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ISO/DIS 5003

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Vignole railway rails 43 kg/m and above

Rails Vignole et profils spéciaux pour aiguillages en acier non traité pour chemins de fer — Spécifications techniques de livraison

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Foreword

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International Standard ISO 5003 was prepared by Technical Committee ISO/TC 17, *Steel*, Subcommittee SC 15, *Railway rails, rail fasteners, wheels and wheelsets.*

Vignole railway rails 43 kg/m and above

1 Scope

This standard specifies the terms and definitions, information to be supplied by the purchaser , tolerances for dimensions, length, technical requirements, inspection rules, identification, certification, quality assurance system for hot rolled and heat treated steel rails for railway.

This standard specifies Vignole railway rails of 43 kg/m and greater linear mass, for conventional and high speed railway track usage.

Nineteen pearlitic steel grades are specified covering hardness range of 200 to 400 HBW and include non heat treated carbon manganese steels, non heat treated alloy steels, and heat treated carbon manganese and low alloy steels.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 404 Steel and steel products – General technical delivery requirements

ISO 1099 Metallic materials – Fatigue testing – Axial force controlled method

ISO 3887 Steels – Determination of depth of decarburization

ISO 4967 Steel – Determination of content of nonmetallic inclusions-Micrographic method using standard diagrams

ISO 4969 Steel – Macroscopic examination by etching with strong mineral acids

ISO 6892-1 Metallic materials – Tensile testing – Part 1: Method of test at room temperature

ISO 6506-1 Metallic materials – Brinell hardness test – Part 1: Test method

ISO 4968 Steel – Macroscopic examination by sulphur print (Baumann method)

ISO 14284 Steel and iron-Sampling and preparation of samples for the determination of chemical composition

ISO 12108 Metallic materials – Fatigue testing – Fatigue crack growth method

ASTM E45 Standard test methods for determining the inclusion content of steel

ASTM E399 Standard Test Method for Linear-Elastic Plane-Strain Fracture Toughness K_{Ic} of Metallic Materials

3 Terms and Definitions

3.1
heat
liquid steel melt tapped out of a converter or electric arc furnace which includes after continuous casting a given number of blooms relating to the weight of the heat and the extension of the mixing zone.

Note: In the case of sequence casting the blooms belonging to the mixing zone should be clearly defined.

3.2
sequence
Any number of heats, of the same steel grade, which undergo continuous casting in tundishes.
Note: Tundishes can be used in parallel if the caster has many strands.

3.3
heat treated rail
Rail that has undergone accelerated cooling from austenitizing temperature during the metallurgical transformation period.

3.4
off-line heat treated rail
All rolled rail that has undergone re-austenitization for heat treatment purposes.

3.5
on-line heat treated rail
Heat treated rail that has not undergone re-austenitization after rolling.

3.6
rolling process
Process between the blooms leaving the heating furnace and exiting the finishing pass.

3.7
isothermal treatment process
Process whereby blooms are held for a period of time at an elevated temperature for diminishing the hydrogen content.

NOTE 1 For maximum efficiency this is as near to (but below) the pearlite to austenite transformation temperature as is practically possible.

NOTE 2 This process is sometimes referred to as sub critical diffusion annealing.

3.8
rail running surface
curved surface of the rail head. Area between both gauge corners (transition points of the head inclination and the first head radius).

4 Information to be supplied by the purchaser

The purchaser shall provide the supplier with the following information at the time of enquiry or order:

a) the rail profile (by referring to any other standard or submitting a drawing);
b) the steel grade (see 7.2 and Annex A);
c) the profile tolerances (see Table 2)
d) the straightness class ‘A’ or ‘B’ of rail (see Table 3);
e) the nonmetallic inclusion determination method and if applicable: the class ‘1’ or ‘2’ of rail (see Table 11);
f) the determination of the macrostructure (see 5.10);
g) the lengths of rail (see Table 2 and 6.3);
h) undrilled or drilled rail ends to take fish bolts, and location and dimensions of holes when required (see Table 2 and 6.4);

i) paint code requirements (see 9.4.4).

5 Test methods

5.1 Test items, testing frequency and test methods

Test items, sampling position, sampling numbers and test methods shall be as given in Tables 1a and 1b.

Table 1a Testing frequency for acceptance testing

Test items	Hot-rolled rails	Heat-treated rails	Relevant sub-clause
Chemical composition	One per heat	One per heat	5.2
Hydrogen	One per heat (2 tests from first heat in sequence)	One per heat (2 tests from first heat in sequence)	5.3
Total oxygen	One per sequence[a]	One per sequence[a]	5.4
Tensile	One per heat[a,b, d]	One per heat[a,c]	5.5
Hardness	One per heat[a,b]	One per heat[a,c]	5.6
Microstructure	Not required for grades HR200, HR220,HR235 and HR260A. One per 1000 tonnes or part thereof for grades HR260B,HR280,HR310A, HR310B,HR320,HR325[a, b]	One per 100 tonnes of heat treated rail[a,c]	5.7
Decarburization	One per 1000 tonnes or part thereof[a,b]	One per 500 tonnes or part thereof[a,c]	5.8
Nonmetallic inclusions	One per sequence[b]	One per sequence[b or c]	5.9
Macrostructure	One per 500 tonnes or part thereof[a,b]	One per 500 tonnes or part thereof[a,b or c]	5.10
Dimension	Whole length	Whole length	6.1
straightness	Whole length	Whole length	6.2
Surface quality	Whole length	Whole length	7.9
Ultrasonic test	Whole length	Whole length	5.11

a. Samples shall be taken at random but only rails from blooms outside the mixing zone between heats when continuously cast in sequence.
b. Samples shall be cut after rolling.
c. Samples shall be cut after heat-treating for heat treated rails.
d. one calculation per heat / one testing per 2,000 tonnes if agreed between purchaser and manufacturer

Table 1b Testing frequency for periodic tests

Test items	Hot-rolled rails and Heat-treated rails	Relevant sub-clause
Residual stress	Tests shall be done for all grades at least once every 5 years or after any relevant change in the production process. The manufacturer shall only carry out testing on a 60 kg/m profile or the heaviest section produced.	5.12
Fracture toughness(K_{Ic})		5.13
Fatigue crack growth rate		5.14
Fatigue test		5.15
Longitudinal hardness test	Heat-treated rails	5.16

5.2 Chemical composition

The chemical composition shall be determined on the liquid.

When the solid chemical composition shall be checked on the requirement of the purchaser, this shall be carried out at the position of the tensile test piece (see Figure 1).

5.3 Hydrogen content

The hydrogen content of the liquid steel shall be measured by determining pressure of hydrogen in the steel using an on-line immersion probe system or the method agreed between the purchaser and manufacturer.

At least two liquid samples shall be taken from the first heat of any sequence using a new tundish and one from each of the remaining heats and analyzed for hydrogen content (see Table 1a). The first sample from the first heat in a sequence shall be taken from the tundish at the time of the maximum hydrogen concentration.

When testing of rails is required rail samples shall be taken at the hot saw at a frequency of one per heat at random. However on the first heat in a sequence, the rail sample shall be from the last part of a first bloom teemed on any strand. Hydrogen determination shall be carried out on samples taken from the centre of the rail head, and determined by automatic machine.

5.4 Total oxygen content

The total oxygen content can be determined in the liquid or solid.

If the total oxygen content is determined from the solid rail head, the testing positions are shown in Figure 2.

5.5 Tensile test

Test samples shall be taken from the rail head as shown in Figure 1.

The tensile properties shall be determined in accordance with ISO 6892-1 by using a round tensile test piece with the dimensions as follows:

- diameter 10 mm;
- original gauge length 50 mm.

In the case of dispute, the tensile test pieces shall be maintained at a temperature of 200°C for 6 h before testing.

For hot rolled rails, the tensile strength and elongation may be determined as agreed between purchaser and manufacturer by a correlation to the chemical composition based on the statistic data analysis. The method to be applied is shown in Annex B.

5.6 Hardness

5.6.1 General requirements

Brinell hardness tests (HBW) shall be carried out in accordance with ISO 6506-1. The method used is on the discretion of the manufacturer.

In case of dispute, test shall be done using HBW 2.5/187.5.

5.6.2 Surface hardness

The surface hardness shall be tested for position RS as shown in Figure 3.

The surface hardness shall be tested on the centre line of the rail head crown. 0.5 mm shall be ground from the running surface before a hardness impression is made.

5.6.3 Internal hardness

For heat treated rails the internal hardness shall be tested in accordance with ISO 6506-1 at the testing positions shown in Figure 3.

The internal hardness of heat-treated rails of any steel grade shall be determined on a transverse specimen cut from the end of the rail. The specimen shall be ground or milled so that the transverse surfaces are parallel.

5.7 Microstructure

The microstructure testing position in the rail head shall be as shown in Figure 1, and shall be determined at a magnification of ×500.

5.8 Decarburization

Decarburisation depth shall be assessed by means of a hardness test using HBW 2.5/187.5 indentation. The test shall be performed at three points in the centre of the rail crown after minimal preparation of the rail head surface (less than 0.2mm material removed). None of the hardness test results shall be more than 7 points lower than the minimum hardness of the specified grade (e.g. 253HBW for 260 grade rail).

As an alternative or in the case of dispute decarburisation depth shall be measure metallographically.The testing position in the surface of rail head shall be as shown in Figure 4. The test shall be made to measure the depth of closed ferrite network in accordance with ISO 3887.Photomicrographs showing examples how to determine the depth of decarburization are shown in Figure 5.

5.9 Nonmetallic inclusions

5.9.1 General requirements

Samples shall be taken from one of the last blooms of the last heat of the sequence. From each sample 2 specimens shall be tested.

The nonmetallic inclusions testing position in the rail head is shown in Figure 6.

5.9.2 Testing methods

The test shall comply with the method shown in Annex C.

As agreed between purchaser and manufacturer (see 4e), alternative methods may be used:

- Method A in standard ISO 4967,
- Method A in standard ASTM E45.

5.10 Macrostructure

Macrostructure of transverse rail sections shall be tested in accordance with ISO 4969 or ISO 4968, as agreed between purchaser and manufacturer (information given by the purchaser in 4f).

5.11 Ultrasonic test

5.11.1 Testing area

The minimum cross-sectional area examined by the ultrasonic technique shall be:

at least 70 % of the head;

at least 60 % of the web;

and the area of the foot to be tested shall be as shown in Figure 7.

By convention these areas are based on projecting the nominal crystal size of the probe. The head shall be tested from both sides and from the running surface.

5.11.2 Sensitivity requirements

The sensitivity levels of the automated equipment used shall be a minimum of 4 dB greater than the level required to detect the reference reflectors described in 5.11.3. A rail giving an echo referring to a possible defect shall be separated by means of an automatic trigger/alarm level combined with a marking and/or sorting system. For possible retesting, the test sensitivity shall be increased to 6 dB instead of 4 dB.

The system shall incorporate continuous monitoring of interface signals and, if present, backwall echo signals.

5.11.3 Calibration rails

There shall be a calibration rail for each profile to be tested ultrasonically. The positions of the artificial defects are given for the rail head, web and foot of the 60E1 profile (see Annex D) in Figures 8, 9 and 10 respectively. Calibration rails for other profiles with calibration defects similar to those in accordance with Figures 8, 9 and 10 for 60E1 shall be available.

Other methods of calibration may be used but these methods shall be equivalent to that described above.

5.12 Residual stress

5.12.1 Test sample rail

The manufacturer shall only carry out testing on a 60 kg/m profile or the heaviest section produced. For residual stress tests there shall be 6 sample rails, which be taken from finished

roller straightened rails, and test pieces shall be taken from the full roller straightened part of the rail.

5.12.2 Test pieces

Each of the 6 test pieces from the rail section shall be 1000 mm in length.

5.12.3 Test method

The residual stresses in the rail foot shall be determined in accordance with Annex E.

5.13 Fracture toughness (K_{Ic})

5.13.1 Test sample

The rails used for this test shall be of the same profile as used for 5.12.

Three rail test pieces shall be taken from the full roller straightened part of rails from three different heats and different strands.

From each of the three rail test pieces, a minimum of 5 samples shall be produced.

These samples shall not be subject to any further mechanical or thermal treatment.

5.13.2 Test pieces test method

Fracture toughness test shall be performed in accordance with Annex F.

5.14 Fatigue crack growth rate

5.14.1 Test sample rail

The rails used for this test shall be of the same profile as used for 5.12.

Three rail test pieces shall be taken from the full roller straightened part of rails from three different heats and different strands.

From each of the three rail test pieces, a minimum of 3 samples shall be produced.

These samples shall not be subject to any further mechanical or thermal treatment.

5.14.2 Test pieces

A three point bend, single edge notch test piece, of the dimensions and location within the rail shown in Figure 11 shall be used.

5.14.3 Test method

Tests shall be carried out in accordance with the general requirements of ISO 12108.

5.14.4 Number of tests and test conditions

A minimum of 3 tests from each sample rail shall be performed under the following conditions:

— test temperature shall be within the range +15℃ to +25℃;

— R = 0.5 (R = minimum cyclic load/maximum cyclic load);