



BSI Standards Publication

# Railway applications — Infrastructure — Acceptance of works

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Part 1: Works on ballasted track — Plain line, switches and crossings

## National foreword

This British Standard is the UK implementation of EN 13231-1:2023. It supersedes BS EN 13231-1:2013, which is withdrawn.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 committee manager.

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English Version

## Railway applications - Infrastructure - Acceptance of works - Part 1: Works on ballasted track - Plain line, switches and crossings

Applications ferroviaires - Voie - Réception des travaux  
- Partie 1: Travaux de voie ballastée - Voie courante et  
appareils de voie

Bahnanwendungen - Oberbau - Abnahme von Arbeiten  
- Teil 1: Arbeiten im Schotteroberbau - Gleise, Weichen  
und Kreuzungen

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**CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels**

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## European foreword

This document (EN 13231-1:2023) 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of an identical text or by endorsement, at the latest by May 2024, and conflicting national standards shall be withdrawn at the latest by May 2024.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 13231-1:2013.

The main changes compared to the previous edition EN 13231-1:2013 are listed below:

- Enlargement of the scope by inclusion of:
  - requirements for substructure works as the quality of these works is substantial for the building of new tracks or the renewal of existing tracks;
  - conformity requirements of all track materials with the relevant acceptance criteria of the customer and the specifications provided by the supplier.
- New structure of this document in order to offer higher processability/workability and clearer responsibilities in the track works acceptance process as follows:
  - separate clause for acceptance process including acceptance procedure, responsibilities and warranty specifications;
  - separation of requirements for new tracks and renewal works from those for maintenance works; systematic treatment of requirements for working parameters and track components;
  - separate consideration of requirements for corresponding measuring systems and specific documentation of measurements in a normative Annex;
  - structured presentation of the requirements for positioning, functionality, safety dimension and quality checks for switches and crossings and rail expansion devices, and separate consideration of corresponding measuring devices in a normative Annex.
- Implementation of new available measurement technologies on tamping and stabilizing machines.
- Comprehensive clarification on tamping, ballast stabilizing and ballast cleaning processes and sustainable use of track ballast.
- Revision of the existing tolerances.
- Definition of new parameters and the respective tolerances.
- Improved coordination with EN 13848 series by systematic references.

This document is one of the EN 13231 series “*Railway applications — Track — Acceptance of works*” as listed below:

- *Part 1: Works on ballasted track — Plain line, switches and crossings* (the present document)
- *Part 2: Acceptance of reprofiling rails in plain line, switches, crossings and expansion devices*
- *Part 5: Procedures for rail reprofiling in plain line, switches, crossings and expansion devices*

Any feedback and questions on this document should be directed to the users' national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organisations 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, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.

## **Introduction**

The European rail network has a variety of different track construction types, track components, construction materials, working equipment and methods. These have evolved historically and are also a result from different geographical and climatic conditions.

Therefore, in some cases, this document provides only minimum requirements. Additionally, national regulations may apply for particular parameters.

## 1 Scope

This document specifies technical requirements and tolerances for the acceptance of works on ballasted track situated on:

- plain line;
- switches and crossings; and
- rail expansion devices as part of the track

for 1 435 mm and wider track gauge railways.

The works on ballasted track, hereafter referred to as track works, concern construction of new track, track renewal and track maintenance.

This document specifies the requirements for substructure works, track geometry, absolute track position, working parameters of on track machines, track components, ballast cross section, structure gauge, stressing works, specific measurements and quality checks for switches and crossings and rail expansion devices, and for the measuring systems used to perform measurements, verifications and checks for the scope of acceptance. Requirements for responsibilities and documentation necessary for the acceptance of track works are specified.

This document also requires compliance of all track materials with the customer's relevant acceptance criteria and specifications provided by the supplier.

This document does not cover works related to reprofiling the railhead or the associated measurements, except for some measurements related to safety, as these works are covered by other parts of EN 13231 series.

Platform reconstruction works and level crossing works are not covered by this document.

This document does not apply to urban rail systems or ballastless track.

## 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 932-1, *Tests for general properties of aggregates — Part 1: Methods for sampling*

EN 13145, *Railway applications — Track — Wood sleepers and bearers*

EN 13230 (all parts), *Railway applications — Track — Concrete sleepers and bearers*

EN 13232 (all parts), *Railway applications — Track — Switches and crossings*

EN 13450, *Aggregates for railway ballast*

EN 13481 (all parts), *Railway applications — Track — Performance requirements for fastening systems*

EN 13803, *Railway applications — Track — Track alignment design parameters — Track gauges 1 435 mm and wider*

EN 13848 (all parts), *Railway applications — Track — Track geometry quality*

EN 14033-2:2017, *Railway applications — Track — Railbound construction and maintenance machines — Part 2: Technical requirements for travelling and working*

EN 15273-1, *Railway applications — Gauges — Part 1: General — Common rules for infrastructure and rolling stock*

EN 15273-3, *Railway applications — Gauges — Part 3: Structure gauges*

### 3 Terms and definitions

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

ISO and IEC maintain terminology 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

##### **absolute track position**

position of the track measured from surrounding geodetic reference points

#### 3.2

##### **acceptance**

declaration of the customer to the contractor that the works have been achieved in accordance with the contract

##### 3.2.1

##### **acceptance process**

set of interrelated or interacting activities in order to deliver the acceptance

##### 3.2.2

##### **acceptance procedure**

specific way to carry out the acceptance process

#### 3.3

##### **Actuation Locking Detection System**

##### **ALDS**

system that ensures the correct movement and locking, and enables the verification of correct positioning of the moveable parts of switches and crossings

#### 3.4

##### **anti-creep device**

device to stop or limit relative longitudinal movement between switch and stock rails

#### 3.5

##### **ballast stabilization**

dynamic conditioning of the ballast bed which provides compaction of the ballast bed and an increase of the lateral track resistance

##### 3.5.1

##### **natural stabilization**

achieved by train passing in service or machine passing during construction

**3.5.2****artificial stabilization**

applied by means of ballast compacting tools or dynamic stabilising equipment

**3.6****bearer**

sleeper for switches and crossings and rail expansion devices

**3.7****design track gauge**

design value of track gauge for a given track section, which might be different from the nominal track gauge

[SOURCE: EN 13848-5:2017, 3.2]

**3.8****design value**

parameter adopted within the design phase/design process

**3.9****design track position**

position of the track, in a geodetic reference system, defined in the track design process

Note 1 to entry: The control of the design documents and layouts for new or upgraded tracks according to EN 13803-1 and EN 13803-2 or other regulations is not part of this document.

**3.10****deviation from design track position**

vertical and lateral difference between absolute track position and design track position

**3.11****fixed objects**

permanent objects along the track as platform, bridge, level crossing, multiple switches, overhead wire

**3.12****insulated rail joint**

mechanical rail joint with the additional function to separate the rail ends electrically

[SOURCE: EN 16843:2023, 3.7].

**3.13****maintenance**

all other works than construction of new track and renewal

**3.14****mechanical rail joint**

mechanical assembly, for example with fishplates to join two rail ends

[SOURCE: EN 16843:2023, 3.3].

**3.15****minor defect**

defect which does not reduce the functionality and/or lifetime of the track component

### 3.16

#### **neutral temperature**

temperature value, set by the customer based on the mean value of the lowest and highest expected rail temperature

Note 1 to entry: The customer may add an offset to the mean value in order to reduce the compressive forces in the rail at high temperatures.

#### 3.16.1

##### **neutral temperature range**

deviation from the neutral temperature

### 3.17

#### **neutralization**

stressing works of the rail involving release of the track to normal traffic at the nominal speed

### 3.18

#### **new track**

complete track construction on a new line where none existed before, applying new materials, including ballast and substructure material

### 3.19

#### **nominal track gauge**

reference value for track gauge used by individual networks

[SOURCE: EN 13848-5:2017, 3.1]

### 3.20

#### **OTM**

##### **on-track machine**

machine specially designed for construction and maintenance of the track and infrastructure as a self-propelling or as a hauled vehicle, when it is running on its own rail wheels

[SOURCE: EN 17343:2023, 3.1.7.8.1.1, modified (without Note 1 to entry and SOURCE)]

#### 3.20.1

##### **OTMM**

##### **track construction and maintenance machine**

self-propelled or hauled machine/vehicle which is used in construction, maintenance and/or improvement of the quality of the infrastructure and which is equipped with a track geometry measuring system

Note 1 to entry: OTMMs are a subset of on-track machines (OTM).

### 3.21

#### **plain line**

any section of track excluding switches and crossings and rail expansion devices

### 3.22

#### **pre-neutralization**

stressing works of the rail involving release of the track to normal traffic at a speed limit

**3.23****rail anchor**

device clamped to the rail foot, fitted close to sleeper, to prevent longitudinal displacement of the rail relative to the sleeper

**3.24****renewal**

replacement of track components, switches and crossings and rail expansion devices applying new materials, including the ballast and possibly formation layer material, if necessary

Note 1 to entry: Renewal can be complete renewal or partial renewal.

Note 2 to entry: The customer specifies, depending on the amount of the partial renewal, whether the limits for new tracks or maintenance shall be applied.

**3.25****sleeper anchor**

device placed in the middle or at the head of sleepers to increase lateral track resistance

**3.26****stress-free temperature**

rail temperature at which the rail is free of thermal stress

**3.27****substantial defect**

defect which reduces the functionality and/or lifetime of the track component

**3.28****tamping**

correction works of track geometry and absolute track position by machines or manually-operated devices

**3.29****tolerance**

permissible deviation from reference or designed value

**3.30****track components**

rails, welds, rail fastenings, sleepers and bearers, mechanical rail joints, insulated rail joints, anti-creep devices, sleeper anchors, ballast, under ballast mats

**3.31****track geometry**

geometric description of the track, characterized by the principal track geometric parameters: track gauge, longitudinal level, cross level, alignment and twist as described in EN 13848-1

**3.32****track geometry quality**

assessment of excursions in the vertical and lateral planes from the mean or designed geometrical characteristics of specified parameters which give rise to safety concerns or have a correlation with ride quality

## 4 Acceptance of track works

### 4.1 General

Acceptance is the declaration of the customer to the contractor, that specified works have been executed in accordance with the contract. Acceptance is achieved by following the acceptance process, in accordance with the acceptance procedure.

Acceptance shall only take place when the works have been completed in accordance with the requirements of the contract.

Works on ballasted track including plain line, switches and crossings and rail expansion devices cover:

- new track,
- renewal or partial renewal and maintenance of track components,
- removing and relaying existing track because of works on substructure (e.g. bridges, tunnels, earthworks, etc.),
- ballast cleaning and compacting,
- works to correct track geometry,
- stressing works and
- welding.

### 4.2 Acceptance process

The acceptance process begins when the contractor informs the customer of the completion of their works and requests the acceptance by means of a written notification.

Representatives of the customer and of the contractor take part in the acceptance process.

For the purpose of acceptance, each part of the track concerned shall be verified as follows:

- for the preliminary acceptance the customer shall carry out a series of checks and verifications in the frameworks of a preliminary acceptance as listed in 4.3.3;
- for the acceptance of new tracks or renewal works, measurements and verifications shall be performed according to the requirements specified in Clause 5;
- for the acceptance of maintenance works, measurements and verifications shall be performed according to the requirements specified in Clause 6.

In case of substantial defects, acceptance should be postponed until their elimination or shall be the subject of negotiation between both parties. Substantial defects shall be documented (e.g. in an acceptance form, report, etc.).

In case of minor defects, acceptance should be granted either with reservations or with allowance and should be documented (e.g. in an acceptance form, report, etc.) as well as, when required, the period granted for their elimination.

The result of the acceptance shall be documented in written form, outlining the results achieved according to 4.3.4.

## 4.3 Acceptance procedure

### 4.3.1 Deadlines

Acceptance procedure shall take place after the written notification from the contractor has been registered. The time interval between notification and date of acceptance shall be specified by the customer in the contract.

### 4.3.2 Responsibilities

After the completion of works, the contractor shall notify the customer in writing that the preliminary procedure to the acceptance can be carried out.

The customer and contractor shall specify in the contract who will carry out the measurements, verifications and checks and how they will be documented.

The customer shall carry out the preliminary procedure for the acceptance of the works.

The personnel and equipment necessary for carrying out the preliminary acceptance procedure shall be provided by the contractor or by the customer in accordance with the contract.

### 4.3.3 Preliminary procedure to the acceptance

The preliminary procedure to the acceptance consists of the following operations:

- checking volume and extent of the works carried out;
- checking the records of the measurements and tests according to the contract;
- checking the documents according to the contract (e.g. drawings, notes of calculations, measuring reports, certificates of used material and of measuring instruments, quality control, etc.);
- listing of works not executed in accordance with the contract;
- listing of non-conformities (missing documents, certificates of used material and of measuring instruments, other evidence).

### 4.3.4 Results of the acceptance process

The consequences of the acceptance process shall be notified to the contractor as follows:

- acceptance is granted; or
- acceptance is granted with reservations; or
- acceptance is granted with allowance; or
- acceptance is not granted.

If the acceptance is granted with reservations, the contractor shall take the necessary actions to correct the defects and/or supply the missing documents within the period of time as agreed in the contract. After completion of corrective works, the preliminary acceptance procedure shall again be applied to the corrected defects.

If the acceptance is granted with allowance, the customer decides, in accordance with the contract, which defects, if any, shall not be corrected and shall be the subject of negotiation between both parties.

If the acceptance is not granted, the contractor shall take the necessary actions to fulfil the acceptance requirements as specified in the contract. After completion of the acceptance requirements, the acceptance procedure shall again be applied.

#### 4.3.5 Warranty

The warranty is a contractual term and specifies the right of the customer to have defects corrected by the contractor even after acceptance, if the customer can prove that the defect is a result of an incorrect (faulty) production by the contractor. The warranty is limited by a warranty period which shall be specified in the contract together with the warranty conditions and which starts after acceptance.

## 5 Acceptance of plain line, switches and crossings and rail expansion devices – new track and renewal

### 5.1 General

Prior to acceptance and depending on the type of track works, measurements and checks shall be carried out on new or renewed plain line and switches and crossings and rail expansion devices manually, or by automatic means, and shall be documented.

The measurements and checks shall be carried out as follows:

- substructure works as specified in 5.2, see also Figure 1;
- track geometry of plain line, switches and crossings and rail expansion devices as specified in 5.3;
- absolute position of plain line, switches and crossings and rail expansion devices as specified in 5.4;
- working parameters of on track machines:
  - tamping works as specified in 5.5.2;
  - ballast compaction and stabilization works as specified in 5.5.3;
  - ballast replacement/cleaning works as specified in 5.5.4;
- track components:
  - rails as specified in 5.6.2;
  - welds as specified in 5.6.3;
  - mechanical rail joints as specified in 5.6.4;
  - insulated rail joints as specified in 5.6.5;
  - rail fastening systems as specified in 5.6.6;
  - sleeper spacing, bearer spacing, out of squareness of sleepers and bearers and voiding of sleepers and bearers as specified in 5.6.7, 5.6.8, 5.6.9 and 5.6.10;
  - ballast as specified in 5.6.14;
  - under ballast mat as specified in 5.6.15;
  - substructure material as specified in 5.6.16, see also Figure 1;

- ballast cross section as specified in 5.7;
- structure gauge as specified in 5.8;
- neutralization works as specified in 5.9;
- specific measurements and quality checks for switches and crossings and rail expansion devices as specified in 5.10;
- damage caused to rails, sleepers, bearers, fastenings, cables and other track equipment, as well as displacements of the sleepers, bearers or rail pads which occurred during the works;
- compliance of all track materials with the customer's relevant acceptance criteria or specifications, in particular acceptance of associated works as well as approval and acceptance of the material provided by the contractor.

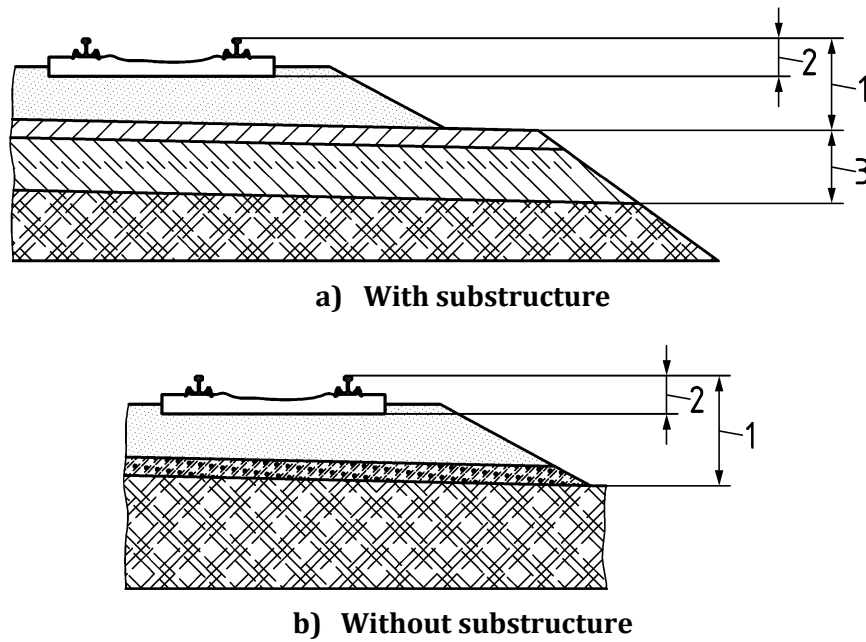
Documentation shall consist of a report substantiated with figures and objective observations, justifying how acceptance criteria has been met. It shall be signed and dated by the author.

The customer may request additional documented measurements or checks, if contractually agreed.

## 5.2 Substructure works

The substructure layers, see Figure 1, shall be produced according to the following requirements:

- the load-bearing and deformation behaviour is as homogeneous as possible;
- the load-bearing capacity and frost resistance are not impaired by impurities or fine grain accumulations;
- no segregation of the grain mixture occurs;
- even compaction with an appropriate water content is undertaken;
- avoiding of grain fragmentation.

**Key**

- |   |                 |
|---|-----------------|
|   | ballast         |
|   | formation layer |
|   | subgrade        |
|   | subballast      |
|   | subsoil         |
| 1 | superstructure  |
| 2 | track panel     |
| 3 | substructure    |

**Figure 1 — Ballast track cross section**

The grain mixture itself shall be frost-resistant and frost-proof, have specified soil-mechanical properties and shall withstand the stresses during installation and in traffic.

The geometric and soil-mechanical properties of the substructure layers shall be inspected for acceptance at certain intervals, that shall be specified by the customer.

The customer shall specify the geometric requirements for the substructure layers, the minimum values for soil-mechanical properties and the content of material certificate as follows:

- a) geometric requirements:
- cross section;
  - thickness of the substructure layers;
  - gradient of the substructure layers;
  - flatness of the substructure layers.

- b) soil-mechanical minimum properties:
  - degree of compaction of the material (usually Proctor density, e.g. 90 % of the maximum value);
  - load-bearing capacity (stiffness measured using a load plate, dynamic or static).
- c) the material certificate shall contain:
  - grain size distribution;
  - frost criteria;
  - percentage of crushed and broken surfaces.

The customer may request different values for different speed classes.

The customer may specify other requirements for renewals.

Adequate drainage is required to ensure the proper function of the substructure layers. Requirements for acceptance should be specified by the customer but are outside of the scope of this document.

### 5.3 Track geometry quality

Accepted track (including switches and crossings and rail expansion devices) shall comply with the tolerances shown in Table 1.

Definitions for track geometry parameters and requirements for measurement and analysis methods are specified in the EN 13848 series.

The tolerance limits in Table 1 are specified for loaded track measurements, which are recommended. For unloaded track measurements, the customer shall specify the tolerances for the track geometry parameters, which may be stricter.

The customer specifies whether OTMMs or other devices, depending on the type of the track, are permitted to be used when measuring the track geometry. Requirements for the measuring systems and the measurement methods are specified in A.2.

In case of partial renewal, the customer shall specify whether Table 1 or Table 28 or a combination of both is applicable. The values of the tolerances should be specified by the customer.

For tracks built with used materials, including switches and crossings and rail expansion devices, the tolerances for the parameters shall be specified by the customer.

For track geometry measuring systems working with a chord and a space curve output, the space curve output should be used.

The time of acceptance shall be specified in the contract.

**Table 1 — Track geometry quality – Acceptance tolerances for loaded track - new track and renewal**

| Parameters                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | Type class         |                   |                    |                    |                    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-------------------|--------------------|--------------------|--------------------|
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | I                  | II                | III                | IV                 | V                  |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | Speed range (km/h) |                   |                    |                    |                    |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | $v \leq 80$        | $80 < v \leq 120$ | $120 < v \leq 160$ | $160 < v \leq 230$ | $230 < v \leq 360$ |
| Track gauge for plain line (mm)<br>(deviation from design value <sup>a</sup> )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | +4,0<br>-3,0       | +4,0<br>-3,0      | +4,0<br>-2,0       | +4,0<br>-2,0       | +4,0<br>-2,0       |
| Track gauge for switches and crossings and rail expansion devices <sup>b</sup> (mm)<br>(deviation from design value <sup>a</sup> )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | +4,0<br>-3,0       | +4,0<br>-3,0      | +4,0<br>-3,0       | +4,0<br>-3,0       | +4,0<br>-3,0       |
| Cross level (mm)<br>(deviation from design value <sup>a</sup> )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | ±3,0               | ±3,0              | ±3,0               | ±3,0               | ±3,0               |
| 10 m chord longitudinal level (mm) <sup>c</sup><br>(mean-to-peak)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | ±7,0               | ±5,0              | ±4,0               | ±3,5               | ±3,5               |
| D1 Longitudinal level (mm)<br>(mean-to-peak)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          | ±5,0               | ±3,5              | ±3,0               | ±2,5               | ±2,5               |
| D2 Longitudinal level (mm) <sup>d</sup><br>(mean-to-peak)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | N/A                | N/A               | N/A                | ±3,0               | ±2,0               |
| 10 m chord alignment (mm) <sup>c</sup><br>(mean-to-peak)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | ±6,0               | ±4,5              | ±3,5               | ±3,5               | ±3,5               |
| D1 Alignment (mm)<br>(mean-to-peak)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | ±4,5               | ±3,5              | ±2,5               | ±2,5               | ±2,5               |
| D2 Alignment (mm) <sup>d</sup><br>(mean-to-peak)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | N/A                | N/A               | N/A                | ±3,0               | ±2,0               |
| Twist (mm/m) considering a 3 m base-length <sup>e</sup><br>(deviation from design value to peak)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | ±1,5               | ±1,0              | ±1,0               | ±1,0               | ±1,0               |
| <p><sup>a</sup> In many cases customers have specified a design gauge of 1 437 mm in plain line. In curves with small radius significantly higher design gauges may be used.</p> <p><sup>b</sup> In addition to the requirements for switches and crossings and rail expansion devices, the requirements from 5.10.3 apply. Special design of switches and crossings and rail expansion devices with gauge widening or anomaly of running edges as described in Annex B, may be considered. For additional specification see national regulation.</p> <p><sup>c</sup> Divided e.g. 6 m / 4 m.</p> <p><sup>d</sup> The values given are a recommendation.</p> <p><sup>e</sup> In case of high design twist (e.g. in short transition curves), less stringent tolerances for twist may be used in order to comply with the twist limits as specified in EN 13848-5.</p> |                    |                   |                    |                    |                    |

The rate of change of track gauge should be specified by the customer, if needed.

In addition to limiting the peak values according to Table 1, the track quality of longitudinal level (standard deviation over 200 m) should not be worse than the track quality class B according to

EN 13848-6 along the entire/whole tamping section. As the track quality classes specified in EN 13848-6 are defined in the *D1* domain, the track quality tolerances specified in EN 13848-6 should be adapted according to Annex C if chord measurements are used.

## 5.4 Absolute track position

Accepted track (including switches and crossings and rail expansion devices) shall comply with the acceptance tolerances in this clause.

Absolute track position should be determined by means of measurements referenced to a defined network of survey points, consisting of geodetic fixed points and geodetic referenced points, see also A.3.

In order to ensure lifting reserves during the lifetime of the track, tolerances in the vertical position should be set accordingly.

Acceptance tolerance range for deviation from design track position should be:

- 30 mm (e.g.  $\pm 15$  mm) for vertical position;
- 20 mm (e.g.  $\pm 10$  mm) for horizontal position.

The time of acceptance shall be specified in the contract.

When acceptance is completed directly after the tamping works the tolerance values may become stricter.

Requirements for the surveying measurements and corresponding measuring systems are specified in A.3.

The tolerance range may be stricter for:

- high speed lines;
- area of fixed objects (e.g. bridges, platforms, tunnels);
- curves with small radius (e.g.  $r < 600$  m); and
- switches and crossings and rail expansion devices.

Distance between tracks shall be measured, when required, by the customer. The tolerances are specified by the customer.

## 5.5 Working parameters of on track machines (OTMs)

### 5.5.1 General

Many working parameters have significant influence on the quality and the sustainability of track works. Often, they cannot be checked after completion of the works, therefore the parameters listed in the following clauses should be measured during the working process according to A.4.

### 5.5.2 Tamping

#### 5.5.2.1 General

The quality of the works of the tamping machines should be evaluated and documented by measuring the working parameters specified by the customer according to A.4.

#### 5.5.2.2 Lift and shift of track

The permitted maximum lift and shift value of track per tamping pass is dependent on the construction of the track (type of rails, sleepers and fastenings), on the geometrical dimensions of the tamping machine (bending line of the rail) and, on the required compaction.

To obtain a precise and durable track quality, the maximum lift and shift value of the track per tamping pass shall be specified by the customer.

To avoid rail overstressing, the maximum lift and shift shall not exceed the requirements specified in EN 14033-2.

When lifting and shifting the track during tamping works, the requirements specified in EN 14033-2:2017, Table 1, regarding tensile stress in the rail, apply.

Newly manufactured machines should be able to digitally record the lift and shift performed for each rail and at each tamping cycle.

**NOTE** The lift and shift of track in this clause describes the performed track movements by means of the tamping unit (lifting and shifting unit) during each tamping process.

### 5.5.2.3 Penetration depth of tamping tools

The penetration depth of the tamping tools is defined as the difference between top of the rail and the upper line of the tamping tool plate. The penetration depths applied during the tamping works depend on the construction height of the track (height of rails, sleepers and rail fastening systems).

The tamping depth should be selected in such a way that the distance between the lower face of the sleeper (including under sleeper pads) and the upper line of the tamping tool plate is in the range of 15 mm to 20 mm, see Figure 2.

Dimensions in millimetres

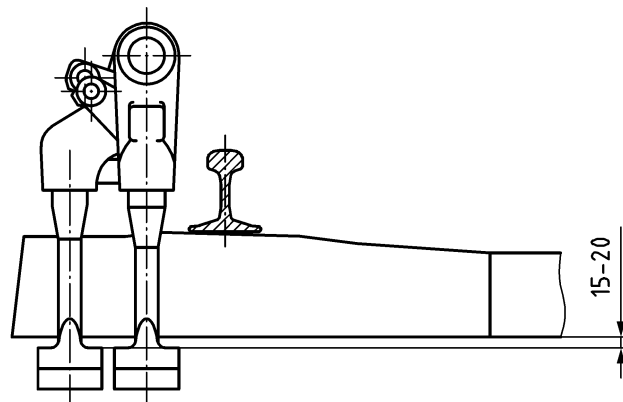


**Figure 2 — Distance tamping tool plate to sleeper**

The values for the penetration depth shall be specified by the customer. The penetration depth of the tamping tools during tamping should be documented.

A change of the track structure height requires adjustment of the tamping depth of the tamping tools. This adjustment shall be documented.

Newly manufactured machines should be able to digitally record the penetration depth of the tamping tools during each tamping process.

### 5.5.2.4 Squeezing time of tamping tools

The values for the squeezing time shall be specified by the customer.

The squeezing time of the tamping tools is dependent on the grain size of the track ballast, the density of the ballast bed (e.g. fouling) and the determined lift value of the track.

For every squeezing, one measurement shall be carried out. The squeezing time should not be less than 0,8 s.

The total squeezing time should be in the range of 0,8 s to 1,2 s.

#### **5.5.2.5 Quality control factors of tamping works**

According to A.4.2.

#### **5.5.2.6 Measuring systems – Documentation of functional test and calibration**

A functional test of the track measuring system shall be carried out before and may be carried out after each tamping operation according to the manufacturer's manual. The results of the functional test shall be documented.

The functional test can be not needed if an inertial measurement unit (IMU) based track geometry measuring system is used.

The calibration of the track geometry measuring system shall be carried out according to EN 13848-3. Validation and calibration of other measuring systems (e.g. working parameters) shall be carried out according to the manufacturer's manual.

### **5.5.3 Ballast compaction and stabilization works**

#### **5.5.3.1 General**

During new track construction or renewal works, the different layers of ballast should be successively compacted in order to have the whole ballast bed in a settled condition and to preserve the quality of the new track geometry.

The compacting of the ballast bed could be done by surface compacting tools or dynamic stabilizing units. For more information, see A.4.3.

For the stabilization of the ballast bed, a natural or a mechanical stabilization should be applied.

The mechanical stabilization aims to simulate the passage of traffic while preserving the track geometry and should be preferred to natural stabilization.

The customer shall specify whether track works stabilized by dynamic stabilizing units (equipment) or by surface compacting tools are accepted.

An assessment and acceptance shall take place considering the measurement and documentation of the working parameters (done by the machine), as specified in A.4.3. The customer shall specify these parameters.

#### **5.5.3.2 Working parameters**

The customer shall specify the values and tolerances of the working parameters to be set for the track stabilization or surface compacting tools.

The values and tolerances should be specified by considering the track characteristics such as type of rail and sleeper, ballast condition, maintenance or renewal works and the required compaction level.

#### **5.5.3.3 Acceptance measurements**

Machines equipped with surface compacting tools (head or crib compactors) work at a fixed frequency. They should be equipped with a system recording at least the following parameters for each compaction cycle:

- vertical load or pressure;
- duration of compaction works.

Machines equipped with dynamic stabilizing units should record the following additional parameters:

- vibration frequency;
- imbalance variation;
- working speed.

#### **5.5.4 Ballast replacement/cleaning works**

##### **5.5.4.1 General**

An assessment and acceptance shall take place by measuring and documenting the working parameters as specified in A.4.4. The customer shall specify these parameters.

The customer shall specify whether the works performed by ballast replacement/cleaning machines, unequipped or partially equipped with systems able to measure ballast replacement/cleaning working parameters, are accepted.

If unequipped machines are used, the data can be collected manually. In this case, the customer shall determine the extent of data collection.

In case of ballast replacement, the new ballast shall meet the criteria of the customer.

##### **5.5.4.2 Degree of fouling**

After ballast replacement/cleaning, sampling shall be carried out to verify the degree of fouling. The number of samples depends on the length of the construction site. At least one sample should be taken per construction site or, if necessary, one sample every 800 m shift.

The samples shall be taken from the discharge conveyor belts, which bring the cleaned ballast into the ballast bed. The procedure of sampling shall be carried out in accordance with EN 932-1.

The degree of fouling (expressed in mass percentage of grains < 22,4 mm) after ballast bed cleaning should not be higher than that for new ballast in accordance with EN 13450, taking into account the regrinding of new ballast during transport in accordance with EN 13450.

##### **5.5.4.3 Flatness and crossfall**

Ballast replacement and ballast cleaning machines should be equipped with systems that can measure flatness of the track formation surface. Alternatively, flatness can be measured with a 4 m batten.

The deviation from a 4 m straight line should be a maximum of  $\pm 30$  mm in the cross section.

The crossfall determines the direction and quality (reliability) of water drainage. Ballast replacement and ballast cleaning machines should be equipped with systems that can measure the crossfall.

The crossfall shall be determined by the customer before the works (e.g. 5 %). The deviation should be a maximum of  $\pm 1$  %. Track sections on which the specifications cannot be met for certain reasons (e.g. railway crossing) shall be clearly documented.

##### **5.5.4.4 Excavation depth and width**

The excavating depth is the thickness of the ballast bed that is removed by the track maintenance machine for cleaning or complete removal. Ballast replacement and ballast cleaning machines should be equipped with systems that can measure the excavating depth.

The required excavating depth and width shall be determined by the customer before the works. The deviation of the excavation depth should be a maximum of  $\pm 25$  mm for on-track ballast bed rehabilitation and a maximum of  $\pm 30$  mm for off-track ballast bed rehabilitation.

Sections of track in which the specifications cannot be met for certain reasons (e.g. existing structures) shall be clearly recorded and substantiated.

#### **5.5.4.5 Lateral track guidance**

The tolerance for lateral deviation of track position from design track position after ballast cleaning works should be specified by the customer (typically  $\pm 20$  mm).

### **5.6 Track components**

#### **5.6.1 General**

Rail fastening systems shall comply with EN 13481 (all parts). Concrete sleepers shall comply with EN 13230 (all parts) and wood sleepers shall comply with EN 13145. Ballast material shall comply with EN 13450.

For acceptance of the track works, a quality check of all components shall be carried out according to the relevant standards to ensure that the track is free of defects and correctly installed.

#### **5.6.2 Rails**

Rails are covered by EN 13231-2, EN 13231-5, EN 16729 (all parts) and EN 17397-1.

#### **5.6.3 Welds**

The acceptance of welding works including traceability and identification in conjunction with track works is covered by EN 14730 (all parts) and EN 14587 (all parts). Recording of parameters for flash-butt welding shall be done according to A.5.1. Further non-destructive testing shall be required to verify the integrity of the welds if specified by the customer.

#### **5.6.4 Mechanical rail joints**

Requirements for mechanical rail joints and corresponding test procedures are covered by EN 16843.

The nominal value for gaps in mechanical rail joints shall be specified by the customer depending on rail temperature, rail length and fastening system.

Maximum permissible tolerances for gaps, dips and peaks at mechanical rail joints shall be specified by the customer.

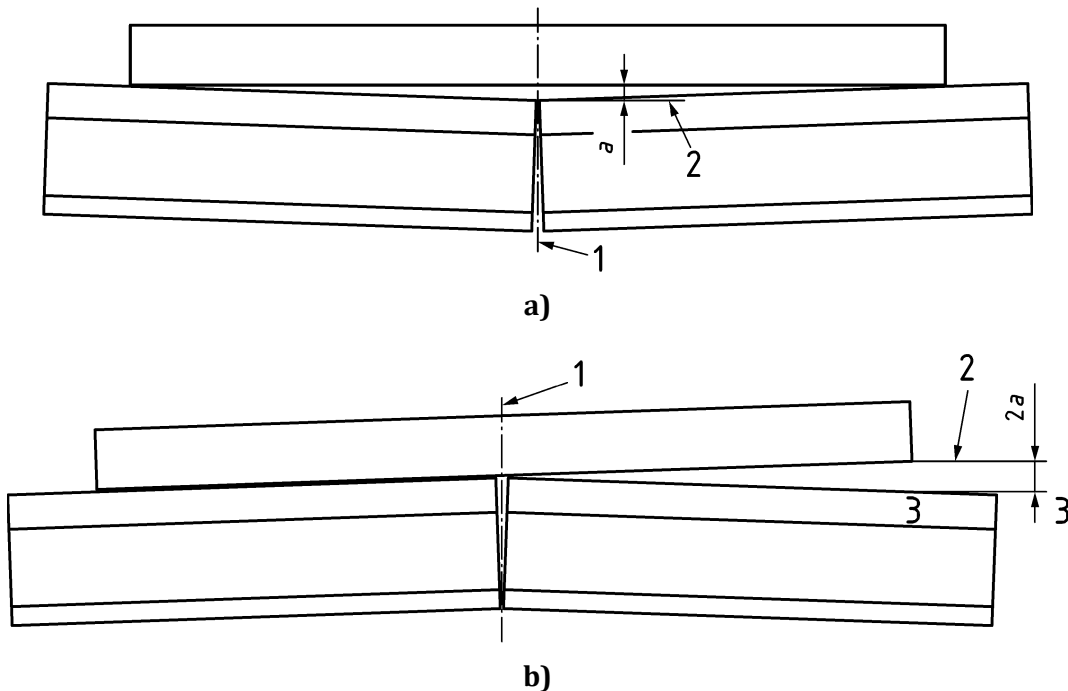
#### **5.6.5 Insulated rail joints**

Requirements for type approval and for acceptance of insulated rail joints and corresponding test procedures are covered by EN 16843.

The customer shall specify the acceptance criteria for installation of insulated rail joints.

Dips shall not exceed 0,5 mm on railhead and 0,5 mm on running edge, both over 1 m.

The vertical dip (value "a") of an insulated rail joint shall not exceed the value specified by the customer, see Figure 3.

**Key**

|                |                                                                                                             |
|----------------|-------------------------------------------------------------------------------------------------------------|
| $a$            | vertical dip value                                                                                          |
| $2a$           | double value of vertical dip $a$ , which occurs at the rail's centreline of joint longitudinal position     |
| 1              | horizontal position of centreline of joint between two rails; vertical centreline of measurement instrument |
| 2 (Figure 3 a) | vertical position of top of the rail at centreline of joint location                                        |
| 2 (Figure 3 b) | vertical position of lower edge of measurement instrument, measured at measurement instrument's end         |
| 3              | vertical position of top of the rail, measured at the measurement instrument's end                          |

**Figure 3 — Measurement of vertical dip or hog for insulated rail joints**

### 5.6.6 Rail fastening systems

Rail fastening systems are specified in EN 13481 (all parts).

All rail fastening systems shall be complete and correctly fitted according to the manufacturers technical specifications and customer's instructions.

The customer shall specify the inspection criteria and the corresponding tolerances needed to ensure the required clamping force of the rail fastening systems.

In general, visual inspection of the rail fastening system shall be carried out continuously over the entire length of the construction site during the works. The inspection criteria shall be checked and documented according to the customer's requirements.

If a deviation from the specified criteria is detected during the inspection of the rail fastening system, verification and corrective actions should also be carried out and documented for all rail fastening systems since the last verification and documentation.

The contractor may use other assessment methods when proving the correlation between the alternative and the prescribed measurement method. Tightening torque for example may be used as an orientation value for screws.

Requirements for the documentation of fastening works are specified in A.5.2.

### 5.6.7 Sleepers and bearers

Concrete sleepers and bearers are covered by EN 13230 (all parts).

Wood sleepers and bearers are covered by EN 13145.

Steel sleepers and bearers are covered by ISO 6305-3.

Polymeric composite sleepers and bearers are covered by ISO 12856-1 and plastic sleepers and bearers are covered by prEN 17318 (all parts).

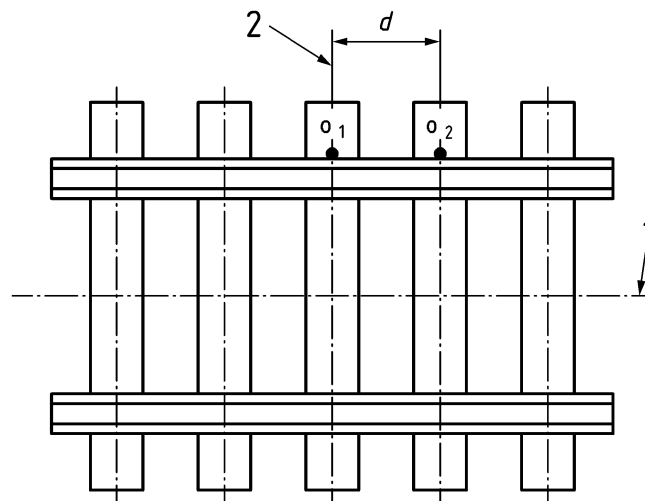
Visual inspection shall take place in order to detect minor and substantial defects on sleepers and bearers.

### 5.6.8 Sleeper spacing

Permissible deviation from the designed sleeper spacing  $d$  should be  $\pm 20$  mm (except at welds or other justifiable cases) and shall be verified by sampling, see Figure 4. Checking shall be made at least every 200 m on 10 consecutive sleepers.

The number of sleepers within 1 000 m shall not vary by more than 1 % of the designed number of sleepers.

Additional requirements for sleeper spacing measurement are specified in A.5.3.



#### Key

- $d$  sleeper spacing
- 1 longitudinal axis of rail track
- $o_1, o_2$  positions of outer rail fastenings (e.g. screws, clamps, etc.)
- 2 longitudinal axis of a sleeper

**Figure 4 — Measurement of sleeper spacing**

### 5.6.9 Bearer spacing

Permissible deviation from the designed bearer spacing in individual cases shall be  $\pm 10$  mm.

Additional requirements for bearer spacing measurement are specified in A.5.4.

### 5.6.10 Out of squareness of sleepers and bearers

This subclause is only applicable on customer's request.

Permissible deviation from squareness of sleepers shall be  $\pm 10$  mm, see Figure 5.