Technical Specification

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Mechanical vibration — Ground-borne noise and vibration arising from rail systems —

Part 34: Characterizing irregularity of the running surfaces with respect to vibration excitation

Vibrations mécaniques — Vibrations et bruits initiés au sol dus à des lignes ferroviaires —
Partie 34: Caractérisation des irrégularités de surface de roulement associées à l'exitation vibratoire

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Foreword

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This document was prepared by Technical Committee ISO/TC 108, *Mechanical vibration, shock and condition monitoring*, Subcommittee SC 2, *Measurement and evaluation of mechanical vibration and shock as applied to machines, vehicles and structures*.

A list of all parts in the ISO 14837 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

The mechanisms of excitation of ground-borne noise and vibration from railway systems are listed in ISO 14837-1:2005, 4.2.2, which identifies five excitation mechanisms acting at the wheel-rail interface. These mechanisms include

a) moving loads (quasistatic) excitation,

b) excitation caused by wheel or rail roughness,

c) parametric excitation,

d) wheel or rail defects, and

e) discontinuities of the track.

This document is concerned with excitation by roughness. The aim of this document is to

f) define the term roughness used in connection with the source of ground vibration from railways,

g) provide guidance regarding the procedures that can be used for roughness excitation measurement and analysis, and

h) provide guidance regarding the equipment that can be used to measure roughness excitation.

The term acoustic roughness is already defined by common use and in EN 15610. The mechanism by which acoustic roughness generates vibration, leading to noise in the range f = 50 Hz to f = 6 kHz, is essentially the same as that which is a source of ground vibration in the frequency ranges of approximately f = 1 Hz to f = 80 Hz and approximately f = 20 Hz to f = 250 Hz, that leads to ground-borne or structure-borne noise. This document therefore draws upon the established definitions, methods of measurement and methods of analysis for acoustic roughness to provide guidance for the measurement and analysis of the roughness pertaining to ground-borne vibration and ground-borne noise.

Mechanical vibration — Ground-borne noise and vibration arising from rail systems —

Part 34: Characterizing irregularity of the running surfaces with respect to vibration excitation

1 Scope

This document specifies methods for measuring and analysing irregularities of running surfaces for use in the prediction and assessment of ground-borne noise and vibration arising from railway systems. This document

a) defines the data that can be described as rail or wheel roughness and that can be used to quantify a source term for the generation of the dynamic forces that can lead to ground-borne vibration from railway vehicles,

b) gives guidance regarding the types of equipment that can be used to measure roughness as a variation of height along the running direction of the rail surface or wheel parameter,

c) gives guidance regarding the methods that can be used to obtain an estimate of the roughness wavelength spectrum from measurement records taken over a length of rail head or wheel perimeter, and

d) gives guidance regarding the presentation of a roughness spectrum representing the condition of a length of rail or of a wheel related to its ability to generate vibration.

This document does not

e) give guidance regarding the characterization of localized geometrical features (e.g. switches, crossings, rail squats, occasional rail joints and localized geometrical defects of the running surface). These features are likely to produce dynamic forces that are not linear with their amplitude because of the change of geometry at the wheel-rail contact. Hence these features are not characterized by methods of analysis defined within this document. Annex A provides further information regarding the characterization of localized geometrical features,

f) give guidance regarding the specification or testing of roughness measurement equipment that can be used. Annex B provides an overview of measuring equipment,

g) give guidance regarding the measurement or analysis of track quality for any other purpose than the assessment of ground-borne vibration,

h) present any example of roughness spectra intended to represent typical roughness. Roughness levels vary greatly between track sites and any examples used in this document have not been selected on any other basis than their usefulness for the purpose of demonstrating the principles of analysis,

i) promote any particular make, model or manufacturer of measurement equipment, and

j) recommend or promote software for the implementation of the analysis procedure.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply. For an explanation of roughness-related terms, see Clause 4.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
running surface
part of the wheel tread or the rail head, along which the wheel-rail contact passes during rolling

Note 1 to entry: In the case of the rail this is the bright band of the surface of the rail head that contains all the running positions of the wheel-rail contact.

[SOURCE: EN 15610:2019, 3.9]

3.2
roughness
variation in height of the rail or wheel running surface associated with a particular noise or vibration phenomenon

3.3
roughness spectrum
amplitude of the roughness expressed as a function of the roughness wavelength λ

[SOURCE: EN 15610:2019, 3.2, modified — "acoustic" has been deleted in the term and the definition.]

3.4
roughness level
L_r
level expressed in decibels, given by the following formula:

$$L_r = 10 \cdot \log_{10} \frac{r_{\mathrm{RMS}}^2}{r_0^2}$$

where

L_r is the roughness level in dB;

r_{RMS} is the root mean square roughness in µm; and

r_0 is the reference roughness with r_0 = 1 µm

Note 1 to entry: This definition applies to values measured either in the form of a roughness wavelength spectrum or for a specific roughness wavelength band.

[SOURCE: EN 15610:2019, 3.3, modified — "acoustic" has been deleted in the term and the definition and Note 1 to entry has been replaced.]

3.5
roughness wavelength
λ
ratio expressed in m given by the following formula:

$$\lambda = v / f$$

where

f is the frequency in Hz

v is the train speed in m/s

4 Characterizing roughness related to vibration excitation

4.1 Roughness and noise or vibration phenomena

Roughness is the variation in the height of the rail or wheel running surface. Therefore,

a) acoustic roughness is the roughness associated with the excitation of rolling noise,

b) ground-borne noise roughness is roughness associated with the excitation of ground-borne or structure-borne noise, and

c) ground-borne vibration roughness is roughness associated with the excitation of low-frequency ground vibration.

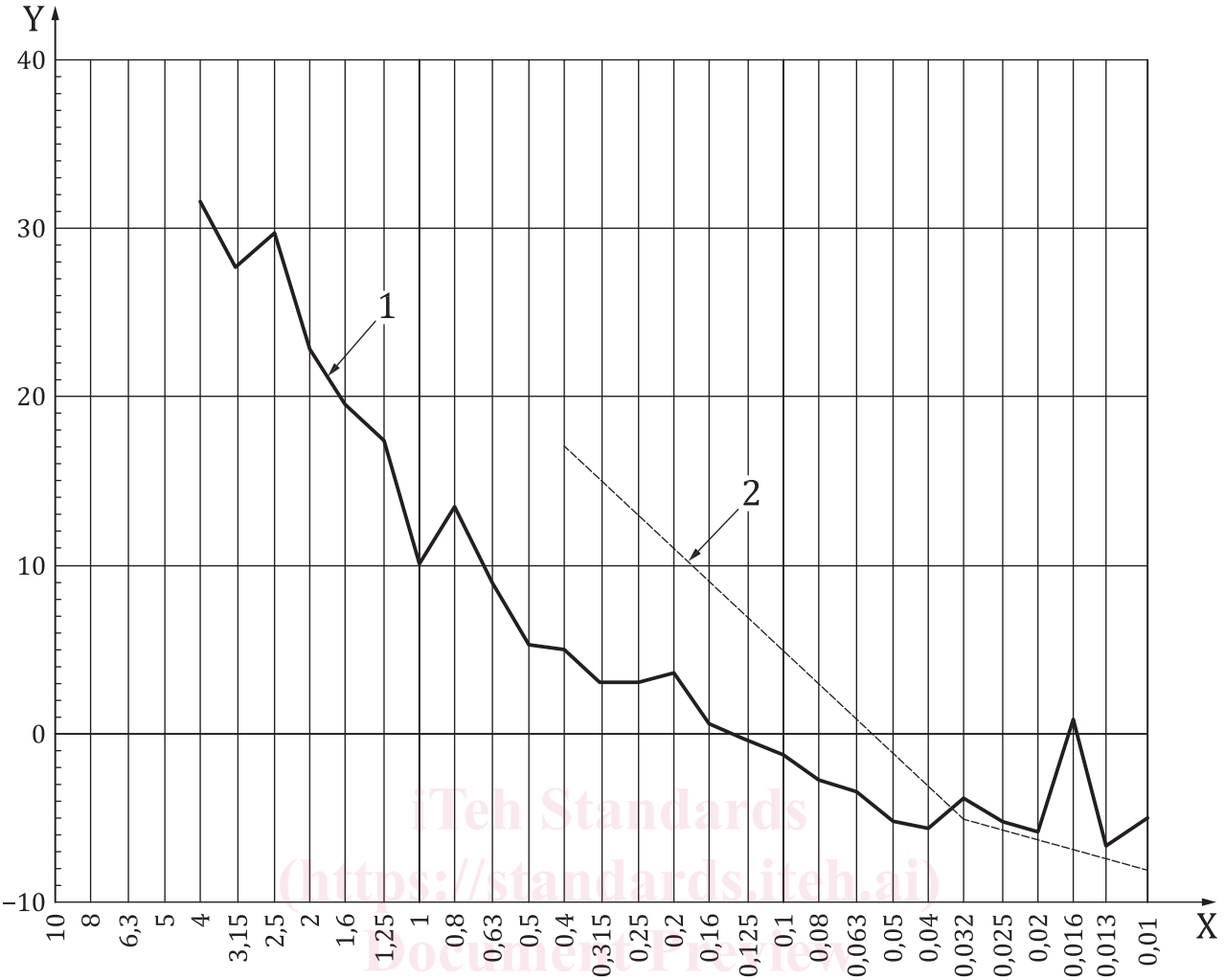
The vehicle-track interaction equation for the excitation of force by vertical profile irregularities in the height of the rail and/or wheel running surfaces is the same for 4.1 a), b) and c). Only the roughness wavelength range changes.

4.2 Roughness spectrum

The roughness spectrum is an estimation of the statistical properties of the roughness record over the length of measurement. A roughness spectrum represents the general geometrical condition of the running surface and does not represent the geometry of localized features (e.g. a crossing nose, rail joint, dipped joint or certain kinds of track or rail or wheel defect) that do not occur with sufficient frequency in a measurement record to be part of its statistical summary of the condition of the track or running surface.

4.3 Roughness level

Figure 1 shows an example of a measured roughness spectrum. It is presented in accordance with the requirements of EN 15610 but with the roughness wavelength range extended to λ = 4 m to include the roughness associated with the excitation of low-frequency ground vibration and ground-borne noise. The presentation is given in logarithmically scaled one-third-octave bands, with the roughness level as a function of the roughness wavelength, in decreasing order. The default upper limit for a test section specified in ISO 3095:—, Figure 5 is shown as a reference. This limit is specified to λ = 0,4 m. For the range λ = 0,032 m to λ = 0,4 m the limit increases at a rate of 20 dB/decade.



Key

X roughness wavelength λ in m, logarithmically scaled

Y roughness level L_r in dB in one-third octave bands

1 measured roughness spectrum

2 ISO 3095:—, Figure 5 upper limit

Figure 1 — Example of a roughness spectrum presented in accordance with the guidance given in EN 15610

4.4 Roughness wavelength range

Table 1 illustrates the relationship between roughness wavelength, train speed and the resulting excitation frequency. The shaded cells indicate the range of roughness wavelengths defined as acoustic roughness in EN 15610. Roughness wavelengths that lead to low-frequency ground-borne vibration (approximately f = 1 Hz to f = 80 Hz) or ground-borne and structure-borne noise (approximately f = 20 Hz to f = 250 Hz) require a roughness definition which includes data to longer roughness wavelengths than for acoustic roughness.

At short roughness wavelengths (e.g. λ < 1 m), roughness is defined by the wear patterns of the running surfaces of the wheels and the rails. At long roughness wavelengths (e.g. $\lambda \geq 1$ m) roughness is defined by the vertical alignment of the track. Long roughness wavelengths are therefore affected by the construction quality, the construction method and the condition of the track substructure and ballast.