



SLOVENSKI STANDARD SIST EN 13674-1:2004

01-junij-2004

Željezniške aplikacije - Proga - Šina - Del 1: Vignolske železniške šine 46 kg/m in več

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

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

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

ITeH STANDARD PREVIEW
(standards.iteh.ai)

Ta slovenski standard je istoveten z: **EN 13674-1:2003**
<https://standards.iteh.ai/catalog/standards/sist/06d5d5ef-54d9-4030-b0cb-19e5a286ba8f/sist-en-13674-1-2004>

ICS:

45.080 Varnost in zdravje Šine in železniški deli Rails and railway components

SIST EN 13674-1:2004 en

iTeh STANDARD PREVIEW
(standards.iteh.ai)

SIST EN 13674-1:2004

<https://standards.iteh.ai/catalog/standards/sist/0bd5d5ef-54d9-4030-b0cb-19e5a286ba8f/sist-en-13674-1-2004>

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 13674-1

September 2003

ICS 45.080

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 46 kg/m

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

This European Standard was approved by CEN on 28 February 2003.

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 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 Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Slovakia, Spain, Sweden, Switzerland and United Kingdom.

[SIST EN 13674-1:2004](https://standards.iteh.ai/catalog/standards/sist/0bd5d5ef-54d9-4030-b0cb-19e5a286ba8f/sist-en-13674-1-2004)

<https://standards.iteh.ai/catalog/standards/sist/0bd5d5ef-54d9-4030-b0cb-19e5a286ba8f/sist-en-13674-1-2004>



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Contents

	Page
Foreword.....	4
Introduction	5
1 Scope	7
2 Normative references	7
3 Terms and definitions.....	7
4 Information to be supplied by the purchaser.....	8
5 Steel grades.....	9
6 Profile drawings/properties/mass	9
7 Manufacture.....	9
7.1 Product integrity	9
7.1.1 Factory production control.....	9
7.1.2 Best practice manufacture.....	10
7.2 Blooms.....	10
7.3 Rails.....	10
7.4 Identification.....	10
7.4.1 Branding	10
7.4.2 Hot stamping	11
7.4.3 Cold stamping	11
7.4.4 Other identification.....	11
8 Qualifying tests	12
8.1 Procedure	12
8.2 Fracture toughness (K_{Ic}).....	12
8.2.1 Test pieces and test methods.....	12
8.2.2 Qualifying criteria	12
8.3 Fatigue crack growth rate	13
8.3.1 Test method.....	13
8.3.2 Test pieces.....	13
8.3.3 Number of tests and test conditions	13
8.3.4 Qualifying criteria	13
8.4 Fatigue test	13
8.4.1 Test method.....	13
8.4.2 Test pieces.....	14
8.4.3 Number of tests and test conditions	14
8.4.4 Qualifying criteria	14
8.5 Residual stress in rail foot	14
8.5.1 Test method.....	14
8.5.2 Test pieces.....	14
8.5.3 Measurements	14
8.5.4 Qualifying criteria	14
8.6 Variation of centre line running surface hardness of heat treated rails	14
8.7 Tensile strength and elongation.....	15
8.8 Segregation	15
8.9 Other qualifying requirements.....	16
9 Acceptance tests	16
9.1 Laboratory tests.....	16
9.1.1 General.....	16
9.1.2 Chemical composition.....	16
9.1.3 Microstructure.....	20

9.1.4	Decarburisation.....	21
9.1.5	Oxide cleanness.....	21
9.1.6	Sulfur prints.....	21
9.1.7	Hardness.....	22
9.1.8	Tensile tests	22
9.1.9	Retest procedures	23
9.2	Dimension tolerances.....	23
9.2.1	Profile.....	23
9.2.2	Straightness, surface flatness and twist.....	24
9.2.3	Cutting and drilling.....	27
9.3	Gauges.....	27
9.4	Inspection requirements/tolerances for internal quality and surface quality	27
9.4.1	Ultrasonic test requirements	27
9.4.2	Surface quality	29
Annex A (normative) Rail profiles		44
Annex B (normative) Standard test method for the determination of the plane strain fracture toughness (K_{IC}) of rails		68
Annex C (normative) Method for the determination of rail foot surface longitudinal residual stresses		74
Annex D (normative) Limiting sulfur prints.....		77
Annex E (normative) Profile and drilling gauges.....		91
Annex F (informative) Comparison of steel designations referred to in this standard compared to those in EN 10027-1 and EN 10027-2.....		104
Annex ZA (informative) Clauses of this European Standard addressing essential requirements or other provisions of EU Directives.....		105
Bibliography		106

SIST EN 13674-1:2004

<https://standards.iteh.ai/catalog/standards/sist/0bd5d5ef-54d9-4030-b0cb-19e5a286ba8f/sist-en-13674-1-2004>

EN 13674-1:2003 (E)**Foreword**

This document (EN 13674-1:2003) 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 March 2004, and conflicting national standards shall be withdrawn at the latest by March 2004.

This document has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of **EU Directive(s)**.

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.

This part of EN 13674 is the first of a series of standards for rails.

Railway applications – Track:

- *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 planned for publication include the following:

- Special purpose rail – Part 1: Grooved and associated construction.
- Flash butt welding of new rails R220 and R260 grade rails in a fixed plant.
- Flash butt welding of new R260Mn and R350HT grade rails in a fixed plant.
- Flash butt welding of new R220 and R260 grade rails by mobile welding machines at sites other than at a fixed plant.
- Flash butt welding of R220 and R260 grade reusable rails.
- Flash butt welding in association with crossing construction.
- Approval of aluminothermic welding processes.
- Tests for qualification of aluminothermic welders, approval of contractors and acceptance of welds.
- Restoration of rails by electric arc welding.

Annexes A, B, C, D and E are normative. Annex F is informative.

This document includes a Bibliography.

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

Introduction

This Introduction provides an explanation of the concepts, and reasoning used in the production of this standard. Its inclusion also ensures that during future revisions restrictions are removed as technology progresses and to hold them where it has not, thus ensuring continued safety as new producers, products and technologies are introduced.

The most commonly used standards of the world for the supply of railway rails have been reviewed during the preparation of this standard. However, modern rail production technology and the requirements of high speed railways within the Community have demanded a completely new look at the philosophy and content of this part of EN 13674.

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.

iTeh STANDARD PREVIEW

The qualifying tests introduce a number of performance requirements not previously seen in national or international standards. They also include typical results from relevant acceptance tests.

Rail grading is based on hardness rather than tensile strength.

The acceptance tests have been designed to control those characteristics of the rail steel and rail that are of relevance to the production of high quality rails and the demands of the railway.

The steel grades covered by this part of EN 13674 reflect trends in railway usage and heat treated rails are included. The standard includes rail profiles for Vignole rails having a linear mass 46 kg/m and above.

To ensure the supply of high quality rails, some restrictions on production processes have been imposed.

The standard supersedes other standards covered by the scope and applies to all procurements falling inside the requirements of the European Procurement Directive (93/38/EEC of 14th June 1993). In addition CEN required, where possible, a performance based standard, 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 reflects this change in philosophy from the traditional content of rail standards. A review was undertaken of the most commonly used rail standards of the world. All relevant aspects important to both user and manufacturer were considered with the aim of ensuring that all of the content had specific usefulness and relevance. For example rail grading and much of the standard has been based on hardness rather than tensile strength. Whilst the two are directly related, hardness is very quick and cheap to carry out and provides more relevant guidance to the user particularly where properties vary in different parts of the profile.

Since many rail manufacturers would have not previously carried out proving trials, 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.

One aspect of the standard which is a complete break from tradition is the inclusion of quality assurance and inspection clause as part of product integrity.

EN 13674-1:2003 (E)

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.

Ideally, manufacturing techniques should not be referenced in a product standard. However, some rail attributes are either not known in an exact manner or are not measurable with satisfactory statistical significance. In such cases best practice manufacturing techniques have been included as a last resort. The equipment specified is that which gives the best probability of achieving the required product for use in track. In the future new technology can add to, but preferably will reduce or delete such items.

Examples of areas where the technological state of the art renders the standard less than complete include:

- oxide/oxygen relationships;
- hydrogen test techniques;
- roller straightening effects on residual stresses;
- roller straightening effects on contact scrub;
- measurement and effect of residual stresses throughout the rail.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

SIST EN 13674-1:2004

<https://standards.iteh.ai/catalog/standards/sist/0bd5d5ef-54d9-4030-b0cb-19e5a286ba8f/sist-en-13674-1-2004>

1 Scope

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

Seven pearlitic steel grades are specified covering a hardness range of 200 to 390 HBW and include non heat treated carbon manganese steels; non heat treated alloy steels; and heat treated carbon manganese and low alloy steels.

There are 21 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

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text, and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

EN 10002-1, *Metallic materials - Tensile testing - Part 1: Method of test at ambient temperature.*

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

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 6506-1:1999).*

ISO 1099:1975, *Metals - Axial load fatigue testing.*

ISO 4968:1979, *Steel - Macrographic examination by sulfur print (Baumann method).*

BS 6835-1:1988, *Method for determination of the rate of fatigue crack growth in metallic materials - Fatigue crack growth rates of above 10^{-8} m per cycle.*

DIN 50602:1985, *Microscopic examination of special steels using standard diagrams to assess the content of non-metallic inclusions.*

ASTM E399:1991, *Standard test method for plane strain fracture toughness of metallic materials.*

3 Terms and definitions

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

3.1 heat

one 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.

EN 13674-1:2003 (E)**3.2****sequence**

any number of heats, of the same steel grade, which undergo continuous casting in tundishes. 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**re-heated rail**

all 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 tests**

special tests 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 tests**

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

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) the rail profile (see annex A);
- b) the steel grade (see clause 5);
- c) the profiles class, 'X' or 'Y' (see 9.2.1);
- d) the straightness class 'A' or 'B' of rail as specified in 9.2.2;
- e) the lengths of rail (see 9.2.3 and Table 10);
- 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 treatments to be applied to bolt holes;
- h) tolerances for bolt holes to which special processes are to be applied;

i) paint code requirements (see 7.4.4).

5 Steel grades

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

The steel grade designations referred to in this standard are compared to those in EN 10027-1 and EN 10027-2 in informative annex F.

Table 1 — Steel grades

Grade ^a	Hardness range (HBW)	Description	Branding lines
R200	200 to 240	Carbon – manganese (C-Mn) Non heat treated	No branding lines
R220	220 to 260	Carbon – manganese (C-Mn) Non heat treated	_____
R260	260 to 300	Carbon – manganese (C-Mn) Non heat treated	_____ _____
R260Mn	260 to 300	Carbon – manganese (C-Mn) Non heat treated	_____ _____
R320Cr	320 to 360	Alloy (1 %Cr) Non heat treated	_____ _____ _____
R350HT	350 to 390 ^b	Carbon – manganese (C-Mn) Heat treated	_____ _____
R350LHT	350 to 390 ^b	Low alloy, heat treated	_____ _____ _____
^a See Table 5 for chemical composition/mechanical properties. ^b See Table 7 for hardness requirements.			

6 Profile drawings/properties/mass

Rail profiles, dimensions, properties and linear masses are given in annex A. The tolerances of certain dimensions shall be as given in Table 8. All other quantities are informative only.

NOTE Linear masses have been calculated based on the density of steel of 7850 kg/m³.

7 Manufacture

7.1 Product integrity

7.1.1 Factory production control

All Vignole 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.

EN 13674-1:2003 (E)

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

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

7.1.2 Best practice manufacture

The product shall be manufactured to the best practices as specified in 7.1.

NOTE This is to ensure that the rail attributes, described in the introduction, which are not known in an exact manner or are not practically measurable, achieve the required high level of product integrity in track.

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.
<https://standards.iteh.ai/catalog/standards/sist/0bd5d5ef-54d9-4030-b0cb-19e5a286ba8f/sist-en-13674-1-2004>

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) the identification of the mill;
- b) the steel grade as shown in Table 1;
- c) the last two figures of the year of manufacture;
- d) the rail profile identification as shown in annex A.

EXAMPLE

ROLLING MILL _____ 96 60 E 1

(60 E 1 profile rail rolled 1996 and 260 HBW carbon-manganese rail steel grade).

ROLLING MILL _____ 96 60 E 1

(60 E 1 profile rail rolled 1996 and 350 HBW heat treated carbon-manganese rail steel grade).

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 5 m.

If hot stamping every 5 m is not practical, the identity of the rail shall be applied by hot stamping or rotary burn near the end of the rail.

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 number of the heat from which the rail has been rolled;
- the number of the strand and position of bloom within the strand;
- the 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

Rails of straightness class A shall be identified with a green mark and the position of the green mark is to be specified by the purchaser. The steel grade may additionally be identified using paint. The purchaser shall specify the colour and position of the paint application.

EN 13674-1:2003 (E)**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 9.1.2.2.

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. In addition the residual stress test shall be carried out on all available grades every 2 years.

The manufacturer shall only carry out testing on the 60 E 1 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 9.1.8.3).

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 in 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_{1c})**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_{1c} 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 K_{Ic} (MPa m ^{1/2})
R200 and R220	30	35
R260 and R260Mn	26	29
R320Cr	24	26
R350HT	30	32
R350LHT	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 BS 6835-1.

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.

iTeh STANDARD PREVIEW
(standards.iteh.ai)

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;
- $R = 0,5$ ($R = \text{minimum cyclic load}/\text{maximum cyclic load}$);
- 3 point bend test piece loading span shall be $4W$ (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	$\Delta K = 10 \text{ MPa m}^{1/2}$	$\Delta K = 13,5 \text{ MPa m}^{1/2}$
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.