BRITISH STANDARD

BS EN 15610:2009

# Railway applications — Noise emission — Rail roughness measurement related to rolling noise generation

ICS 17.140.30; 93.100

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The UK participation in its preparation was entrusted to Technical Committee EH/1/2, Transport noise.

A list of organizations represented on this committee can be obtained on request to its secretary.

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# EN 15610

May 2009

ICS 17.140.30; 93.100

English Version

# Railway applications - Noise emission - Rail roughness measurement related to rolling noise generation

Applications ferroviaires - Bruit à l'émission - Mesurage de la rugosité des rails relative à la génération du bruit de roulement

Bahnanwendungen - Geräuschemission - Messung der Schienenrauheit im Hinblick auf die Entstehung von Rollgeräusch

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## Contents

Page

**Foreword** ..... 4

**1 Scope** ..... 5

**2 Normative references** ..... 5

**3 Terms and definitions** ..... 6

**4 Symbols** ..... 8

**5 Measuring system requirements** ..... 8
**5.1 General** ..... 8
**5.2 Accuracy of the output signal** ..... 8
**5.3 Dimensions of the probe** ..... 8
**5.4 Tracking of the probe** ..... 9
**5.5 Sampling interval** ..... 9
**5.6 Record length** ..... 9

**6 Data acquisition** ..... 9
**6.1 General** ..... 9
**6.2 Test section requirements** ..... 9
**6.2.1 Track structure** ..... 9
**6.2.2 Localized geometric features** ..... 9
**6.3 Reference surface choice** ..... 9
**6.4 Data sampling** ..... 11
**6.4.1 General** ..... 11
**6.4.2 Longitudinal sampling** ..... 11
**6.4.3 Lateral sampling** ..... 11
**6.5 Preparation of the rail head surface** ..... 12
**6.6 Acoustic roughness acquisition** ..... 12

**7 Data processing** ..... 12
**7.1 Principle** ..... 12
**7.2 Spike removal technique** ..... 12
**7.3 Curvature processing** ..... 13
**7.4 Spectral analysis** ..... 14
**7.4.1 Method A: Fourier analysis** ..... 14
**7.4.2 Method B: digital filtering** ..... 15
**7.5 Procedure for extending the wavelength range** ..... 15
**7.6 Averaging process** ..... 15

**8 Acceptance criteria** ..... 15

**9 Presentation of the data** ..... 15

**10 Report** ..... 16

**Annex A** (informative) **Examples of rail defects** ..... 17

**Annex B** (informative) **Example of program code to implement acoustic roughness processing** ..... 19
**B.1 Purpose** ..... 19
**B.2 Conditions of use** ..... 19
**B.3 List of Matlab program files** ..... 19
**B.4 Input data file requirements** ..... 19
**B.5 Processing options** ..... 20
**B.6 Spectral analysis** ..... 20
**B.7 1/3 octave reporting** ..... 20
**B.8 Output** ..... 20



Documents
Document Sharing Hub

Full document details: BS EN 15610:2009

**B.9 Listing** ..... **21**
**B.9.1 file RoughProcess.m** ..... **21**
**B.9.2 21**
**B.9.3 file ruw_curve_rp.m** ..... **27**
**B.9.4 file noct_rp.m** ..... **28**

**Annex C** (normative) **Algorithm used to synthesize a one-third octave band spectrum from a corresponding narrow band spectrum** ..... **31**

**Annex ZA** (informative) **Relationship between this European Standard and the Essential Requirements of EU Directive EU 2008/57/EC** ..... **32**

**Bibliography** ..... **34**

Documents
Document Sharing Hub



Full document details: BS EN 15610:2009

## Foreword

This document (EN 15610:2009) 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 November 2009, and conflicting national standards shall be withdrawn at the latest by November 2009.

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 has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EC Directives 2001/16/EC, 96/48/EC and 2008/57/EC.

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

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, 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.



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## 1 Scope

**1.1** This European Standard specifies a direct method for characterizing the surface roughness of the rail associated with rolling noise ("acoustic roughness"), in the form of a one-third octave band spectrum.

This standard describes a method for:

a) selecting measuring positions;

b) data acquisition;

c) measurement data processing in order to estimate a set of one-third octave band roughness spectra;

d) presentation of this estimate for comparison with limits of acoustic roughness;

e) comparison with a given upper limit in terms of a one-third octave band wavelength spectrum.

**1.2** It is applicable to the:

a) performance testing of reference track sections for the measurement, within a period of three months before or after roughness characterization, of noise emitted by railway vehicles for acceptance testing purposes;

b) acceptance of the rail surface condition only in the case where the result of the direct measurement of the acoustic roughness is regarded as an established acceptance criterion.

**1.3** It is not applicable to the:

a) measurement of rail roughness using an indirect method;

b) measurement of combined wheel-rail roughness;

c) analysis of the effect of wheel-rail interaction, such as a “contact filter”;

d) approval of rail reprofiling, including rail grinding operations, except for those where the acoustic roughness (and not the level of corrugation) is an established approval criterion;

e) characterization of track geometry.

Testing and approval of measuring apparatus are not part of the scope of this standard.

## 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 61260, *Electroacoustics — Octave-band and fractional-octave-band filters (IEC 61260:1995)*

EN ISO 266, *Acoustics — Preferred frequencies (ISO 266:1997)*

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## 3 Terms and definitions

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

**3.1**
**acoustic roughness**
*r(x)*
variation in the height of the rail running surface associated with rolling noise excitation expressed as a function of distance x along the rail

**3.2**
**acoustic roughness spectrum**
$\tilde{r}(\lambda)$
amplitude of the acoustic roughness expressed as a function of the wavelength $\lambda$

**3.3**
**acoustic roughness level**
$L_r$
level expressed in decibels, given by the following equation:

$$L_r = 10 \cdot \log\left(\frac{\mathrm{r}_{RMS}{}^2}{\mathrm{r}_0^2}\right) \tag{1}$$

where: $L_r$ is the acoustic roughness level in dB,

$\mathrm{r}_{RMS}$ is the root mean square roughness in µm,

$\mathrm{r}_0$ is the reference roughness; $\mathrm{r}_0$ = 1 µm.

NOTE This definition applies to values measured either in the form of a wavelength spectrum, or for a specific wavelength band.

**3.4**
**corrugation**
periodic wear pattern of the rail running surface

**3.5**
**direct roughness measurement method**
refers to an acoustic roughness measurement method for which the transducer has to be applied directly to the rail surface so that the rail roughness is measured independently of the wheel running surface roughness and independently of any effect of wheel-rail interaction

**3.6**
**indirect roughness measurement method**
refers to an acoustic roughness measurement method that measures a quantity that is the result of wheel-rail interaction, such as noise, rail or axle box vibration, whereby the original excitation by the combined wheel and rail roughness is inferred

**3.7**
**test section**
specific section of track associated with a particular set of measurements



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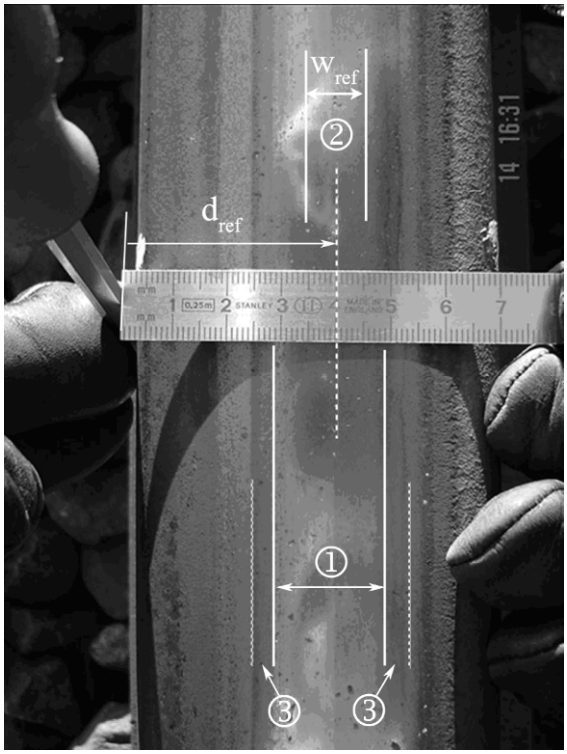
**3.8**
**running band**
bright surface of the rail head that contains all the running positions of the wheel-rail contact, associated with current traffic

**3.9**
**reference surface**
surface of the rail head, within the running band, that is chosen for the acoustic roughness assessment

**3.10**
**reference length**
dimension of the reference surface in the longitudinal rail direction

**3.11**
**reference width**
$w_{ref}$
dimension of the reference surface across the rail

Figure 1 shows an example of some of the defined terms:




**Key**

① running band
② reference surface
③ partially conditioned surface

**Figure 1 — Example showing defined parameters**



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## 4 Symbols

C(x): circular curve of radius 0.375 m used for the acoustic roughness processing;

$d_{ref}$: position, relative to the outer surface of the rail head, of the longitudinal axis of symmetry of the reference surface;

h: height of a spike;

$L_r$: acoustic roughness level;

r(x): acoustic roughness function;

r'(x): acoustic roughness function processed with the spike removal and curvature algorithm;

w: width of a spike;

$w_{ref}$: width of the reference surface;

x: variable of the distance along the rail;

$x_i$: particular position along the rail;

z: mean value of height over a given interval;

$\tilde{r}(\lambda)$: discrete Fourier Transform of r(x);

λ: wavelength.

## 5 Measuring system requirements

### 5.1 General

Regardless of the fact that this European Standard does not specify any measuring system evaluation or approval, the requirements of the measuring system are defined. This is done solely in terms of output data and parameters relevant to the output data.

The following measuring system requirements apply.

### 5.2 Accuracy of the output signal

The measuring system shall be capable of making valid measurements in the wavelength range and at the relevant acoustic roughness levels for the test site being characterized.

However, where it is required simply to show that the estimated acoustic roughness does not exceed a given upper limit, the measuring system shall effect valid measurements for one-third octave band acoustic roughness levels equal to or greater than this limit. This case applies particularly for test section approval.

### 5.3 Dimensions of the probe

If a contact probe is used, the probe tip shall be spherical and its radius shall not exceed 7 mm.

In the case of a non-contacting sensor, its effective width shall be less than the sampling interval.



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### 5.4 Tracking of the probe

The measuring system probe shall follow a line on the rail head parallel to the field (outer) face of the rail head, with a tolerance of ± 1 mm.

### 5.5 Sampling interval

The measuring system shall provide data with a sampling interval less than or equal to 1 mm.

### 5.6 Record length

The system shall provide records of length ≥ 1 m.

## 6 Data acquisition

### 6.1 General

The aim of the data acquisition procedure is to obtain digitized records of the acoustic roughness of the two rails in the test section measured at a sufficiently high sampling rate per unit of length of rail, and with a record length sufficient to derive from it the acoustic roughness spectrum. Record lengths of at least 1 m are required to estimate the acoustic roughness spectrum covering the wavelength range up to the 0,25 m one-third octave band.

NOTE To attain wavelengths greater than 0,25 m, records longer than those specified in this subclause should be obtained.

### 6.2 Test section requirements

#### 6.2.1 Track structure

The track structure shall be constant along the test section, at least in terms of the following parameters: rail cross-section, rail inclination and rail supporting structure. In the case of a ballasted track, the rail supporting structure parameters are: the rail pad type, the rail fasteners, the sleeper type, the sleeper spacing and the ballast.

NOTE If the track structure changes, separate test sections should be defined and the acoustic roughness of each should be assessed and presented.

#### 6.2.2 Localized geometric features

From the strict point of view of acoustic roughness data acquisition, there is no specific requirement for the test section. However, the rail along the test section may contain localized geometrical features (e.g.: rail defects, wheel burns, etc.), that should not be included in the assessment of the acoustic roughness related to the generation of rolling noise.

NOTE The localized rail defects are not significant in the assessment of the acoustic roughness related to the rolling noise component.

### 6.3 Reference surface choice

#### 6.3.1 General

The acoustic roughness of the test section shall be assessed over a reference surface. The reference surface is specified, inside the running band, as follows:



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a) length along the rail;

b) transverse width $w_{ref}$,

c) relative distance $d_{ref}$ to the field face of the rail.

### 6.3.2 Cases

It is the responsibility of the measurement team to define the length, width and position of the reference surface of the two rails and to justify its decision.

Where the acoustic rail roughness measurement is required for rolling stock type acceptance testing, any of the three following cases for that justification shall be used:

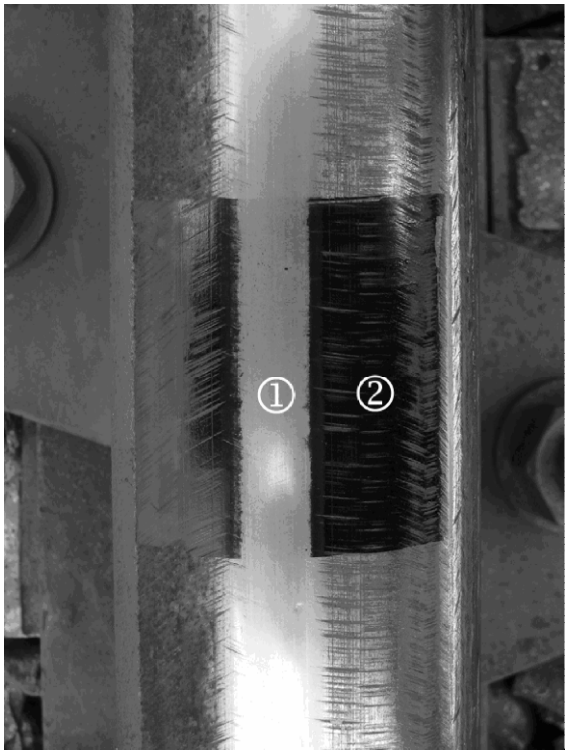
a) Case 1: the running band on the rail head is clear visually and it is known that this running band is produced by the rolling stock to be measured.

Considering that the wheel-rail contact zone is approximately 10 mm wide, any partially conditioned area at the edges of the running band that are less than half this width shall not be considered to be part of the running band.

b) Case 2: the wheel-rail contact zone can be measured for the specific train under test at the time of the acceptance test.

NOTE 1 It is recommended that a line be drawn across the rail head with a permanent marker to identify the wheel-rail contact position satisfactorily. It is advisable to check the position at both ends of the test section.

Figure 2 shows a sample application of this method:




**Key**

① effective running band of the trainset wheels
② marker ink outside the rolling band

**Figure 2 — Example of using a permanent marker on the rail surface**



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