BS EN 13481-4:2012

BSI Standards Publication

Railway applications — Track — Performance requirements for fastening systems

Part 4: Fastening systems for steel sleepers

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National foreword

This British Standard is the UK implementation of EN 13481-4:2012. It supersedes BS EN 13481-4:2002 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee RAE/2, Railway Applications - Track.

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

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Foreword

This document (EN 13481-4:2012) 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of an identical text or by endorsement, at the latest by November 2012, and conflicting national standards shall be withdrawn at the latest by November 2012.

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 supersedes EN 13481-4:2002.

The main changes in this revision of EN 13481-3:2002 are as follows:

a) the ranges of test loads have been extended to cover the new categories of fastening systems (5.3, Table 2 and 5.4, Table 3);

b) advice on attenuation of noise and vibration has been added (Annex B).

This European Standard is one of the series EN 13481 "*Railway applications – Track – Performance requirements for fastening systems*" which consists of the following parts:

— *Part 1: Definitions*

— *Part 2: Fastening systems for concrete sleepers*

— *Part 3: Fastening systems for wood sleepers*

— *Part 4: Fastening systems for steel sleepers*

— *Part 5: Fastening systems for slab track with rail on the surface or rail embedded in a channel*

— *Part 7: Special fastening systems for switches and crossings and check rails*

NOTE Part 6 does not exist in this series.

These European Standards are supported by the test methods in the series EN 13146 "*Railway applications – Track – Test methods for fastening systems*".

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 EU Directive(s).

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Introduction

A series of tests is used to assess the suitability of fastening systems for use in railway track.

In this European Standard a requirement for longitudinal rail restraint is included to control rail creep and pull apart in the event of a broken rail. Measurement of torsional resistance is included for use in assessing the risk of track buckling. The laboratory test for the effect of repeated loading is specified to assess the potential long term performance of the fastening in track. The test for clamping force is only suitable for laboratory use.

1 Scope

This European Standard is applicable to fastening systems, in categories A – C and E as specified in EN 13481-1:2012, 3.1, for use on rectilinear steel sleepers in ballasted track with maximum axle loads and minimum curve radii in accordance with Table 1.

Table 1 — Fastening category criteria

Category	Maximum design axle load kN	Minimum curve radius m
A	130	40
B	180	80
C	260	150
E	350	150
NOTE The maximum axle load for categories A and B does not apply to maintenance vehicles.		

The requirements apply to:

— fastening systems which act on the foot and/or web of the rail including direct fastening systems and indirect fastening systems;

— fastening systems for the rail sections in EN 13674-1 (excluding 49E4) and EN 13674-4+A1.

This standard is not applicable to fastening systems for other rail sections, rigid fastening systems or special fastening systems used at bolted joints or glued joints.

This standard is for type approval of a complete fastening assembly only.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 13146-1:2012, *Railway applications – Track – Test methods for fastening systems – Part 1: Determination of longitudinal rail restraint*

EN 13146-2:2012, *Railway applications – Track – Test methods for fastening systems – Part 2: Determination of torsional resistance*

EN 13146-4:2012, *Railway applications – Track – Test methods for fastening systems – Part 4: Effect of repeated loading*

EN 13146-5:2012, *Railway applications – Track – Test methods for fastening systems – Part 5: Determination of electrical resistance*

EN 13146-6:2012, *Railway applications – Track – Test methods for fastening systems – Part 6: Effect of severe environmental conditions*

EN 13146-7:2012, *Railway applications – Track – Test methods for fastening systems – Part 7: Determination of clamping force*

EN 13146-8:2012, *Railway applications – Track – Test methods for fastening systems – Part 8: In service testing*

EN 13146-9:2009+A1:2011, *Railway applications – Track – Test methods for fastening systems – Part 9: Determination of stiffness*

EN 13481-1:2012, *Railway applications – Track – Performance requirements for fastening systems – Part 1: Definitions*

EN 13674-1, *Railway applications – Track – Rail – Part 1: Vignole railway rails 46 kg/m and above*

EN 13674-4+A1, *Railway applications – Track – Rail – Part 4: Vignole railway rails from 27 kg/m to, but excluding 46 kg/m*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN 13481-1:2012 apply.

4 Symbols

For the purposes of this document, the following symbols apply.

F_{HFAmax} static preload applied in measurement of high frequency stiffness of assembly, in kN;

F_{LFA1} minimum force applied in measurement of dynamic low frequency stiffness of assembly, in kN;

F_{LFAmax} reference force for measurement of dynamic low frequency stiffness of assembly, in kN;

F_{LFP1} notional fastening clip force assumed for measurement of dynamic low frequency stiffness of pad, in kN;

F_{LFPmax} reference force for measurement of dynamic low frequency stiffness of pad, in kN;

F_{max} axial load at which gross slip occurs in the longitudinal rail restraint test (EN 13146-1:2012), in kN;

F_{SA1} notional fastening clip force assumed for measurement of static stiffness of assembly, in kN;

F_{SAmax} force applied to assembly in measurement of static stiffness of assembly, in kN;

F_{SP1} notional fastening clip force assumed for measurement of static stiffness of pad, in kN;

F_{Spmax} force applied to pad in measurement of static stiffness of pad, in kN;

k_{HFAD} transfer stiffness in measurement of high frequency stiffness of assembly, in N/m;

k_{LFA} low frequency dynamic stiffness of assembly, in MN/m;

L lateral component of force transmitted by the wheel to the rail head as shown in Figure 1, in kN;

P_L component of load parallel to the running surface of the rails, in kN;

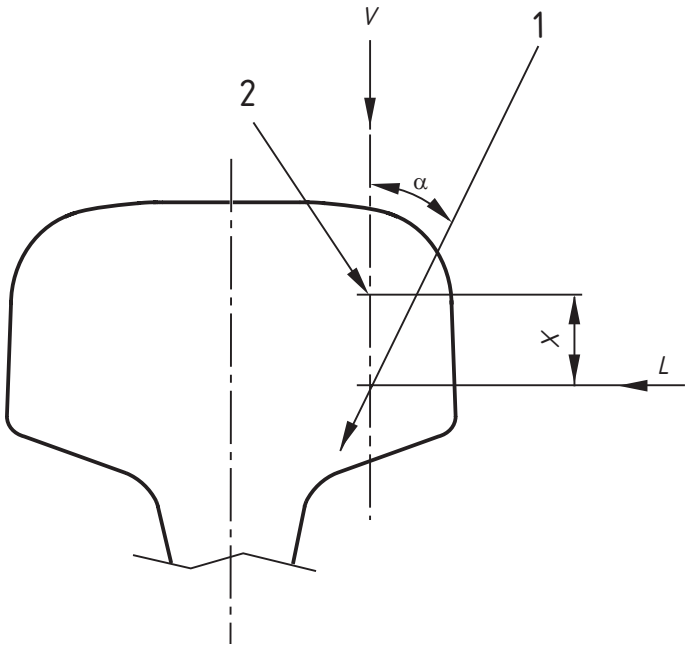
P_V component of load normal to the running surface of the rails, in kN;

V vertical component of load transmitted by the wheel to the running surface at the rail head as shown in Figure 1, in kN;

X distance between the line of application of P_L and the centre of the gauge corner radius of the rail head as shown in Figure 1, in mm;

α angle between the load line and a line normal to the running surface of the rails as shown in Figure 1, in °.

NOTE $\frac{L}{V} = \frac{P_L}{P_V} = \tan \alpha$



Key

1 line of load application
2 centre of gauge corner radius

Figure 1 — Load application position

5 Requirements

5.1 Longitudinal rail restraint

The longitudinal rail restraint shall be not less than 7 kN when measured by the procedure in EN 13146-1.

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On structures such as long bridges, the longitudinal force transmitted between the track and the structure may be calculated by the method in EN 1991-2. The value of F_{max} measured in accordance with EN 13146-1 may be used in the calculation. In such cases, and subject to agreement between the purchaser and manufacturer, the minimum requirement for longitudinal restraint may be reduced.

5.2 Torsional resistance

When required by the purchaser, the torsional resistance shall be measured by the procedure in EN 13146-2 and the result reported.

5.3 Pad and assembly stiffness

As required by EN 13146-4, the assembly static stiffness and assembly low frequency dynamic stiffness shall be measured in accordance with EN 13146-9+A1. Measurement of the rail pad static stiffness is required at the purchaser's discretion in accordance with EN 13146-8. If the purchaser requires any of the following it shall be measured in accordance with EN 13146-9+A1:

— pad low frequency dynamic stiffness;

— assembly high frequency dynamic stiffness.

Test loads are given in Table 2.

NOTE Guidance on the measurement of pad high frequency dynamic stiffness is given in EN 13146-9:2009+A1:2011, Annex A. For the measurement of assembly properties at acoustic frequency see EN 15461+A1.

Table 2 —Loads for measurement of stiffness

Fastening category	F_{SP1} and F_{LFP1} kN	F_{SPmax} and F_{LFPmax} kN	F_{SA1} and F_{LFA} kN	F_{SAmax} and F_{LFAmax} kN
A	16	51	1	32
B	18	64	1	43
C	18	85	1	64
E	20	119	1	95

5.4 Effect of repeated loading

As required by EN 13146-4, this shall be determined by the procedure in EN 13146-4 with the following addition: that sleepers shall be tested in accordance with EN 13146-4:2012, 7.4 and Figure 5, but the steel sleeper, or pair of sleepers, shall be supported on elastomeric soffit pads as described in Annex A.

The test loads and positions in Table 3 shall be used.

Table 3 — Test loads and positions

Fastening category	α [a] degrees	X [a] mm	$P_V/\cos\alpha$ kN [a,b]	
			$K_{LFA} < 200$ [c] MN/m	$K_{LFA} \geq 200$ [c] MN/m
A	38,6	25 [d]	55	55
B	38,6	25 [d]	62	65
C	33	15 [d]	75	83
E	40	75 [d]	100	108

[a] The positions and test loads apply only to rail sections included in EN 13674-1 (excluding 49E4) and EN 13674-4+A1.
[b] The test loads reflect the typical axle loads and curve radii in EN 13481-1:2012, 3.1.
[c] Low frequency dynamic stiffness of assembly measured, at 5 Hz, in accordance with EN 13146-9+A1.
[d] For web supported rail the rail section shall be unmodified (i.e. $X = 0$).

The following measurements shall be performed before and after repeated loading. The change in performance shall not exceed the values shown below. For fastening systems which support the web of the rail, the change in clamping force does not apply.

— Longitudinal rail restraint change ≤ 20 %;

— Vertical stiffness change ≤ 25 %;

— Clamping force change ≤ 20 %;

— Electrical resistance (see 5.5).

Compliance with Category E implies compliance with Categories C and E.

Compliance with Category B implies compliance with Categories A and B.

NOTE 1 The requirement for change in vertical stiffness is not applicable to fastening systems with a static stiffness ≥ 300 MN/m.

NOTE 2 The test result for electrical resistance is valid only for the section and steel thickness of the sleeper used for the test.

5.5 Electrical resistance

This shall be not less than 5 kΩ when measured in accordance with EN 13146-5. One only of the three sleepers shall be tested before and after the repeated load test in 5.4. The user may specify a higher value for use with certain track circuits. During the repeated load test sequence, the edges of the rail pad shall not be removed for the clamping force test. The clamping force test procedure for assemblies not incorporating a rail pad (EN 13146-7:2012, 7.3) shall be used with the pad in position.

NOTE This requirement relates to signalling currents only, not to traction currents. Guidance on traction currents is given in EN 50122-2.

5.6 Effect of exposure to severe environmental conditions

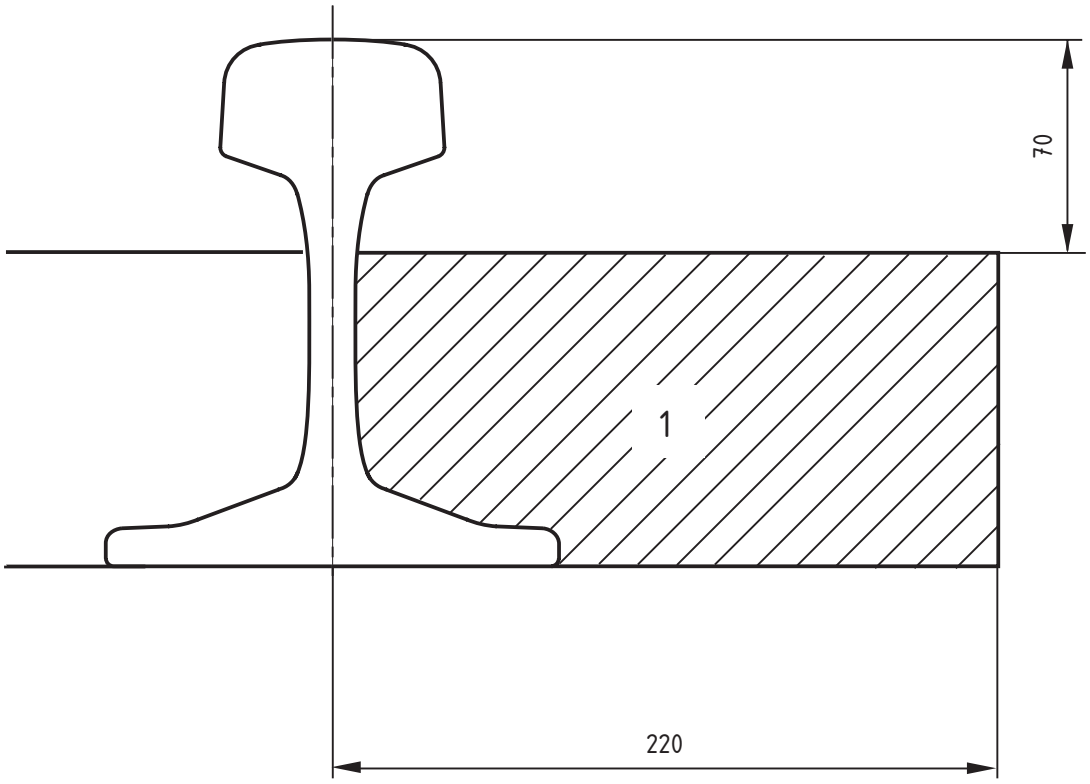
Following exposure to the salt spray test in accordance with EN 13146-6:2012, the fastening assembly shall be capable of being dismantled, without failure of any component and re-assembled using manual tools provided for this purpose.

5.7 Dimensions

The overall dimensions shall be within the envelope shown in Figure 2 to avoid interference with vehicles including track maintenance vehicles.

This requirement does not apply to web support fastening systems. For such fastening systems, the minimum flangeway shall comply with national regulations and the envelope of the fastening systems shall be provided by the supplier.

Dimensions in millimetres



Key

1 envelope for rail fastening assembly

NOTE 1 This is applicable to all rail sections in EN 13674-1 and EN 13674-4+A1 excluding 49E4.

NOTE 2 Envelope is symmetrical about rail centre line.

NOTE 3 Where an outside conductor rail is used, the width of the envelope is reduced to 180 mm.

Figure 2 — Envelope for rail fastening

5.8 Effect of fastening system tolerances on track gauge

Calculations shall be provided by the manufacturer to show the maximum variation in static track gauge which can arise from the fastening system. The calculations shall be based on the design dimensions of the rail section given in EN 13674-1 or EN 13674-4+A1 and shall include any assumption about the position of the rail within the fastening assembly and the tolerances on all component parts of the fastening system. It shall not include tolerances arising from the location of the fastening components in the sleeper or from any baseplate location. The variation in track gauge, calculated in this way, shall not exceed ± 1 mm.

The manufacturer shall also provide a drawing of the interface between the fastening system and the sleeper. This drawing shall include:

— the external gauge point of the rail fastening system which defines the track gauge (for example holes, pressed out features or elements welded to sleepers);

— the dimension and the tolerance between internal and external gauge points for the rail section for which the fastening assembly is designed;

— drawings with dimensions and tolerances of components of the fastening system;

— the design inclination of the rail seat.

5.9 Clamping force

This shall be determined by the procedure in EN 13146-7:2012. The result shall be reported.

This requirement is not applicable to web support fastening systems.

5.10 In-service testing

When required by the user, in-service testing shall be carried out in accordance with EN 13146-8:2012.

5.11 Attenuation of noise and vibration

Advice on the attenuation of noise and vibration is given in Annex B.

6 Test specimens

When used for type approval testing, the test specimens shall be provided by the organization commissioning the test. Any change in the materials or design of one or more components, which could affect performance in relation to the requirements of this European Standard, shall necessitate retesting of the complete fastening assembly.

7 Fitness for purpose

The manufacturer shall ensure that the fastening systems supplied comply with the requirements of this European Standard. Specifications for individual components shall be provided by the manufacturer at the time the assembly is presented for testing.

NOTE Users of this European Standard are advised to consider the desirability of quality system assessment and registration against EN ISO 9001 by an accredited third party.

8 Marking, labelling and packaging

Where there is adequate space for legible marking and no effect on performance, each component shall be permanently marked with raised or indented symbols or letters which identify the manufacturer and include the particular component reference. When components are packed in containers, each container shall be labelled with details of the components and with the production batch number or date of manufacture.

Annex A
(normative)

Effect of repeated loading – Steel sleeper configuration

A.1 Symbols

For the purposes of this annex the following symbols apply:

d_{max} average maximum deflection when measuring static stiffness of soffit pad, in mm;

d_{min} average minimum deflection when measuring static stiffness of soffit pad, in mm;

K_{SPS} static stiffness of soffit pad, in MN/m;

P_{Vmax} maximum load in measurement of soffit pad stiffness, in N;

P_{Vmin} minimum load in measurement of soffit pad stiffness, in N.

A.2 Test arrangement

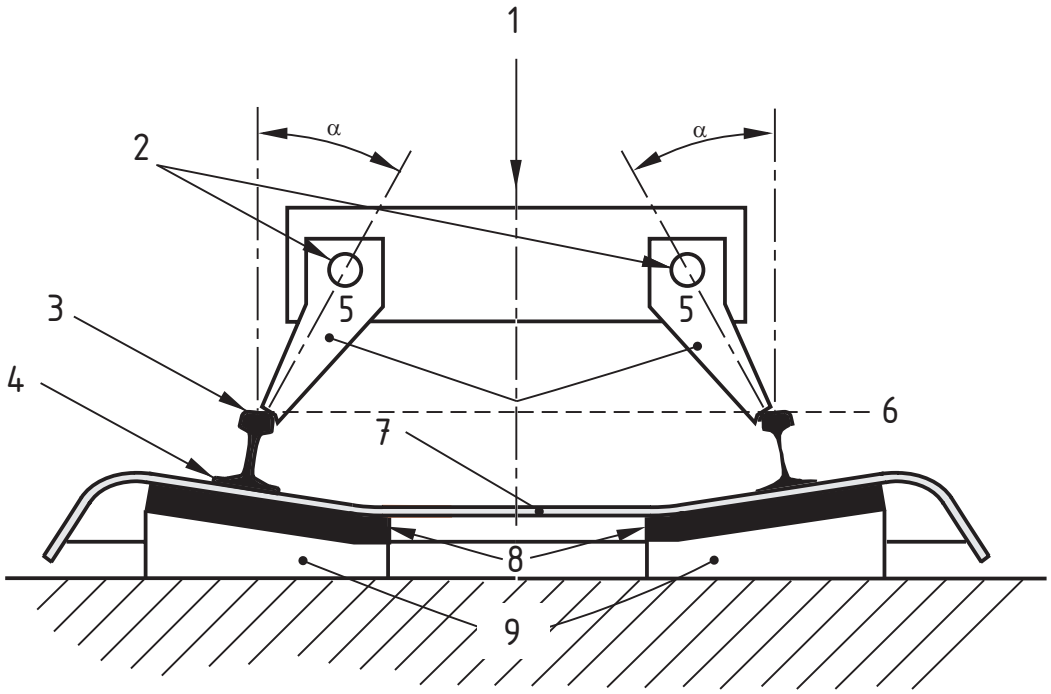
The sleeper, or two sleepers if required in accordance with EN 13146-4:2012, 6.1, are mounted as shown in Figure A.1. The sleeper is placed on elastomeric soffit pads so that the only contact between the sleeper and the supporting test rig is through the pads. The outer ends of the soffit pads shall be coincident with the outer end of the flat area adjoining the curved end of the sleeper. The dimensions of the soffit pads are shown in Table A.1.

Table A.1 — Soffit pad dimensions (mm)

Length	Width	Depth
800	Nominal width of sleeper soffit (+ 0 to − 5)	0,25 × shorter plan dimension of the pad
NOTE The soffit pad may be cut away to the minimum extent necessary to accommodate any projection of the rail fastening inside the sleeper trough.		

The secant stiffness of each pad shall be 28 MN/m to 40 MN/m. To verify that the soffit pad stiffness is correct, four displacement transducers are positioned around each rail seat to measure sleeper movement relative to the mounting block. The transducers shall be positioned adjacent to each side of the rail edge and either side of the fastening. The measurement shall be made between the maximum load $2P_V$ and a minimum of 10 kN (5 kN minimum vertical load per rail seat). The average sleeper displacement shall be calculated using Formula (A.1) at each rail seat, to determine the stiffness of each soffit pad.

$$K_{SPS} = \frac{P_{V\,max} - P_{V\,min}}{d_{max} - d_{min}} \qquad \text{(A.1)}$$



Key

1 load = $2P_V$
2 one or two pivots in the loading beam and one other pivot point above or below the actuator
3 short length of rail of the required section
4 fastening system with appropriate pad
5 loading mechanism which allows free rotation of the rail under load
6 plane of running surface
7 sleeper
8 soffit pad
9 mounting block on test rig

Figure A.1 — Test arrangement

A.3 Test report

In addition to the items listed in EN 13146-4:2012, Clause 9, the test report shall include the following information:

a) soffit pad dimensions and details of the material;

b) sleeper section dimensions and wall thickness.

Annex B
(informative)

Vibration and noise

B.1 General

The physical behaviour of the rail fastening system influences vibration transmitted into the track structure, and noise emitted from the track and the structure. Prediction models for structural and environmental vibration and noise may require input parameters which relate to this behaviour. In some situations, rail fastenings may be designed to control vibration transmission: in such cases these parameters are especially important.

This annex gives advice on the parameters and their use.

B.2 Symbols

For the purposes of this annex the following symbols and those in Clause 4 apply:

D_i insertion loss, in dB

k_{HFAD} transfer stiffness in measurement of high frequency stiffness of assembly, in N/m

j_ω $\sqrt{-1}$

k transfer stiffness, in N/m

Z_F foundation impedance, in dB

Z_O source impedance, in dB

B.3 Parameters for environmental vibration calculations

In order to predict or analyse environmental vibration and secondary noise caused by the passage of trains, it is necessary to know the stiffness of the rail fastening assembly subjected to vibration at appropriate amplitudes and frequencies. In general, it is not possible to replicate both the amplitude and the frequency in a small scale laboratory test.

Tests may be carried out with representative load amplitudes, at frequencies up to 20 Hz. When required, such tests should be carried out in accordance with EN 13146-9:2009+A1:2011, 7.2. The maximum load, F_{LFAmax}, is given in Table 2 and any test frequency may be specified in the range 3 Hz to 10 Hz. The result of this test is the low frequency dynamic stiffness of the fastening assembly, k_{LFA}, for the specified track category and frequency.

Tests may be carried out at higher frequencies, but only at very small amplitudes of load. When required, such tests are carried out in accordance with EN 13146-9:2009+A1:2011, 7.3. The pre-load F_{HFAmax} applied is 50 % of the maximum load, F_{LFAmax}, given in Table 2. The result of this test is a graph of transfer stiffness, k_{HFAD}, against frequency for the specified track category.

B.4 Calculating the vibration attenuation

The attenuation of a fastening system can be expressed in terms of the insertion loss (D_i) which describes the reduction in the level of sound power transmitted to the foundation.

For fastening systems that can be modelled by a single degree of freedom system of transfer stiffness k, the calculation, using Formula (B.1) involves the foundation impedance (Z_F) and the source impedance (Z_O).

$$D_i = 20\lg\left|1+\frac{j\omega Z_F Z_O}{kZ_F + Z_O}\right| \text{dB} \qquad \text{(B.1)}$$

The derivation of Z_F and Z_O cannot be given in general terms as it depends on details of the vehicles and track. Further information is given in [5].

B.5 Environmental noise

Many models used for prediction of railway noise require input of a value for rail fastening stiffness. This value is derived from the test procedure given in EN 15461+A1, which requires tests to be carried out on a complete panel of railway track.

Where such a panel of track is not available, and it is necessary to estimate the stiffness from tests on a single rail fastening assembly, indicative values of stiffness for noise prediction may be obtained by carrying out the test in EN 13146-9:2009+A1:2011, 7.3, but with no pre-load (i.e. $F_{HFAmax} \approx 0$).

Bibliography

[1] EN 1991-2, *Eurocode 1: Actions on structures – Part 2: Traffic loads on bridges*

[2] EN 15461+A1, *Railway applications – Noise emission – Characterisation of the dynamic properties of track sections for pass by noise measurements*

[3] EN 50122-2, *Railway applications – Fixed installations – Electrical safety, earthing and the return circuit – Part 2: Provisions against the effects of stray currents caused by d.c. traction systems*

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