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R 1005/III

RAILWAY ROLLING STOCK MATERIAL

AXLES FOR TRAILER STOCK

1st EDITION

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BRIEF HISTORY

The ISO Recommendation R 1005/III, *Railway rolling stock material – Axles for trailer stock*, was drawn up by Technical Committee ISO/TC 17, *Steel*, the Secretariat of which is held by the British Standards Institution (BSI).

Work on this question led, in 1967, to the adoption of a Draft ISO Recommendation based on a corresponding UIC* code.

In January 1968, this Draft ISO Recommendation (No. 1377) was circulated to all the ISO Member Bodies for enquiry. It was approved, subject to a few modifications of an editorial nature, by the following Member Bodies :

Austria	Hungary	Romania
Belgium	India	South Africa, Rep. of
Canada	Israel	Spain
Colombia	Italy	Sweden
Czechoslovakia	Korea, Rep. of	Switzerland
Denmark	Netherlands	Turkey
Finland	New Zealand	U.A.R.
France	Norway	United Kingdom
Germany	Portugal	Yugoslavia

Three Member Bodies opposed the approval of the Draft :

Brazil
Japan
U.S.A.

The Draft ISO Recommendation was then submitted by correspondence to the ISO Council, which decided, in March 1969, to accept it as an ISO RECOMMENDATION.

* Union Internationale des Chemins de Fer (International Union of Railways).

ISO Recommendation R 1005/III March 1969

RAILWAY ROLLING STOCK MATERIAL

AXLES FOR TRAILER STOCK

1. SCOPE

This ISO Recommendation applies to the manufacture of axles, rough-forged or rough-rolled, solid or hollow, in non-alloy steel, for trailer stock.

2. CLASSIFICATION

The axles should be supplied in accordance with the instructions on the order :

(*a*) normalized*, or

(*b*) rough-forged or rough-rolled, or

(*c*) oil-hardened and tempered.

3. CHEMICAL COMPOSITION

The axles should be manufactured from non-alloy steel** of the following chemical purity :

phosphorus	$\leqslant 0.05$ %
sulphur	$\leqslant 0.05$ %
phosphorus + sulphur	$\leqslant 0.09$ %

In the case of steel produced by the acid open hearth or electric acid-lined furnace process, the following percentages may be accepted :

phosphorus	$\leqslant 0.06$ %
sulphur	$\leqslant 0.06$ %

* Normalizing should be understood to mean leaving the part to cool after forging or rolling, until it has reached ambient temperature, then heating it uniformly to a temperature above that of the transformation point, and maintaining it at that temperature for a sufficiently long period, before leaving it to cool in still air sheltered from draughts.

** For this steel, the content of elements other than carbon should not exceed the following limits :

manganese	1.20 %	molybdenum	0.05 %
silicon	0.50 %	vanadium	0.05 %
nickel	0.30 %	copper	0.30 %
chromium	0.30 %		

4. MECHANICAL PROPERTIES

4.1 Tensile strength R_m

The tensile strength R_m for the various conditions of delivery should be as follows :

- in the normalized condition (i.e. axles delivered normalized or as-forged, or as-rolled) : between 50 and 65 kgf/mm^2 *
- in the oil-hardened and tempered condition : between 55 and 63 kgf/mm^2

If it is necessary for the normalized test piece to be taken from an oil-hardened and tempered axle it should have a tensile strength at least 3 kgf/mm^2 less than that of a test piece from the same axle in the delivery condition.

4.2 Coefficient of quality C

The coefficient of quality (defined in Table 1 below) should be as follows :

- normalized : $C \geqslant 110$
- oil-hardened and tempered : $C \geqslant 113$

TABLE 1

L_0	C
$8.16\sqrt{S_0}$	$R_m + 2.5\,A$
$5.65\sqrt{S_0}$*	$R_m + 2.2\,A$
$4\sqrt{S_0}$	$R_m + 2\,A$

* This formula should preferably be adopted. The other formulae are retained provisionally.

where

L_0 is the gauge length used to measure the elongation after fracture, expressed in millimetres;

S_0 is the cross-sectional area of the gauge length of the test piece, expressed in square millimetres;

R_m is the tensile strength, expressed in kilogrammes-force per square millimetre;

A is the percentage elongation after fracture.

4.3 Resistance to impact

The axle should be able under successive impacts to withstand two bends and two straightenings in accordance with the conditions laid down in clause 15.1, without breaking or cracking.

4.4 Notched bar impact strength KCU

The notched bar impact strength should be as specified in Table 2, below.

TABLE 2

	Normalized		Oil-hardened and tempered	
	Longitudinal	Transverse	Longitudinal	Transverse
KCU at + 20 °C (kgf.m/cm^2)	$\geqslant 5$	$\geqslant 2$	$\geqslant 8$	$\geqslant 3$

* Tighter ranges, but not tighter than 10 kgf/mm^2, may be specified by the purchaser within the limits set out above.

5. PHYSICAL CHARACTERISTICS

5.1 Macrostructure

After ordinary polishing, the surface examined should show no sign of discontinuity.

The sulphur print obtained should not reveal worse faults than those shown in the prints contained in the album forming an Annex to this ISO Recommendation.

5.2 Soundness and appearance

The axles should be sound throughout and without cracks, blowholes, inclusions, flaws, burrs, lack of metal, laps, sand lines, or any other defect detrimental to their use.

The finished condition of the machined surfaces, if any, should comply with the indications on drawings or comparison specimens.

6. DIMENSIONAL CHARACTERISTICS

The axles should be manufactured in accordance with the information given in the standards or drawings relating to the shape, dimensions and dimensional tolerances.

Unless more definite information is given in the standard, drawing or order, hot-forging or rolling should always be sufficient to ensure that the diameters of the rough axle do not exceed the diameters of the finished axle by more than 33 mm at the wheel seats, or more than 20 mm at other parts.

In addition, the rough forging should be entirely capable of producing a finished forging complying with the following conditions :

The diameters of the bloom should not exceed the diameters of the finished axle by more than 20 mm or by less than 5 mm at the wheel seats, or by more than 7 mm and less than 3 mm for other parts.

7. IDENTIFYING MARKS

Each axle should be stamped with the identifying marks defined in the standard or drawing, and in particular with

- the number of the cast,
- the manufacturer's mark,
- the number of the month and the last two figures of the year of manufacture,
- the state of delivery : normalized (N), rough-forged (B), or oil-hardened and tempered (V).

Example : 4532 – XY – 2 . 69 – N

These marks should be hot-stamped in the position and with the characters shown on the drawing. Where no indication is given on the drawing, they should be lightly stamped to a depth which will allow them to be completely removed by finishing operations.

8. STEELMAKING PROCESS

The axles should be made exclusively from steel produced by the open hearth or electric processes; the purchaser may, however, authorize other processes if he regards them as equivalent.

9. MANUFACTURE OF THE AXLES

9.1 Forging and cropping

The axles should be manufactured from ingots. The latter should be made into axles either by forging only, or by rolling into round bars or blooms and then forging, or by rolling only.

If the axles are made by forging only, their maximum section should be not more than one-third of the minimum section of the original ingots.

If the axles are made by rolling into round bars or blooms and then forging, the section of the round bars or blooms should be at least equivalent to double the final maximum section, the latter being not more than one-quarter of the minimum section of the original ingot.

If the axles are made by rolling only, or by rolling followed by forging not in accordance with the above condition, their section should be not more than one-fifth of the minimum section of the original ingot.

During hot working, the material should be completely freed from piping and other defects by cropping off the defective portions from the top and bottom end of the ingot.

Superficial defects which may be observed on the ingot sections or on the blooms should be eliminated.

The portions which, according to the drawings, should be left black, may be brought to their final shape and dimensions either

- by forging or rolling, when they should be suitably trimmed, or
- by turning, when all traces of marks should be eliminated by a final surface cut.

Rough axles should be carefully centred so as to allow the correct execution of subsequent turning operations.

The centres of rough axles should be such as to enable the centres of the finished axles to be obtained without difficulty.

9.2 Heat treatment

After forging and stamping of the identifying marks, the axles should be either

- normalized, if this is required on the order, or
- oil-hardened and tempered, if this is required on the order (and after boring, if necessary).

The normalizing of the cast of axles ordered as rough-forged can also be carried out by mutual agreement between the manufacturer and the purchaser, for the purpose of improving unsatisfactory mechanical properties; in this case, the properties obtained after this operation should conform to those required for axles ordered as normalized.

10. REMOVAL OF SURFACE DEFECTS

Surface defects may be eliminated by removing metal with a machine tool or a grinding wheel provided that the dimensional tolerances are maintained.

A blowpipe should not be used for removing defects.

Any treatment which is carried out with the object of hiding a defect should be strictly forbidden and should result in the rejection of the complete order.

11. SUBMISSION FOR ACCEPTANCE

11.1 During production

The accepting agent should have at his disposal the charts of correctly calibrated recording pyrometers in order to verify the furnace temperatures.

The purchaser may dispense with the above-mentioned temperature verifications, if he considers this advisable.

11.2 Finished axles ready for delivery

The axles should be submitted for acceptance ready for delivery, grouped according to their cast; each cast may include axles of different types. Axles from the same cast, having received the same heat treatment and presented at the same time, form a lot.

12. TYPES AND NUMBERS OF TESTS

The axles should be subjected to the following verifications and tests :

- At the manufacturer's works
  - in all cases
    - tensile test* in the delivery condition
  - if requested on the order by the purchaser
    - falling weight test
    - longitudinal notched bar impact test

    (one of the following two tests should always be carried out : falling weight test or longitudinal notched bar impact test.)
    - transverse notched bar impact test
    - tensile test* when normalized (on oil-hardened and tempered axles)
    - macroscopic and macrographic examinations
- At the laboratory of the purchaser (or at the manufacturer's works after prior agreement with the purchaser)
  - if requested on the order by the purchaser
    - verification of chemical purity
    - verification of percentage contents of elements specified on the order

The falling weight test, the tensile test and the notched bar impact test should be performed on the number of axles indicated in Table 3.

TABLE 3

Number of axles in lot	Number of axles to be tested
⩽ 50	1
> 50	2

The purchaser may, if he considers this advisable, reduce the number of axles for test to be taken from lots of between 51 and 65 from 2 to 1.

The chemical analysis should be performed on one axle per cast taken from those indicated in Table 3.

The macroscopic and macrographic examinations should be performed at both ends of each of the axles which have not undergone destructive testing.**

When the size of the batch submitted is equal to or less than 15, the falling weight test should not be specified, but each of the axles should have an excess length which permits tensile test pieces and longitudinal and possibly transverse notched bar impact test pieces and sections for macroscopic and macrographic examination to be taken.

The series of tests specified should be performed on one of the axles.

13. INTERPRETATION OF TESTS – ADDITIONAL TESTS

Any characteristic which does not comply with the specified requirements can result in the rejection of the corresponding lot.

If the purchaser agrees to additional tests, the number of axles to be submitted to these tests should be defined by special agreement between the supplier and the purchaser.

* See clause 14.2.1.

** The purchaser can have the macrographic and macroscopic examinations carried out on a lesser proportion of axles; the testing procedure should then be agreed with the manufacturer.

14. SELECTION AND PREPARATION OF SAMPLES AND TEST PIECES

14.1 Selection of sample

The accepting inspector should select from each cast submitted the axle(s) intended for testing, and he should stamp them.

He should mark on each of them the sample section from which are to be taken the tensile and impact test pieces.

Where the falling weight test is specified, the sample section should be taken from one of the least deformed parts of the axle subjected to this test.

14.2 Number and position of test pieces

14.2.1 *Tensile test*. One or two test pieces should be taken from the sample section in accordance with the following requirements :

TABLE 4

Condition of axle as ordered	Test piece (to be tested in the delivery condition)	Test piece (to be tested after normalizing treatment)
normalized	1	
rough-forged or rough-rolled		1
oil-hardened and tempered	1	1

The test pieces should be taken from the positions indicated in Figure 1 in the case of solid axles or in Figure 2 in the case of hollow axles; their longitudinal axes should be parallel to that of the axle.

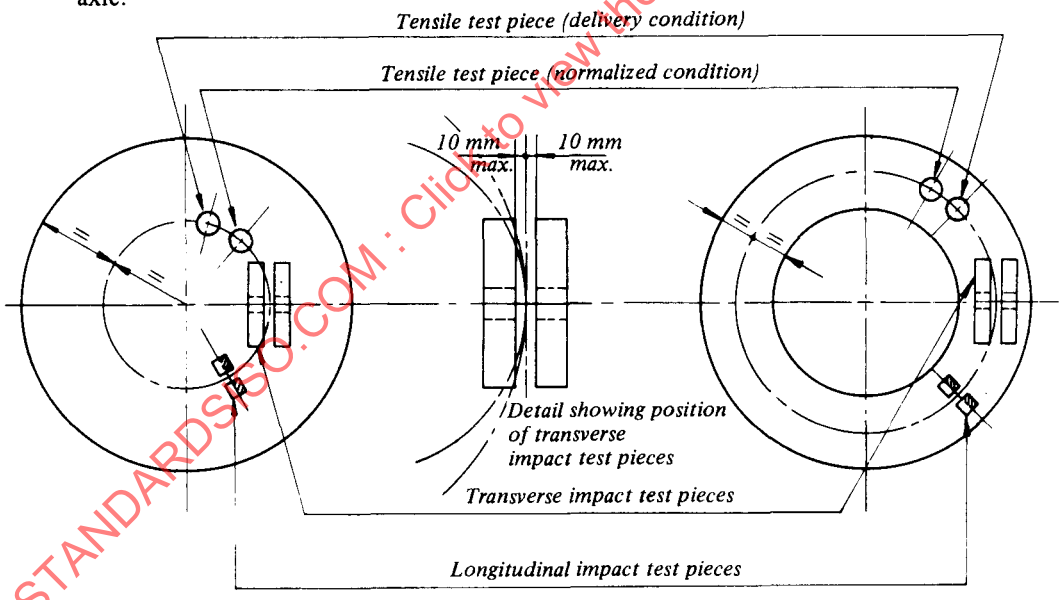

FIG. 1 – **Solid axle**

FIG. 2 – **Hollow axle**

14.2.2 *Notched bar impact test*. The following test pieces should be taken from the positions indicated in Figure 1 in the case of solid axles or in Figure 2 in the case of hollow axles :

- two test pieces for the longitudinal impact test;
- two test pieces for the transverse impact test.

14.2.3 *Macrographic and macroscopic examinations*. A round section should be taken from each end of each axle to be examined.*

14.2.4 *Chemical analysis*. Unless otherwise indicated in the order, a sample representing the average composition of a complete section and weighing at least 50 g should be taken from one of the axles to be tested.

14.3 Stamping, cutting up and preparation of test pieces

The samples should be cut, stamped and marked in accordance with the instructions and in the presence of the accepting inspector. The marking of the impact test piece should be such as to show, without doubt, which side of the test bar was originally parallel to a plane tangent to the outer surface of the axle.

The cutting up of the samples and the preparation of the test pieces should take place completely cold and precautions should be taken so that there is no surface work hardening or appreciable heating of the metal.

After machining, if marks left by the tool are likely to affect the results of the test, they should be eliminated either by passing through a grinding machine (with abundant spraying) or by polishing with a fine rasp and emery paper, provided that the method of rectification selected maintains the dimensions and the form of the test piece within the tolerances specified for the corresponding test.

The "normalized" tensile test piece should be normalized.

The impact test pieces should remain in the delivery condition when the axles are ordered normalized or oil-hardened and tempered or should be subjected to a normalizing treatment when the axles are ordered rough-forged.

One of the flat surfaces of the round section intended for the macroscopic and macrographic examination should be polished.

The test pieces should retain the stamp marks of the accepting inspector.

* Except in the case described in footnote** on page 9.

15. TESTING

15.1 Falling weight test

15.1.1 *Test piece*. The test piece should be the axle.

15.1.2 *Test method*. The falling weight test should be carried out by means of a guided hammer.

The hammer should be symmetrical in mass and shape in relation to the guides. It should weigh 1000 kg.

The striking face of the hammer should terminate in a cylindrical section with a radius not exceeding 100 mm, and the axis of which is horizontal and in the plane of the two guides.

The centre of gravity of the hammer should be placed as low as possible in the plane of the guides and equidistant from the two guides.

The height of the guided section of the hammer should be appreciably greater than the distance between the two guides.

The guides should be absolutely rigid, even and vertical; they should be so arranged that friction caused by the falling hammer is reduced to a minimum.

The trip gear should not produce any side movement in the hammer during its release.

The anvil block and its foundation should have a mass of at least 25 times that of the hammer; the mass of the metal anvil block should not be less than 10 000 kg.

The anvil and its block should be fitted with two level supports, with axes 1.500 m apart, which should be firmly fixed to it, and be directly supported without any intermediate part.

The surface of each of the supports on which the axle rests should be of such a shape that the distance between the support points of the axle varies only slightly during the test.

The temperature of the axle to be tested should not exceed 25 °C.

The axle to be tested should be placed on the two supports so that its centre is under the falling hammer.

The axle should first of all be bent by means of two successive blows from the hammer, falling from a height H, expressed in metres, calculated from the expression

$$H = \frac{0.30 \times D^2}{P}$$

where

P is the actual mass of the hammer, in kilogrammes, which may vary slightly from 1000 kg;

D is the effective diameter of the axle at its centre, in millimetres.

The axle should then be turned and struck, so as to straighten it, with two further blows from the hammer falling from the height H, defined above.

The test should be continued by submitting the axle to a second bending opposite from the first and to a second straightening, each effected by two blows from the hammer falling from the height H defined above.

15.1.3 *Results to be obtained* : see clause 4.3.

15.2 Tensile test

15.2.1 *Test piece*. The test piece should comply with ISO Recommendation R 82, *Tensile testing of steel*.

The gauge length should be calculated, in principle, by means of the formula

$$L_0 = 5.65\sqrt{S_0}$$

The following gauge lengths can, however, be adopted provisionally :

$$L_0 = 8.16\sqrt{S_0}$$

$$L_0 = 4\sqrt{S_0}$$

15.2.2 *Test method*. The tensile test should be carried out in accordance with ISO Recommendation R 82.

15.2.3 *Results to be obtained* : see clauses 4.1 and 4.2.