SLOVENSKI STANDARD
SIST EN 17495:2022

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Železniške naprave - Akustika - Ugotavljanje dinamične togosti elastičnih tirničnih komponent v povezavi s hrupom in vibracijami - Sestavi tirničnih podlag in tirnih pritrdilnih elementov

Railway Applications - Acoustics - Determination of the dynamic stiffness of elastic track components related to noise and vibration - Rail pads and rail fastening assemblies

Bahnanwendungen - Akustik - Bestimmung der dynamischen Steifigkeit von elastischen Komponenten im Oberbau in Bezug auf Schall und Schwingungen - Zwischenlagen und Schienenbefestigungssysteme

Applications ferroviaires - Acoustique - Détermination de la raideur dynamique des composants élastiques de la voie pour le bruit et les vibrations - Semelles sous rail et systèmes de fixation du rail

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ICS:

17.140.30	Emisija hrupa transportnih sredstev	Noise emitted by means of transport
93.100	Gradnja železnic	Construction of railways

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English Version

Railway Applications - Acoustics - Determination of the dynamic stiffness of elastic track components related to noise and vibration: Rail pads and rail fastening assemblies

Applications ferroviaires - Acoustique - Détermination de la raideur dynamique des composants élastiques de la voie pour le bruit et les vibrations: Semelles sous rail et systèmes de fixation du rail

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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European foreword

This document (EN 17495:2022) 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of an identical text or by endorsement, at the latest by February 2023, and conflicting national standards shall be withdrawn at the latest by February 2023.

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Introduction

Airborne rolling noise and structure-borne noise that propagates through the ground and rolling stock, are excited during rolling wheel-rail interaction by the *acoustic roughness* (see EN 15610) of the wheel and rail surfaces. For this reason, models for railway noise and vibration use a measure of track-support stiffness determined at amplitudes of vibration caused by acoustic roughness and under the load of a train and/or the rail fastening system.

This document sets out requirements for a laboratory measurement of the dynamic stiffness of rail pads and rail fastening assemblies relevant to noise and vibration models.

The purpose is to provide data for assessment and specification of the acoustic performance of track components.

An alternative technique to determine input data for rolling noise models is to measure track decay rates according to EN 15461 (see also Bibliography [1]).

NOTE In contrast to the test methods elaborated in this document, other methods exist that can deliver values for dynamic stiffness and loss factor of elastic components and fastening assemblies. They are not thought to attain the quality and comparability required for standardization and they are not within the scope or content of this document. For more information on these methods, see Bibliography [2 – 6].

1 Scope

This document specifies laboratory test procedures to determine a high-frequency dynamic stiffness, “acoustic stiffness”, of resilient components of rail fastening assemblies.

This document is applicable to complete rail fastening assemblies and to pad components of fastening systems including both discrete and continuous fastening systems.

It is applicable to the measurement of the dynamic transfer stiffness under a prescribed pre-load and the associated hysteretic damping loss factor.

It provides measurement methods and pre-load, excitation and frequency range conditions for application to ground borne and structure borne noise as well as for rolling noise.

It is not applicable to the measurement of the stiffness of pads and fastening assemblies under static or low-frequency dynamic loading used for track mechanics.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 13481-1, *Railway applications - Track - Performance requirements for fastening systems - Part 1: Definitions*

EN ISO 7500-1:2018, *Metallic materials - Calibration and verification of static uniaxial testing machines - Part 1: Tension/compression testing machines - Calibration and verification of the force-measuring system (ISO 7500-1:2018)*

EN ISO 10846-1, *Acoustics and vibration - Laboratory measurement of vibro-acoustic transfer properties of resilient elements - Part 1: Principles and guidelines (ISO 10846-1)*

EN ISO 10846-2, *Acoustics and vibration - Laboratory measurement of vibro-acoustic transfer properties of resilient elements - Part 2: Direct method for determination of the dynamic stiffness of resilient supports for translatory motion (ISO 10846-2)*

EN ISO 10846-3, *Acoustics and vibration - Laboratory measurement of vibro-acoustic transfer properties of resilient elements - Part 3: Indirect method for determination of the dynamic stiffness of resilient supports for translatory motion (ISO 10846-3)*

ISO 7626-1:2011, *Mechanical vibration and shock — Experimental determination of mechanical mobility — Part 1: Basic terms and definitions, and transducer specifications*

ISO 16063-21, *Methods for the calibration of vibration and shock transducers — Part 21: Vibration calibration by comparison to a reference transducer*

ISO 21948, *Coated abrasives — Plain sheets*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 13481-1 and EN ISO 10846-1 and the following apply.

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

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

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

3.1
acoustic stiffness
dynamic stiffness of an elastic track support component or fastening assembly that is measured under a static preload and at small amplitudes of displacement or velocity applied in the frequency range relevant to noise or vibration perception

Note 1 to entry: It is the measure of stiffness addressed by this document for use in noise and vibration models.

3.2
acoustic damping
loss factor associated with the acoustic stiffness

4 Symbols and abbreviated terms

For the purposes of this document, the symbols in Table 1 apply.

Table 1 — Symbols

Symbol	Meaning	Relevant subclause
a_1	acceleration of the upper mass (input), in m/s^2	7.3.2
a_2	acceleration of the force-measuring platform or lower mass (output), in m/s^2	7.3.2
F_2	force on the measuring platform (output) in the direct measurement method, in N	7.3.2
j	$\sqrt{-1}$	7.3.2
k_A	acoustic stiffness, in N/m	7.3.5
k_D	transfer stiffness measured by the direct method, in N/m	7.3.2
k_I	transfer stiffness measured by the indirect method, in N/m	7.4.2
k_L	lower isolators combined support stiffness in the indirect method, in N/m	7.4.2
m_2	mass of the measuring platform and any parts of the fastening assembly below the resilient element in the direct method, or the blocking mass in the indirect method, in kg	7.3.2 7.4.2
η_A	acoustic loss factor, (dimensionless)	7.3.5
u_1	displacement of the upper mass $= -a_1 / \omega^2$, in m	7.3.2
u_2	displacement of the lower mass in the indirect method $= -a_2 / \omega^2$, in m	7.3.2
v_1	excitation velocity $= a_1 / j\omega$, in m/s	7.3.2
ω	angular frequency, in rad/s	7.3.2

NOTE The subscript 1 denotes a quantity at the input and subscript 2 denotes a quantity at the output side of the test specimen.

5 General requirements

5.1 General

Good quality measurements depend upon the competence of the measurement team, control of the environmental conditions, estimation of measurement uncertainties, measurement traceability, control of data, handling of samples, and the reporting of results.

NOTE Guidance is provided in EN ISO/IEC 17025:2017.

5.2 Apparatus

5.2.1 General

The test equipment shall conform to the following requirements in order to produce repeatable results over the frequency range and applied loads specified in this document. In particular, the following requirements shall be applied for the transducers used.

5.2.2 Accelerometers

Accelerometers shall be calibrated at the laboratory temperature in the frequency range of interest and shall have a sensitivity level which is frequency independent to within 0,5 dB and the sensitivity to cross-axis accelerations shall be smaller than 5 % of the main axis of sensitivity. Calibration shall be carried out according to ISO 16063-21.

All accelerometers used shall have an internal resonance frequency at least twice the upper limit of the working frequency range.

Where measurements are summed from multiple accelerometers, the measurement resulting from the whole transducer and signal acquisition system shall conform to the requirements stated above.

5.2.3 Force transducers

Force transducers used for the measurement of the dynamic force shall be calibrated in the frequency range and temperature range of interest and have a sensitivity level which is frequency independent to within 0,5 dB and the sensitivity to cross-axis forces shall be smaller than 5 %. Calibration shall be carried out according to the mass-loading technique as described in ISO 7626-1:2011.

If the transducer has an associated sensitivity-level function to compensate for its variation of sensitivity with force amplitude, the effective calibration of the system shall meet the 0,5 dB requirement.

All force transducers used for the measurement of dynamic force shall have an internal resonance frequency at least twice the upper limit of the working frequency range.

Where measurements are summed from multiple force transducers, the measurement resulting from the whole transducer and signal acquisition system shall conform to the requirements stated above.

Force transducers used for the measurement of the static preload shall be calibrated over the working range to Class 1 according to EN ISO 7500-1:2018.

5.2.4 Signal acquisition and processing equipment

The spectral resolution shall provide at least one discrete frequency in each one-third-octave band in which the result is required.

5.2.5 Load applying equipment

The equipment shall be capable of maintaining the required preload over the period of the test at the set value to within ±5 %.

5.2.6 Temperature environment

Measurements shall be made within a tolerance of a particular temperature even if the measurement is only required at nominal room temperature. A controlled environment shall therefore be provided capable of maintaining a set temperature within the required tolerance and for sufficient time for specimens to acclimatize to that temperature stably and for the measurement procedure to be completed.

6 Requirements for different application cases

6.1 Preloads

Different preloads and frequency ranges are required according to whether the stiffness is to be used in the assessment of rolling noise (1), bridge noise (2) or ground borne vibration (3) (low-frequency vibration, and "ground borne noise"). Table 2 specifies the preloads that shall be used in cases (1) to (3). The frequency range for each case is stated as a minimum requirement and a preferred requirement.

Table 2 — Preloads used for different application cases

Case	Component	Preload values kN	Minimum frequency range (one-third octave bands) Hz	Preferred frequency range (one-third octave bands) Hz
Rolling noise / train interior rolling noise (1)	Rail pad	18	80 - 400	50 – 1 250
	Fastening assembly or baseplate pad	5		
Bridge noise (2)	Rail pad	18; 35; 50; 68	80 - 400	25 – 2 000
	Fastening assembly or baseplate pad	5; 18; 35; 50		
Ground borne noise (3)	Rail pad	18; 35; 50; 68	50 - 200	10 - 400
	Fastening assembly or baseplate pad	5; 18; 35; 50		

The minimum frequency range requirement should be achievable in most cases with either the direct or indirect measurement methods set out below. The preferred frequency range reflects more closely the requirements of acoustic calculations.

The approach sets a range of values for the preload and it is up to the user of the results to select or interpolate from this to determine the appropriate stiffness value for the rail seat load of the noise or vibration assessment.

For fasteners or pads with complicated load-deflection behaviour it may be advisory to make extra measurements at intermediate preload values.

Higher preloads may be omitted in cases where a fastening assembly or pad is not designed to take such high loads.

6.2 Excitation amplitudes

The amplitude of dynamic excitation imposed on the sample shall be a vibration velocity of (5 ± 2) mm/s RMS at the frequency of the measurement. If it is required to test whether the acoustic stiffness of the sample varies with the amplitude of imposed deformation, a second measurement shall be carried out with a vibration velocity of (1,6 ± 0,4) mm/s RMS.

It shall be demonstrated that the amplitude of excitation at each frequency of the test has been achieved within the specified range.

NOTE These excitation velocity amplitudes correspond to the order of magnitude of vibration induced by the acoustic roughness of the wheel and rail running surfaces (see e.g. [11]).

7 Test methods

7.1 General

In this document, two different measurement methods are specified. They are termed the "direct method", and the "indirect method" following the terms used in EN ISO 10846-2 and EN ISO 10846-3 in which stiffness measurements are described for the general case of resilient supports.

In this document, the two methods are fully described in the specific application to measurement of the acoustic stiffness and damping of rail pads or rail fastening assemblies.

In either method, the sample (pad or fastening assembly) to be tested is submitted in turn to each of the static preloads given in Table 2, and excited dynamically at a vibration velocity as given in 6.2.

7.2 Arrangements applying to both the direct and indirect methods

7.2.1 Mounting arrangement for a pad

Where the test sample is a pad, it shall be mounted between the loading plates as shown in Figure 1. For tests on continuous pads, used in slab track, a length of pad of 150 mm shall be used.