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Railway applications - Noise emission - Characterisation of the dynamic properties of track sections for pass by noise measurements

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ICS

English Version

Railway applications - Noise emission - Characterisation of the dynamic properties of track sections for pass by noise measurements

Applications ferroviaires - Emission sonore - Caractérisation des propriétés de sections de voie pour le mesurage du bruit au passage

Bahnanwendungen - Schallemissionen - Charakterisierung der dynamischen Eigenschaften von Gleisabschnitten für Schallmessungen von vorbeifahrenden Zügen

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 256.

If this draft becomes a European Standard, 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.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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

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Foreword

This document (prEN 15461:2006) has been prepared by Technical Committee CEN/TC 256 “Railway applications”, the secretariat of which is held by DIN.

This document is currently submitted to the CEN Enquiry.

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 Directive 96/46/EC.

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

Introduction

The rolling interaction between the wheels of a railway vehicle and the track results in vibration that, in turn, causes rolling noise. The vibration response of the track structure determines the track component of this noise.

1 Scope

This European Standard specifies a method for characterizing the structural dynamics of a track relative to the track-radiated component of rolling noise.

This European Standard describes a method for:

— acquiring mechanical frequency-response function data at a track site;

— post-processing measured data in order to calculate an estimate of the rates of decay of vibration along the rails in an audible frequency range related to the rolling noise;

— presenting this estimate for assessment against lower boundary limits of decay rates.

It is applicable to testing the performance of reference track sections for measuring noise from railway vehicles for acceptance test purposes.

It is applicable only to open track.

The method is not applicable for characterizing the vibration behaviour of track-supporting structures such as bridges or embankments.

The method assumes that vibration waves in the rail can be measured as a single propagating vertical bending wave and a single lateral bending wave of the rail acting as a simple beam. Although the track rail does not behave in this way throughout the frequency range covered by the measurement, this simplification allows the "decay rates" to be used an assessment of the dynamic behaviour of the track, which is one of the key parameters influencing rolling noise generation.

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

WI 00256200, *Railway applications — Rail roughness measurements related to noise generation — Definition and procedures*[1)]

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

EN ISO IEC 17025:2000, *General requirements for the competence of testing and calibration laboratories*

1) in preparation

ISO 7626-1:1986, *Vibration and shock — Experimental determination of mechanical mobility — Part 1: Basic definitions and transducers*

ISO 7626-5 :1994, *Vibration and shock — Experimental determination of mechanical mobility — Part 5: Measurements using impact excitation with an exciter which is not attached to the structure*

3 Terms and definitions

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

3.1
frequency-response function (FRF)
freuqncy-dependent ratio of the motor-response phasor to the phasor of the excitation force (ISO 7626-1)

NOTE 1 In this standard, the term frequency-response function (FRF) is used to refer generically either to accelerance (acceleration response/excitation force) or to mobility (velocity response/excitation force). The term is not used to refer to receptance (dynamic compliance) in this document.

NOTE 2 The FRF is generally calculated as the cross spectrum between the response and the force divided by the auto spectrum of the force. This estimate of the FRF is called an H1 estimate.

NOTE 3 A set of FRFs between a single excitation point and multiple response points or even between a single response point and multiple excitation points can be used. In this standard, the case of a fixed accelerometer and a roving instrumented hammer is most easily applicable.

3.2
accelerance
FRF representing the acceleration per unit force, expressed as a spectrum versus frequency (see also ISO 76261)

NOTE In this standard, it is not specifically defined as a complex quantity since the term is used to encompass the FRFs expressed as a one-third octave spectrum

3.3
mobility
FRF representing the velocity per unit force expressed as a spectrum versus frequency (see also ISO 7626-1)

NOTE In this standard, it is not specifically defined as a complex quantity since the term Is used to encompass the FRFs expressed as a one-third octave spectrum

3.4
direct FRF, driving-point FRF
FRF for which the response is measured at the same location (as close as physically possible with hammer and accelerometer) and in the same direction (both force and response vertical or lateral) (see also ISO 7626-1)

3.5
transfer FRF
FRF for which the response amplitude is measured at a different location from the force application location

NOTE It is strongly recommended that the direction and location of the application force and the response are known in order to define the FRF.

3.6
track decay rate
the rate of attenuation of vibration amplitude of either vertical or lateral bending wave motion in the rail as a function of the distance along the rail

NOTE It is represented by a one-third octave spectrum of values expressed in decibels per metre (dB/m) representing attenuation over distance

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

3.8
centre of test section
midpoint of the test section

3.9
accelerometer location
fixed position of the accelerometer(s) for which a full set of FRF measurements is taken

3.10
structural waves
vibration waves that are propagated along the rail resulting in a deformation of the whole rail section

NOTE For example, vertical and or lateral bending waves of the rail acting like a beam or waves that involve modes of cross-sectional deformation of the rail and propagate along the rail. Waves of vibration with wavelengths very much shorter than the cross-section dimensions of the rail, such as ultrasonic Rayleigh waves or shear and compression waves in the rail material are not included in the definition for the purposes of this standard.

3.11
one-third octave spectrum
vibration spectra of velocity or acceleration, excitation force spectra, FRF spectra of either mobility or accelerance and the resulting decay rates

NOTE However, the definition is standardized and relates to a spectrum of the summed squared values or the root mean squares of the FRFs in each of the preferred one-third octave frequency bands (see EN ISO 266)

3.12
narrow-band spectrum
any spectrum expressed in terms of frequency bandwidth smaller than one-third octave band, either a proportional bandwidth or constant bandwidth such as might be produced by a Fast Fournier Transform (FFT)

3.13
frequency analyser
a digital device for acquiring the signals from transducers and processing the signals to produce either a narrow-band spectrum or a one-third octave band spectrum

NOTE 1 The system supplies at least two simultaneous channels.

NOTE 2 The signals are filtered by anti-aliasing filters before being sampled digitally (see ISO 7626-5 for more details).

3.14
reference track (section)
see definition in WI 00256200

3.15
instrumented hammer
a device to apply the excitation impact on the rail with a built-in force transducer. The usable frequency range depends on the duration of the force pulse generated

NOTE The excitation bandwidth is controlled by the choice of hammer mass and the stiffness of the tip (see ISO 7626-5 for more details).

4 Symbols and abbreviations

x position along the track

dx *d*ifferential operator on x

Δx interval on x

x_{max} position at maximum distance considered along the track

$A(x)$ FRF at the position x along the track

β decay constant of the response amplitude

Δ decay rate

FRF frequency-response function

FFT Fast Fourier Transform

5 Test method

5.1 Principle

The decay rates are determined on the basis of a point FRF and a number of frequency-response function measurements relative to the location on the rail of the excitation force application point. An instrumented hammer shall be used to excite the rail. An accelerometer located at a number of positions along the rail at different distances from the excitation point shall be used to measure the response. Rather than apply the excitation at a single point and relocate the accelerometer along the rail, it is advisable to fix the accelerometer at a specific position and move the excitation point to a series of locations along the rail.

The whole set of FRFs shall be measured successively for lateral and vertical excitation and the response directions.

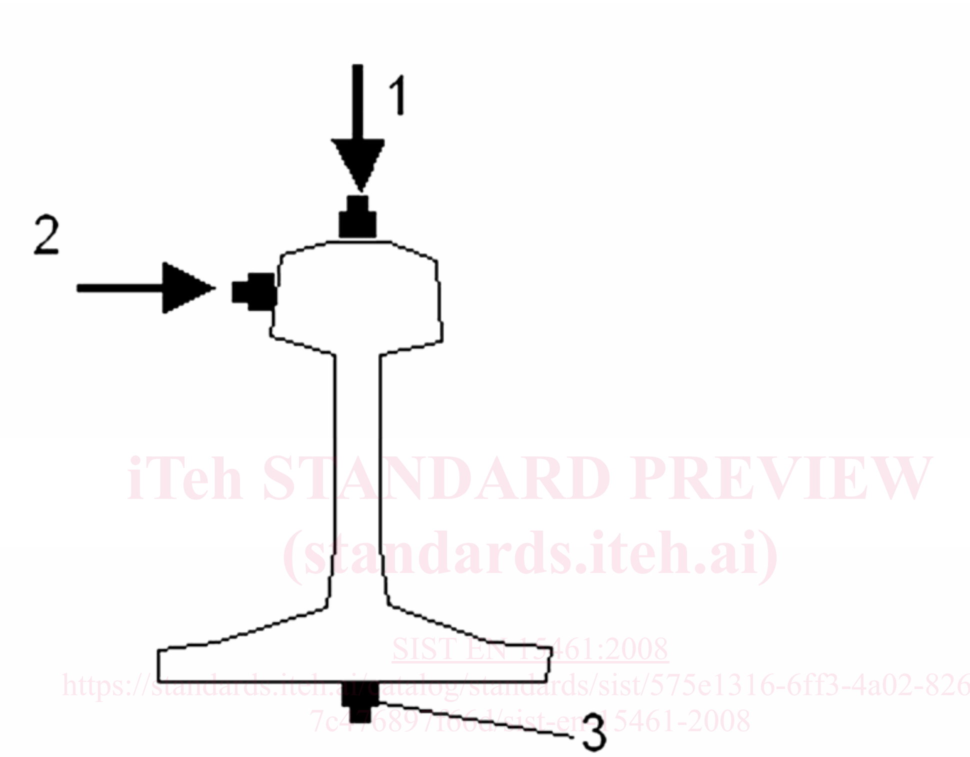
The measurements shall be carried out with the fixed accelerometers at the same time in the vertical and lateral directions (see Figure 1) or by using successive positions of the accelerometers in the directions (vertical and lateral) corresponding to that of the application force. In each case, the accelerometer(s) shall be secured on the rail (either directly with the adhesive, or by a suitable glued stud) at the locations shown in Figure 1.

NOTE It is preferable to isolate the transducer from the rail electrically in order to maintain the integrity of the measuring system.

The accelerometer(s) shall be fixed:

— in the vertical direction on the longitudinal axis of the rail, preferably on the rail head. If this is not possible, it (they) should be fixed under the rail foot;

— in the transverse direction, on the outside face of the rail head preferably. If this is not possible, it (they) should be fixed on the gauge face of the rail.



Key

1 $F_{vertical}$
2 $F_{lateral}$
3 Accelerometer

Figure 1 — Position of the accelerometers on the rail cross-section

A force pulse is applied to the rail head in each direction with an instrumented hammer fitted with a tip of appropriate hardness to ensure a good quality measurement of the force and the response in a frequency range of 50 Hz to 6 000 Hz.

NOTE A hardened steel tip with a light hammer is required in practice to obtain good quality measurements at the upper limits of the frequency band. In most cases, it is suitable for the lower frequency band limits also. However, a slightly softer tip may produce better quality results for the low frequencies. A good measurement technique requires only a light tap with the hammer as it does not then damage the rail surface. ISO 7626-5 specifies the conditions of use of the consistency functions ensuring good quality of the measured data.

Using a frequency analyser with two or more simultaneous channels or any other digital means of signal acquisition and processing, a set of transfer FRFs shall be measured for the response of the rail in the vertical