
International Standard



1005/6

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**Railway rolling stock material —
Part 6 : Solid wheels for tractive and trailing stock —
Quality requirements**

*Matériel roulant de chemin de fer — Partie 6 : Roues monoblocs pour le matériel moteur et pour le matériel remorqué —
Prescriptions de qualité*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

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.

International Standard ISO 1005/6 was developed by Technical Committee ISO/TC 17, *Steel*, and was circulated to the member bodies in December 1980.

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It has been approved by the member bodies of the following countries :

Austria	Iran	South Africa, Rep. of
Bulgaria	Iraq	Spain
Canada	Italy	Sweden
China	Japan	Switzerland
Czechoslovakia	Korea, Dem. P. Rep. of	United Kindgom
Egypt, Arab Rep. of	Korea, Rep. of	USA
Finland	Netherlands	USSR
Germany, F.R.	Poland	Venezuela
Hungary	Rcmania	

The member bodies of the following countries expressed disapproval of the document on technical grounds :

Australia
Belgium
France
India

This International Standard cancels and replaces ISO Recommendation R 1005/6-1969, of which it constitutes a technical revision.

Railway rolling stock material — Part 6 : Solid wheels for tractive and trailing stock — Quality requirements

1 Scope and field of application

1.1 This part of ISO 1005 specifies requirements for the manufacture and supply of rolled, forged or cast solid wheels for tractive and trailing stock of unalloyed steels in accordance with table 1 and clause 4.

NOTE — Another International Standard for solid wheels is in preparation (see table 1, footnote 1).

1.2 In addition to this International Standard, the requirements of ISO 404 are applicable.

2 References

ISO 82, *Steel — Tensile testing.*

ISO 83, *Steel — Charpy impact test (U-notch).*

ISO/R 377, *Selection and preparation of samples and test pieces for wrought steel.*¹⁾

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

ISO 5948, *Railway rolling stock material — Ultrasonic acceptance testing.*

ISO 6506, *Metallic materials — Hardness test — Brinell test.*

NOTE — Pending publication of this revision as an International Standard, it will be necessary for the relevant requirements to be agreed by the purchaser and the manufacturer.

3 Information to be supplied by the purchaser

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

a) the number of this International Standard;

b) the grade of steel (see 4.1 and table 1);

c) the type of heat treatment (see 4.2 and 6.5);

d) the dimensions of the wheel (see 5.4);

e) the finish of machined surfaces (see 5.2.1);

f) whether the composition may be verified by cast analysis (see 5.1);

g) if macroscopic and macrographic tests are required (see 5.2.2.1, 5.2.2.2 and table 2);

h) if ultrasonic testing is required (see 5.2.2.3 and table 2);

j) magnetoscopic test (cast wheels only) (see 5.2.2.4 and table 2);

k) if checks on uniformity of Brinell hardness is required (see 5.2.3 and table 2);

m) for surface-treated wheels, the total wear depth (see 5.2.4);

n) whether in the case of finished wheels the position and amount of residual static unbalance shall be marked (see 5.2.6);

p) if any special marking is required (see 5.5);

q) the manufacturing process for cast wheels (see 6.2.2);

r) the conditions for machining and the elimination of unbalance (see 6.6);

s) if special inspection is required (see clause 7);

t) if special preparation and sampling of test pieces is required (see 7.7.2 and 7.7.3);

u) the method of protection against corrosion (see 8.1);

v) if the conditions of guarantee are to be agreed (see clause 9).

1) Under revision.

4 Classification

The solid wheels shall be specified in the order or its appended document according to the grade of steel, the heat-treatment condition of delivery, the degree of finish and any optional tests or inspection required (see table 2, column 4).

4.1 Steel grades

This International Standard covers the following grades of steel in accordance with the properties given in table 1 :

- a) hot-formed (rolled or forged) wheels : R1, R2, R3, R6, R7, R8 and R9;
- b) cast wheels : RC1, RC2, RC3, RC6, RC7, RC8 and RC9.

4.2 Types of heat-treatment condition of delivery

The wheels shall be supplied

- a) untreated (no symbol) — R1, R2, R3 and RC1, RC2 and RC3, or
- b) normalized or normalized and tempered (symbol N) — R1, R2, R3 and RC1, RC2 and RC3, or
- c) surface treated (symbol T) — R6, R7, R8, R9 and RC6, RC7, RC8 and RC9, or
- d) immersion quenched and tempered (symbol E) — R6, R7, R8, R9 and RC6, RC7, RC8 and RC9.

Irrespective of the heat-treatment condition specified, where no effective degassing has been carried out, suitable precautions, which may include for example slow cooling, shall be taken to avoid the formation of flakes (hydrogen cracking). If so requested, the representative of the railway authority shall be informed of the precautions taken.

Surface treatment (T) shall consist first of heating the wheel for a sufficient time to bring it uniformly to a temperature of at least 825 °C, then hardening the rim, for example with a jet of water under pressure, followed by tempering to a minimum temperature of 500 °C; the wheel is then left to cool in still air, preferably in a covered cooling pit or under a cover.

4.3 Degree of finish

The degree of finish on delivery may be as follows :

- a) rough-machined, when the wheel has received no final machining, but has been rough-machined on all or only certain portions which have to be machined;
- b) half-finished, when the wheel has received final machining on certain portions which have to be machined and are considered as finished, the other portions designated as rough-machined having received no final machining;

c) finished, when all portions of the wheel having to be machined have undergone their final machining, except those which, for example the final machining operation on the bores, are normally carried out by the wheel set manufacturer immediately before mounting the wheels on the axles.

5 Requirements

5.1 Chemical composition

The maximum contents of the various elements are given in table 1. These values apply to the product analysis. If the purchaser agrees, the manufacturer may verify the composition by cast analysis instead of by product analysis.

5.2 Physical properties

5.2.1 Appearance

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

The finish of the machined surfaces shall be as specified in the order or its appended documents, or by comparison specimens. The order or its appended documents may require certain wheels to be completely machined over their entire surface, including that of the boss.

The surfaces of the wheel shall not show any marks other than in the positions specified in the order or its appended documents. Brinell-hardness-testing impressions may, however, be left on the surface of the rim.

5.2.2 Soundness

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

5.2.2.1 Macroscopic appearance

After polishing, examination of the surface shall reveal no discontinuity.

5.2.2.2 Macrographic appearance

The sulphur print shall not reveal any worse faults than those shown in the prints contained in the album given in the annex to this part of ISO 1005.¹⁾

5.2.2.3 Ultrasonic flaw detection test

5.2.2.3.1 When the comparison method of ultrasonic flaw-detection testing (see ISO 5948) is to be used, as specified in 7.8.9 and ISO 5948, and if the order does not specify details of the acceptance standard, the following shall apply :

1) The album will be incorporated in this document at the time of final publication.

Wheels giving rise to no more than 10 defect signals in the rim for which the ratio of the amplitude of the defect signal or supplementary echo to that of the backwall echo of an adjacent sound zone does not exceed 0,25, shall be accepted, provided that there is at least 15 mm between two adjacent defect signals.

5.2.2.3.2 For the distance-gain-size (DGS) method (see ISO 5948), the acceptance standard shall be agreed in the absence of an appropriate International Standard.

5.2.2.4 Magnetoscopy (cast wheels only)

The examination of the lateral surfaces of the wheels by magnetic methods shall not reveal any defects, indicated by an accumulation of powder, greater than that specified in the order or its appended documents. No residual magnetism capable of causing the persistent presence of magnetic dust detrimental to the satisfactory behaviour of the wheels in service shall remain in the parts after examination.

5.2.3 Uniformity of hardness

If stated in the order, the difference between the extreme hardness values recorded on the rims of wheels of the same grade of steel with the same dimensions, coming from the same batch, shall not exceed 30 HBS.

5.2.4 Depth of the treated part (T wheels only)

The thickness of the treated part, estimated from the results of the hardness sequence tests (see 7.7.3.6.2), shall be not less than the total wear depth specified in the order or its appended documents.

The order or its appended documents may also specify the minimum hardness at the limit of the wear depth.

The surface treatment shall not modify the characteristics of the zone between rim and web (see table 1, footnote 9).

5.2.5 Residual stresses (T wheels only)

The object of surface treating is in part to produce favourable residual compression stresses circumferentially in the rim of the wheel. The manufacturer shall demonstrate that the procedure used for surface treatment results in an adequate magnitude of residual circumferential compression. One method of doing this is described in 7.8.8.

5.2.6 Mass distribution — Balancing

If specified in the order or its appended documents, the position and amount of the residual static unbalance of finished wheels shall be suitably marked (see 5.5, last paragraph).¹⁾

5.3 Mechanical properties

The mechanical properties of the wheels shall be those shown in table 1.

5.4 Dimensional characteristics

5.4.1 The dimensions of the wheels shall be given in the order or its appended documents.

5.4.2¹⁾

5.5 Manufacturer's brand marks

Each wheel shall be supplied with stamped-on or cast-on marks as specified on the order or its appended documents.

Unless otherwise specified, each wheel shall receive the following marks :

- a) manufacturer's mark;
- b) cast number;
- c) grade of steel and heat-treatment condition (see 4.2);
- d) date of manufacture (month and last two figures of the year of manufacture);
- e) the inspector's mark.

Unless otherwise specified, the position and the type of the marks shall be as follows :

The marks appertaining to a) to d) shall be made on the outside face of the hub. Stamps with acute-angled character forms shall not be used (see 6.4).

If according to 5.3.6 the position and amount of the residual static unbalance shall be marked, the marking shall, unless otherwise agreed, be carried out as follows :

The position of the unbalance shall be indicated by suitable colour paint in a radial stripe of about 15 mm width. The unbalance value shall be given, in gram metres, by painted numbers below the end of the stripe.

6 Manufacture

6.1 Steelmaking process

The wheels shall be made from steel produced by open hearth, electric arc or basic oxygen processes; other processes may be used by agreement between the manufacturer and the purchaser.

The steel shall be killed in the furnace or in the ladle and shall be bottom-poured, unless otherwise agreed.

¹⁾ An International Standard dealing with residual unbalance, tolerances on dimensions and form and permitted machining allowances is in preparation.

6.2 Manufacturing process

6.2.1 Rolled wheels : Rough-machining, rolling

Rolled wheels shall be manufactured from ingots or blooms capable of producing two or more wheels after removal of discards. Special individual ingots may only be used with the prior agreement of the purchaser. Cropping shall be sufficient to eliminate defective sections of the ingot. Any superficial defects shall be completely removed before or during working. Any sections which are to be rolled or forged into wheels and which are not completely sound shall be dealt with in accordance with 6.3.

The sections of ingots or blooms shall be forged, pierced and rough shaped by a hammer or press. They shall be finally shaped by rolling or by drop forging supplemented by sizing if necessary. The finished rolled or forged wheels shall comply with 5.4.

Suitable precautions shall be taken during hot-working to ensure that material is not damaged by excessive temperatures (overheating) or by grain growth due to cessation of work at high temperatures. Generally, forging should not be done at temperatures above 1 260 °C, and should terminate between 850 and 1 000 °C. After forging or rolling, sizing where applicable and stamping the identification marks, the wheels shall be left to cool in still air. If the steel has not been degassed, suitable precautions shall be taken to avoid the formation of flakes (see 4.2).

6.2.2 Cast wheels

The wheels shall be manufactured in accordance with processes specified by the purchaser; the manufacturing process shall fix the number of feeder-heads in particular, and their volume and position.

6.3 Removal of defective sections

Defective sections which do not comply with the soundness characteristics specified in 5.2.2 shall be removed before or during the manufacture of the wheels.

6.4 Identification of the wheels during manufacture

All ingots, sections and wheels shall be suitably marked at each stage of manufacture so that before delivery each wheel can be identified as specified in 5.5. Where punched identification marks differ from the final identification marks defined in 5.5, they shall be sufficiently shallow not to remain visible on the finished wheel.

6.5 Heat treatment

The wheels shall undergo the heat treatment specified in the order or its appended documents (see 4.2).

6.6 Machining and elimination of unbalance

The conditions for machining shall be chosen so that the wheels comply with the requirements for surface quality and tolerances for the dimensional requirements.

Unless otherwise specified, correction of unbalance shall be obtained by machining off-centre of the fillet between the web and the rim, on the flange side (see figure 1). The thickness of the metal removed shall not exceed 4 mm and the dressed surface shall be carefully blended into the adjacent surfaces.

Under no circumstances may additional weights be attached.

Drilling of holes for balancing is not permitted for wheels of tractive stock. Prior agreement by the purchaser shall be obtained if this method of balancing is to be used for wheels for trailing stock.

6.7 Removal of surface defects

6.7.1 Authorized repairs

With the exception of finished sections on which no retouching is authorized, superficial defects may be eliminated prior to static balancing by chipping or machining or by soft grinding, provided that no heat cracking is produced, that the dimensional tolerances are maintained and that, where necessary, it is ensured that any defect is completely eliminated by an appropriate means, for example by a magnetoscopic test.

6.7.2 Unauthorized repairs

Any welding, gas torch treatment, heating, electric burns, filling by metallization, electrolytic or chemical deposits, etc., and any retouching with the object of concealing a defect, are not permitted and shall result in the rejection of the complete batch.

7 Inspection

7.1 Responsibilities and type of inspection

7.1.1 The purchaser shall specify in the order whether inspection to ensure compliance with manufacturing methods (see clause 6) and with the quality requirements (see clause 5) is to be carried out either

- a) under delegated inspection by the qualified department of the manufacturer, or
- 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 2, column 5, shall apply.

7.1.2 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.

7.2 Inspection of manufacture

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

7.2.1 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 wheels and seek his prior 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 International Standard.

7.2.2 The manufacturer shall at the time of submission for acceptance, certify that the manufacturing requirements of this International Standard have been complied with (see 7.5).

7.3 Inspection of the characteristics of the wheels

7.3.1 Types of test

Table 2 specifies the types of test to be carried out and whether they are mandatory or optional.

7.3.2 Test unit and subdivision into batches

The appropriate unit for each type of test is given in table 2, column 7.

For acceptance testing, wheels shall be grouped in batches. Each batch shall be formed of wheels produced from the same cast and having undergone the same heat treatment. It may include wheels of a different shape, provided that, in the case of wheels for tractive stock, all the wheels in the batch are of the same nominal diameter and the same rim section.

7.3.3 Condition of wheels when submitted for inspection

When submitted for inspection, the condition of wheels shall comply with the requirements of table 2, column 6.

7.4 Submission for inspection by the purchaser

7.4.1 The purchaser [see 7.1.1 b)] shall be notified in writing (see 7.5.2) of the date of submission for inspection, stating the

number of wheels in each batch and the order reference number.

7.4.2 If the inspection, which in accordance with table 2, is to be carried out after machining, is the responsibility of the purchaser [see 7.1.1 b)], then the manufacturer may submit the material in two stages :

- a) after the final heat treatment but before machining, and
- b) in the final delivery condition.

7.5 Certification

7.5.1 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. The final test certificate shall also include the results of the following tests :

- chemical analysis;
- tensile test;
- impact test;
- hardness sequence test.

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

- a) at the time of delivery, if he has the delegated responsibility for all tests, or
- b) at the time of the first submission for inspection (see 7.4.2), if for that part of the testing he has the delegated responsibility.

7.6 Number of checks and tests

The number of wheels per test unit to be subjected to the checks and the number of tests per wheel are given in table 2, columns 8 to 10.

7.7 Sampling and preparation of samples and test pieces

7.7.1 Sampling

After identifying the batch, the inspector shall select at random the wheel(s) intended for testing and indelibly stamp them.

He shall outline on each of these wheels a sample segment (figure 2) from which the test pieces shall be taken.

7.7.2 Preparation of samples and test pieces

If a residual stress test is required, this test shall be carried out before cutting out the test segment.

Unless otherwise specified, the conditions of preparation of samples and test pieces, shall be carried out in accordance with the requirements of ISO/R 377, with the following additional requirement.

The samples and test pieces shall retain the inspector's identification marks and stamps, and may not be altered except in his presence.

7.7.3 Number and position of test piece

Test pieces shall be taken from the previously marked sample sections, and shall be stamped for identification by the responsible inspector.

7.7.3.1 Product analysis

Unless otherwise specified in the order or its appended documents one of the following samples shall be taken from one of the test wheels :

- at least 50 g of millings representing the average of a radial section of the wheel;
- or, as for example in the case of spectrographic analysis, one sample from the tensile test piece shown in position ① of figure 2.

7.7.3.2 Tensile test

One test piece shall be taken from each test wheel from position ① of the sample shown in figure 2.

In the case of surface-treated wheels (T), one further tensile test piece shall be taken from position ② shown in figure 2.

The test pieces shall be prepared in accordance with the requirements of ISO 82, the test piece preferably having a diameter of at least 10 mm with a gauge length of 5 × diameter.

7.7.3.3 Impact test (U-notch)

Three test pieces shall be taken from the sample at the positions shown in figure 2. The impact test pieces shall be marked to identify their longitudinal surfaces which are parallel to section AA (see figure 2). The test pieces shall be prepared in accordance with the requirements of ISO 83. The axis of the cylindrical bottom of the notch shall be parallel to diameter AA in figure 2.

7.7.3.4 Macroscopy and macrography

The test piece shall consist of a radial slice through the whole cross-section of the wheel, with one surface ground or polished sufficiently to eliminate machining marks and to obtain a clear macrographic image.

7.7.3.5 Static unbalance

The test piece shall consist of the finished wheel.

7.7.3.6 Hardness

7.7.3.6.1 Uniformity of hardness

Each wheel to be tested (see table 2) shall be subjected to a Brinell hardness test on the plane face of the rim on the side opposite the flange. The position selected for indentation shall be on a circumference with a radius approximately 25 mm less than that of a running circle (see figure 3). The position shall, where appropriate, be prepared by grinding in order to remove any decarburized material.

7.7.3.6.2 Hardness sequence

The test piece shall consist of a small plate comprising the complete radial section of the rim and its joint with the web, selected from the sample segment (see figure 3). One of its faces shall be prepared in accordance with ISO 6506. The hardness indentations shall be situated on the three lines shown in figure 3 at a distance from the tread of 5 mm and 35 mm and in the centre of point A. If the limit of wear is nearer to the tread than 35 mm, the indentations shall be made at this limit instead of 35 mm.

7.7.3.7 Ultrasonic test

The test piece shall consist of the wheel after heat treatment. Unless otherwise agreed, it shall be scanned on the face of the rim situated on the side of the flange in accordance with ISO 5948.

7.7.3.8 Magnetoscopy

The test piece shall consist of the wheel. The parts to be examined, except for the bore surface, shall be previously machined to the final dimensions specified in the order or its appended documents.

7.8 Test methods

7.8.1 Chemical analysis

The chemical analysis shall be carried out in accordance with the methods defined by the corresponding International Standards or by any other appropriate methods. In case of dispute, only test methods recommended by ISO shall be used.

7.8.2 Tensile test

The tensile test shall be carried out in accordance with the requirements of ISO 82.

7.8.3 Impact test (with U-shaped notch)

The impact test shall be carried out in accordance with the requirements of ISO 83.

7.8.4 Macroscopic examination

The polished surface of the test piece shall be examined with a magnification not more than 5.

7.8.5 Macrographic examination

If the examination defined in 7.8.4 is satisfactory, the macrographic image of the test piece shall be obtained by applying, to its polished and degreased surface, a sheet of gelatine silver bromide paper first saturated in water containing 2 % (V/V) of pure sulphuric acid, and leaving for at least 3 min.

7.8.6 Static balance

The residual unbalance shall be checked by a suitable device agreed by the purchaser.

7.8.7 Brinell hardness

The Brinell hardness test shall be carried out in accordance with the requirements of ISO 6506.

The hardness sequence test shall be carried out with a ball of nominal diameter of not more than 5 mm.

7.8.8 Check on the direction of residual stresses

Two marks 100 mm apart shall be made in the centre of the thickness of the rim, on the flat surface on the side opposite the flange; a radial cut from the top of the flange through to the bore shall then be made half-way between the two marks.

The distance between the marks shall then be measured; it shall have reduced by at least 1 mm.

7.8.9 Ultrasonic flaw detection test

The tests shall be carried out in accordance with the requirements in ISO 5948.

For ultrasonic flaw detection tests carried out by the comparison method (see ISO 5948), the sensitivity shall be adjusted in such a way that the height of the first backwall echo is 50 mm.

7.8.10 Magnetoscopic examination¹⁾

The procedure for magnetoscopic examination shall be stated in the order or its appended documents. Otherwise, the procedure shall be as specified by national standards. For the purpose of this examination, the method of detection by magnetic ink shall be used. The sensitivity of the method shall be checked by means of a magnetizing test.

After examination and demagnetising, the absence of residual magnetism shall be checked by ensuring that the wheel exerts no attraction to a non-magnetised piece of ferromagnetic steel, or by means of a magnetic test.

7.8.11 Checking of appearance

The appearance shall be checked by visual inspection before delivery.

7.8.12 Checking of dimensions²⁾

7.9 Conclusion of the inspection

Any defects in appearance or dimensions and balancing, shall result in rejection of the wheel. The same shall apply to any ultrasonic or magnetoscopic examination revealing defects greater than those which may be tolerated.

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

Before delivery, all accepted wheels shall be marked by the inspector after the final inspection and the inspector's marks shall be placed in the same position as the manufacturer's marks.

7.10 Retests

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

8 Delivery

8.1 Protection against corrosion during transport

After inspection and, before storage or despatch, at least all finished machined parts of the accepted 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 wheels should be inspected, immediately on arrival at their destination, to see if a renewal of the protection is necessary.

8.2 Protection against mechanical damage during transport

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

9 Guarantee

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

1) An International Standard for magnetoscopic acceptance testing of railway rolling stock material is in preparation.

2) An International Standard dealing with dimensions is in preparation.