APTU Uniform Rules (Appendix F to COTIF 1999)

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

FREIGHT WAGONS - (UTP WAG) - ANNEX M

VEHICLE TRACK INTERACTION AND GAUGING

AXLE

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]

M.1 DESIGN ASSESSMENT

M.1.1 GENERAL

The following major phases for the definition of an axle are:

a) Identification of the forces to be taken into account and calculation of the moments on the various sections of the axle.

b) Selection of the diameters for axle-body and journals. On the basis of the selected diameters, calculation of the diameters for the other sections.

c) The options taken shall be verified by:
   - Stress calculation for each section.
   - Comparison of the stresses with the maximum permissible stresses.

     The permissible stresses are essentially defined by:
     - The steel grade.
     - Whether the axle is solid or hollow.

M.1.2 IDENTIFICATION OF FORCES AND CALCULATION OF MOMENTS.

Two types of forces shall be addressed:
- Masses in motion.
- Braking.

[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.

M.1.3 GEOMETRICAL AND DIMENSIONAL TOLERANCES

M.1.3.1 Selection of the diameters for journals and axle body.

In selecting the diameters of the journals and axle body, reference shall be made initially to existing sizes of associated components e.g. bearings.

The selection of diameters shall be verified by comparing the calculated stresses with the maximum permissible stresses. A very shallow groove (0,1 to 0,2 mm) shall be provided, so that the end of the inner bearing ring does not cause any notch effect on the journal.

M.1.3.2 Selection of the diameters of the various seats from the diameter of the axle body or of the journals.

M.1.3.2.1 Collar bearing surface

In order to standardise whenever possible, the diameter of the collar bearing surface shall be 30 mm greater than that of the journal. The transition between the journal and the collar bearing surface shall be provided as illustrated in figure M3 (detail V).

M.1.3.2.2 Transition between the collar bearing surface and wheelset

In order to standardise whenever possible, this transition shall have only one radius of 25 mm.

If this value cannot be met, the highest possible value shall be selected in order to minimise the stress concentration on this area.

M.1.3.2.3 Wheelset

The ratio between the wheelset and the axle body diameters shall be at least equal to 1,12 at the wheel seat wear limit. It is recommended that this ratio is at least 1,15 for an axle in new condition.

The transition between these two areas shall be provided in such a way that the stress concentration remains at the lowest possible level.

In order to have the lowest value of the stress concentration factor at the transition between axle body and wheelset, the value of the biggest radius on the axle body side shall be at least 75 mm.

M.1.4 MAXIMUM PERMISSIBLE STRESSES.

The maximum permissible stresses shall be derived from:

- The fatigue limit in rotating bending for the various areas of the axle.
- The value of a factor of safety ‘S’ which varies with the steel grade.

M.1.4.1 Steel grade EA1N

The following values shall be used:

- For a solid axle :
  - 200 N/mm^2 without press-fit.
  - 120 N/mm^2 with press-fit.
- For a hollow axle :
  - 200 N/mm^2 without press-fit.
  - 110 N/mm^2 with press-fit (apart from journal).
  - 94 N/mm^2 with press-fit on the journal.
  - 80 N/mm^2 for the surface of the bore.

For solid and hollow axles, the value of security coefficient ‘S’, by which fatigue limits shall be divided to obtain the maximum permissible stresses is 1,2.

For hollow axles, these permissible stresses are applicable if the ratio of journal diameter to bore diameter is < 3 or the ratio of wheelset diameter to bore diameter is < 4.

M.1.4.2 Steel grades other than EA1N.

The fatigue limit shall be determined for the following areas of the axle:

- The surface of the axle body.
- The bearing surface with an equal clamping condition at the wheelsets.

In the case of a hollow axle, the fatigue limit shall also be determined for the bearing surface with an equivalent bearing/axle interference condition.

- The surface of the bore.

The value of the factor of safety 'S' shall be determined with regard to the sensitivity of the steel grade to the notch effect.

M.2 PRODUCT ASSESSMENT

M.2.1 MECHANICAL CHARACTERISTICS:

M.2.1.1 Characteristics from tensile test

The values to be obtained at the mid-radius of solid axles or at the mid-distance between external and internal surfaces of hollow axles are given in table M1.

Table M1

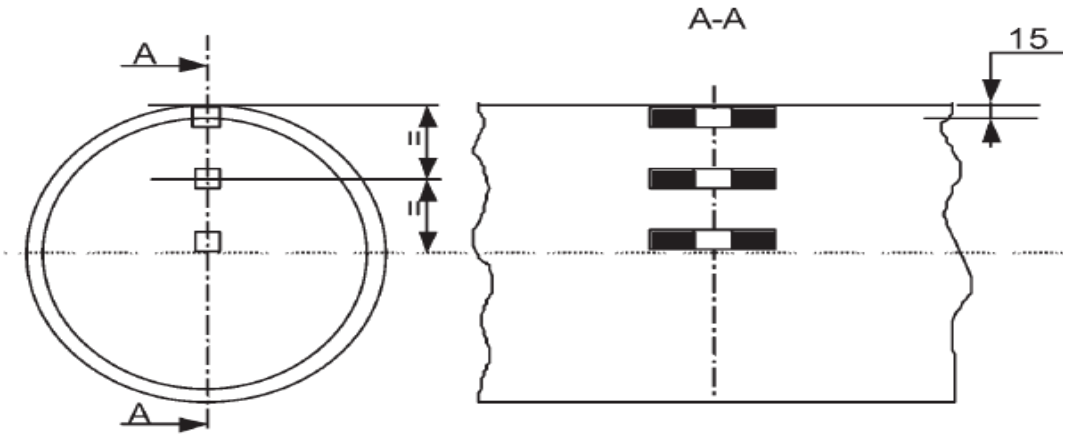
R_{eH} (N/mm^2) (1)	R_m (N/mm^2)	A_5 %
≥ 320	≥ 550	≥ 22
(1) If no distinctive yield strength is present, the proof stress $R_{p0,2}$ shall be determined.		

M.2.1.2 Impact test characteristics

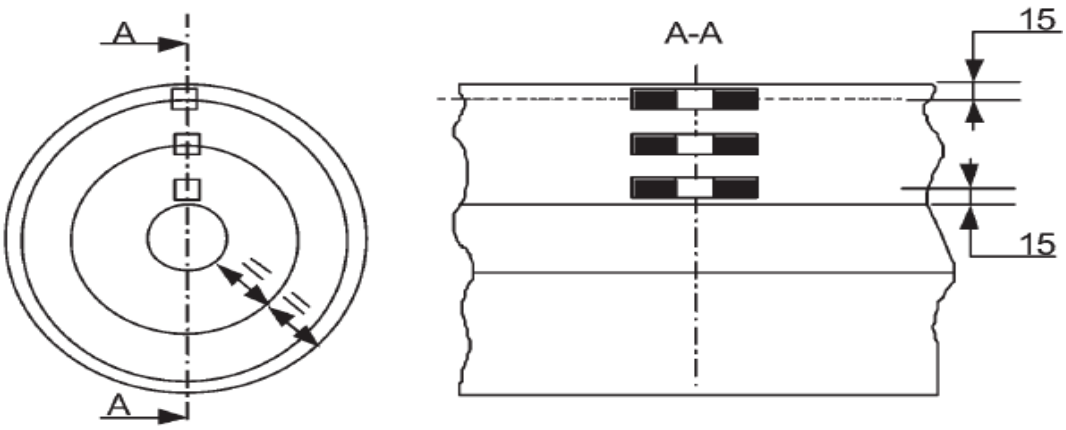
Impact test characteristics shall be determined at 20 °C in the longitudinal and transverse direction. Three test samples shall be taken from adjacent positions from each test section. The test samples shall be taken from the locations indicated in fig M1. Values to be obtained at the mid-radius of solid axles, or at the mid-distance between external and internal surfaces of hollow axles, are given in table M1.

No individual values shall be lower than 70 % of the values in table M2.

Figure M1



Solid axle



Hollow axle

Table M2

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

M.2.2 MICROSTRUCTURE CHARACTERISTICS

The microstructure shall be one of ferrite and pearlite. The grain size shall not be greater than those defined by the reference diagram of type V of ISO 643.

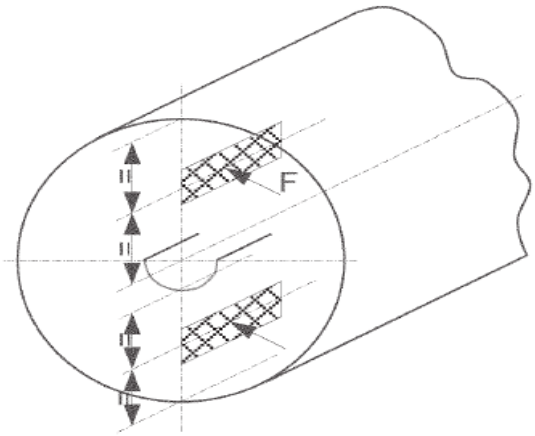
M.2.3 MATERIAL MICROGRAPHIC CLEANLINESS

Material cleanliness shall be measured by micrographic examination (ISO 4967 method A). The location from which the samples shall be taken is shown in fig. M2. Maximum values of thick series inclusions to be obtained are given in table M3.

Table M3

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

Figure M2



M.2.4 INTERNAL INTEGRITY

Internal integrity shall be determined by ultrasonic examination.

Axles 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. For the purposes of this test, a standard defect shall be a 3 mm diameter flat-bottomed hole.

There shall be no attenuation of the back echo higher than 4 dB due to inclusions or internal defects.

M.2.5 PERMEABILITY TO ULTRASOUND

Axles shall be permeable to ultrasound. This shall be verified by a recorded ultrasound test for each axle.

The echo obtained on the axles under test shall have an amplitude higher than or equal to 50 % of full screen height, after preliminary calibration of the apparatus on a standard wedge. The height of the background noise level shall be lower than 10 % of full screen height.

M.2.6 SURFACE CHARACTERISTICS

M.2.6.1 Surface finish

The axle surface shall not show any marks other than those at the positions stipulated in this Annex.

Permissible surface roughness (R_a) of finished or ready to assemble parts is given by table M4. Symbols are as shown in figure M3.

Table M4

Designation	Symbol	Surface roughness [1] R_a (µm)	
		Rough – machined	Finished or Ready for Assembly
End of the axle			
Axle end and chamfer	a	—	6,3
Axle centre face (plain 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
Wheelset			
Wheelset diameter	e	12,5	0,8/1,6 [3]
Lead in taper	f (detail U)		1,6
Body			
Inner transitional radii to wheelset	g (detail T)	—	1,6
Axle body diameter	l		3,2 [2]
Brake disc seat diameter	h	12,5	0,8/1,6 [3]
Bearing seat and seal seat diameter	j	12,5	0,8
Transitional radii between two seats	k (detail S)		1,6
Bore	m		3,2
Diameter	(detail R1)		

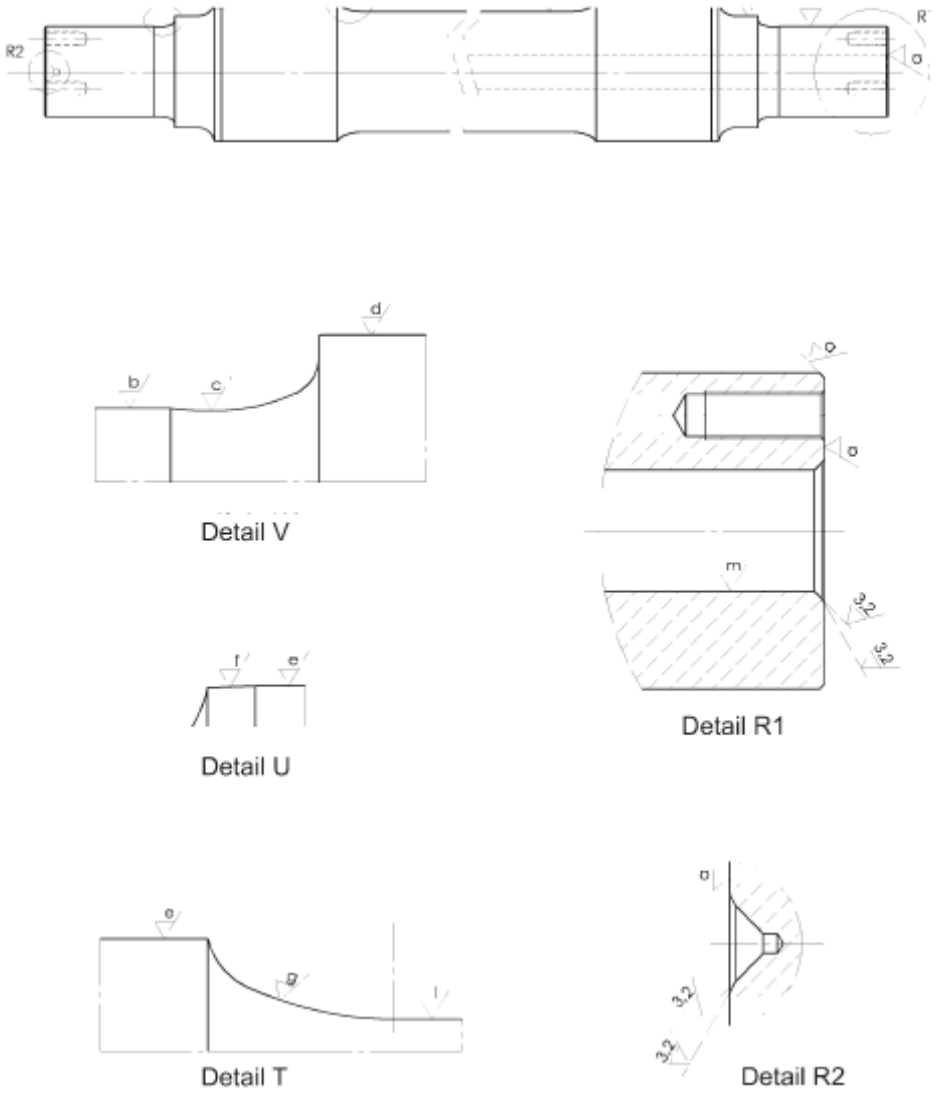
(1) For old axle types with plain bearing journals, the requirements are in the standards that deal with these products.

(2) 6,3 may be agreed if both the fatigue limits F1 or F2 defined in 5.5.2.1.4. and the sensitivity required for the in-service ultrasonic control are achieved.

(3) In-service Non Destructive Examination of axles may require smaller values of surface finish.

Figure M3

Roughness symbols



M.2.6.2 Surface integrity

Surface integrity shall be determined by a magnetic particle test for all axles for the external surfaces and additionally for hollow axles by an ultrasonic examination or an equivalent method for the bore surface. On the external surface of the axle, transverse defects are not permissible.

M.2.6.3 Geometrical and dimensional tolerances

The required geometrical tolerances are given in table M5. Symbols used are shown in figure M4.

The required dimensional tolerances are given in table M6. Symbols used are shown in figure M5.

Table M5

Designation	Symbol	Geometrical tolerances (1) (2) (mm)	
		Rough – machi-ned	Finished or Ready for Assembly
Journal and abutment			
Journal cylindricity	n		0,015
Run out of the vertical face of the abutment relative to the reference Y-Z	o_1		0,03
Run out of the abutment relative to the reference Y-Z	o_2		0,03
Wheelset			
Run out relative to the reference Y-Z	p	1,5	0,03
Cylindricity		0,1	0,015
Axle body			
Run out relative to the reference Y-Z	t		0,5
Bore			
Concentricity relative to the reference Y-Z	u		0,5
Holes for fixing axle end caps			
Concentricity relative to the reference Y-Z	v		0,5
Machining centre run out relative to the reference Y-Z (details R1/ R2)	w_1 w_2		0,02 0,03

(1) For parameters which do not have a tolerance defined in this table, the general tolerances of EN 22768-2 shall be applied.

(2) For old axle types with plain bearing journals, the requirements are in the standards that deal with these products.

Figure M4

Geometrical symbols

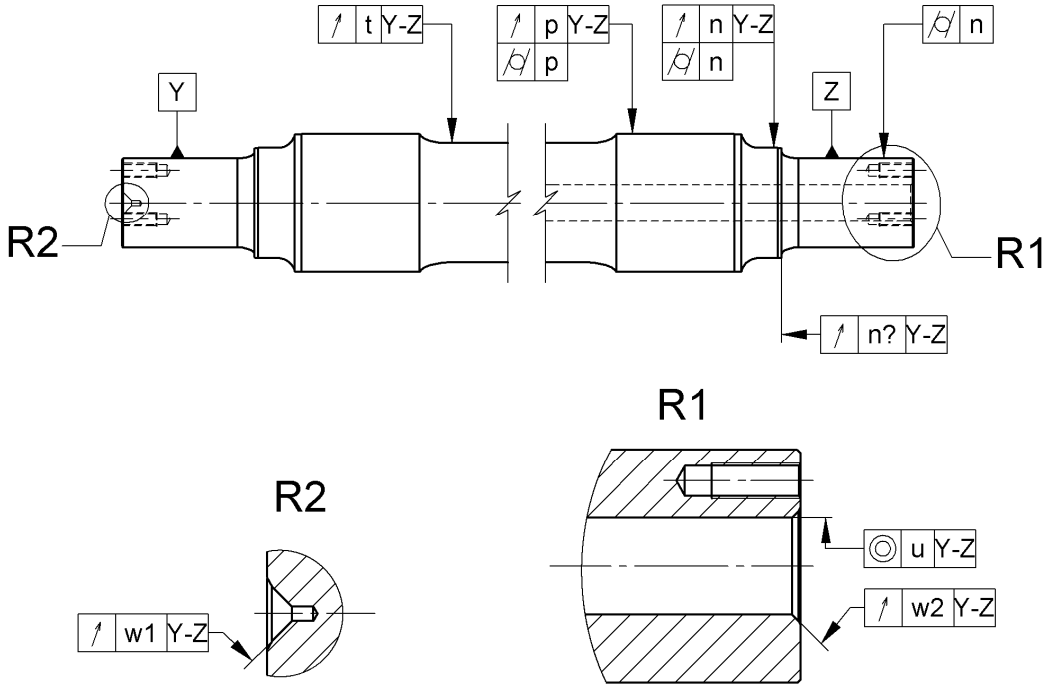


Table M6

Designation	Symbol	Dimensional tolerances [1](mm)
		Ready for assembly
Longitudinal sizes.		
Length of axle ([2])	A	± 1
Length of wheelset (including collar)	B	0/-0,5
Length over abutments (between reference planes)	C	± 0,5 [5]
Journal bearing seat length	D	[3]
Abutment length	E	+1/0
Depth of journal groove		See detail V
Length of journal groove	G	detail V [3]
Diameters		
Diameter of journal	H	[3]
Wheelset diameter	I	
Abutment diameter	N [3]	[3]
Diameter of body	P	+2/0
Sizes of other parts of axles		

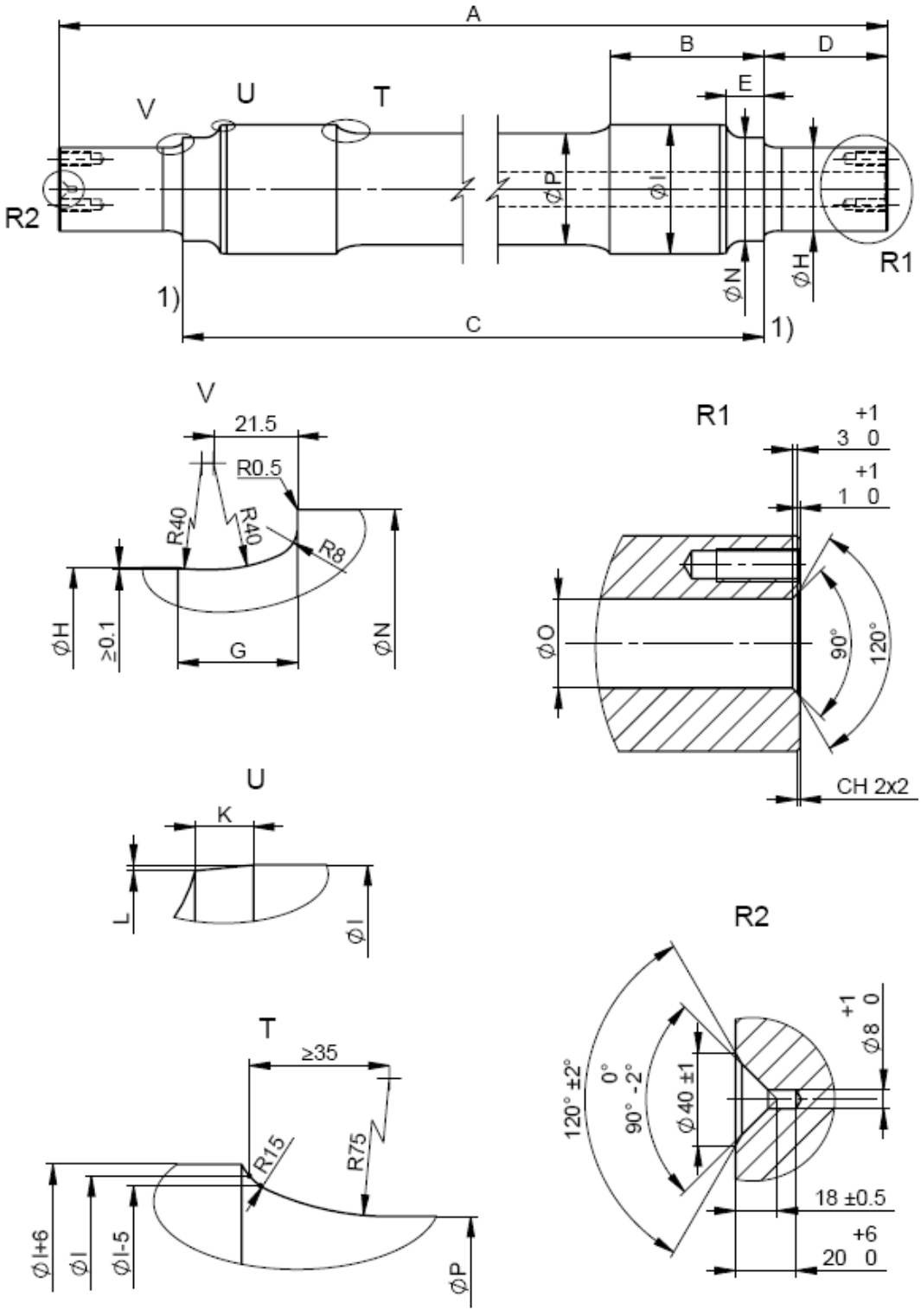
Designation	Symbol	Dimensional tolerances

		[1](mm)
		Ready for assembly
Axle machining centres		
Plain axles		See detail R2 [4]
Hollow axles		See detail R1 [4]
Holes for fixing axle end caps	See detail R1 [4]	
Drilling concentricity		0,5
Drilling depth		+2/0
Thread depth		+2/0
Variation between drilling and thread		≥10
Lead in taper		
Wheelset conical length	K (detail U) [3]	0/-3
Wheelset taper depth	L (detail U) [3]	0,1
Diameter of bore	O (detail R1)	1
Transitional radii — wheelset/body		See detail T [3]

(1) For parameters which do not have a tolerance defined in this table, the general tolerances of EN 22768-2 shall be applied.
(2) Attention is drawn to the fact that compliance with tolerances over the total length 'A' shall not allow all the individual tolerances to be applied cumulatively to the particular dimensions.
(3) According to the requirements of the drawing or documents accompanying the order.
(4) Other geometries may be proposed and defined in the order.
(5) Other values may be agreed for special applications.

Figure M5

Dimensional symbols



M.2.7 FINAL PROTECTION AGAINST CORROSION

M.2.7.1 General

All exposed axle surfaces shall be protected as defined by the wheelset design specification.

M.2.7.2 Resistance to specific corrosive products

The protection systems applied to the exposed axle surfaces shall consider; environmental factors, corrosive materials, vehicle cargo, mechanical damage, etc.