International Standard 1005/2

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Railway rolling stock material — Part 2 : Tyres, wheel centres and tyred wheels for tractive and trailing stock — Dimensional, balancing and assembly requirements

Matériel roulant de chemin de fer — Partie 2 : Bandages, corps de roues et roues bandagées pour matériel moteur et matériel remorqué — Prescriptions dimensionnelles d'équilibrage et d'assemblage

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 1005/2 was prepared by Technical Committee ISO/TC 17, *Steel*.

It calcels and replaces ISO Recommendation R 1005/2-1969, of which it constitutes a technical revision.

Users should note that all International Standards undergo revision from time to time and that any reference made herein to any other International Standard implies its latest edition, unless otherwise stated.

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Railway rolling stock material — Part 2 : Tyres, wheel centres and tyred wheels for tractive and trailing stock — Dimensional, balancing and assembly requirements

1 Scope and field application

1.1 This part of ISO 1005 specifies the dimensional requirements,[1] the surface roughness and, as appropriate, the permissible residual static unbalance for tyres, wheel centres and tyred wheels in the various degrees of finish, and in addition the manufacturing requirements for tyred wheels.

1.2 The quality requirements for tyres are given in ISO 1005/1 and the quality requirements for wheel centres are given in ISO 1005/4.

1.3 In addition to the requirements of this part of ISO 1005, the general technical delivery requirements of ISO 404 apply.

2 References

ISO/R 286, *ISO system of limits and fits — Part 1 : General, tolerances and deviations.*

ISO 404, *Steel and steel products — General technical delivery requirements.*

ISO 468, *Surface roughness — Parameters, their values and general rules for specifying requirements.*

ISO 1005, *Railway rolling stock material*

— *Part 1 : Rough-rolled tyres for tractive and trailing stock — Quality requirements.*

— *Part 4 : Rolled or forged wheel centres for tyred wheels for tractive and trailing stock — Quality requirements.*

— *Part 6 : Solid wheels for tractive and trailing stock — Quality requirements.*

— *Part 7 : Wheelsets for tractive and trailing stock — Quality requirements.*

ISO 1101, *Technical drawings — Geometrical tolerancing — Tolerancing of form, orientation, location and run-out — Generalities, definitions, symbols, indications on drawings.*

3 Information to be supplied by the purchaser

The purchaser shall supply the following information in the enquiry and order :

a) the number of this part of ISO 1005;

b) a dimensioned drawing of the product;

c) the degree of finish (see clause 4);

d) the speed regime in which the finished wheel will operate, i.e. normal or high speed (see tables 7, 8 and 9);

e) where appropriate, the dimensional requirements for wheel centres delivered in the condition "rough machined" and for rough machined portions of wheel centres delivered in the condition "half finished" (see 5.2.1.2);

f) the dimensional requirements and surface roughness values if they deviate from this part of ISO 1005 (see tables 5 to 8, and 5.1.1, 5.2.1, 5.2.2, 5.3.1.1, 5.3.1.2, 5.3.2 and 5.3.3);

g) the roughness values if R_y is to be used (see 5.2.2, 5.3.1.2 and 5.3.3.1);

h) if, for wheel centres and tyred wheels for trailer stock other than freight stock, a maximum static unbalance is required (see 5.2.4.1 and 5.3.4.1);

j) if, for wheel centres and tyred wheels for tractive stock, a maximum static unbalance is required (see 5.2.3.2 and 5.3.4.2) also the values which shall apply;

1) The term "dimensional requirements" covers machining allowances, dimensional tolerances and tolerances of form and position.

k) if the position and amount of unbalance is required to be marked on the wheel centre or tyred wheel [see 5.2.3.3, 5.3.4.3 and 5.9.8b)];

m) the details of the method of assembling the tyre on the wheel centre, if the requirements deviate from this part of ISO 1005 (see 5.3);

n) the value of factor x for the interference fit of tyre wheel centre (see 5.3.1.2);

p) the shape of retaining ring if not specified on the accompanying drawing (see 5.3.1.3);

q) if specific geometrical tolerances are required to be verified (see 5.3.2.1.2 and 6.3.7.4);

r) if a surface quality standard is required for surfaces which the purchaser permits to be left unmachined in the "finished" and "ready for assembly" conditions (see 5.3.3.2);

s) if one of the optional verifications is required (see 6.3.7.4 and tables 6 to 9);

t) if compliance with the requirements for the surface roughness is to be verified, the number of wheel centres and/or tyred wheels to be inspected (see 6.2.2 and 6.3.7.5);

u) if special inspection is required (see 6.3.1);

v) the method of protection against corrosion (see 7.1);

w) the conditions of the guarantee (see clause 8).

4 Terms for the degree of finish

The various conditions of tyre, wheel centre and tyred wheel and stages of manufacture referred to in this part of ISO 1005 are given in 4.1 to 4.3.

4.1 Tyres

4.1.1 Unmachined

For rolled tyres, "unmachined" indicates the "black" rough-rolled tyre (see ISO 1005/1) without any subsequent machining other than that which may have been carried out by the manufacturer to enable the tyre to conform to the required standard.

4.1.2 Finished and ready for assembly

The tyre may be assembled by shrink fitting on to the wheel centre with only a minimum of machining on the interface surfaces or with other surfaces partly or finally machined — this being according to the manufacturer's process methods. The "finished" and "ready for assembly" conditions are therefore covered in the sub-clause dealing with the assembly of the tyre on to the wheel centre (see 5.3.1) and the sub-clauses for dimensional tolerances and surface roughness requirements of the tyred wheel (see 5.3.2 and 5.3.3).

4.2 Wheel centres

4.2.1 Unmachined

For forged, rolled or cast wheel centres, "unmachined" indicates the "black" as-forged, as-rolled or as-cast condition without any subsequent machining other than that which may have been carried out by the manufacturer to enable the wheel centre to conform to the required standard.

4.2.2 Rough machined

In accordance with ISO 1005/4, "rough machined" indicates the condition in which the wheel centre has received no final machining, but has been rough machined on all or only certain portions which have to be machined.

4.2.3 Half finished

In accordance with ISO 1005/4, "half finished" indicates a condition in which the wheel centre has received final machining on certain portions which have to be machined and are considered as finished, whereas other portions are unmachined or rough machined.

4.2.4 Finished

In accordance with ISO 1005/4, "finished" indicates the wheel centre condition in which all portions of the wheel centre which are required, by the order or the drawing, to be machined have undergone all machining operations other than those normally carried out by the manufacturer immediately before mounting the wheel centre on the axle, i.e. final finishing operation of the bore and, in the case of wheel centres which are to be tyred subsequent to mounting on the axle (see 5.3.1), perhaps the rim.

4.2.5 Ready for assembly

"Ready for assembly" indicates the wheel centre condition in which all necessary machining operations have been carried out.

For clarity, this International Standard differentiates between

a) wheel centres ready for assembly of the tyre;

b) wheel centres ready for assembly to the axle.

4.3 Tyred wheels

4.3.1 Finished

"Finished" indicates the tyred wheel condition in which all portions of the tyred wheel which are required, by the order or drawing, to be machined have undergone all machining operations other than those normally carried out by manufacturer immediately before mounting the tyred wheels on the axle, i.e. final "finishing" operation of the bore. This restriction means that the requirements for the rough finished bore are covered in table 7 and those for the finally finished bore are covered in table 8.

4.3.2 Ready for assembly

"Ready for assembly "indicates the tyred wheel condition in which all necessary machining operations have been carried out.

5 Requirements

5.1 Tyres

5.1.0 Introduction

The tyres shall conform in shape, dimensional and physical requirements to the purchaser's drawing accompanying the order or the enquiry. Where dimensional requirements and surface roughness values are not stated on the order or drawing, 5.1.1 shall apply.

5.1.1 Dimensional requirements

5.1.1.1 For the condition "unmachined" (see 4.1.1), the dimensional requirements shall be as indicated in table 5.

5.1.1.2 For the condition "finished" and "ready for assembly" (see 4.1.2), the dimensional requirements and surface roughness requirements shall be as indicated in 5.3.1.2, 5.3.2 and 5.3.3.

5.2 Wheel centres

5.2.0 Introduction

The wheel centres shall conform in shape, dimensional and physical requirements to the purchaser's drawing accompanying the order or the enquiry. Where dimensional requirements, surface roughness values and permissible residual unbalance are not stated on the order or drawing, 5.2.1 to 5.2.4 shall apply.

5.2.1 Dimensional requirements

5.2.1.1 For the condition "unmachined" (see 4.2.1) and for unmachined portions of wheel centres, the dimensional requirements shall be as indicated in table 6 (see also table 7, footnote 4).

5.2.1.2 For the condition "rough machined" (see 4.2.2) and for rough machined portions of wheel centres, the dimensional requirements shall, where appropriate, be agreed at the time of the enquiry and order.

5.2.1.3 For the condition "finished" (see 4.2.4) and for finished portions of wheel centres, the dimensional requirements shall be as indicated in table 7. For the condition "ready for assembly" (see 4.2.5.1 and 4.2.5.2), the appropriate dimensional requirements indicated in table 8 respecting the bore and the rim shall also be observed (see also 5.3.1.1).

5.2.1.4 If for wheel centres the tolerances can be met by the manufacturing process, machining is not required.

5.2.2 Surface roughness

Unless otherwise agreed, the arithmetic mean deviation of the profile, R_a, for machined surfaces in the "finished" and "ready for assembly" conditions shall be as given in table 1.

Table 1 — Surface roughness of wheel centres

Part	Condition	Arithmetic mean deviation of the profile [1], R_a (µm)
Bore	Finished	< 12,5
	Ready for assembly to axle	1,6 to 3,2
Rim	Finished	< 12,5
	Ready for assembly of tyre	< 3,2
Rim faces [2]	Finished	< 12,5
	Ready for assembly of tyre	< 3,2
All other parts	Finished or ready for assembly	< 12,5

1) If the maximum height of the profile, R_y (see ISO 468), is used, the values shall be agreed between the interested parties.

2) The requirement "ready for assembly" is applicable to wheel centres where the tyres are to be secured with retaining rings.

5.2.3 Residual static unbalance

5.2.3.1 If a maximum static unbalance is required, the static unbalance for wheel centres for trailer stock other than freight stock shall, in the condition "finished" and "ready for assembly", unless otherwise agreed, not exceed the values given in table 2.

Table 2 — Static unbalance for wheel centres

Operating speed, v (km/h)	Maximum static unbalance (g·m)
$v \leqslant 100$	—
$100 < v \leqslant 120$	100
$120 < v \leqslant 200$	60

5.2.3.2 For wheel centres for tractive stock, values of static unbalance, if required, shall be agreed at the time of enquiry and order.

5.2.3.3 The correction of unbalance, if required, shall be carried out in accordance with ISO 1005/4 and, if specified in the order or its appended documents, the position and amount of unbalance shall be suitably marked on the centre (see ISO 1005/4).

5.2.4 Oil injection grooves

If an oil injection groove in the bore of the "ready for assembly" wheel centre is specified by the purchaser (see ISO 1005/7), this and the associated drilled and tapped hole for the oil pressure connection shall be machined to the requirements of the purchaser's drawing accompanying the enquiry or order. Special care shall be taken with the blending of the groove and the bore to ensure that there are no sharp edges or projections.

5.3 Tyred wheels

The tyred wheels shall conform in shape, dimensional and physical requirements, and in method of assembly, to the purchaser's order or drawing accompanying the enquiry or order. Where machining allowances, dimensional tolerances, surface roughness values, permissible unbalance or details of the method of assembling the tyre on the wheel centre are not stated on the order or the drawing, 5.3.1 to 5.3.8 shall apply.

5.3.1 Assembly of tyre on to wheel centre

The tyre may be assembled, by shrink fitting, on to the wheel centre before or after the wheel centre has been assembled on to the axle according to the requirements of ISO 1005/7.

5.3.1.1 Wheel centre

The wheel centre shall be final machined on the rim portion to the requirements of the purchaser's drawing, submitted with the order and to the dimensional requirements of tables 7 and 8, and the surface roughness and balancing requirements in 5.2.2 and 5.2.3.

5.3.1.2 Tyres

The tyre shall be machined in the inner diameter (bore) and in the snip and retaining ring groove, to the requirements of the purchaser's drawing submitted with the order. The bore diameter shall be produced with a surface roughness, $R_a \leqslant 3{,}2$ µm and a parallelism tolerance not greater than 0,075 mm, care being taken to ensure that any small radii in the bore and the retaining ring groove are as specified in the purchaser's drawing. The faces of the tyre may be machined to finished dimensions or part finished to provide a clean face for rolling of the tyre over the retaining ring (see 5.3.1.4). The inner diameter of the tyre shall be bored to a tolerance, $c_{\text{tyre bore}}$, of $^{0{,}0}_{-0{,}12}$ mm, and shall have an interference fit with the rim of the wheel centre when both are measured at room temperature in accordance with the equation

$$c_{\text{tyre bore}} = a_{\text{centre}} - \frac{x a_{\text{centre}}}{1\,000}$$

where

a_{centre} is the value on the outside diameter of the rim of the wheel centre;

x is a factor chosen from the range 1,1 to 1,5 taking into account influences such as the design and stiffness of the wheel centre.

5.3.1.3 Retaining ring

The retaining ring shall be used in its rolled condition. It shall be prepared to the correct length, the ends being either squared or scarfed, as specified by the purchaser, and rolled to the appropriate diameter in a manner to avoid any twist.

5.3.1.4 Assembly

Immediately before assembly, the mating surfaces of the tyre bore and wheel rim shall be cleaned to remove any protective coating, rust or foreign matter. The tyre shall be uniformly heated to a temperature necessary to obtain just enough expansion for it to be fitted and shall not exceed 300 °C, the wheel centre being kept at room temperature. The tyre shall be positioned on to the wheel centre, care being taken to ensure that the inner surface of the rim is in contact with the snip (collar) of the tyre. The tyre shall then be allowed to contract by cooling in still air. Water cooling shall not be used. While the tyre is still hot, the retaining ring shall be fitted, ensuring that it rests correctly at the bottom of the groove. The lip of the tyre shall then be closed down on to the retaining ring by machine rolling with a progressively applied pressure, the tyre temperature being not higher than 200 °C. When finally positioned and rolled down, any gap between the ends of the retaining ring shall not exceed 3 mm. The use of making-up pieces shall not be allowed. On completion of the rolling of the tyre lip, a check shall be made to ensure tightness of the ring and that the lip is free from cracks.

5.3.2 Dimensional requirements

5.3.2.1 For tyred wheels in the conditions "finished" (see 4.3.1) and "ready for assembly" (see 4.3.2), the dimensional

requirements shall be as indicated in tables 7 and 8 as appropriate (see also 5.3.2.1.1 and 5.3.2.1.2).

5.3.2.1.1 The manufacturer shall ensure that for all relevant geometrical characteristics not indicated in table 8 (for example the geometrical characteristics given in table 9) the tolerances are maintained such that, when the tyred wheels are assembled on to the axle (see ISO 1005/7), the tolerance values of the wheelset as required in ISO 1005/7 are achieved without further machining.

5.3.2.1.2 If in special cases, despite the difficulties mentioned in 6.3.7.4, instead of the requirements of 5.3.2.1.1 specific geometrical tolerances of the tyred wheel are required for compliance of the tyred wheel with the order, this shall be agreed at the time of enquiry and order. In this case, the tolerances in table 9 shall apply, unless otherwise agreed.

5.3.3 Surface roughness

5.3.3.1 Unless otherwise agreed, the arithmetic mean deviation of the profile, R_a, for machined surfaces in the "finished" and "ready for assembly" conditions shall be as given in table 3.

5.3.3.2 For unmachined surfaces in the "finished" and "ready for assembly" conditions, the surface quality shall be agreed at the time of enquiry and order (see table 6, footnote 4 and table 7, footnote 4).

5.3.4 Residual static unbalance

5.3.4.1 If a maximum static unbalance is required, the static unbalance for tyred wheels for trailer stock other than freight stock shall, in the condition "finished" and "ready for assembly", unless otherwise agreed, not exceed the values given in table 4.

Table 4 — Static unbalance for tyred wheels

Operating speed, v (km/h)	Maximum static unbalance (g·m)
$v < 100$	—
$100 < v < 120$	125
$120 < v < 200$	75

5.3.4.2 For tyred wheels for tractive stock, values of static unbalance, if required, shall be agreed at the time of enquiry and order.

5.3.4.3 The correction of unbalance of the tyred wheel, if required, shall be carried out generally in accordance with ISO 1005/4 and, if specified in the order or its appended documents, the position and amount of unbalance of the tyred wheel shall be indicated by a suitable colour paint in a radial stripe of about 15 mm width. The unbalance value, expressed in gram metres, shall be shown by painted numbers below the end of the stripe.

5.3.5 Oil injection grooves

If an oil injection groove, in the bore "ready for assembly" tyred wheel, is specified by the purchaser (see ISO 1005/7), this and the associated drilled and tapped hole for the oil pressure connection shall be machined according to the requirements of the purchaser's drawing accompanying the enquiry or order. Special care shall be taken with the blending of the groove and the bore to ensure that there are no sharp edges or projections.

5.3.6 Appearance

Those parts remaining black shall blend smoothly into the machined portions.

The finish of the machined surface shall be as specified in the order or its appended documents, by comparison specimens, or as specified in 5.3.3.

The surface of the wheel centres shall not show any marks other than in the positions specified in the order or its appended documents.

Table 3 — Surface roughness of tyred wheels

Part	Condition	Arithmetic mean deviation of the profile[1] R_a (µm)
Bore	Finished	$R_a < 12,5$
	Ready for assembly	$1,6 < R_a < 3,2$
All other parts	Finished or ready for assembly	$R_a < 12,5$

1) If the maximum height of the profile, R_y (see ISO 468), is used, the values shall be agreed between the interested parties.

5.3.7 Soundness

The tyred wheels shall be sound throughout and without any defects detrimental to their use.

5.3.8 Brand marks

Each tyred wheel shall be marked on the tyre and on the wheel centre in accordance with the separate requirements of ISO 1005/1 and ISO 1005/4. In addition,

a) the tyred wheel shall be branded with the inspector's stamp following assembly of the tyre on to the wheel and finish machining carried out;

b) if static balancing has been carried out subsequent to the assembly of the tyre on to the wheel centre, and if specified on the order or its appended documents, the position and amount of residual unbalance shall be marked on the wheel in accordance with 5.3.4.3.

6 Inspection

6.1 Tyres

For the inspection of the dimensional characteristics, the requirements of table 5 and ISO 1005/1 shall apply.

6.2 Wheel centres

6.2.1 Dimensional characteristics

For the inspection of the dimensional characteristics, the requirements of tables 6 and 7 and ISO 1005/4 shall apply.

6.2.2 Surface roughness

If compliance with the requirements for the surface roughness is to be verified, the number of wheel centres to be inspected and all other necessary details shall be agreed at the time of enquiry and order.

6.2.3 Residual static unbalance

If a verification of the residual static unbalance is required, this shall be carried out in accordance with the requirements of ISO 1005/6.

6.3 Tyred wheels

6.3.1 Responsibilities and type of inspection

6.3.1.1 The purchaser shall specify in the order whether inspection to ensure compliance with assembly methods (see 5.3.1) and with the dimensional, roughness and balancing requirements (see 5.3.2, 5.3.3 and 5.3.4) is to be carried out either

a) under delegated inspection by the qualified department of the manufacturer;

b) in the presence of the purchaser, his representative or a body designated by him.

Unless otherwise specified in the order, the provisions of table 10, column 4 shall apply.

6.3.1.2 Delegation of inspection by the purchaser to the qualified department of the manufacturer does not remove the right of the purchaser to monitor the effectiveness of the manufacturing controls and of the testing and inspection methods.

In this respect, he shall be allowed to witness any of the tests made under the responsibility of the manufacturer and to inspect the recorded results.

6.3.2 Inspection of manufacture

Whether the inspection of manufacture is the responsibility of the manufacturer's qualified department or of the purchaser, 6.3.2.1 and 6.3.2.2 shall apply.

6.3.2.1 The manufacturer shall advise the purchaser of the principal process which will be used in completing the order, and shall advise the purchaser of any subsequent fundamental changes which he proposes to introduce and which may affect the quality of the tyred wheels and seek his agreement.

If the inspection remains the responsibility of the purchaser, his representative shall be allowed to inspect the manufacturing processes used in order to ensure compliance with the requirements of this part of ISO 1005 and the prior agreement.

6.3.2.2 The manufacturer shall, at the time of submission for acceptance, certify that the manufacturing requirements of this part of ISO 1005 have been complied with (see 5.3).

6.3.3 Inspection of the characteristics of the tyred wheels

6.3.3.1 Types of tests

Table 10 specifies the types of tests to be carried out and whether they are mandatory or optional.

6.3.3.2 Condition of wheels when submitted for inspection

When submitted for inspection, the tyred wheels shall be in the final delivery condition.

6.3.4 Submission for inspection by the purchaser

The purchaser [see 6.3.1.1 b)] shall be notified in writing (see 6.3.5.2) of the date of submission for inspection, stating the number of tyred wheels in each batch and the order reference number.

6.3.5 Certification

6.3.5.1 Whether the inspection of manufacture is the responsibility of the manufacturer's qualified department or of the purchaser, the manufacturer shall certify that the manufacturing requirements of this part of ISO 1005 have been complied with.

6.3.5.2 The manufacturer shall provide the relevant certificate for those tests and checks for which he is responsible, at one of the following times:

a) at the time of delivery, if he has the delegated responsibility for all tests;

b) at the time of the submission for inspection (see 6.3.4).

6.3.6 Number of checks and tests

The number of tyred wheels per test unit to be subjected to the checks and tests is given in table 10, column 5.

6.3.7 Test methods

6.3.7.1 Fit of tyre on to wheel centre

The assembly shall be checked to ensure that the fit of the tyre on the wheel centre and of the tyre-retaining ring is correct and secure.

6.3.7.2 Static balance

If verification of the residual static unbalance of each tyred wheel is required, this (see 5.3.4) shall be checked by means of a suitable device agreed by the purchaser.

6.3.7.3 Checking of the appearance

The appearance shall be checked by visual inspection before delivery.

6.3.7.4 Checking of dimensions

The dimensions shall be checked in accordance with the requirements of 5.3.2. Because of the practical difficulties of verification of certain dimensional values under production conditions, the dimensional characteristics for which in the last column in tables 6, 7, 8 and 9 an "o" is indicated, shall only be verified if agreed at the time of enquiry and order (see also 5.3.2.1.2). Definitions of the various geometrical tolerance terms are given in ISO 1101/1.

6.3.7.5 Surface roughness

If compliance with the requirements for the surface roughness is to be verified, the number of wheels to be inspected and all other necessary details shall be agreed at the time of enquiry and order.

6.3.8 Conclusion of the inspection

Any defects in the fit of the tyre and retaining ring, appearance or dimensions and balancing shall result in rejection of the tyred wheel.

Any other result not conforming to the required standard shall result in the rejection of the corresponding batch, subject to the requirements of ISO 404.

Before delivery, all accepted tyred wheels shall be marked by the inspector after the final inspection and the inspector's marks shall be placed adjacent to the manufacturer's marks.

6.3.9 Retests

Unless otherwise agreed, the requirements for retests in ISO 404 shall apply.

7 Delivery

7.1 Protection against corrosion during transport

After inspection, and before storage or despatch, at least all finished machined parts of the accepted tyred wheels shall be protected against corrosion by a method agreed with the purchaser.

NOTE — The efficiency of any protective coatings is only of limited life, especially under conditions of sea transport or in geographical regions of high humidity. Therefore the delivered tyred wheels should be inspected, immmediately on arrival at their destination, to see if a renewal of the protection is necessary.

7.2 Protection against mechanical damage during transport

The finished machined portions, especially the bores of the tyred wheels, shall be provided with effective protection against mechanical damage before despatch.

8 Guarantee

The conditions of guarantee shall be agreed between the purchaser and the manufacturer at the time of enquiry and order.

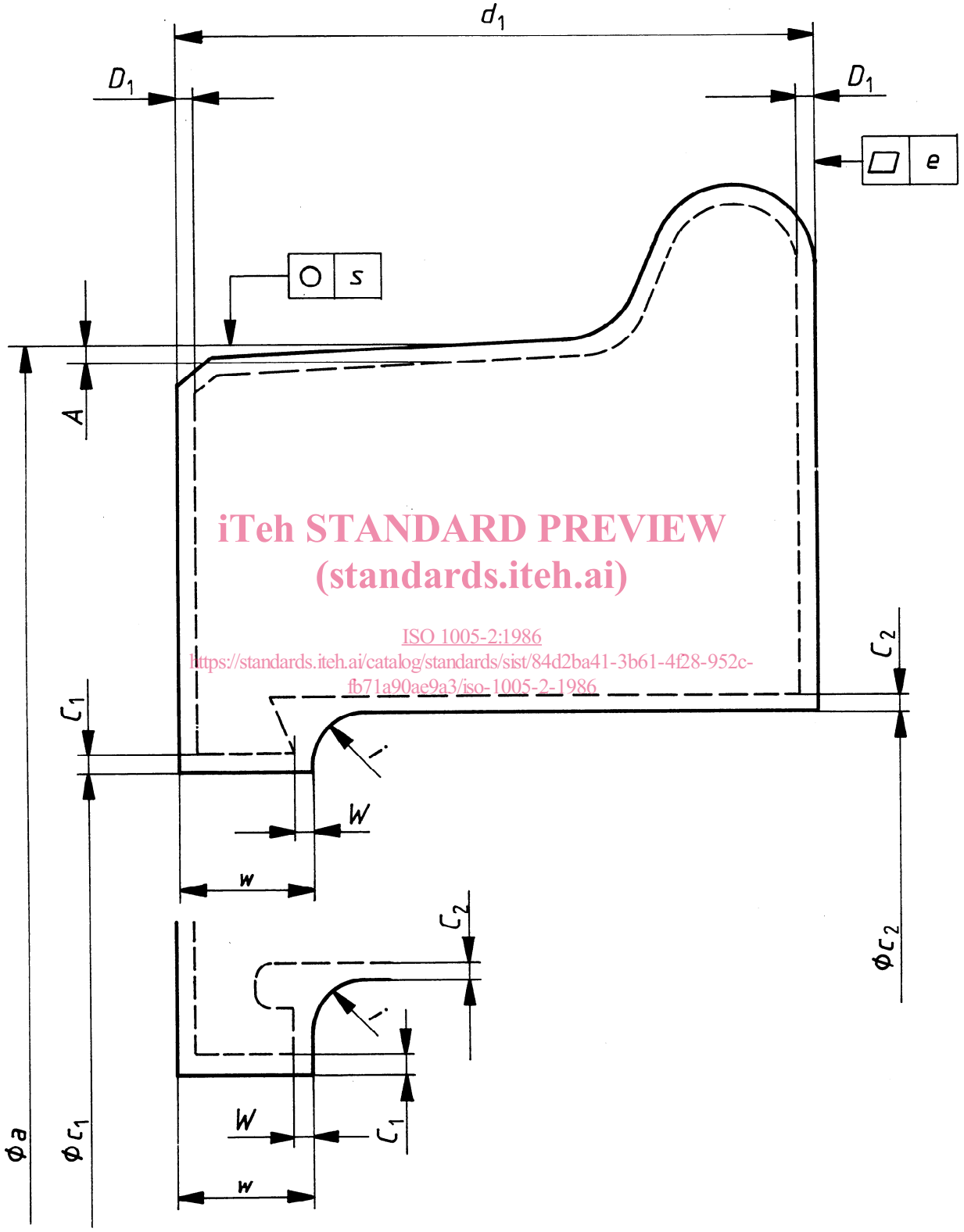

Figure 1 — Symbols for the dimensional characteristics, specified in table 5, for unmachined portions of rolled tyres

Table 5 — Dimensional and geometrical requirements for unmachined[1] portions of rolled tyres

Designation		Symbol in figure 1 for dimensional tolerances	Symbol in figure 1 for geometrical tolerances	Machining allowance mm	Tolerance mm	Verification[2]
External diameter		A		3		m
		a			$+\ 8$ 0	
Internal diameter		C_2		3		m
		c_2			0 $-\ 10$	
Width		D_1		3		m
		d_1			$+\ 3$ 0	
Snip	Internal diameter	C_1		3		m
		c_1			0 $-\ 10$	
	Width	W		3		m
		w			$+\ 3$ 0	
	Radius	i		Not greater than the depth of the snip	$\left[\frac{c_2 - c_1}{2}\right]$	m
Circularity ○			s		2	m
Flatness ▱			e		2	m

1) For definition of "unmachined", see 4.1.1.

2) m = is mandatory.