SLOVENSKI STANDARD
SIST EN 15461:2008+A1:2010

01-december-2010

Železniške naprave - Hrup - Opis dinamičnih lastnosti tirnega odseka za merjenje hrupa vozečih vlakov

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

Bahnanwendungen - Schallemission - Charakterisierung der dynamischen Eigenschaften von Gleisabschnitten für Vorbeifahrtgeräuschmessungen

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

Ta slovenski standard je istoveten z: EN 15461:2008+A1:2010

ICS:

17.140.30	Emisija hrupa transportnih sredstev	Noise emitted by means of transport
45.060.01	Železniška vozila na splošno	Railway rolling stock in general

SIST EN 15461:2008+A1:2010 en,fr,de

EUROPEAN STANDARD

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English Version

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

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COMITÉ EUROPÉEN DE NORMALISATION
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Foreword

This document (EN 15461:2008+A1:2010) 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of an identical text or by endorsement, at the latest by May 2011, and conflicting national standards shall be withdrawn at the latest by May 2011.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 includes Amendment 1, approved by CEN on 2010-09-28.

This document supersedes EN 15461:2008.

The start and finish of text introduced or altered by amendment is indicated in the text by tags !A1! !A1!.

!A1! 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. !A1!

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 United Kingdom.

Introduction

The interaction between the wheels of a railway vehicle and the track during operation is translated by vibrations which, in movement, generate rolling noise. The vibration response of the track structure determines the level of its sound contribution to this noise.

The method assumes that the vibration waves in the rail can be regarded as the superposition of two bending waves, one vertical and the other transverse, of the rail represented as a simple beam. Although the track rail does not behave in this way over all the frequencies covered by the measurement, this simplification permits the "decay rates" to be measured for an estimation of the dynamic behaviour of the track which is one of the basic parameters influencing the generation of rolling noise.

1 Scope

This European Standard specifies a method for characterizing the dynamic behaviour of the structure of a track relative to its contribution to the sound radiation associated with the rolling noise.

This European Standard describes a method for:

a) acquiring data on mechanical frequency response functions on a track;

b) processing measurement data in order to calculate an estimate of the vibration decay rates along the rails in an audible frequency range associated with the rolling noise;

c) presenting this estimate for comparison with the lower limits of the decay rates.

It is applicable for evaluating the performance of sections of reference tracks for measuring railway vehicle noise within the framework of official approval tests.

The method is not applicable for characterizing the vibration behaviour of tracks on loadbearing structures such as bridges or embankments.

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 — Normal frequencies (ISO 266:1997)*

EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories (ISO/IEC 17025:2005)*

ISO 2041, *Vibration and shock — Vocabulary*

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

ISO 7626-5, *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)
frequency-dependent ratio of the motor-response phasor to the phasor of the excitation force (see ISO 7626-1)

NOTE 1 In this document, the term also refers to the mean spectral amplitude of the FRF in the form of a one-third octave spectrum.

NOTE 2 In this standard, the term frequency-response function (FRF) is used to refer generically either to accelerance (accelerometric response/excitation force) or to mobility (speed response/excitation force). The term is not used to refer to receptance (dynamic compliance).

NOTE 3 The FRF is generally calculated as the interspectrum ratio between the response and the force with the autospectrum. This estimate of the FRF is called estimate H1.

NOTE 4 A set of FRF between a single excitation point and multiple response points or even between a single response point and multiple excitation points may be used. In this standard, the case of a fixed accelerometer and a mobile instrumented excitation hammer is the easiest to implement.

3.2
accelerance
complex ratio of the acceleration at one point in a mechanical system to the force at the same point or at a different point during a single harmonic motion (see also ISO 7626-1 and ISO 2041)

NOTE Accelerance is an FRF currently expressed as a narrow-band complex spectrum. It is also used in this standard to express a one-third octave spectrum.

3.3
mobility
complex ratio of the speed at one point in a mechanical system to the force at the same point or at a different point during a single harmonic motion (see also ISO 7626-1 and ISO 2041)

NOTE Mobility is an FRF currently expressed as a narrow-band complex spectrum. It is also used in this standard to express a one-third octave spectrum.

3.4
direct FRF, FRF at the point of application
FRF for which the response is measured at the same position (as close as possible physically with an impact hammer and an accelerometer) and the same direction (see also ISO 7626-1)

NOTE In this standard, the term refers both to force and response FRF in the vertical and transverse directions.

3.5
transfer FRF
FRF for which the response amplitude is measured at a different position to the force application point

NOTE In order to define the FRF, the direction and position of the application force and the response should be mentioned.

3.6
decay rate on the track
vibration amplitude decay rate of the vertical or transverse bending waves of the rail as a function of the distance along the rail

NOTE It is represented by a one-third octave band spectrum of the values of the decay rate, expressed in decibels per metre (dB/m) representing the attenuation as a function of the distance.

3.7
test section
<railway applications> section of track specifically associated with a particular set of measurement data

3.8
accelerometer position
fixed position of the accelerometer(s) for which a complete set of FRF measurements is taken

3.9
structural wave
vibration wave that is propagated along the rail resulting in a deformation of the whole rail section

NOTE For example, vertical and transverse bending waves of the rail behaving like a beam or waves that involve deformation modes in the cross-section of the rail propagating along the rail. The vibration waves with wavelengths that are smaller than the rail cross-section dimensions, such as the Rayleigh ultrasonic waves or the shear or compression waves in the material are not covered in the definition associated with the subject of this standard.

3.10
one third-octave band spectrum
spectrum of the added squared values or the root mean squares of the FRF in each of the normal frequencies one-third octave band (see EN ISO 266).

NOTE In this document, also refers to the speed and acceleration vibration spectrum, to the excitation effort spectrum, to the mobility and acceleration FRF spectrum and to the resulting decay rate.

3.11
reference track section
portion of track used to characterize the rail system noise emission performances that meet the requirements of the interoperability technical specifications from the railway interoperability directives

NOTE These requirements cover the track vibration response via the track decay rate and the acoustic roughness level of the rail. They are intended to ensure the reproducibility of the measurements

3.12
instrumented hammer
instrument with an integrated force transducer for applying an excitation force to the structure

4 Symbols and abbreviations

x position along the track. The reference position $x_0 = 0$ is situated at the measuring point of the direct FRF,

dx differential operator over x,

n number of measuring positions,

Δx_n n^{th} interval,

x_{max} position of the maximum distance considered along the track,

$A(x_n)$ FRF at position x_n along the track,

β response amplitude decay constant,

DR decay rate,

FRF frequency-response function,

FFT fast Fourier transform

5 Principles

The decay rates are determined on the basis of an FRF at the application point and a certain number of frequency-response function measurements relative to the position on the rail of the excitation force application point (transfer function). An instrumented hammer shall be used to excite the rail. For the purpose of this standard, an accelerometer shall be fixed to the rail and the measurements shall be taken for various distances from the force application point in relation to it.

The full set of FRF shall be measured in the vertical and transverse directions. The decay rates of the vertical and transverse bending waves as a function of the distance shall be calculated on the basis of this set of FRF measurements.

The stages of the test method are specified in the following subclauses.

6 Data acquisition

6.1 Selection of the test section

The test section shall meet the following conditions:

a) the constitution of the track shall be constant over the whole test section for all the parameters that could affect the decay rates. These parameters include the rail cross-sections, the stiffness of the pad beneath the rail, the cant of the rails and the space between the sleepers;

b) the test section shall be fitted with long welded rails. Specifically, it shall not have any rail expansion joints.

6.2 Position of the accelerometers

Within the test section, each position to which the accelerometer is fixed to the rail shall satisfy the following conditions:

a) it shall be located inside the test section, at least 20 m from the centre of the test section;

b) it shall be located at the median point of a space between the sleepers;

c) the accelerometer shall not be located close to rail supports in an unusual condition; in particular:

1) there shall be no pumping sleeper less than 3 metres from the accelerometer position;

2) there shall be no missing or damaged fastening clip (or fastening of any other type, if necessary) on the supports directly adjacent to the measuring accelerometer position;

3) the accelerometer shall not be located less than 5 m from a rail weld;

4) the accelerometer shall not be located less than 40 m from a rail expansion joint.

Three measurements of the direct FRF shall be carried out at three potential accelerometer positions at least, compatible with the requirement of 6.2 c). If at least two of the FRF are similar, it can be regarded that these accelerometer positions are representative of the whole test section, and subsequently can be used for the rest of the measurements. If no accelerometer position is found in the first set of potential positions, others shall be sought, and their direct FRF verified, until a set is identified that does comply.

NOTE If no accelerometer position is obtained with this procedure, it is probably because the structure of the test section is not sufficiently homogeneous to be characterized by a single decay rate spectrum. Therefore, another test section should be sought.

6.3 Assembly of the accelerometers

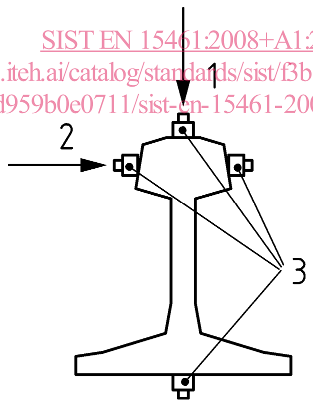
The accelerometer(s) shall be fixed:

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

b) in the transverse direction, on the outside face of the rail head.

The accelerometer(s) shall be kept on the rail (either directly with the adhesive, or by a suitable support stuck on) at the positions shown in Figure 1.

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



Key

1 vertical force

2 transverse force

3 accelerometers

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

6.4 Excitation force

A force pulse is applied to the rail head in the vertical and transverse directions with an instrumented hammer fitted with a tip of adequate rigidity to ensure a good quality measurement of the force and the response in a frequency range of interest.

NOTE A titanium 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. On the other hand, a less stiff tip can produce better quality results for the low frequencies. In the frequency band of interest, a good measuring technique only requires light taps with the hammer as it does not then damage the surface of the rail. ISO 7626-5 specifies the conditions of use of the coherence functions to ensure good quality of the measured data.

6.5 Acquisition system

The acquisition system shall comprise:

a) a spectrum analyser with two channels or more, or any equivalent numerical equipment for the digital acquisition and processing of the signals;

b) an instrumented hammer, and

c) an accelerometer with a suitable signal conditioning system.

Anti-aliasing filters shall be used prior to the numerical sampling of the signal.

NOTE Alternative equipment may be used for the analogue integration of the acceleration signal so as to acquire a speed signal on the analyser. In this case, better quality of the measurement is obtained by recording the mobility (speed/force) rather than the accelerance (acceleration/force). A better signal-to-noise ratio in the low frequencies is obtained when the responses measured are very weak compared to those obtained in the high frequencies as the dynamic of the data prior to recording or numerical sampling is reduced.

The measuring equipment shall meet the requirements of EN ISO/IEC 17025.

6.6 Acquisition of the FRF

A set of FRF shall be measured for the response of the rail in the vertical direction based on a vertical force pulse and a second set for the transverse response of the rail with transverse excitation. The FRF shall finally be expressed in the form of a one-third octave spectrum covering at least the frequency bands between 100 Hz and 5 000 Hz inclusively. If analogue filters are used, they shall meet the requirements of EN 61260.

The FRF shall be measured according to ISO 7626-5. The corresponding FRF measured may be accelerance or mobility; estimation or measurement of these cross terms (vertical force compared to transverse response or *vice versa*) is not necessary.

An average FRF of at least 4 validated pulses shall be taken into account for each elementary FRF. The quality of each FRF measured (reproducibility, linearity etc.) should be checked using its coherence function. It is recommended recording the latter.

NOTE Most of the acquisition systems produce narrow-band data with constant frequency increments. The increment of the frequencies measured, in Hz, is equal to the inverse of the length of the sample, in s, The length of the sample should be limited to the time required for the pulse to be reduced to the level of the background noise of the signal. Therefore, the lowest frequency band is determined by the value of the increment of the spectrum frequency measured and the minimum number of lines to be included per one-third octave band (three should be used).

6.7 Set of measuring positions

Each set of FRF shall contain response measurements at the accelerometer position corresponding to pulses produced on the rail for the set of excitation positions described in Figure 2. The FRF measured may be accelerances (acceleration/force) or mobilities (velocity/force).