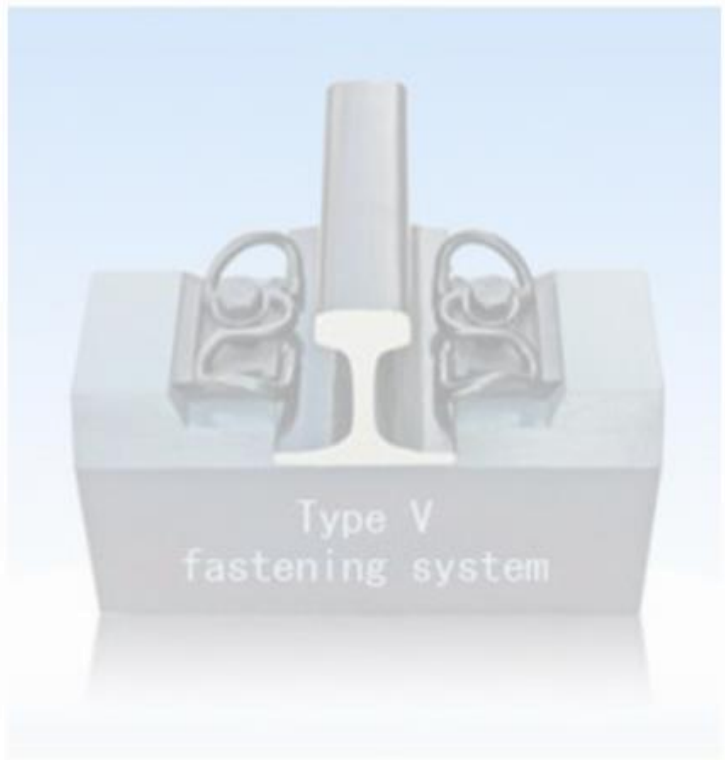
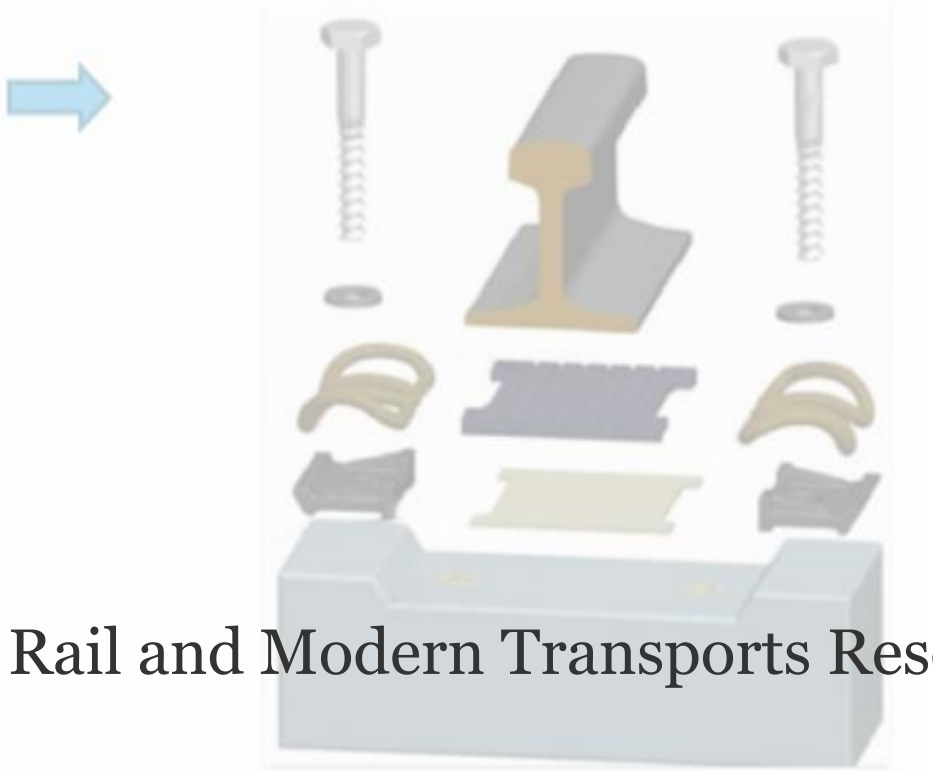
Test method and Requirements for Rail Fastening System





Sutee Olanrithinun

Rail and Modern Transports Research Center, NSTDA

Picture from *https://www.agicorailfasteners.com/railway-fastening-system.html*

Test method and requirements for rail fastening system

Functions of Rail Fastening System

- Fastening rail to a rail support
- Keeping a gauge width constant and its incline
- Transfer load from rail to the track support
- Attenuating of impact load and reducing vibration
- Facilitate track maintenance
- Provide electrical insulation

EN 13481- Railway applications - Track - Performance requirements for fastening systems

EN 13146- Railway applications - Track – Test Method for fastening systems

PERFORMANCE REQUIREMENTS FOR FASTENING SYSTEMS ON CONCRETE SLEEPERS

PERFORMANCE REQUIREMENTS FOR FASTENING SYSTEMS ON CONCRETE SLEEPERS

EN 13481- Railway applications - Track - Performance requirements for fastening systems,

- Part 1: Definition,
- 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 6 (European Prestandard): Special fastening systems for attenuation of vibration
- Part 7: Special fastening systems for switches and crossings and check rails
- Part 8: Fastening systems for track with heavy axle loads

PERFORMANCE REQUIREMENTS FOR FASTENING SYSTEMS ON CONCRETE SLEEPERS

EN 13481

Table 1 — Fastening category criteria

Category	Maximum design axle load kN	Minimum curve radius m
A	130	40
B	180	80
C	260	150
D	260	400
E	350	150
NOTE The maximum axle load for categories A and B does not apply to maintenance vehicles.		

PERFORMANCE REQUIREMENTS FOR FASTENING SYSTEMS ON CONCRETE SLEEPERS

Performance requirements for fastening systems for use on concrete sleepers in ballasted track include:

- longitudinal rail restraint,
- torsional resistance,
- attenuation of impact loads,
- effect of repeated loading,
- electrical resistance of fastening system and sleeper,
- effect of exposure to severe environmental conditions,
- overall dimensions,
- effect of fastening system tolerances on track gauge, clamping force,
- cast-in fastening components,
- and in-service testing

PERFORMANCE REQUIREMENTS FOR FASTENING SYSTEMS ON CONCRETE SLEEPERS

Required longitudinal rail resistance depends on the speed limit and the special requirements of substructure

- not less than 7 kN (controlled over the measurement process according to EN 13146-1) on the conventional rail lines
- not less than 9 kN on high-speed lines (≥250 km/h).

PERFORMANCE REQUIREMENTS FOR FASTENING SYSTEMS ON CONCRETE SLEEPERS

- The torsional resistance is measured in accordance with EN 13146-2

- For fastening systems having medium or high attenuation of dynamic loads, test shall be conducted in accordance with EN 13146-3
  - in the range from 15 % to 30 %
  - for high attenuation > 30 %

PERFORMANCE REQUIREMENTS FOR FASTENING SYSTEMS ON CONCRETE SLEEPERS

- **The electrical insulation shall be not less than 5 kΩ when measured in accordance with EN 13146-5**
  - The user may specify a higher value for use with certain track circuits

PERFORMANCE REQUIREMENTS FOR FASTENING SYSTEMS ON CONCRETE SLEEPERS

- **The effect of repeated loading shall be determined by the procedure defined in EN 13146-4 the following measurements shall be performed before and after repeated loading:**

- longitudinal rail restraint (permitted change ≤ 20 %),
- vertical static stiffness change (permitted change ≤ 25 %),
- clamping force (permitted change for fastening systems which act on the foot of the rail ≤ 20 %)

PERFORMANCE REQUIREMENTS FOR FASTENING SYSTEMS ON CONCRETE SLEEPERS

- **Effect of exposure to severe environmental conditions is determined in accordance with based on the salt spray test (EN-13146-6)**

  - After the test, the fastening assembly shall be capable of being dismantled, without failure of any component and reassembled

PERFORMANCE REQUIREMENTS FOR FASTENING SYSTEMS ON CONCRETE SLEEPERS

- **Clamping force for fastening systems (acting on the rail foot) shall be determined by the procedure prescribed in EN-13146-7 and the result shall be reported**

- **Effect of fastening system tolerances on track gauge**
  - The manufacturer shall provide a drawing of the interface between the fastening system and the sleeper
  - The variation in the static track gauge which can arise from the fastening system shall not exceed ±1 mm

- **Other specific requirements for fastening system must be defined by the customer**

TEST METHODS FOR RAIL FASTENING SYSTEMS

CEN/TC 256/SC 1
Railway applications / Infrastructure

Published standards

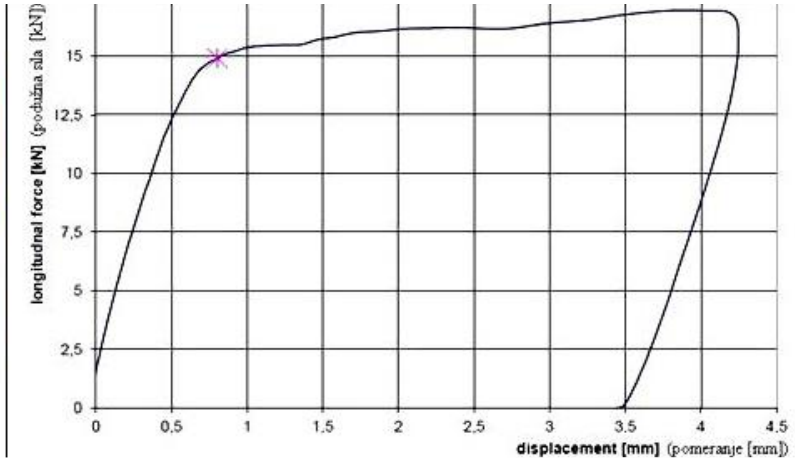
EN 13146-1:2012	Railway applications – Track – Test methods for fastening systems – Part 1: Determination of longitudinal rail restraint
EN 13146-2:2012	Railway applications – Track – Test methods for fastening systems – Part 2: Determination of torsional resistance
EN 13146-3:2012	Railway applications – Track – Test methods for fastening systems – Part 3: Determination of attenuation of impact loads
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

TEST METHODS FOR RAIL FASTENING SYSTEMS

EN 13146-1: Determination of longitudinal rail restraint

- determination of maximum axial load that can be applied to a rail, secured to a sleeper, bearer or element of slab track by a rail fastening assembly, without non-elastic displacement of the rail

1. Fastening assembly including rail pad
2. Short length of rail (about 0.5 m)
3. Sleeper or half sleeper, bearer or element of slab track
4. Load-displacement measuring and recording instrumens
5. Rigid support and restraint to prevent rotation



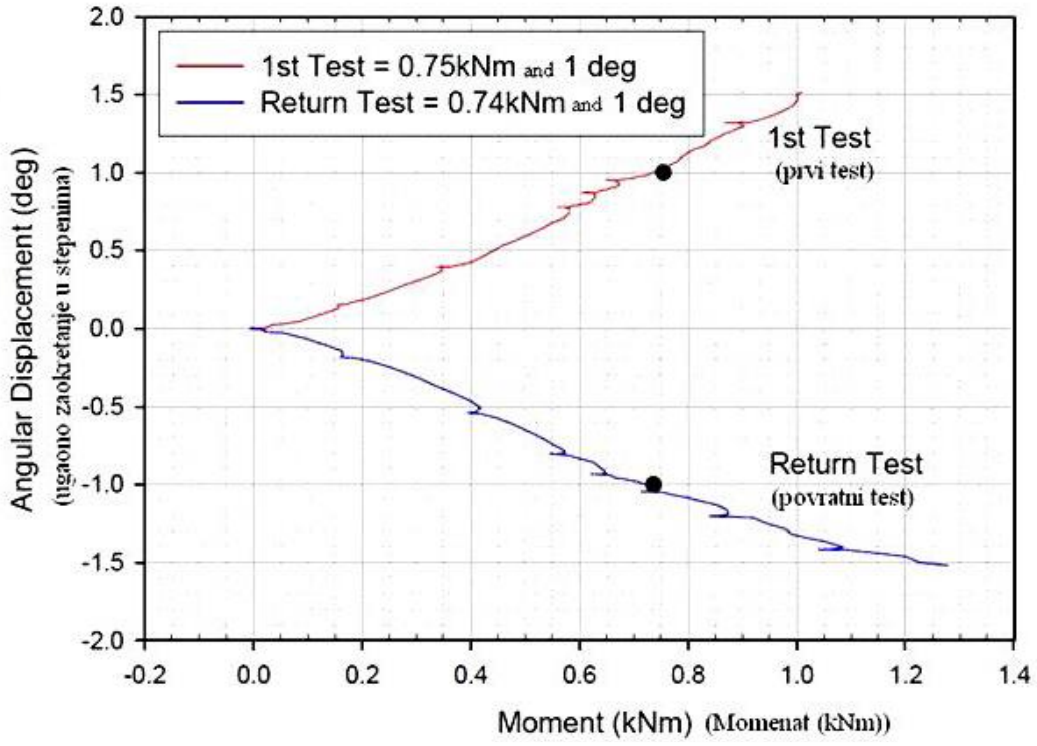
(with measured longitudinal rail restraint 15 kN)

Mićić, Milica, Popović, Zdenka, Lazarević, Luka, "Performance requirements for rail fastening systems on European railway network" in Proceedings / XVII Scientific-Expert Conference on Railways - RAILCON 16, October 13-14, 2016, Niš (2016):137-140

TEST METHODS FOR RAIL FASTENING SYSTEMS

EN 13146-2: Determination of torsional resistance

- determine torsional resistance of complete fastening assembly, which is measured as the moment necessary to rotate a rail through 1° in a plane parallel to the base of the support
- The obtained value of torsional resistance is used in track stability calculations



Mićić, Milica, Popović, Zdenka, Lazarević, Luka, "Performance requirements for rail fastening systems on European railway network" in Proceedings / XVII Scientific-Expert Conference on Railways - RAILCON 16, October 13-14, 2016, Niš (2016):137-140

TEST METHODS FOR RAIL FASTENING SYSTEMS

EN 13146-3: Determination of attenuation of impact loads

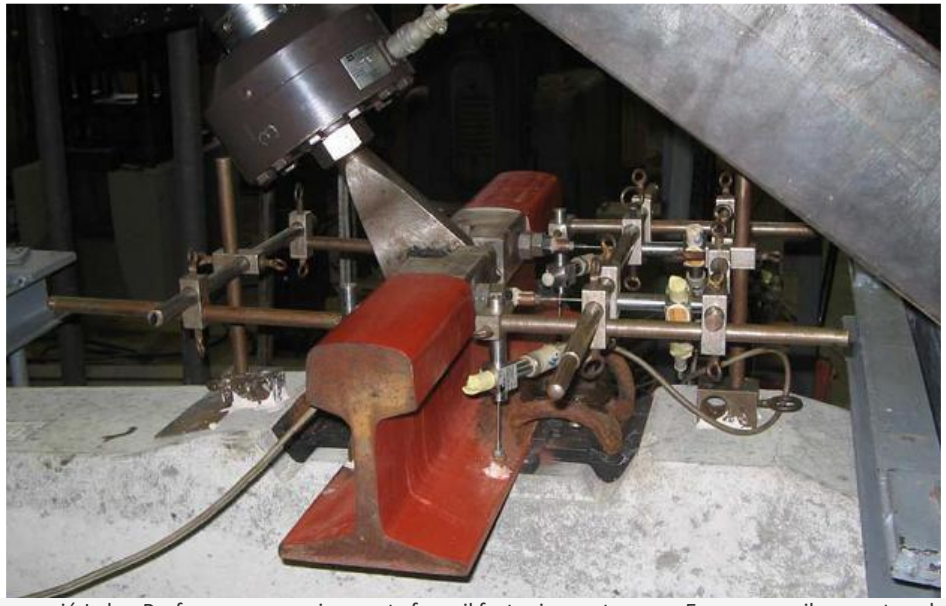
- comparing the strains induced with a low attenuation reference rail pad and with the test pad in the fastening system
- An impact load is applied by dropping a mass onto the rail head
- Rail is fastened to a concrete sleeper or bearer

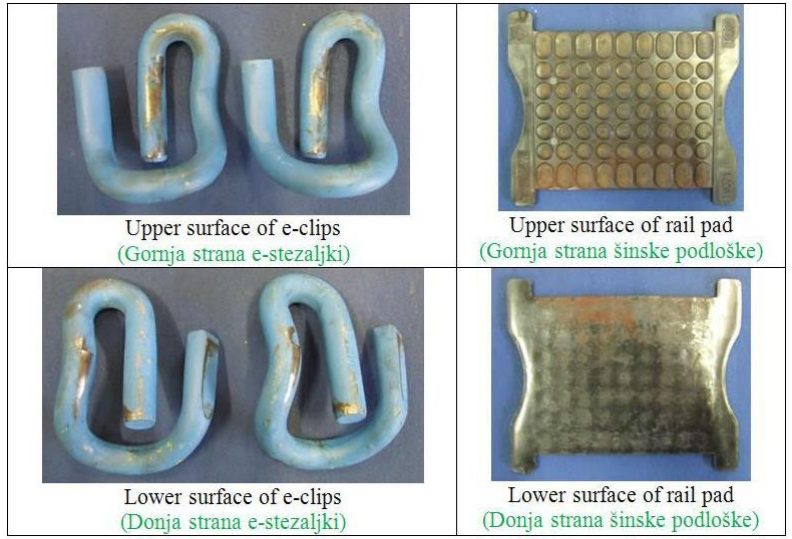
Mićić, Milica, Popović, Zdenka, Lazarević, Luka, "Performance requirements for rail fastening systems on European railway network" in Proceedings / XVII Scientific-Expert Conference on Railways - RAILCON 16, October 13-14, 2016, Niš (2016):137-140

TEST METHODS FOR RAIL FASTENING SYSTEMS

EN 13146-4: Determination of effect of repeated loading

- applying repeated loading which simulates the load caused by traffic on railway track
- used for assessing the long-term performance of fastening system
- test report contains result of visual inspection after the test, mean vertical static stiffness, longitudinal rail restraint, clamping force, mean dynamic rail displacement at the beginning and the end of the repeated load test, mean residual displacement at maximum load





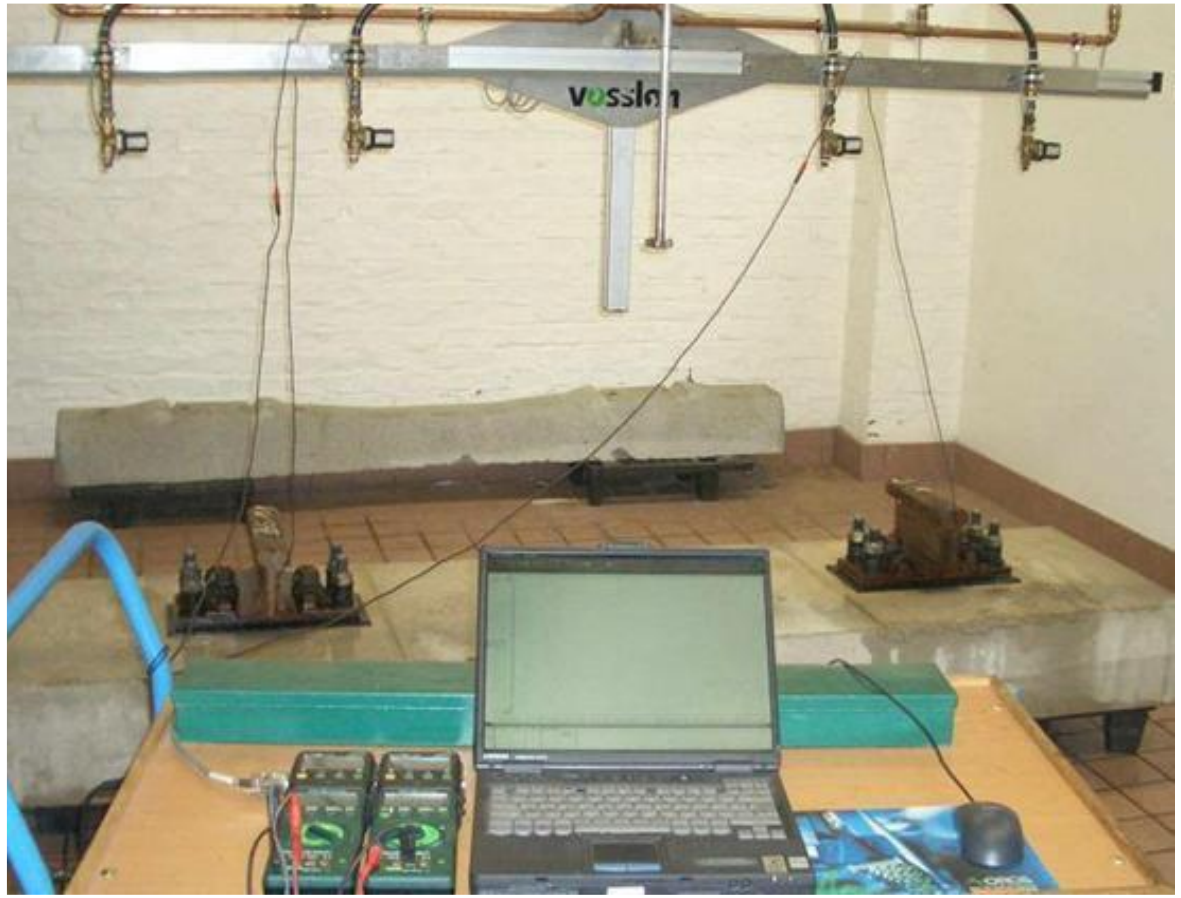
Fastening elements after repeated load test

Mićić, Milica, Popović, Zdenka, Lazarević, Luka, "Performance requirements for rail fastening systems on European railway network" in Proceedings / XVII Scientific-Expert Conference on Railways - RAILCON 16, October 13-14, 2016, Niš (2016):137-140

TEST METHODS FOR RAIL FASTENING SYSTEMS

EN 13146-5: Determination of electrical resistance

- determining electrical resistance in wet conditions
- The electrical resistance between two short lengths of rail fastened to the support (steel or concrete sleeper, bearer or element of slab track) is measured whilst the whole support and fastenings are sprayed with water at a controlled rate



Determining the electrical resistance in wet conditions in laboratory

Mićić, Milica, Popović, Zdenka, Lazarević, Luka, "Performance requirements for rail fastening systems on European railway network" in Proceedings / XVII Scientific-Expert Conference on Railways - RAILCON 16, October 13-14, 2016, Niš (2016):137-140

TEST METHODS FOR RAIL FASTENING SYSTEMS

EN 13146-6: Effect of severe environmental conditions

- determining the effects of severe environmental conditions on the fastening system
- During the test, the complete fastening assembly is exposed to a salt spray and the effect on ease of dismantling, and reassembly, and condition of individual components is recorded
- Test report includes change in appearance of each component during the test and any failure to dismantle or reassemble the fastening system

- The future revisions of this standard should include test procedures for covering other environmental conditions

The equipment for the salt spray test

Mićić, Milica, Popović, Zdenka, Lazarević, Luka, "Performance requirements for rail fastening systems on European railway network" in Proceedings / XVII Scientific-Expert Conference on Railways - RAILCON 16, October 13-14, 2016, Niš (2016):137-140

TEST METHODS FOR RAIL FASTENING SYSTEMS

EN 13146-7: Determination of clamping force

- measuring clamping force acting on the foot of a rail
- determined by measuring the force necessary to separate the rail from the surface on which it is supported

Test arrangement for measuring the vertical force necessary to separate the rail from support structure in laboratory

Mićić, Milica, Popović, Zdenka, Lazarević, Luka, "Performance requirements for rail fastening systems on European railway network" in Proceedings / XVII Scientific-Expert Conference on Railways - RAILCON 16, October 13-14, 2016, Niš (2016):137-140

TEST METHODS FOR RAIL FASTENING SYSTEMS

EN 13146-8: In service testing

- provides a procedure which can be used to compare the performance of new or modified fastening systems in track with systems whose performance is known
- The fastening system under test is installed in track at the same time and at the same conditions (the same grade and section of rail, sleepers, bearers or slab track of the same material and design, as well as location in track with similar geometry and service conditions) as a reference fastening system
- Length of the test section should not be less than 500 sleepers with installed test fastening system and 500 sleepers with installed reference fastening system
- Duration of the test corresponds to the traffic dynamics required to pass over the test track and shall not be less than one year

Mićić, Milica, Popović, Zdenka, Lazarević, Luka, "Performance requirements for rail fastening systems on European railway network" in Proceedings / XVII Scientific-Expert Conference on Railways - RAILCON 16, October 13-14, 2016, Niš (2016):137-140

TEST METHODS FOR RAIL FASTENING SYSTEMS

EN 13146-8: In service testing

Inspection of the test and reference fastening systems includes:

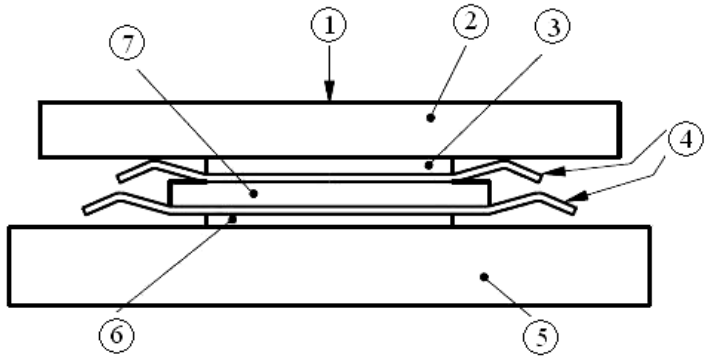
- track gauge measurement
- longitudinal movement of rail, relative to the sleeper or slab support, and maximum daily temperature range
- effect on performance of signaling systems
- clamping force (on not less than 10 assemblies) using the manufacturer's recommended test method for use in track
- security of attachment to the sleepers,
- condition of the rail head
- condition of sleepers including rail seat area
- condition of individual fastening components
- ease of assembly and removal using the tools recommended by the manufacturer

Mićić, Milica, Popović, Zdenka, Lazarević, Luka, "Performance requirements for rail fastening systems on European railway network" in Proceedings / XVII Scientific-Expert Conference on Railways - RAILCON 16, October 13-14, 2016, Niš (2016):137-140

TEST METHODS FOR RAIL FASTENING SYSTEMS

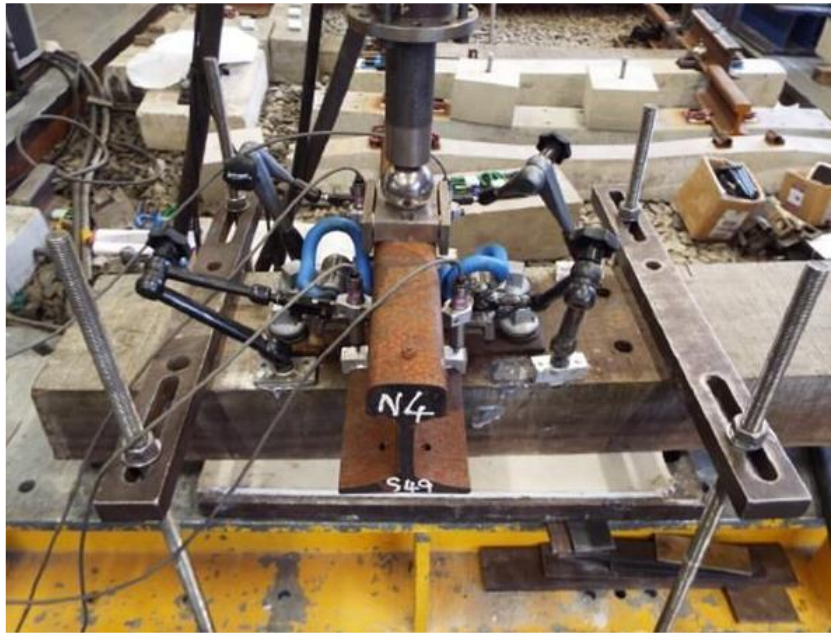
EN 13146-9: Determination of stiffness

- provides together test methods for measuring the stiffness of pads and fastening assemblies under static, low frequency and high frequency dynamic loading



1. force applied normal to the test pad
2. metal plate
3. upper load distribution plate
4. abrasive cloth
5. base
6. lower load distribution plate /if necessary/
7. pad to be tested

Test arrangement for measuring the stiffness of pad



Static and Dynamic stiffness test arrangement for complete rail fastening assemblies

Mićić, Milica, Popović, Zdenka, Lazarević, Luka, "Performance requirements for rail fastening systems on European railway network" in Proceedings / XVII Scientific-Expert Conference on Railways - RAILCON 16, October 13-14, 2016, Niš (2016):137-140

Example: The main technical parameters

No.	Item	Performance Index
1	Applied rail type	GB standard 60kg steel rail
2	Rail gauge	1435mm
3	Rail bottom slope	1:40 rail bottom slope is placed on the railway sleeper
4	Longitudinal resistance of rails	In general, the longitudinal resistance of each set of rail fastener and rails is larger than 9kN;
5	Elasticity of rail fastening system	The rail pad has a static stiffness of 50 to 70 kN/mm.
6	Fatigue performance	After 3 million load cycles, the fastener system has no damage, and the buckle pressure changes is less than 20%; the longitudinal resistance of the rail changes is less than 20%; the static stiffness of the joint changes is less than 25%.
7	Insulation resistance	The fastener system is tested according to **EN13146-5**, and the insulation resistance between the two rails is greater than 5kΩ.

Example: The main technical parameters

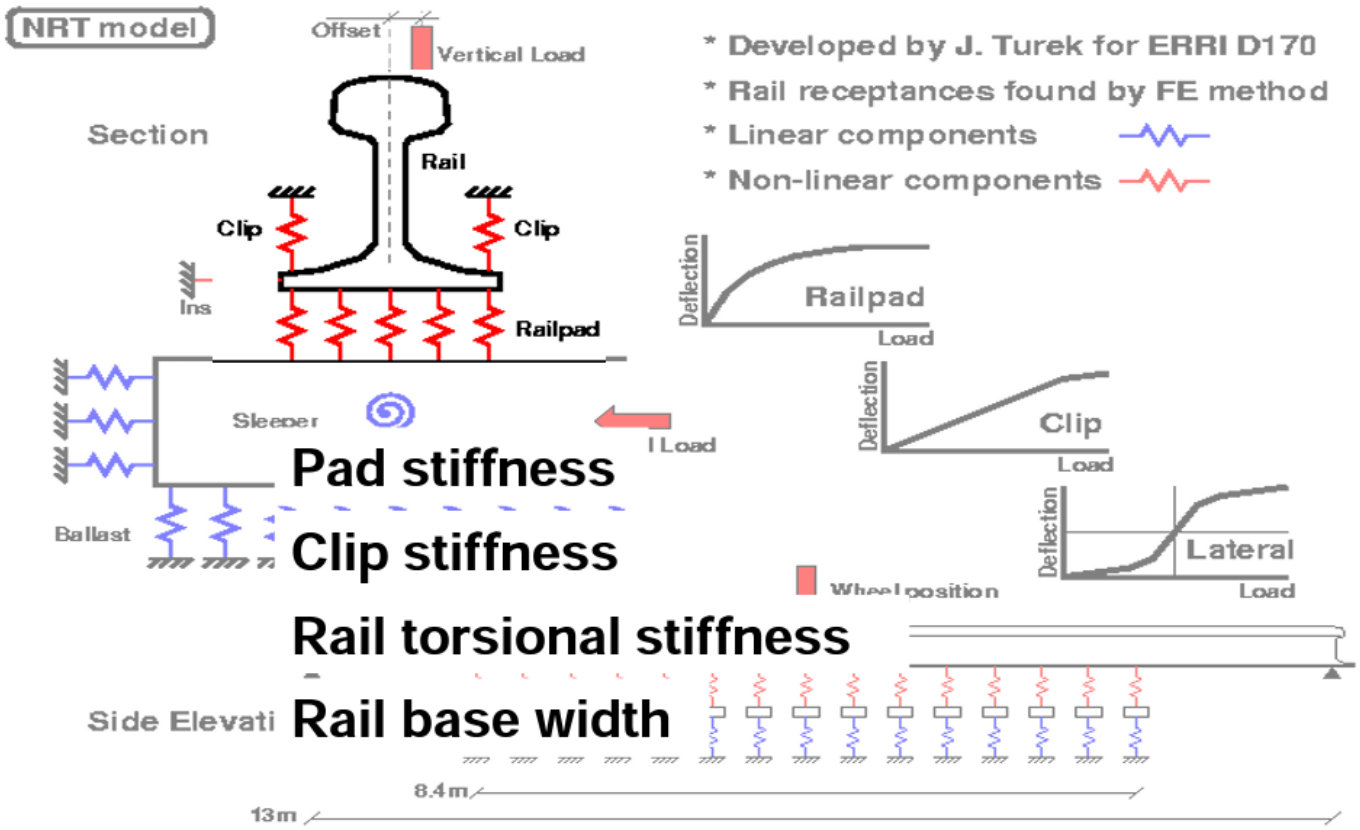
No.	Item	Performance Index
8	Harsh environmental conditions	The fastener system can be successfully disassembled with a manual disassembly tool after the 300h salt spray test described in **EN13146-6**.
9	Adjustment amount between left and right of rail	The adjustment of the left and right position of the single-strand rail: -4~+2mm; Rail gauge adjustment: -8 ~ +4mm, adjustment level is 1mm.
10	Rail height position	The adjustment amount is 0mm.
11	Buckle pressure and spring range	FC1504 type spring bar: buckle pressure is 10kN, spring range is 12mm; FC1306 type spring bar: buckle pressure is 3kN.
12	Pulling resistance of the embedded parts	pulling resistance of the embedded iron seat in the railway sleeper is not less than 60kN.

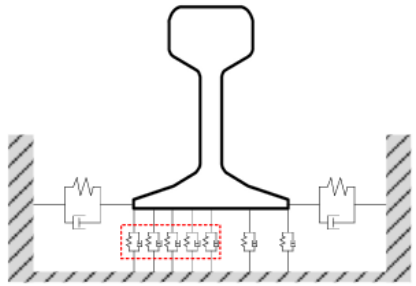
2.3 Specifications for fastening systems

- Transfer static loads from rail to track support (Parts 3,4)
- Maintain track gauge and rail inclination (Parts 4,6)
- Anchor rail to track support
  - … buckling (Part 2)
  - … pull-apart (Parts 1,7)
- Provide electrical insulation … (steel, concrete) (Part 5)
- Attenuate dynamic forces … (concrete, steel) (Part 3)
- Facilitate maintenance of track (Part 8)
- Durability (Parts 4,6,8)

Rail Fastening System Development

3.2 How much does the rail roll?



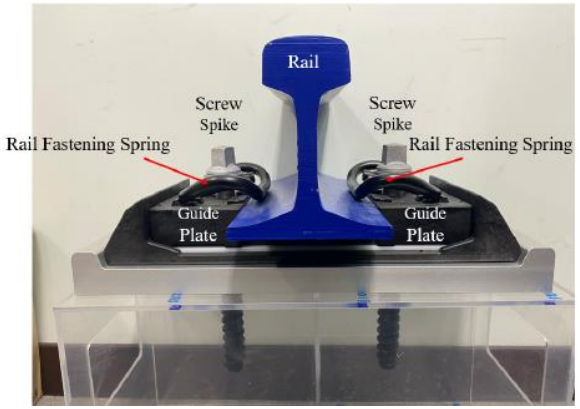


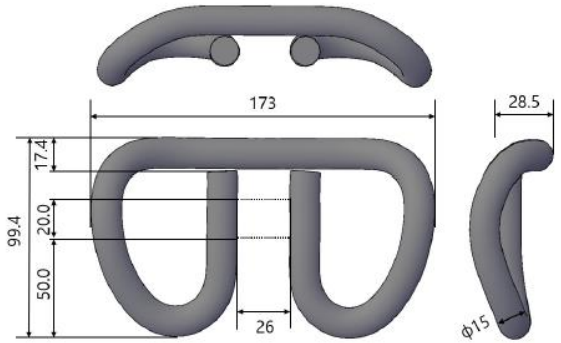
Theoretical design model of stiffness partitioning on the left and right sides of the rail pad

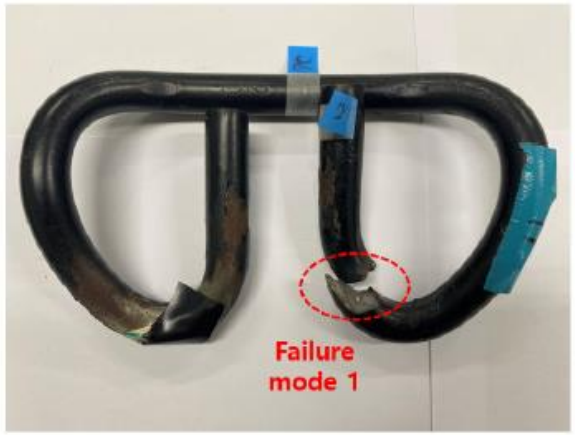
Structural design model of stiffness partitioning on the left and right sides of the rail pad

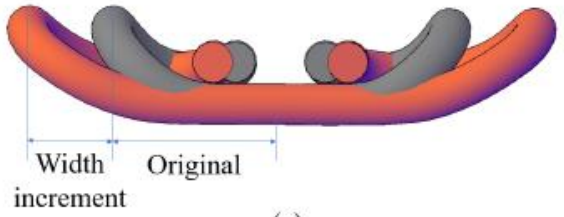
*Tientie group, Rail pads in fastener system

Example: Rail Clip Development in Korea









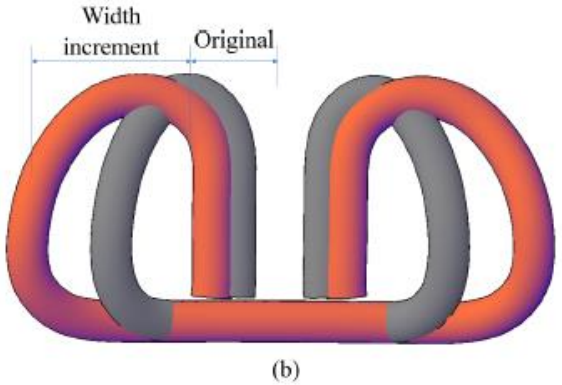
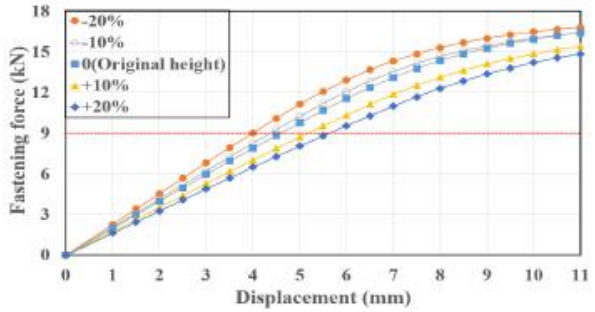
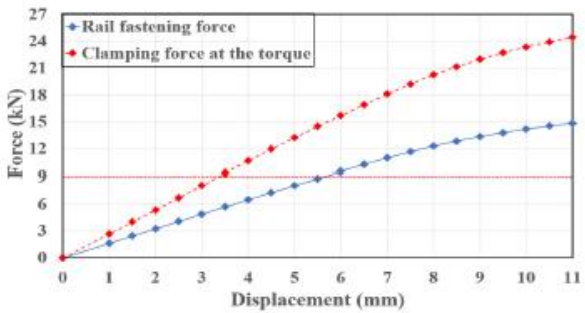
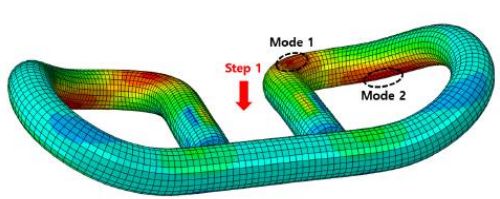
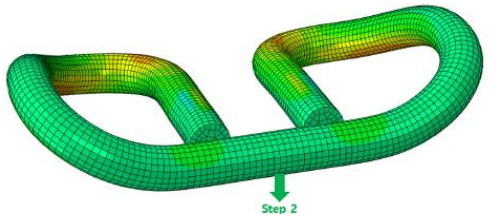


Figure 11. Perspective view of the change in the spring width: (a) front; (b) plan views.

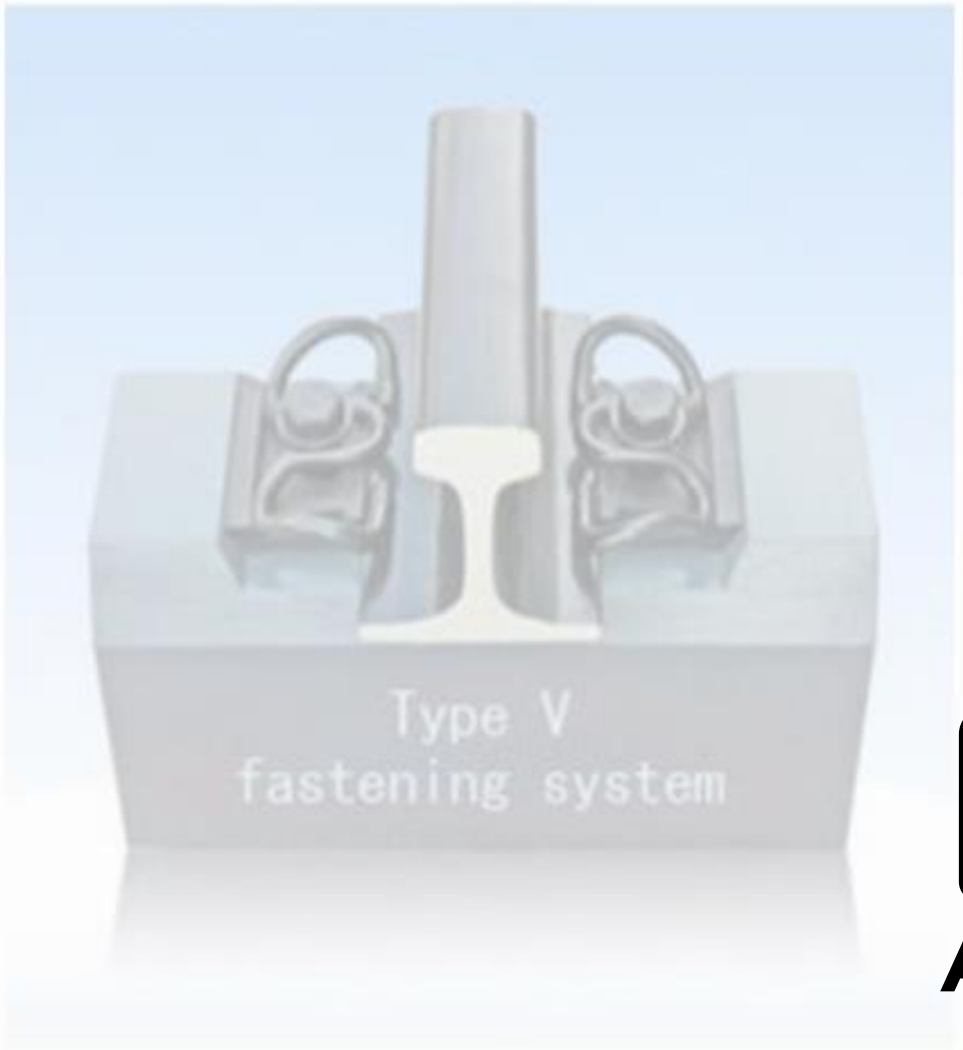


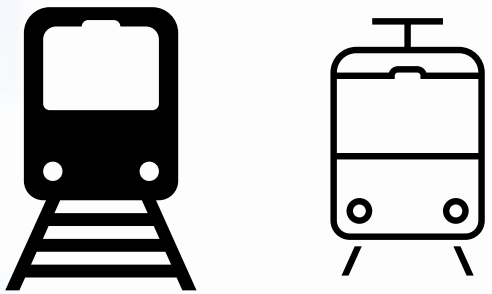


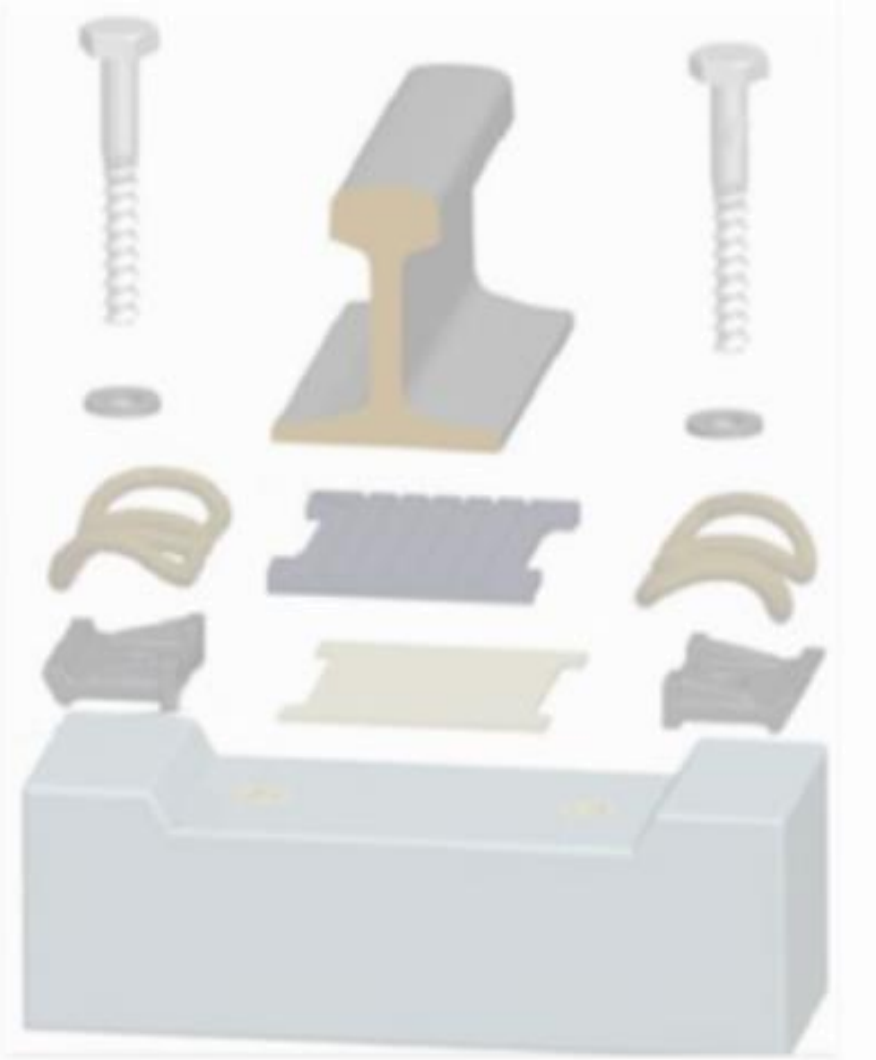




Fang, X.-J.; Park, Y.-C.; Hu, J.-W.; Sim, H.-B. Comparison of Fatigue Performances Based on Shape Change of Rail Fastening Spring. *Appl. Sci.* **2023**, *13*, 1770. https://doi.org/10.3390/app13031770







Picture from *https://www.agicorailfasteners.com/railway-fastening-system.html*