Steel Grade	Minimum Brinell hardness value
ER6	225
ER7	235
ER8	245

L.2.1.3 Heat treatment homogeneity

The hardness values measured on the rim shall be contained within a range of 30 HB.

L.2.2 MECHANICAL CHARACTERISTICS LINKED TO SAFETY:

L.2.2.1 Impact test characteristics

Two sets of impact tests shall be carried out; one set with test specimens at + 20 °C, one set with test specimens at – 20 °C. In each set of tests, three specimens shall be tested (marked as specimen 3 in Figure L.2). Table 4 gives the values to be achieved.

The marking of the impact test samples shall enable identification of the longitudinal surfaces that are parallel to section A-A.

The test pieces shall be prepared in accordance with EN 10045-1. The axis of the bottom of the notch shall be parallel to the section A-A in figure L1. At + 20 °C, U notch specimens shall be used. At - 20 °C, V notch specimens shall be used.

Table L4

Steel Grade	KU (in joules) at + 20 °C		KV (in joules) at – 20 °C	
	Average	Minimum	Average	Minimum
ER6	17	12	12	8
ER7	17	12	10	7
ER8	17	12	10	5

L.2.2.2 Toughness characteristic of the rim

This characteristic need only be verified on tread braked wheels (service brake or parking brake). Table L6 gives the minimum values to be achieved.

Table L6

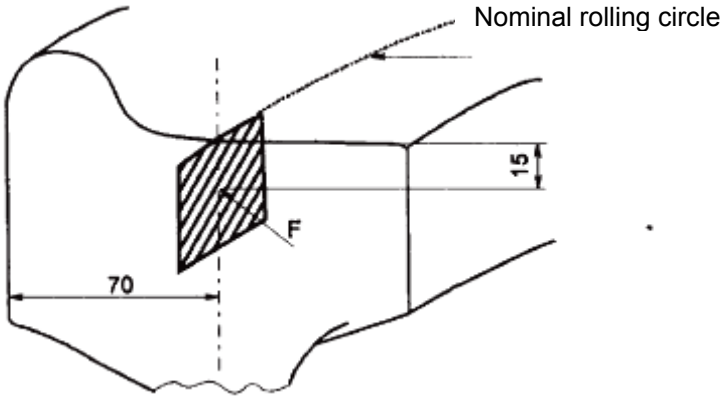
Steel Grade	Average (over 6 test pieces)	Single test piece minimum
	$N/mm^2\sqrt{m}$	$N/mm^2\sqrt{m}$
ER6	100	80
ER7	80	70
ER8	70	60

L.2.3 MATERIAL CLEANLINESS

L.2.3.1 Micrographic cleanliness

Material cleanliness shall be measured by micrographic examination (ISO 4967 method A). The location from which the samples shall be taken is shown in figure L3.

Figure L3



Values to be achieved are given in table L6.

Table 6

Type of inclusions	Thick series (maximum)	Thin series (maximum)
A (Sulphides)	1,5	2
B (Aluminates)	1,5	2
C (Silicates)	1,5	2
D (Globular Oxides)	1,5	2
B+C+D	3	4

L.2.3.2 Internal integrity

Internal integrity of all wheels shall be determined by an automatic ultrasonic examination. Standard defects are flat bottom holes with different diameters.

The rim shall have no internal defects that give echo magnitudes higher than or equal to those obtained for a standard defect, situated at the same depth. The diameter of this standard defect is 3 mm.

There shall be no attenuation of the back echo higher than 4 dB during axial examination.

L.2.4 SURFACE CONDITION

L.2.4.1 Characteristics to be achieved.

According to their use, wheels may be fully or part machined. Their surface shall not show any marks other than those stipulated in here.

The parts which remain as non-machined shall be shot-blasted for Ra < 25 μm, perfectly dressed and smoothly blended into the machined areas.

The average surface roughness (Ra) of “finished” or “ready for assembly” wheels is given in table L8.

Table L8

Area of the wheel	State of Delivery	Roughness Ra (μm)
Bore	Finished	≤12,5
	Ready for assembly (1)	0,8 to 3,2
Web and hub	Finished (2)	≤12,5
Rim Tread	Finished	≤12,5 (3)
Rim Faces	Finished	≤12,5 (3)

(1) If the wheel is to be fitted on a hollow axle, other values may be required for the purpose of the in-service ultrasonic inspection.
(2) If so defined, this area of the wheel may remain unmachined, provided the tolerances indicated in this table are achieved.
(3) ≤ 6,3 if required for a standard defect of 2 mm.

L.2.5 SURFACE INTEGRITY

Surface integrity of the web shall be confirmed by a magnetic particle test or an alternative process having at least equivalent sensitivity. The limit defect shall be equal to 2 mm in the case of a machined web.

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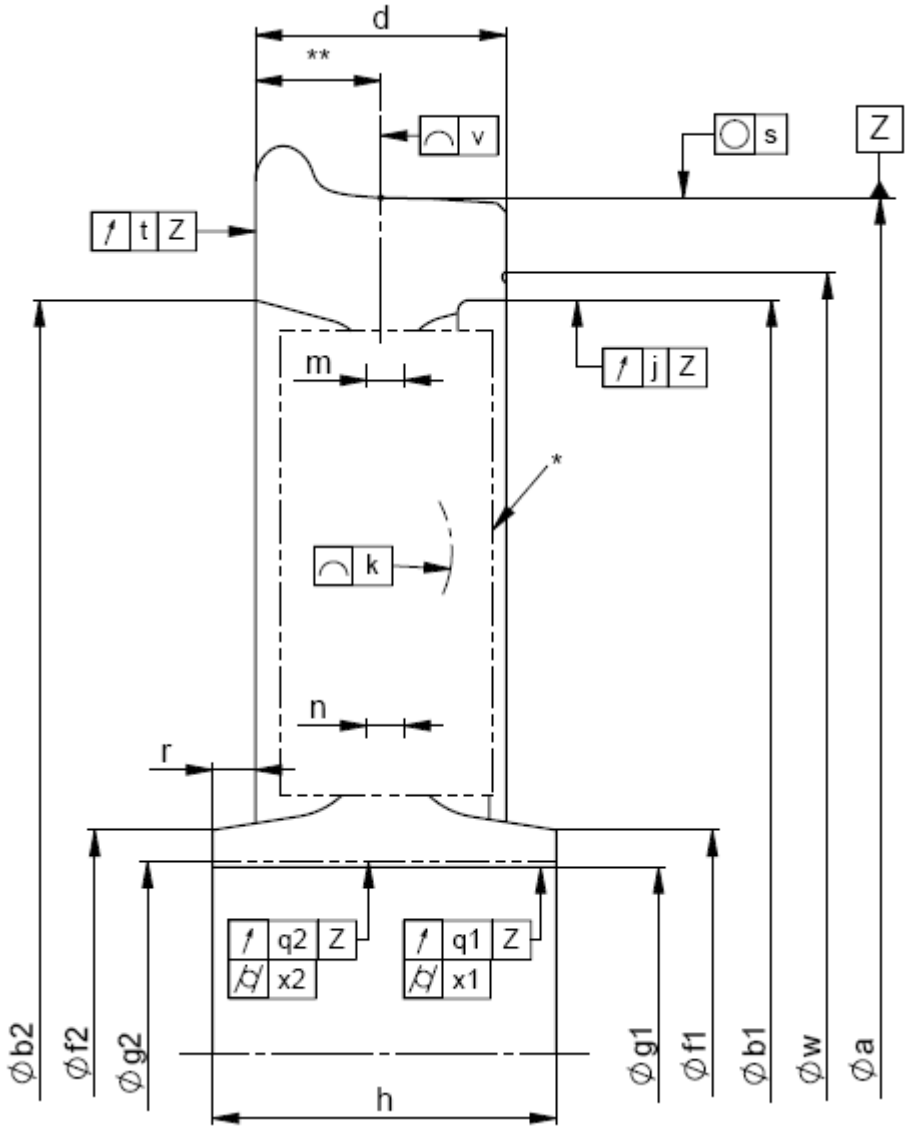
L.2.6 GEOMETRICAL TOLERANCES

The geometry and dimensions of wheels shall be defined by a drawing. The geometrical tolerances shall comply with those in table L9. The symbols used are shown in figure. L4.

Figure L4

Symbols



** Dimensions defined by drawing.
* This area shall be defined to meet the requirements of an interoperability constituent.

Table L9

Tolerances (mm)					
Designation		Symbols (see fig L4)		Values	
		Dimensions	Geometrical	Un-machined	Machined
Rim	External diameter	a			0/+4
	Internal diameter (outer)	b_1			0/-4
	Internal diameter (inner)	b_2		0/-6	0/-4
	Width	d			±1
	Tread profile (3)		v		≤0,5
	Circularity of the tread		s		≤0,2
	Total run out in axial direction		t		≤0,3
	Total run out in radial direction of the jaw hold		j		≤0,2
	External diameter of the groove (i.e. wear line)	w			0/+2
Hub	External diameter (outer)	f_1		0/+10	0/+5
	External diameter (inner)	t_2		0/+10	0/+5
	Internal diameter of the bore:				
	'finished'	g_1			0/-2
	'finished ready' for assembly	g_2		See Annex K or in accordance with the drawing	
	Cylindricity of internal diameter of the bore:				≤0,2
	'finished'		x1		≤ 0,02 (2)
	'finished ready for assembly'		x2		
	Length	h			0/+2
	Hub to wheel overhang	r			0/+2
	Total run out of the diameter of the bore:				
	'finished'		q1		≤0,2
	'finished ready for assembly'		q2		≤0,1
Web	Position for the web at the connection with the rim and the hub		k	≤ 8	≤ 8
	Thickness at the connection with the rim	m		+8/0	+5/0
	Thickness at the connection with the hub	n		+10/0	+5/0

(1) See ISO 1101
(2) Any slight taper within the permitted tolerance shall be such as the 'larger' diameter is at the axle-entry end of the bore on assembly.
(3) From the top of the flange as far as the external chamfer.

L.2.7 STATIC IMBALANCE

The maximum static imbalance of a finished wheel in the delivery condition is defined in table L10.

The means and methods of measurement shall be defined between the customer and the supplier.

Table L10

For vehicles running at Speed v km/h	Static imbalance g · m	Symbol
$v \leq 120$	≤ 125	E3
$120 < v \leq 200$	≤ 75	E2

L.2.8 PROTECTION AGAINST CORROSION

Protection shall be provided in accordance with the wheel design specification.