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Järnvägar – Spår – Räler –
Del 1: Vignolräler fr o m 46 kg/m

Railway applications – Track – Rail –
Part 1: Vignole railway rails 46 kg/m and above

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Denna standard ersätter SS-EN 13674-1+A1:2007, utgåva 1.

The European Standard EN 13674-1:2011 has the status of a Swedish Standard. This document contains the official version of EN 13674-1:2011.

This standard supersedes the Swedish Standard SS-EN 13674-1+A1:2007, edition 1.

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 13674-1

February 2011

ICS 93.100

Supersedes EN 13674-1:2003+A1:2007

English Version

Railway applications - Track - Rail - Part 1: Vignole railway rails 46 kg/m and above

Applications ferroviaires - Voie - Rails - Partie 1: Rails Vignole de masse supérieure ou égale à 46kg/m

Bahnanwendungen - Oberbau - Schienen - Teil 1: Vignolschienen ab 46 kg/m

This European Standard was approved by CEN on 10 December 2010.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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Foreword

This document (EN 13674-1:2011) has been prepared by Technical Committee CEN/TC 256 “Railway applications”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2011, and conflicting national standards shall be withdrawn at the latest by August 2011.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 13674-1:2003+A1:2007.

Annex F provides details of significant technical changes between this European Standard and the previous edition.

This document has been prepared under a mandate given to CEN/CENELEC/ETSI by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive 2008/57/EC.

For relationship with EU Directive 2008/57/EC, see informative Annex ZA, which is an integral part of this document.

This part of EN 13674 is the first of the series EN 13674, *Railway applications – Track – Rail*, which consists of the following parts:

— *Part 1: Vignole railway rails 46 kg/m and above;*

— *Part 2: Switch and crossing rails used in conjunction with Vignole railway rails 46 kg/m and above;*

— *Part 3: Check rails;*

— *Part 4: Vignole railway rails from 27 kg/m to, but excluding 46 kg/m.*

Other standards for rails and corresponding welding processes, already published or under preparation, are:

— EN 14587-1, *Railway applications – Track – Flash butt welding of rails – Part 1: New R220, R260, R260Mn and R350HT grade rails in a fixed plant*;

— EN 14587-2, *Railway applications – Track – Flash butt welding of rails – Part 2: New R220, R260, R260Mn and R350HT grade rails by mobile welding machines at sites other than at a fixed plant*;

— prEN 14587-3, *Railway applications – Track – Flash butt welding of rails – Part 3: Welding in association with crossing construction*;

— EN 14730-1, *Railway applications – Track – Aluminothermic welding of rails – Part 1: Approval of welding processes*;

— EN 14730-2, *Railway applications – Track – Aluminothermic welding of rails – Part 2: Qualification of aluminothermic welders, approval of contractors and acceptance of welds*;

— EN 14811, *Railway applications – Track – Special purpose rail – Grooved and associated construction*;

— EN 15594, *Railway applications – Track – Restoration of rails by electric arc welding*;

— prEN xxxxx, *Railway applications – Track – Forged rail transitions.*

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

This Introduction provides an explanation of the concepts, and reasoning considered for this standard.

Whenever possible this part of EN 13674 is performance based, recognises the European Quality System standard EN ISO 9001 and requires manufacturers to offer the latest proven technology to consistently satisfy the demanding quality of the required product.

This part of EN 13674 has two major divisions:

1) qualifying tests;

2) acceptance tests.

The qualifying tests take into account performance requirements. They also include typical results from relevant acceptance tests.

The acceptance tests control those characteristics of the rail steel and rail that are of relevance to the production of high quality rails including heat treated rails and the demands of the railway.

To ensure the supply of high quality rails, some restrictions on production processes are considered.

The performance based standard applies to all procurements falling inside the requirements of the European Procurement Directive (93/38/EEC of 14th June 1993), taking into account safety implications and at the same time addressing modern production technology and the requirements of high-speed railways. As a result of the Directive it was recognised that there would be few opportunities (and these would have to be for transparent safety considerations) for derogation from the standard to operate between the user and the manufacturer.

The standard includes a prerequisite for all manufacturers to prove conformity against a set of qualifying test criteria at the time of tendering. The Qualifying tests include all "normal" acceptance test results plus new "type-casting" features such as fracture toughness, fatigue and residual stress. To provide users with the necessary confidence, acceptance limits have been based on results from rail known to have performed well in demanding track installations.

The standard includes a quality assurance and inspection clause as part of product integrity.

In order that quality management systems are consistent across all manufacturers and that users have the best assurance for the consistency of required product quality on this safety critical component of the track, this rail standard recommends that the manufacturers' quality assurance systems are at least equivalent to the requirements of EN ISO 9001. The inclusion of this requirement also reduces the need to incorporate detailed method and calibration descriptions on items such as normal chemical composition determination and the need to define more extensive testing.

1 Scope

This European Standard specifies Vignole railway rails of 46 kg/m and greater linear mass, for conventional and high speed railway track usage.

Nine pearlitic steel grades are specified covering a hardness range of 200 HBW to 440 HBW and include non heat treated non alloy steels, non heat treated alloy steels, and heat treated non alloy steels and heat treated alloy steels .

There are 23 rail profiles specified in this standard.

Two classes of rail straightness are specified, differing in requirements for straightness, surface flatness and crown profile. Two classes of profile tolerances are specified.

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.

EN 10163-1, *Delivery requirements for surface condition of hot-rolled steel plates, wide flats and sections — Part 1: General requirements*

EN 10247, *Micrographic examination of the non-metallic inclusion content of steels using standard pictures*

CEN/TR 10261, *Iron and steel — Review of available methods of chemical analysis*

EN 10276-1, *Chemical analysis of ferrous materials — Determination of oxygen in steel and iron — Part 1: Sampling and preparation of steel samples for oxygen determination*

EN ISO 6506-1, *Metallic materials — Brinell hardness test — Part 1: Test method (ISO 6506-1:2005)*

EN ISO 6892-1, *Metallic materials — Tensile testing — Part 1: Method of test at room temperature (ISO 6892-1:2009)*

EN ISO 14284, *Steel and iron — Sampling and preparation of samples for the determination of chemical composition (ISO 14284:1996)*

ISO 1099, *Metallic materials — Fatigue testing — Axial force-controlled method*

ISO 4968, *Steel — Macrographic examination by sulfur print (Baumann method)*

ISO 12108, *Metallic materials — Fatigue testing — Fatigue crack growth method*

ASTM E399, *Standard test method for linear-elastic plane-strain fracture toughness K_{Ic} of metallic materials*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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. 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. Tundishes may 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
re-heated rail
rolled rail that has undergone re-austenitization for heat treatment purposes

3.5
mill 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
qualifying test
special test and criteria which are relevant to some aspects of the service performance of rails. Acceptance tests also form part of the qualifying tests

3.9
acceptance test
test carried out as part of the process and product control system, normally on a heat, sequence or tonnage basis

3.10
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 tender or order:

a) rail profile (see Annex A);

b) steel grade (see Clause 5);

c) profiles class, ‘X’ or ‘Y’ (see 9.2.1);

d) straightness class ‘A’ or ‘B’ of rail as specified in 9.2.2;

e) length(s) of rail (see Table 9);

f) undrilled or drilled rail ends to take fish bolts, and location and dimensions of holes when required (see 9.2.3);

g) any special treatment to be applied to bolt holes and corresponding special tolerances for bolt holes (see 9.2.3);

h) cold stamping on the cut face (see 7.4.3);

i) paint code requirements (see 7.4.4).

5 Steel grades

The applicable steel grades are given in Table 1. The hardness ranges of the steel grades shall conform to those given in Table 1.

For the steel grades in Table 1, the steel names and steel numbers were allocated in accordance with EN 10027-1 and EN 10027-2, respectively.

Table 1 — Steel grades

Steel grade [a]		Hardness range (HBW)	Description	Branding lines
Steel name	Steel number			
R200	1.0521	200 to 240	Non-alloy (C-Mn) Non heat treated	No branding lines
R220	1.0524	220 to 260	Non-alloy (C-Mn) Non heat treated	———
R260	1.0623	260 to 300	Non-alloy (C-Mn) Non heat treated	— ———
R260Mn	1.0624	260 to 300	Non-alloy (C-Mn) Non heat treated	——— ———
R320Cr	1.0915	320 to 360	Alloy (1 %Cr) Non heat treated	——— ——— ———
R350HT	1.0631	350 to 390 [b]	Non-alloy (C-Mn) Heat treated	— ——— ———
R350LHT	1.0632	350 to 390 [b]	Non-alloy (C-Mn) Heat treated	— ——— ——— —
R370CrHT	1.0992	370 to 410	Alloy (C-Mn) Heat treated	— ——— ——— ———
R400HT	1.1254	400 to 440	Non-alloy (C-Mn) Heat treated	——— ——— ———

[a] See Table 5 a) and Table 5 b) for chemical composition/mechanical properties.
[b] See Table 6 for hardness requirements.

6 Profile drawings/properties/mass

Rail profiles, dimensions, properties and linear masses shall be in accordance with Annex A. The tolerances of certain dimensions shall be as given in Table 7. All other quantities are informative only.

NOTE Linear masses have been calculated based on the density of steel of 7,85 kg/dm^3.

7 Manufacture

7.1 Product integrity

Rails shall be produced under a comprehensive system of factory production control which shall ensure confidence in the conformity of the finished product. The system shall address this European Standard to ensure that the finished products consistently comply with requirements to achieve the product integrity necessary to provide assurance of product safety in track.

Manufacturers shall demonstrate continuing compliance, including documented evidence, with the factory production control system required.

NOTE Manufacturers having a factory production control system which complies with EN ISO 9001 are recognised as satisfying the minimum requirements specified by this clause.

7.2 Blooms

Blooms made from basic oxygen steel or electric arc furnace steel that has been secondary ladle arc refined, vacuum degassed and continuously cast, shall be used for the manufacture of rails.

7.3 Rails

7.3.1 The manufacturer shall operate a procedure for the effective removal of scale during the rolling and straightening processes.

7.3.2 The cross-sectional area of the rail shall not exceed one ninth that of the bloom from which the rail is rolled.

7.3.3 Rail straightening shall be by a two stage roller straightening process which straightens the rail about its XX and YY axes as defined in the rail profiles shown in Annex A. End deviations or a localised deviation on the rail may be corrected using pressing.

NOTE Other mandatory processes are described in the relevant clauses within the standard.

7.4 Identification

7.4.1 Branding

Brand marks shall be rolled in relief on one side and in the middle of the web (see Annex A) of each rail at least once every 4 m. The brand marks on the rails shall be clearly legible and shall be 20 mm to 25 mm high, raised between 0,6 mm and 1,3 mm.

The branding line(s) to denote grade shall be 50 mm in length for the long branding line and 25 mm in length for the short branding line.

The brand marks shall include:

a) identification of the mill;

b) steel grade as shown in Table 1;

c) last two figures of the year of manufacture;

d) rail profile identification as shown in Annex A.

EXAMPLES

ROLLING MILL ___ 07 60 E1

(60 E1 profile rail rolled 2007, non-alloy rail steel grade R260).

ROLLING MILL ___ _____ _____ 07 60 E1

(60 E1 profile rail rolled 2007, non-alloy heat treated rail steel grade R350HT).

NOTE The sequence of the branding marks is at the discretion of the manufacturer.

7.4.2 Hot stamping

In addition to the branding requirements of 7.4.1 each rail shall be identified by a numerical and/or alphabetical code system, hot stamped on the non-branded side of the rail web by machine and each rail shall be hot stamped at least once every 10 m.

NOTE Subsequent cutting could result in more than one rail length having the same identity.

The figures and letters used shall be clearly legible and shall be 16 mm high. The stamped characters shall have a flat or radius face (1 mm to 1,5 mm wide) with bevels on each side. The letters and numbers shall be on a 10° angle from vertical and shall have rounded corners. The stamping shall be between 0,5 mm and 1,5 mm in depth along the centre of the web. The design shall be as shown in Figure 1.

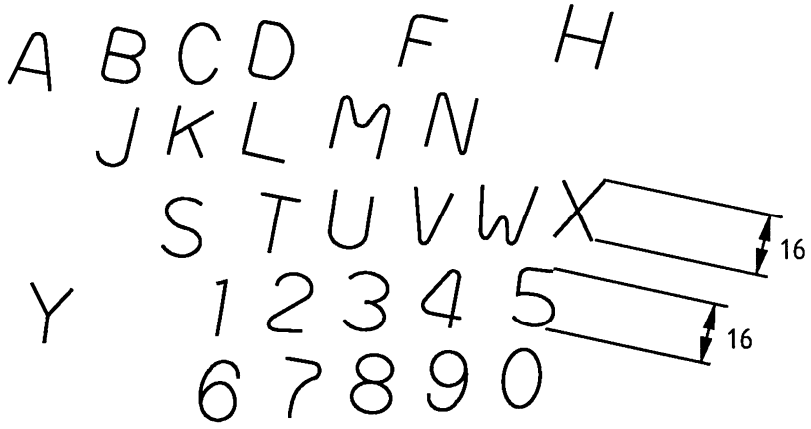

Figure 1 — Design of letters and numbers on a 10° angle for rail stamps

The identification system employed shall be such as to enable the hot stamped marking to be collated with the:

a) number of the heat from which the rail has been rolled;

b) number of the strand and position of bloom within the strand;

c) position of the rail in the bloom (A, B ... Y).

In the event of identification marks having been removed, omitted or requiring alteration, re-identification of such marks shall be made by rotary burr.

7.4.3 Cold stamping

Cold stamping shall only be used on the cut face of the rail within the central portion of the head, at the request of the purchaser.

7.4.4 Other identification

The purchaser shall specify their requirements for any colour coding or special marking instructions and their position on the rail at the time of enquiry or order.

8 Qualifying tests

8.1 Procedure

8.1.1 The manufacturer shall describe any bloom slow cooling or isothermal treatment process used to demonstrate compliance with the requirements of 9.1.3.2.

8.1.2 All qualifying tests as specified in 8.2 to 8.9 shall be undertaken at least once every five years and as a result of any significant production process change for all grades, with the exception of 8.7.1, where predictive equation approval is carried out on an ongoing basis.

The manufacturer shall only carry out testing on the 60E1 profile or the heaviest section produced.

All rail grades and profiles supplied shall conform to the qualifying criteria in accordance with 8.2 to 8.9.

The results for the grades to be supplied shall be provided at the time of tendering.

In the event of a manufacturer not having produced the rail grade prior to the tender enquiry he shall have the option of carrying out such tests on the first available sequence. When the qualifying criteria have been complied with, compliance with the standard is demonstrated and consequently the manufacturer is qualified.

8.1.3 The samples in accordance with 8.1.4 and 8.1.5 shall be removed from finished roller straightened rails. These samples shall not be subject to any further mechanical or thermal treatment (other than the treatment of ageing of the tensile test pieces as described in 9.1.9.2).

8.1.4 Test pieces for fracture toughness, fatigue crack growth rate and fatigue tests (see 8.2, 8.3 and 8.4 respectively) shall be taken from 3 sample rails at least 3 m from the cut ends of the rail. Sample rails shall be from different heats and different strands.

8.1.5 For residual stress tests (see 8.5), there shall be 6 sample rails and the test pieces shall be taken at least 3 m from each rail end.

8.1.6 All tests should be carried out by a laboratory that operates an approved and audited quality assurance system conforming to requirements at least equivalent to EN ISO 9001.

8.1.7 The purchaser shall have access to all test records, calibrations and calculations that contribute to the final results.

8.1.8 All test results shall be reported to the purchaser.

8.2 Fracture toughness (K_{Ic})

8.2.1 Test pieces and test methods

Tests shall be performed in accordance with Annex B.

8.2.2 Qualifying criteria

The value of K_{Ic} shall comply with Table 2.

Table 2 — Minimum single and minimum mean values of K_{Ic}

Steel grade	Minimum single value K_{Ic} (MPa m$^{1/2}$)	Minimum mean value K_{Ic} (MPa m$^{1/2}$)
R200 and R220	30	35
R260 and R260Mn	26	29
R320Cr	24	26
R350HT	30	32
R350LHT, R370CrHT, R400HT	26	29

NOTE In some circumstances K_Q^* values can be used for the purpose of qualification, see B.6.

8.3 Fatigue crack growth rate

8.3.1 Test method

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

8.3.2 Test pieces

A three point bend, single edge notch test piece, of the dimensions and location within the rail shown in Figure 2 shall be used.

8.3.3 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 °C to +25 °C;

— R = 0,5 (R = minimum cyclic load/maximum cyclic load);

— 3 point bend test piece loading span shall be 4 W (see Figure 2);

— cyclic loading frequency shall be within the range 15 Hz to 40 Hz;

— environment: laboratory air.

8.3.4 Qualifying criteria

Fatigue crack growth rates (m/Gc) shall not exceed the values given in Table 3.

Table 3 — Fatigue crack growth rates

Steel grades	ΔK = 10 MPa m^{½}	ΔK = 13,5 MPa m^{½}
All grades except R200 and R320Cr	17 m/Gc	55 m/Gc

8.4 Fatigue test

8.4.1 Test method

Constant amplitude fatigue tests shall be carried out in accordance with ISO 1099.

8.4.2 Test pieces

The test pieces shall be machined from the sample rail as shown in Figure 3.

8.4.3 Number of tests and test conditions

A minimum of 3 test pieces shall be tested from each sample rail under the following conditions:

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

— control variable shall be axial strain amplitude;

— strain cycle shall be symmetrical about the initial, zero load.

8.4.4 Qualifying criteria

For a total strain amplitude of 0,001 35, the life of each specimen shall be greater than 5×10^6 cycles.

NOTE Life is defined as the number of cycles up to the complete separation of the specimen.

8.5 Residual stress in rail foot

8.5.1 Test method

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

8.5.2 Test pieces

Each of the 6 test pieces from the rail section shall be 1 m in length and shall be taken from rails as described in 8.1.3 and 8.1.5.

NOTE Only a small part of the test piece will be destroyed for the purpose of measuring residual stress; the remainder can be used for other qualifying approval tests.

8.5.3 Measurements

Longitudinal residual stress determinations shall be made on the rail foot of each of the 6 test pieces described in 8.5.2. The location of the measurements is shown in Figure C.1.

If data are available for straightness class A rails then class B rails of the same profile need not be tested.

8.5.4 Qualifying criteria

The maximum longitudinal residual stress in the foot shall be 250 MPa for all steel grades.

8.6 Variation of centre line running surface hardness of heat treated rails

This clause only applies to heat treated rails.

For the longest length of rail produced by the manufacturer, a one metre length of rail shall be taken from each end and at 20 m intervals from one end of the rail. These shall be hardness tested (HBW) in accordance with EN ISO 6506-1 along their length at 25 mm intervals on the centreline of the running surface after 0,5 mm has been ground away. The hardness results shall be no more than ± 15 HBW from the mean result obtained.

8.7 Tensile strength and elongation

8.7.1 Predictive equations relating chemical composition to tensile strength and elongation shall be calculated using multiple regression analysis for all non heat treated rails produced. The following procedure shall be carried out:

— development of a predictive equation;

— confirmation of the predictive equation;

— periodic updating of the predictive equation;

— corrective action.

8.7.2 Manufacturers shall calculate, using multiple regression analysis for all naturally hard steel grades produced, predictive equations relating chemical composition to tensile strength and elongation. Each manufacturer shall derive its own predictive equations.

The predictive equations shall be produced from a minimum number of 100 heats and a maximum number of 200 heats.

The equations shall be created by carrying out one valid tensile test per heat. Tensile tests shall be carried out in accordance with 9.1.9.

The predictive equations shall produce results which are within a scatter band governed by the following limits:

— tensile strength: 12,5 MPa (1 standard deviation);

— elongation: 1,0 % (1 standard deviation).

8.7.3 The results of the predictive equations shall be compared with experimentally determined tensile strength and elongation results as described in 9.1.9. This comparison will be achieved by carrying out one valid tensile test every 2 000 tonnes or at least every tenth heat.

The experimental results shall be within plus or minus 25 MPa tensile strength and plus or minus 2 % elongation of those obtained from the predictive equations.

8.7.4 The results of the experimental tensile strength and elongation tests obtained from 8.7.3 shall be used to update the predictive equations. These results shall be accumulated and the equations updated annually. The updated equations shall be based on a minimum of the last 100 results.

8.7.5 If results from the predictive equations or the experimental results are outside the limits set in 8.7.2 and 8.7.3 then actions a), b) and c) and when necessary action d) shall be taken:

a) manufacturer shall carry out an investigation;

b) problem will be resolved by the manufacturer taking appropriate corrective action;

c) manufacturer shall report the findings of a) and b) to the purchaser;

d) if the problem cannot be resolved to the satisfaction of the purchaser, the manufacturer or potential manufacturer shall have failed the approval requirements as specified in 8.7.1. If the physical tests themselves are within the requirements of Table 5 a) the product is satisfactory.

8.8 Segregation

Full section transverse test pieces shall be sulfur printed in accordance with ISO 4968. For this purpose rail sulfur prints shall be taken from each strand from the beginning of every heat, excluding the mixing zone, for five heats.

The samples shall be assessed and classified according to the limiting figures of Annex D. For the process to be accepted, all samples shall be classified as acceptable.