BS EN 12663-2:2010+A1:2023

BSI Standards Publication



# Railway applications — Structural requirements of railway vehicle bodies

Part 2: Freight wagons

bsi.

# National foreword

This British Standard is the UK implementation of EN 12663-2:2010+A1:2023. It supersedes BS EN 12663-2:2010, which is withdrawn.

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# EUROPEAN STANDARD

# NORME EUROPÉENNE

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**EN 12663-2:2010+A1**

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English Version

## Railway applications - Structural requirements of railway vehicle bodies - Part 2: Freight wagons

Applications ferroviaires - Prescriptions de dimensionnement des structures de véhicules ferroviaires - Partie 2 : Wagons de marchandises

Bahnanwendungen - Festigkeitsanforderungen an Wagenkästen von Schienenfahrzeugen - Teil 2: Güterwagen

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



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# Contents

# European foreword

This document (EN 12663-2:2010+A1:2023) 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of an identical text or by endorsement, at the latest by April 2024, and conflicting national standards shall be withdrawn at the latest by April 2024.

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A1⟩ *Deleted text* ⟨A1

This European Standard is part of the series EN 12663, *Railway applications — Structural requirements of railway vehicle bodies*, which consists of the following parts:

— *Part 1: Locomotives and passenger rolling stock (and alternative methods for freight wagons)*

— *Part 2: Freight wagons*

This document supersedes A1⟩ EN 12663-2:2010 ⟨A1.

A1⟩ *Deleted text* ⟨A1

A1⟩ 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.

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## Introduction

The structural design and assessment of freight wagon bodies depend on the loads they are subject to and the characteristics of the materials they are manufactured from. Within the scope of this European Standard, it is intended to provide a uniform basis for the structural design and assessment of the vehicle body.

The loading requirements for the vehicle body structural design and assessment are based on proven experience supported by the evaluation of experimental data and published information. The aim of this European Standard is to allow the supplier freedom to optimize his design whilst maintaining requisite levels of safety considered for the assessment.

## 1 Scope

This European Standard specifies minimum structural requirements for freight wagon bodies and associated specific equipment such as: roof, side and end walls, door, stanchion, fasteners and attachments. It defines also special requirements for the freight wagon bodies when the wagon is equipped with crashworthy buffers.

It defines the loads sustained by vehicle bodies and specific equipment, gives material data, identifies its use and presents principles and methods to be used for design validation by analysis and testing.

For this design validation, two methods are given:

— one based on loadings, tests and criteria based upon methods used previously by the UIC rules and applicable only for vehicle bodies made of steel;

— one based on the method of design and assessment of vehicles bodies given in [A1⟩ EN 12663-1:2010+A2:2023 ⟨A1]. For this method, the load conditions to be applied to freight wagons are given in this European Standard. They are copied in the [A1⟩ EN 12663-1:2010+A2:2023 ⟨A1] in order to facilitate its use when applied to freight wagons.

The freight wagons are divided into categories which are defined only with respect to the structural requirements of the vehicle bodies.

Some freight wagons do not fit into any of the defined categories; the structural requirements for such freight wagons should be part of the specification and be based on the principles presented in this European Standard.

The standard applies to all freight wagons within the EU and EFTA territories. The specified requirements assume operating conditions and circumstances such as are prevalent in these countries.

## 2 Normative references

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

[A1⟩

EN 12663-1:2010+A2:2023, *Railway applications - Structural requirements of railway vehicle bodies - Part 1: Locomotives and passenger rolling stock (and alternative method for freight wagons)*

EN 13749:2021, *Railway applications - Wheelsets and bogies - Method of specifying the structural requirements of bogie frames*

EN 15551:2022, *Railway applications - Railway rolling stock - Buffers*

EN 15663:2017+A1:2018, *Railway applications - Vehicle reference masses*

⟨A1]

## 3 Terms and definitions

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

**3.1**
**freight wagon body**
main load carrying structure above the suspension units including all components which are affixed to this structure which contribute directly to its strength, stiffness and stability

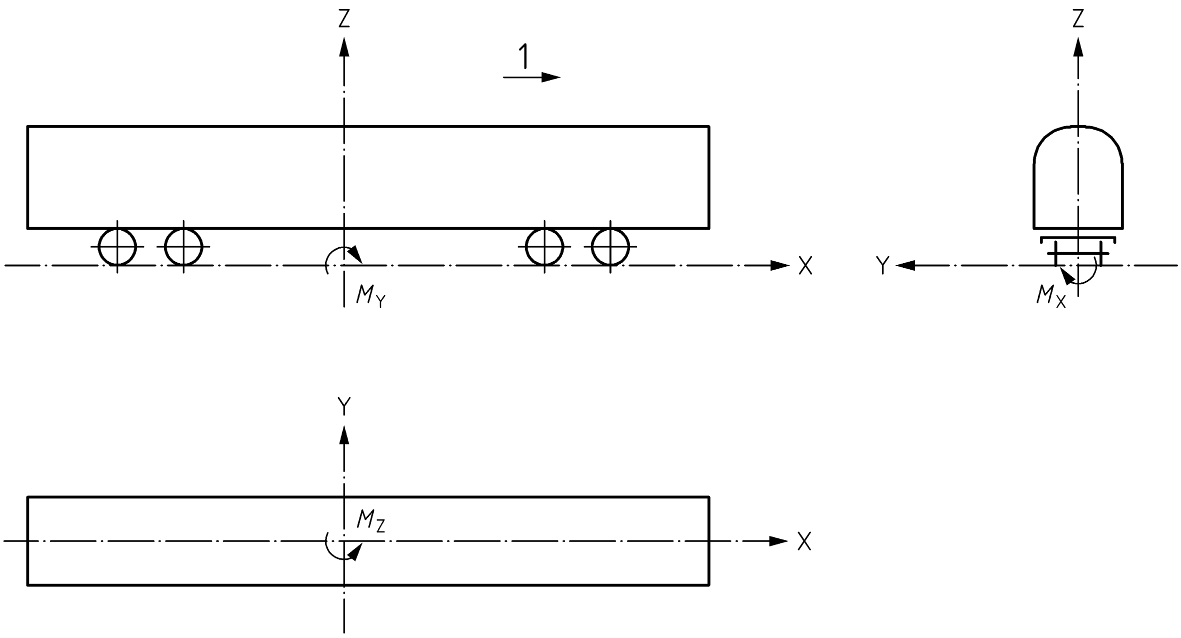
NOTE Mechanical equipment and other mounted parts are not considered to be part of the vehicle body though their attachments to it are.

**3.2**
**equipment attachment**
fastener and any associated local load carrying substructure or frame which connects equipment to the vehicle body



## 4 Coordinate system

The coordinate system is shown in Figure 1. The positive direction of the x-axis (corresponding to vehicle body longitudinal axis) is in the direction of movement. The positive direction of the z-axis (corresponding to vehicle vertical axis) points upwards. The y-axis (corresponding to vehicle transverse axis) lies in the horizontal plane completing a right hand coordinate system.




**Key**

1 direction of movement
X longitudinaldirection
Y lateral direction
Z vertical direction
*M* moment

**Figure 1 — Vehicle coordinate system**

# 5 Load cases

## 5.1 Categories of freight wagons

For the application of this European Standard, all freight wagons are classified in categories.

The classification of the different categories of freight wagons is based only upon the loadings of the vehicle bodies.

NOTE It is the responsibility of the customers to decide as to which category railway vehicles should be designed. There are differences between customers whose choice of the category should take into account the shunting conditions and system safety measures. This is expected and should not be considered as conflicting with this European Standard.

The choice of category from the clauses below shall be based on the load cases as defined in the tables in 5.2.

All freight wagons in this group are used for the transportation of goods. Two categories have been defined:

— Category F-I e.g. vehicles which can be shunted without restriction;

— Category F-II e.g. vehicles restricted in hump and loose shunting.

## 5.2 Load cases

### 5.2.1 General

The loads defined in Table 2 to Table 5 shall be considered in combination with the load due to 1 $g$ vertical acceleration of the mass $m_1$.

The vehicle masses to be used for determining the design load cases are defined in Table 1.

**Table 1 — Definition of the design masses**

| **Definition** | **Symbol** | **Description** |
|---|---|---|
| Design mass of the vehicle body in working order | $m_1$ | The design mass of the vehicle body in working order according to [A1⟩ EN 15663:2017+A1:2018 ⟨A1] without bogie masses. |
| Design mass of one bogie or running gear | $m_2$ | Mass of all equipment below and including the body suspension. The mass of linking elements between vehicle body and bogie or running gear is apportioned between $m_1$ and $m_2$. |
| Normal design payload | $m_3$ | The mass of the normal design payload as specified in [A1⟩ EN 15663:2017+A1:2018 ⟨A1]. |

NOTE For freight wagons the exceptional payload and the normal design payload $m_3$ are the same (see [A1⟩ EN 15663:2017+A1:2018 ⟨A1]).

Where the load cases include loads that are distributed over the structure, they shall be applied in analysis and tested in a manner that represents the actual loading conditions to an accuracy commensurate with the application and the critical features of the structure.

### 5.2.2 Longitudinal static loads for the vehicle body in buffer and/or coupling area

**Table 2 — Compressive force at buffer height and/or coupler height**

Force in kilonewtons

| Freight vehicles | |
|---|---|
| **Category F-I** | **Category F-II** |
| 2 000 [a] | 1 200 [a] |

[a] Compressive force applied to draw gear stop “c” if this draw gear stop is used (see Figure 4).

When the compressive force is applied at the buffer axis, then half of the value shall be used for each buffer axis.



**Table 3 — Compressive force below buffer and/or coupling level**

Force in kilonewtons

| Freight vehicles | |
|---|---|
| **Category F-I** | **Category F-II** |
| 1 500 [a] | 900 [a] |

[a] 50 mm below buffer centre line.

**Table 4 — Compressive force applied diagonally at buffer level (if side buffers are fitted at one or both ends of a single vehicle)**

Force in kilonewtons

| Freight vehicles | |
|---|---|
| **Category F-I** | **Category F-II** |
| 400 | |

For coupling wagons with a draw bar, one force is applied at the location of the buffer and the second is applied in the axis of the wagon, see Figure 2.

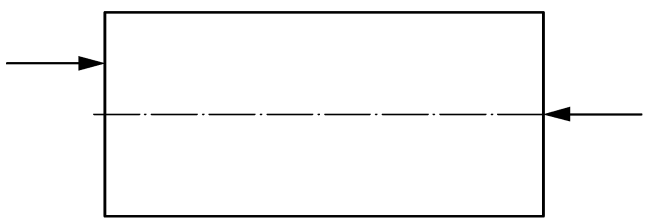


**Figure 2 — Coupling wagon with draw bar**

For coupling wagons with diagonal buffers one force is applied at the location of the side buffer and the second is applied at the location of the diagonal buffer, see Figure 3.

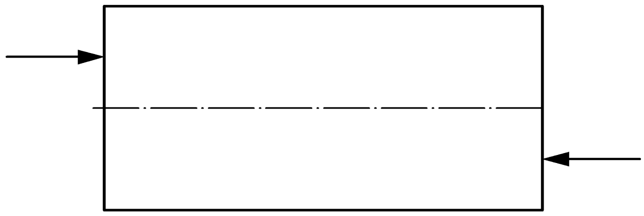


**Figure 3 — Coupling wagon with diagonal buffers**



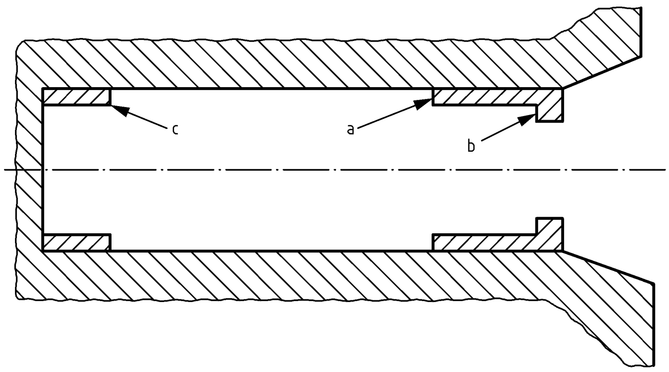
**Table 5 — Tensile force in coupler area**

Force in kilonewtons

| Freight vehicles | |
|---|---|
| **Category F-I** | **Category F-II** |
| 1 500 [a] | |
| 1 000 [b] | |

[a] Tensile force of 1 500 kN applied to the draw gear stops “a” if this draw gear stop is used, see Figure 4.

[b] Tensile force of 1 000 kN applied to the draw gear stops “b” if this draw gear stop is used and for other types of coupler attachments, see Figure 4.




**Key**

a see Table 5

b see Table 5

c see Table 2

**Figure 4 — Draw gear stops**

### 5.2.3 Vertical static loads for the vehicle body

#### 5.2.3.1 Maximum operating load

The maximum operating load as defined in Table 6 corresponds to the exceptional payload of the vehicle.

**Table 6 — Maximum operating load**

Load in newtons

| Freight vehicles | |
|---|---|
| **Category F-I** | **Category F-II** |
| $1,3 \times g \times (m_1 + m_3)$ [a] | |

[a] If the application produces a higher proof load (e.g. due to dynamic effects or loading conditions) then a higher value shall be applied and defined in the specification.



### 5.2.3.2 Lifting and jacking

The forces in Table 7 and Table 8 represent the lifted masses. The equations are given for a two-bogie freight vehicle. The same principle shall be used for freight vehicles with other suspension configurations.

If in some operational requirements, the mass to be lifted does not include the full payload or bogies, the values of $m_2$ and $m_3$ in the following tables shall be set to zero or reduced to the specified value.

**Table 7 — Lifting and jacking at one end of the vehicle at the specified lifting positions**

Load in newtons

| Freight vehicles | |
|---|---|
| **Category F-I** | **Category F-II** |
| $1,0 \times g \times (m_1 + m_2 + m_3)$ | |

NOTE The other end of the vehicle should be supported in the normal operational condition.

**Table 8 — Lifting and jacking the whole vehicle at the specified lifting positions**

Load in newtons

| Freight vehicles | |
|---|---|
| **Category F-I** | **Category F-II** |
| $1,0 \times g \times (m_1 + 2 \times m_2 + m_3)$ | |

For lifting and jacking with displaced support, the load case of Table 8 shall be considered with one of the lifting points displaced vertically relative to the plane of the other three supporting points. For this analysis the amount of vertical displacement of the fourth lifting point relative to the other three lifting points shall be considered to be 10 mm or to be equal to the offset which just induces a lift off of one of the lifting points which ever is smaller. If necessary a higher degree of offset shall be part of the specification.

### 5.2.3.3 Superposition of static load cases for the vehicle body

In order to demonstrate a satisfactory static strength, as a minimum the superposition of static load cases as indicated in Table 9 shall be considered.

**Table 9 — Superposition of static load cases for the vehicle body**

Load in newtons

| Superposition cases | Freight vehicles Category F-I, F-II |
|---|---|
| Compressive force and vertical load | A1⟩ Table 2 and $g \times (m_1 + m_3)$ |
| | Table 3 and $g \times (m_1 + m_3)$ |
| Compressive force and minimum vertical load | Table 2 and $g \times m_1$ |
| Tensile force and vertical load | Table 5 and $g \times (m_1 + m_3)$ |
| Tensile force and minimum vertical load | Table 5 and $g \times m_1$ ⟨A1 |



### 5.2.4 Static loads at interfaces

#### 5.2.4.1 Load cases for body to bogie connection

The body to bogie connection shall sustain the loads due to 5.2.3.1 and 5.2.3.2.

It shall also sustain separately, in combination with those due to 1 $g$ vertical acceleration of the vehicle body mass $m_1$, the loads arising from:

a) the maximum bogie acceleration in the x direction according to the corresponding category of Table 10;

b) the lateral force per bogie corresponding to the transverse force as defined in A1⟩ EN 13749:2021 ⟨A1 or 1 $g$ applied on the bogie mass $m_2$ whichever is the greater.

#### 5.2.4.2 Load cases for equipment attachments

In order to calculate the forces on the fastenings during operation of the vehicle, the masses of the components are to be multiplied by the specified accelerations in Table 10, Table 11 and Table 12. The load cases shall be applied individually.

As a minimum additional requirement, the loads resulting from the accelerations defined in Table 10 or Table 11 shall be considered separately in combination with the load due to 1 $g$ vertical acceleration and the maximum loads which the equipment itself may generate. The load defined in Table 12 includes the dead weight of the equipment. If the mass of the equipment, or its method of mounting, is such that it may modify the dynamic behaviour of the freight vehicle, then the suitability of the specified accelerations shall be investigated. Especially for container transports, the effect of cross winds on containers' attachment shall be considered.

**Table 10 — Accelerations in x-direction**

Acceleration in metres per square second

| Freight vehicles | |
|---|---|
| **Category F-I** | **Category F-II** |
| $\pm 5 \times g$ | |

**Table 11 — Accelerations in y-direction**

Acceleration in metres per square second

| Freight vehicles | |
|---|---|
| **Category F-I** | **Category F-II** |
| ±1 × *g* | |

**Table 12 — Accelerations in z-direction**



Acceleration in metres per square second

| Freight vehicles | |
|---|---|
| **Category F-I** | **Category F-II** |
| (1 ± *c*) × *g* [a] | |

[a] *c* = 2 at the vehicle end, falling linearly to 0,5 at the vehicle centre.

### 5.2.5 Fatigue load cases

#### 5.2.5.1 Track induced loading

Table 13 and Table 14 give empirical vertical and lateral acceleration levels, suitable for an endurance limit approach for design and assessment of freight wagons consistent with normal European operations.

**Table 13 — Acceleration in y-direction**

Acceleration in metres per square second

| Freight vehicles | |
|---|---|
| **Category F-I** | **Category F-II** |
| ±0,2 × *g* | |

**Table 14 — Acceleration in z-direction**

Acceleration in metres per square second

| Freight vehicles | |
|---|---|
| **Category F-I** | **Category F-II** |
| (1 ± 0,3) × *g* [a] [b] | |

[a] For freight vehicle with double stage suspension (1 ± 0,25) × *g*.

[b] If the application produces a higher load (e.g. due to dynamic effects or loading conditions) then a higher value shall be applied and defined in the specification.

#### 5.2.5.2 Fatigue loads at interfaces of equipments attachments

Equipment attachments shall withstand the loading caused by accelerations due to vehicle dynamics plus any additional loading resulting from the operation of the equipment itself. Acceleration levels may be determined as described in 5.2.5.1. For normal European operations, empirical acceleration levels for items of equipment which follow the motion of the body structure are given in Table 15, Table 16 and Table 17. The number of load cycles shall be $10^7$ each.

**Table 15 — Accelerations in x-direction**

Acceleration in metres per square second

| Freight vehicles | |
|---|---|
| **Category F-I** | **Category F-II** |
| ±0,3 × *g* | |

**Table 16 — Accelerations in y-direction**

Acceleration in metres per square second

| Freight vehicles | |
|---|---|
| **Category F-I** | **Category F-II** |
| ±0,4 × *g* [a] | |
| [a] This value may be reduced in case of two-axle-wagons with improved suspension or wagons with bogies. | |

**Table 17 — Accelerations in z-direction**

Acceleration in metres per square second

| Freight vehicles | |
|---|---|
| **Category F-I** | **Category F-II** |
| (1 ± 0,3) × *g* [a] | |
| [a] For freight vehicle with double stage suspension (1 ± 0,25) × *g*. | |



# 6 Design validation of vehicle body

## 6.1 General

The validation of the design of the wagon body shall be carried out according to one of the two following methods:

— one based on loadings, tests and criteria based upon methods used previously by the UIC rules[1)] and applicable only for vehicle bodies made of steel. This method is described in the 6.2;

— one based on the method of design and validation of vehicles bodies given in [A1⟩ EN 12663-1:2010+A2:2023 ⟨A1] For this method, the specific freight wagon load conditions to be applied are those given in 5.2.

NOTE These loads are copied in [A1⟩ EN 12663-1:2010+A2:2023 ⟨A1] in order to facilitate its use when applied to freight wagons.

The wagons equipped with crashworthy buffers require a specific validation of the design of their body. The method is given in 6.3.

1) See ERRI B12/RP17 8th edition of April 1996 and ERRI B12/RP60 2nd Edition of June 2001.

## 6.2 Design validation of vehicle bodies made of steel

### 6.2.1 Characteristics and requirements with regard to the test setup, measuring and evaluation techniques



Except in special cases, strain gauges shall be used to check each prototype vehicle tested.

The stress measurements planned for the tests shall be carried out by means of resistance strain gauges, typically having a resistance of 120 Ω and a measuring grid length of 10 mm. The characteristics of the gauges used should be specified in the test report.

The gauges shall be affixed in the following conditions:

— in zones not considered critical, in positions on the element such that the mean stress levels can be compared to calculations;

— in the zones considered critical (e.g. around joints and all elements under significant stress), both as close as possible to the edge or edges of the element in question (centre-line of the gauge no more than 10 mm from the edge) and in other positions across the element, with a view to determining the maximum stress in the assembly and the mean stress in this particular element. If the direction of the local principal stress is uncertain, rosette gauges should be used to obtain both the magnitude and direction of the local principal stress.

If the stress measurements are carried out on one half of the wagon at one side relative to the longitudinal axis, several control gauges shall be symmetrically arranged on the other half of the wagon.

Before proceeding with the recording of the stresses, for all static tests preliminary loading shall be carried out in order to stabilize residual stresses due to manufacturing.

It is recommended that these preliminary loads be applied in stages, up to the stipulated maximum loads. After removal of the loads, the strains are considered to be zero. After applying the loads a second time up to the maximum value, the measurement should be considered as decisive.

The layout of the strain gauges is peculiar to each type of construction. Examples are given in Figure 5 to Figure 6.

Even if during the test the stress limits indicated in this standard are reached or exceeded, continuing with the testing programme is recommended if this can contribute to design improvement.

After each type of test, a visual examination of the wagon is made to check that there are no macroscopic damages, significant permanent deformation[2], ruptures.

2) In the case of e.g. sheet metal, visible permanent deformation is to be taken as any deformation of, or greater than 0,5 mm over 100 mm able to be determined using simple measuring techniques.

Dimensions in millimetres

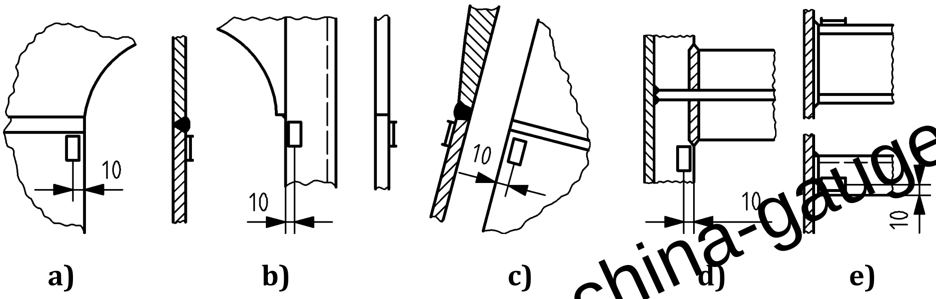
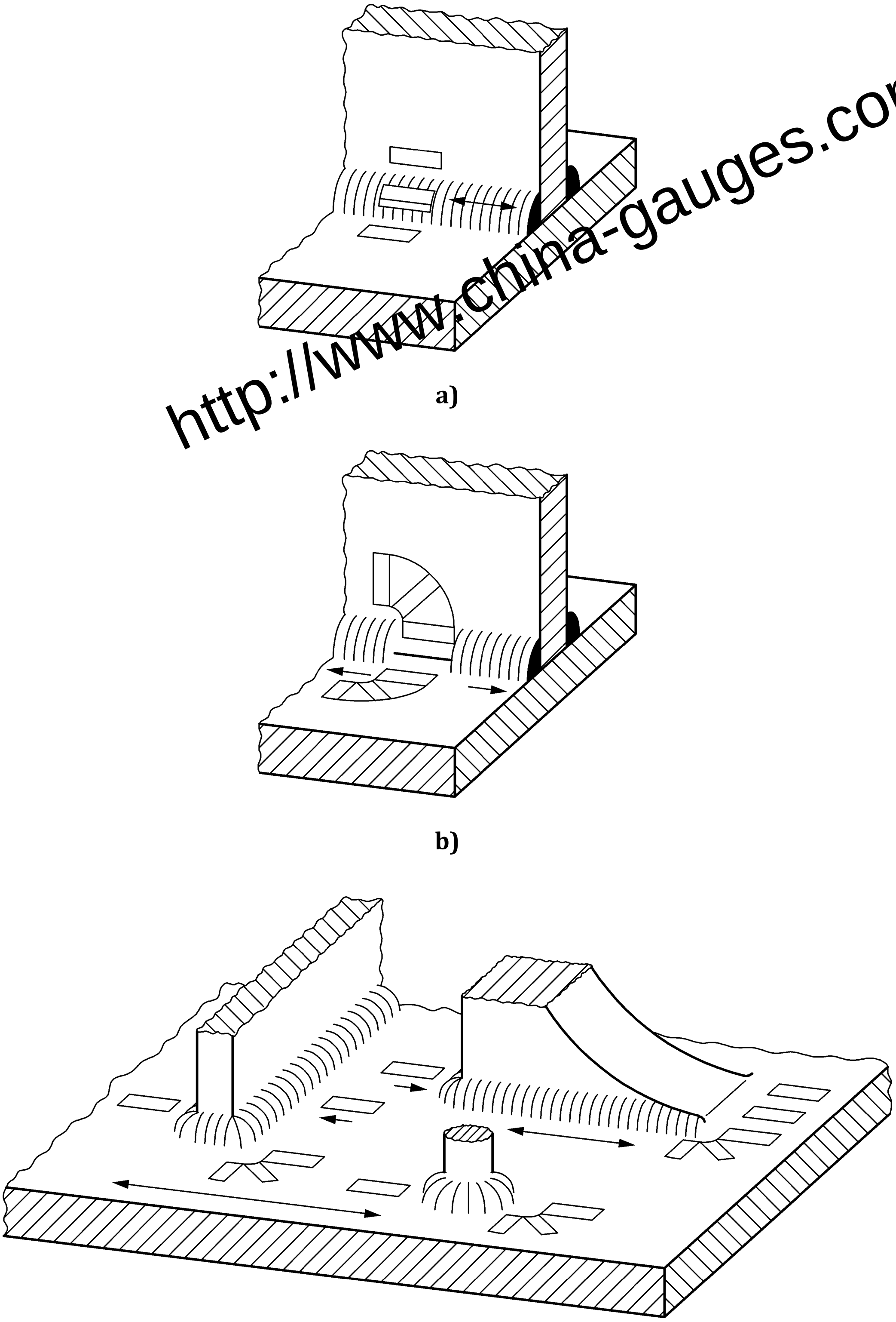





**Figure 5 — Examples of the practical arrangement of strain gauges to demonstrate fatigue strength**






c)

NOTE The arrows indicate the direction of stress.

**Figure 6 — Examples of the practical arrangement of strain gauges to demonstrate fatigue strength**

### 6.2.2 Permissible test threshold values for material tension – Permissible stresses for proof tests

#### 6.2.2.1 Static test at full load

The limits specified in Table 18 shall be adhered to for all the static proof tests carried out.

Values for the yield strength / 0,2 % proof stress ($R_p$), ultimate strength ($R_m$) and elongation ($A$) shall be taken from the relevant European Standards or national standards.

In the case of gauges affixed to the parent metal the measured stresses shall be lower than the values given in Table 18 and after removal of the loads the component shall not exhibit any significant permanent deformation or elongations:



**Table 18 — Limit values of stresses**

| | **Characteristics of the material** | **Limit values of stresses** |
|---|---|---|
| Parent metal | $R_p < 0,8\ R_m$ | $\sigma = R_p$ |
| | $R_p > 0,8\ R_m$ and $A > 10\ \%$ | $\sigma = R_p$ |
| | $R_p > 0,8\ R_m$ and $A < 10\ \%$ | $\sigma = R_m / 1,25$ |
| Parent metal in the immediate vicinity of welds | $R_p < 0,8\ R_m$ | $\sigma = R_p / 1,1$ |
| | $R_p > 0,8\ R_m$ and $A > 10\ \%$ | $\sigma = R_p / 1,1$ |
| | $R_p > 0,8\ R_m$ and $A < 10\ \%$ | $\sigma = R_m / 1,375$ |

NOTE 1 The coefficient of 1,1 is used in order to cover any irregularities due to welding.

An example of limit stresses for commonly used steel grades is shown in Table 19.

**Table 19 — Example for commonly used steel grades**

| | **Limit stress** N/mm$^2$ | | |
|---|---|---|---|
| | S235 | S275 | S355 |
| Parent metal | 235 | 275 | 355 |
| Parent metal in the immediate vicinity of welds | 214 | 250 | 323 |

NOTE 2 Steel grades are from EN 10025 (all parts).

The maximum deflection of the under-frame under the normal design payload shall not exceed 3 ‰ of the wheelbase or of the bogie pivot pitch from the initial position (including the effects of any counter-deflection).

#### 6.2.2.2 Static tests at lower load

When, for practical reasons connected with the design of the vehicle being tested, the full test loads cannot be applied, the limit values of the stresses need to be established accordingly. These are the values given in 6.2.2.1 multiplied by a coefficient equal to the ratio between the value of the load actually applied and the value of the load which ought to have been applied.

### 6.2.3 Static tests to prove the fatigue strength of vehicle bodies

#### 6.2.3.1 General

The limits specified in Table 20 shall be adhered to for all the static fatigue tests carried out.

The static stresses shall not exceed the permissible proof stresses from Table 18.

The permissible stresses depend on:

— the type of material;

— the dynamic coefficient $K$ specified for the particular type of vehicle and the acceleration load case being applied;

— the thickness of the material;

— the point at which the strain gauge is affixed.



#### 6.2.3.2 Limit stresses for the different notch cases for tests on freight wagons

The permissible dynamic stress range $2\sigma_{\text{Alim}}$ is independent from the stress ratio and is given in the first column of Table 20 for commonly used steels S235, S275 and S355 and for different notch cases.

Five types of notch cases are defined as follows:

a) Case A: parent metal or machined butt welds;

b) Case B: butt weld;

c) Case C: butt weld with inertia change;

d) Case D: fillet weld;

e) Case E: projection weld.

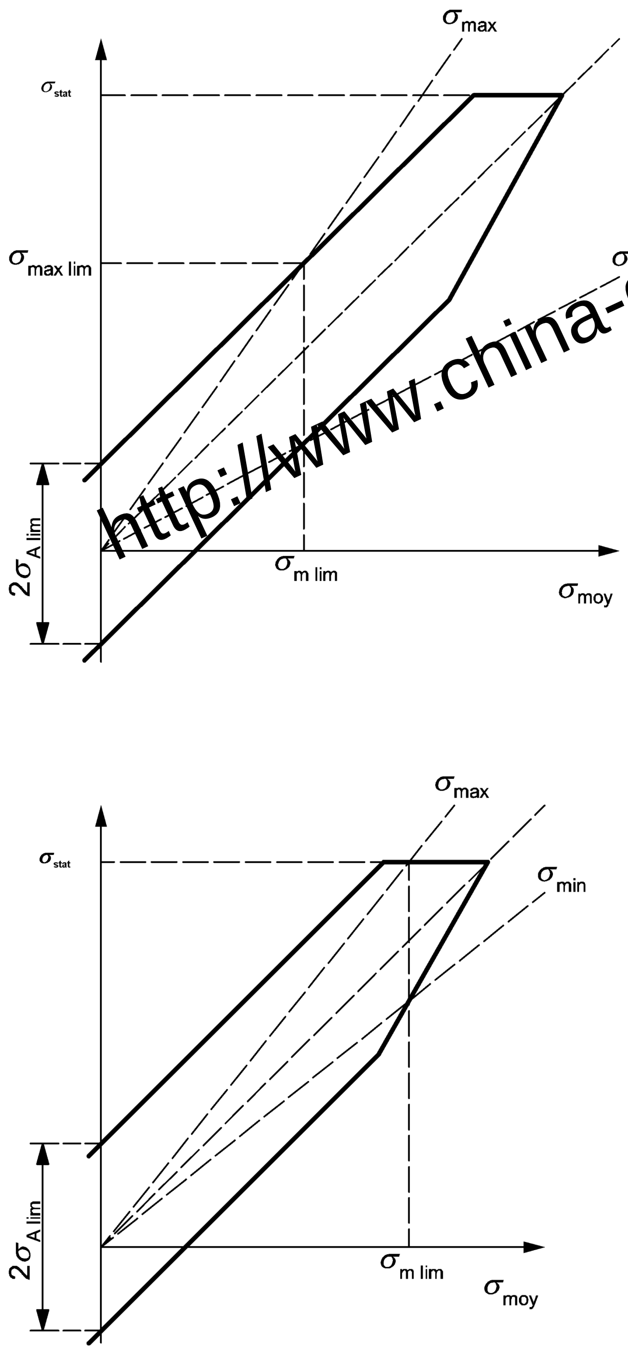
These five notch cases do not cover the full range of structures and, in practice, it is necessary to choose the most suitable notch case for each welded zone tested.

To facilitate and standardize these choices, Table 21 gives practical examples of welded joints which occur frequently in vehicle body structures.

For other material types the permissible dynamic stress range for notch case A shall be calculated from the material yield strength / 0,2 % proof stress as follows:

$$2\sigma_{\text{Alim}} = R_{\text{p}} \times 0{,}46$$

The permissible maximum upper stress $\sigma_{\text{max lim}}$ is additionally limited by the static limit $\sigma_{\text{stat}}$ given in Table 18. Figure 7 shows the principle for derivation of the permissible stress values.






**Key**

$\sigma_m$ mean stress

$\sigma_{stat}$ static limit according to Table 18

$\sigma_{Alim}$ half of the permissible dynamic range of fatigue stresses

$\sigma_{max\ lim}$ = MIN [$\sigma_{Alim}$ × (1 + K) / K ; $\sigma_{stat}$]

$\sigma$max lim permissible upper stress if maximum dynamic load is applied (for the vertical load case): $(1 + K) \times g \times (m_1 + m_3)$; $K$ according to Table 14

$\sigma_{m\ lim} = \sigma_{max\ lim} / (1 + K)$

$\sigma$m lim permissible stress if the nominal load is applied (for the vertical load case): $g \times (m_1 + m_3)$

**Figure 7 — Derivation of permissible fatigue strength values**

As an example for a vertical dynamic factor of $K = 0,3$ according to Table 14, all limit values for commonly used steels S235, S275 and S355 are given in the Table 20 for the different notch cases.

**Table 20 — Permissible limit values for the fatigue checking**

| | | $2\sigma_{Alim}$ N/mm² | | | $\sigma_{mlim}$ for $K = 0,3$ N/mm² | | | $\sigma_{maxlim}$ for $K = 0,3$ N/mm² | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Steel grade | S235 | S275 | S355 | S235 | S275 | S355 | S235 | S275 | S355 |
| Notch case | A | 110 | 128 | 164 | 180<br>165 [a] | 211<br>192 [a] | 273<br>248 [a] | 235<br>214 [a] | 275<br>250 [a] | 355<br>323 [a] |
| | B | 90 | | | 150 | | | 195 | | |
| | C | 80 | | | 133 | | | 173 | | |
| | D | 66 | | | 110 | | | 143 | | |
| | E | 54 | | | 90 | | | 117 | | |

[a] For machined butt weld.

**Table 21 — Joints commonly found in railway applications - Examples for notch-cases**

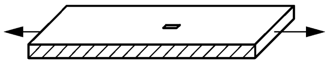
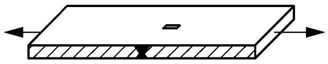
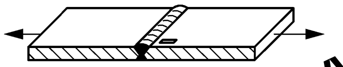
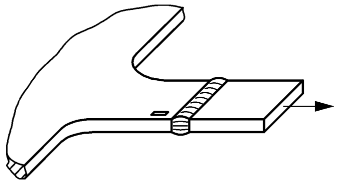
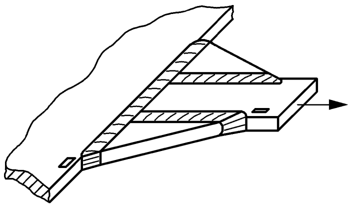
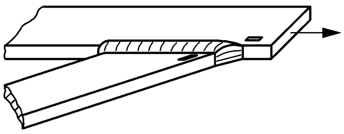
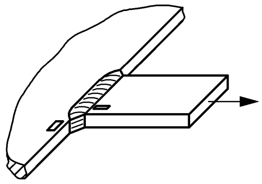
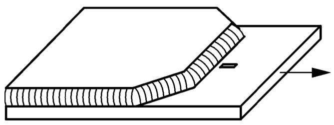
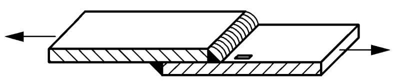
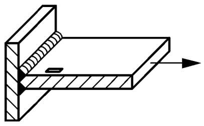
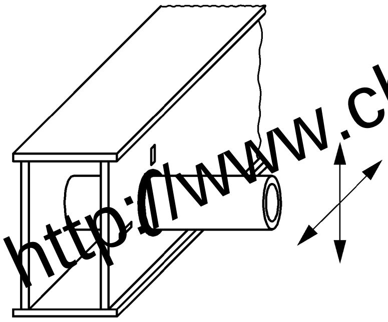
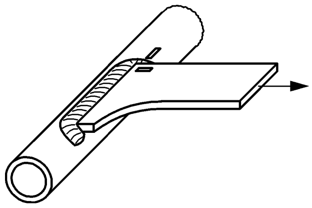
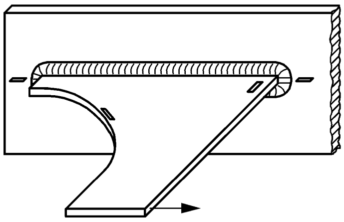
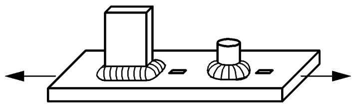
| Case | Sketch | Description | Comments |
|---|---|---|---|
| A | <br> | Away from weld<br>Machined butt weld | Away from weld<br>Machined butt weld |
| B | <br> | Butt weld<br>Butt weld with bevelling | Butt weld |
| B |  | Machined and welded joint | |
| C |  | Corner joint with gusset plates | Butt weld between pieces at an angle to each other |
| C |  | Inclined joint | |
| D |  | Corner joint | Butt weld at 90° |
| D |  | Reinforcing plate | Lap joints |
| D |  | Butt welded lap joint | |

**Table 21** *(continued)*

| Case | Sketch | Description | Comments |
|---|---|---|---|
| D |  | Corner joint | Fillet welds |
| D |  | Joint between tube and straight piece | |
| D |  | Joint between plate and tube | |
| D |  | Joint between plate and web | |
| E |  | Welded securing lug<br>Welded securing stud | |

#### 6.2.3.3 Vertical static load test procedure

##### 6.2.3.3.1 Vertical loads

Dead mass and load mass have to be simulated as close as possible it is in the reality.

##### 6.2.3.3.2 Relaxation of residual stresses in the structure of the wagon

With the heaviest mass (dead mass $m_1$ or maximum load mass $m_3$) relax of stresses by loading, measurement of stresses, unloading and measurement of residual stresses.

If some residual stresses are significant (>50 µm/m of the strain gauge measurement), relax a second and if necessary a third time.

If all residual stresses are nearly equal to 0 (≤50 µm/m of the strain gauge measurement), it is considered as test measurement.

#### 6.2.3.3.3 Test measurement

— Zero value gauges;

— dead load mass test + measurement of the stresses ($\sigma_{\mathrm{m}1}$);

— remove the dead mass load test;

— zero value gauges;

— maximum payload mass test + measurement of the stresses ($\sigma_{\mathrm{m}3}$);

— remove the payload mass;

— zero value gauges;

— order between $m_1$ and $m_3$ is no matter.



#### 6.2.3.3.4 Use of results

— Calculation of ($\sigma_{\mathrm{m}1}$ + $\sigma_{\mathrm{m}3}$) for each gauge;

— use of the results to compare with criteria according to Table 20.

### 6.2.4 Assignment of load cases and permissible stresses

Table 22 contains an unambiguous assignment of the permissible stresses of Clause 6 to the individual load cases in Clause 5.

**Table 22 — Assignment of load cases and permissible stresses**

| Load case | Table/clause no. | Type | Permissible stresses for test |
|---|---|---|---|
| Compressive force at buffer level and/or coupler level | Table 2 | Proof load case | according to 6.2.2 |
| Compressive force below buffer and/or coupling level | Table 3 | Proof load case | according to 6.2.2 |
| Compressive force applied diagonally at buffer level | Table 4 | Proof load case | according to 6.2.2 |
| Tensile force in coupler area | Table 5 | Proof load case | according to 6.2.2 |
| Maximum operating load | Table 6 | Proof load case | according to 6.2.2 |
| Lifting at one end of the vehicle at specified lifting positions | Table 7 | Proof load case | No significant permanent deformation |
| Lifting the whole vehicle at specified lifting positions | Table 8 | Proof load case | No significant permanent deformation |
| Lifting with displaced support | 5.2.3.2 | Proof load case | No significant permanent deformation |
| Superposition of static load cases for the vehicle body | Table 9 | Proof load cases | according to 6.2.2 |
| Proof load cases for equipment attachments | Tables 10, 11, 12 | Proof load case | according to 6.2.2 |
| General fatigue load cases for the vehicle body in z-direction | Table 14 | Fatigue load case | 6.2.3.2 Table 20 |
| Fatigue loads at interfaces | Tables 15, 17 | Fatigue load case | 6.2.3.2 Table 20 |
| Buffing impact testing | Clause 8 | Proof load cases | Cumulation of residual strain maximum 2 ‰ |
| General fatigue load cases in y-direction | Tables 13, 16 | Fatigue load case | a |

[a] The buffing test, specific tests described in Clause 7, and the static test are enough for prove the compliance of this.

### 6.3 Design validation link to crashworthy buffer

If the maximum force $F_{max}$ of plastic deformation of one buffer is higher than 3 000 kN filtered at least at or equal to 100 Hz (according to Table 25) on condition of the dynamic test on crashworthy buffer of [A1⟩ EN 15551:2022 ⟨A1] the new permissible stresses for the stresses measured during the longitudinal static test defined in 6.2 shall be reduced as follows:

$$\text{New permissible stresses} = (\text{Permissible stresses given in Table 18}) \times \frac{3\,000\,kN}{F_{max}}$$

NOTE According to the analysis of many test reports on this subject, this method gives confidence to demonstrate the integrity of the structure and the tank of the wagon using this type of crashworthy buffers.

## 7 Design validation of associated specific equipment

### 7.1 General

Methods apply for all described associated specific equipment of freight wagons. Clause 6 gives limit stresses for steels. For other materials, the limit stresses shall be defined according the method given [A1⟩ EN 12663-1:2010+A2:2023 ⟨A1].

When [A1⟩ EN 12663-1:2010+A2:2023 ⟨A1] is used for validation of the wagon, Clause 7 should be used as a guideline to define the load cases of associated specific equipment.

### 7.2 Static tests on the flaps of flat wagons

#### 7.2.1 Side wall flap

##### 7.2.1.1 General

For these tests the flap shall be removed.

Strain gauges should be affixed especially at the points where the hinges are actually fixed to the flap.

##### 7.2.1.2 Flap dropped down onto a high platform with the top part resting evenly on the platform

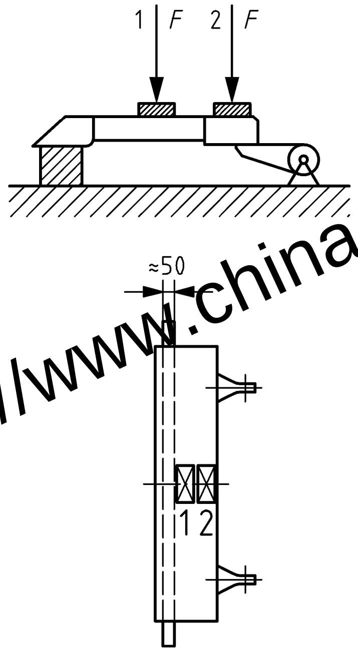
— Flap dropped down into the horizontal position;

— hinges fixed by means of their pin;

— lining inserted under the entire length of the flap;

— application of steadily increasing loads at points 1 and then 2, up to 65 kN, by means of a jack; a piece of wood (350 mm × 200 mm) is arranged as lining between jack and flap (see Figure 8).

Dimensions in millimetres





**Key**

*F* force

NOTE The upper part of the figure is a detail view at larger scale.

**Figure 8 — Flap dropped down onto a high platform with the top part resting evenly on the platform**

### 7.2.1.3 Flap dropped down onto a loading platform which is not parallel with the plane of the wagon

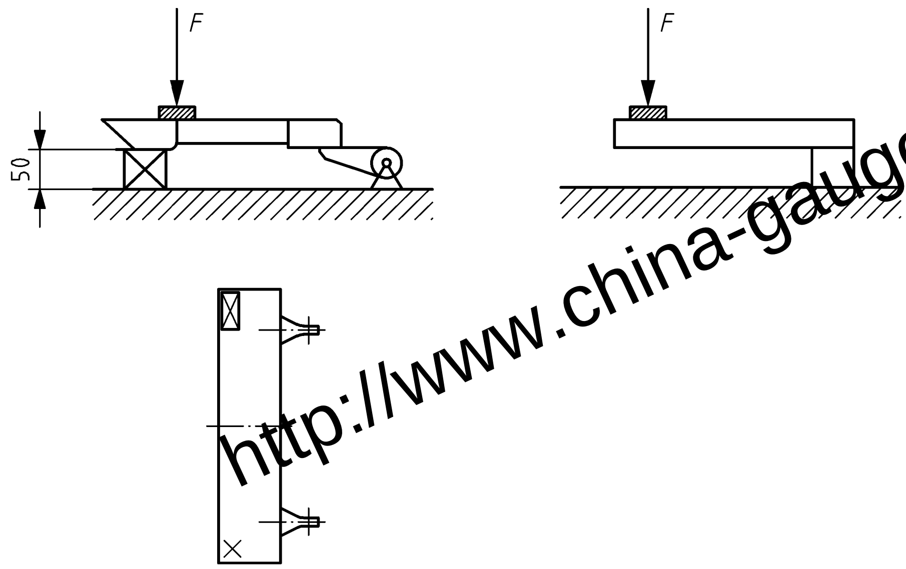
— Flap dropped down into the horizontal position;

— hinges fixed by means of their pin;

— 50 mm wedge (cube) arranged under one end;

— application of the load defined in 7.2.1.2 onto the corner of the flap (see Figure 9).

Dimensions in millimetres






**Key**

*F* force

NOTE The upper part of the figure is a detail view at larger scale.

**Figure 9 — Flap dropped down onto a loading platform which is not parallel with the plane of the wagon**

### 7.2.2 End flap

#### 7.2.2.1 General

For these tests the flap to be tested need not be removed.

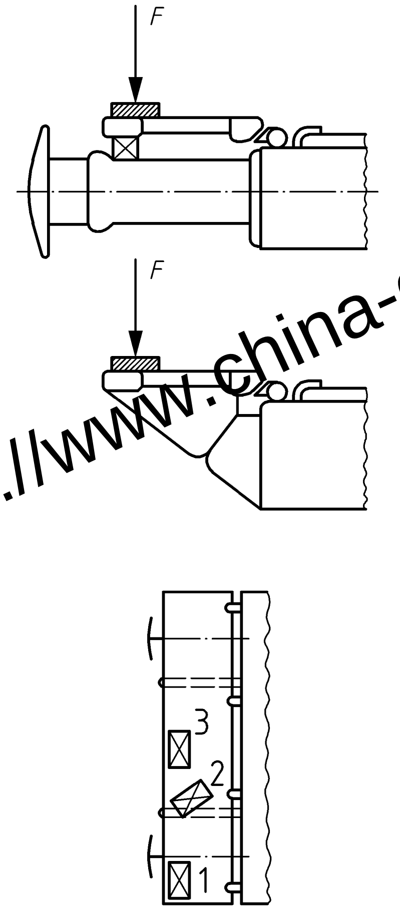
Strain gauges should be affixed especially at the points where the hinges are actually fixed to the flap.

#### 7.2.2.2 Flap dropped down for end-unloading

A load of 65 kN at points 1, 2 and 3 individually (same bearing surface as defined in 7.2.1.2) shall be applied on (see Figure 10):

— flap dropped down onto the buffers; or

— flap dropped down onto supports rigidly fixed to the buffer beam.






**Key**

*F* force

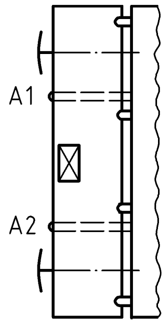
NOTE The upper parts of the figure are detail views at larger scale.

**Figure 10 — Flap dropped down for end-unloading**

**7.2.2.3 End wall flap which, in the vertical position and with the stanchions in place, fulfils its role as "shield" against the longitudinal forces during impacts resulting from loading**

— Flap dropped down onto two supports (A1 and A2) representing the two stanchions;

— application of a load of 75 kN at the centre of the flap (same bearing surface as defined in 7.2.1.2) (see Figure 11).




**Key**

A1 and A2 stanchions for support

**Figure 11 — End wall flap which, in the vertical position and with the stanchions in place, fulfils its role as "shield" against the longitudinal forces during impacts resulting from loading**



### 7.2.3 Results

There shall be no significant permanent deformation as a result of the test, and the permissible stresses according to 6.2.2 should not be exceeded.

## 7.3 Strength of side and end walls

### 7.3.1 Strength of side and end walls at covered wagons

At a height of 1 m above the floor these walls shall be subjected to a gradually increasing force (acting from the inside out).

In the case of refrigerator vans, the characteristics of the material from which the inner skin and the insulation are made shall be taken into account.

There are four loading cases, see Figure 12:

a) transversal force acting on two lateral uprights opposite each other;

b) longitudinal force acting on an end post;

c) in the case of metal walls[3)] with a ventilation opening, transversal force acting on a point in the side wall below the ventilation opening and in line with its vertical centre-line;

d) in the case of metal walls, longitudinal force acting on the centre-line of the end wall.

For tests c) and d) above a hardwood rod shall be used, with a section of 100 mm × 100 mm and with rounded edges.

3) In the case of plywood panels, see UIC-Leaflet 844-3.

Dimensions in millimetres

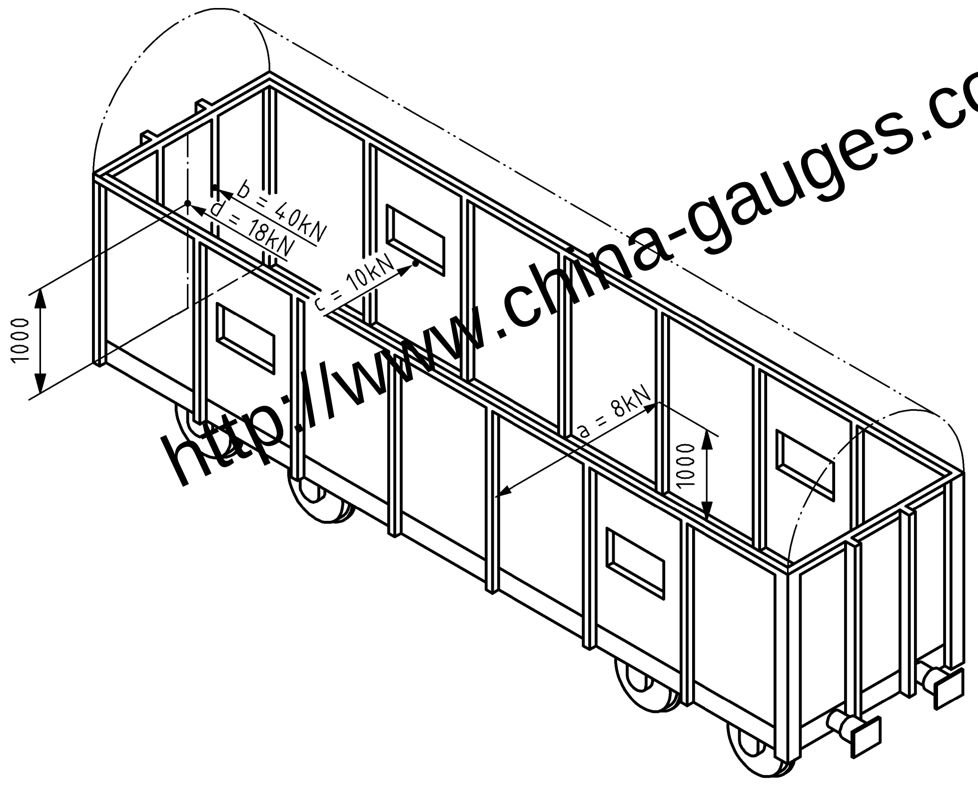





**Figure 12 — Load case locations**

During each test, the minimum forces indicated in Table 23 shall be applied, without, in the loading cases a) and b), the permissible stresses indicated in 6.2.2 being exceeded, and without, for all loading cases a) to d), the significant permanent deformation exceeding the value given in Table 23.

**Table 23 — Permissible significant permanent deformation**

| **Loading case** | **Minimum load to be applied**<br>kN | **Permissible significant permanent deformation at each part**<br>mm |
|---|---|---|
| a | 8,0 | 2 [a] |
| b | 40,0 | 1 [a] |
| c | 10,0 | 3 |
| d | 18,0 | 2 |

[a] Value recorded at the most unfavourable post.

### 7.3.2 Strength of side walls at wagons with full opening roof (roller roof and hinged roof)

The side walls shall be capable of withstanding a total force of 30 kN applied at the four door pillars, 1,5 m above the floor (see Figure 13). The elastic deformation of the upper member shall be lower than the derailing limit of the roof. After removal of the load, the roof shall be in working order.

Dimensions in millimetres

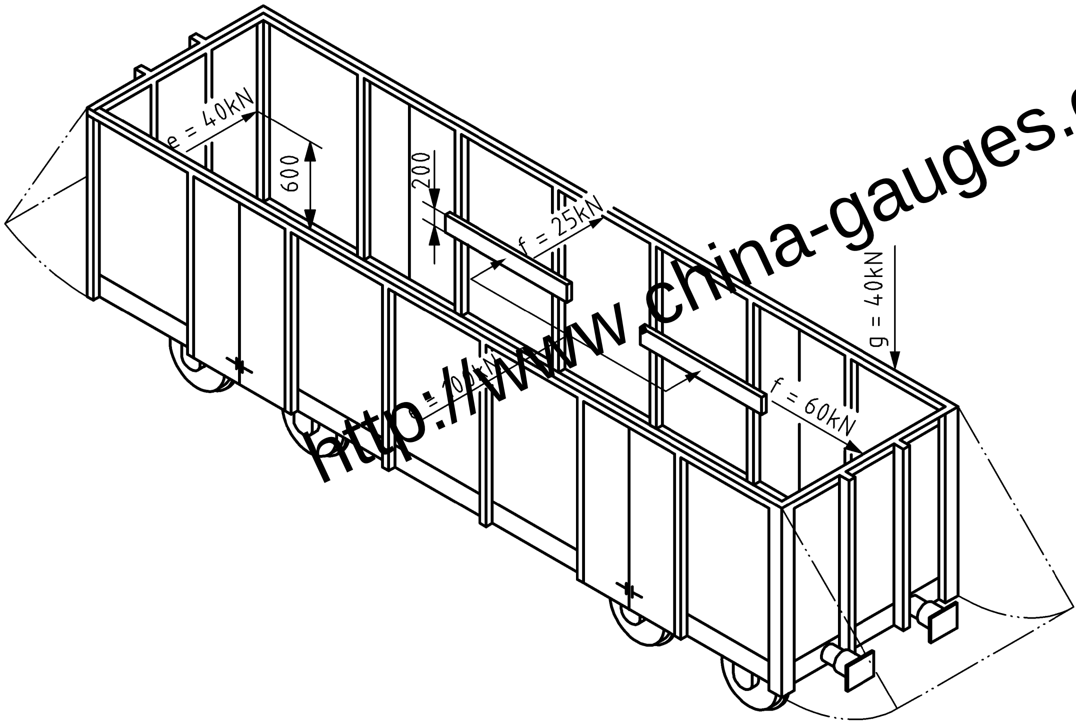





**Figure 13 — High-side-wagons-4central-pillars load case e-f-g**

### 7.3.3 Strength of side walls at high sided open wagons and wagons for the transport of heavy bulk goods

For the verification of the strength to transverse forces and of the edges of side and end rails to impact the following tests are to be carried out:

a) Forcing outwards in the horizontal direction at a level of 1,5 m above the floor:

   1) force of 100 kN applied at four centre posts of each side wall;

   2) force of 40 kN applied at the corner posts of wagons equipped with drop ends.

   The significant permanent deformation at the point where the force is applied shall not exceed 1 mm. In addition, the elastic deformation observed during the test shall not result in any encroachment of the loading gauge.

b) Application of a horizontal force towards the outside of the wagon:

   1) 25 kN at the middle of the upper side wall rails;

   2) 60 kN at the middle of the upper rail of the end swing doors, for wagons equipped with these.

   See Figure 14.

   Significant permanent deformation at the force application point shall not exceed 1 mm.

Dimensions in millimetres

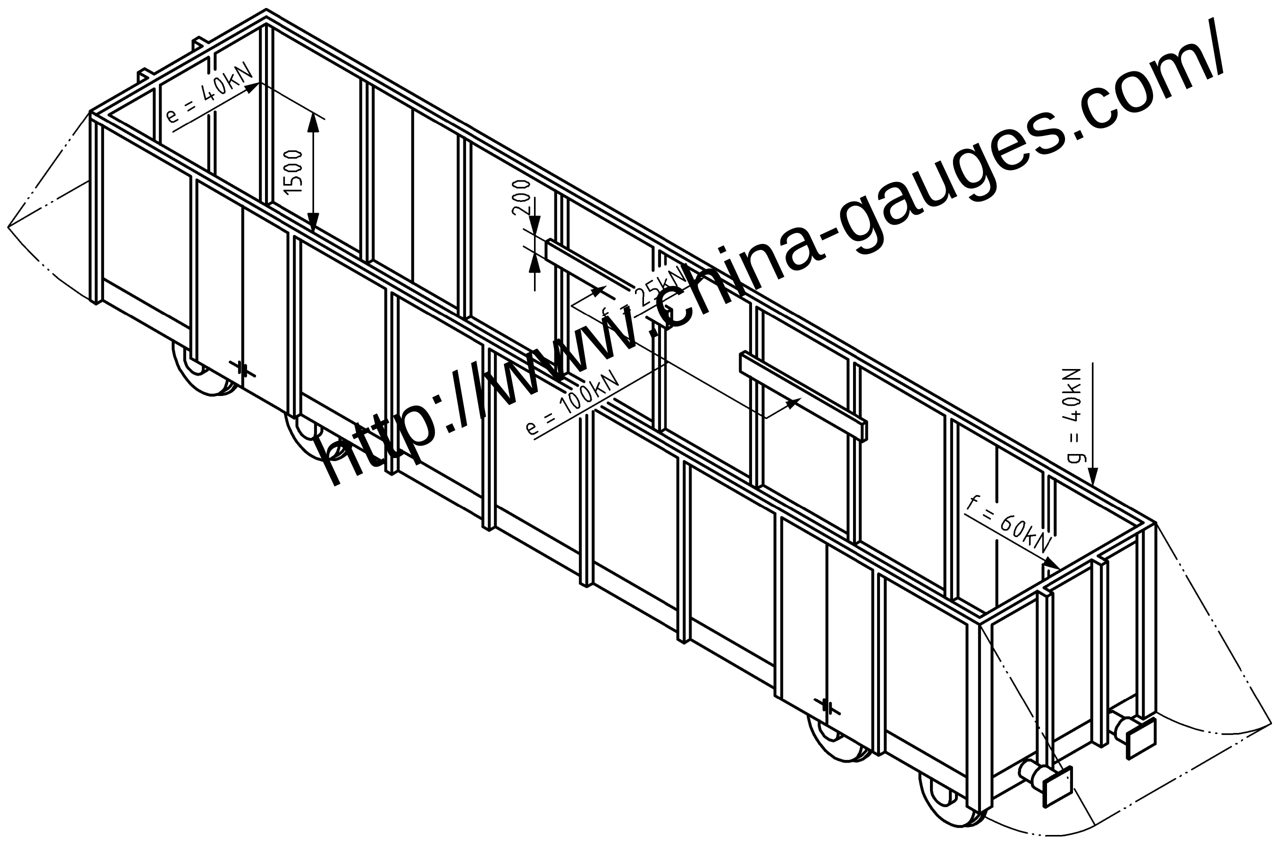



**Figure 14 — High-side-wagons-6central-pillars load case e-f-g**

c) Denting tests on the upper rails of the side walls by applying a vertical force of 40 kN by using a tool according to Figure 15.

Dimensions in millimetres

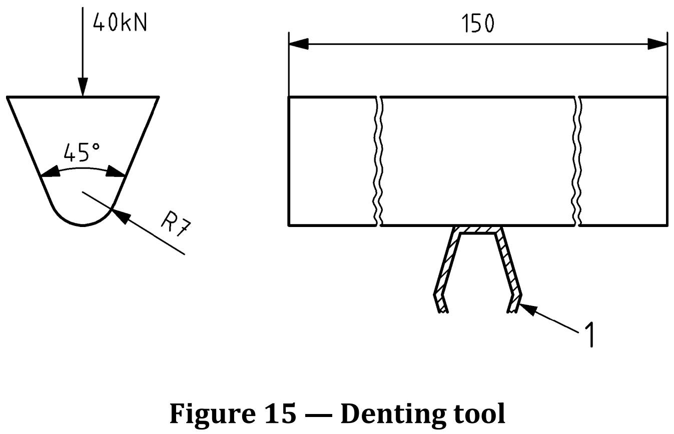



**Figure 15 — Denting tool**

The significant permanent deformation at the point where the force is applied shall not exceed 2 mm.

For the tests a) and b), the stipulated forces shall be applied twice successively and only the deformations measured during the second load application shall be taken into account.

During each of these tests a), b) and c), the permissible stress values in 6.2.2 shall not be exceeded.

#### 7.3.4 Strength of the fixed side wall flaps at flat wagons and composite flat/high sided wagons

The fixed side wall flaps shall be subjected to a force of 30 kN directed horizontally outwards and transmitted through a wooden support piece measuring about 350 mm × 200 mm and applied at the middle of the side, at the top edge.

There shall be no significant permanent deformation as a result of the test.

### 7.4 Strength of the roofs

A fixed roof shall be able to withstand a force of 1 kN applied from outside inwards to a surface area of 200 $cm^2$ without any notable deformation.

Sliding roofs shall withstand a vertical force from the inside outwards of 4,5 kN per link point applied over a 300 mm × 300 mm square area. No deterioration or significant permanent deformation of the elements for closing, rolling and guiding the sliding roofs shall result from the test. It shall be possible to open and shut the sliding roofs without difficulties after the test.

For wagons with full opening roof for the transport of heavy part-load goods or wagons with roll top roofs, the roof shall be able to take a force of 1 kN at the most unfavourable point on an area of 300 mm × 300 mm.

### 7.5 Stresses imposed on the wagon floor by handling trolleys and road vehicles

The wagon floor shall be capable of withstanding, without significant permanent deformation, the stresses imposed by:

a) Handling trolleys:

   1) simultaneous loads of 30 kN on each of the two leading wheels of the trolley;

   2) a wheel contact surface of 220 $cm^2$ with a width of approximately 150 mm;

   3) distance between the centres of the two leading wheels of the trolley: 650 mm;

b) Road vehicles, for flat wagons and multi-purpose flat/open high sided wagons only:

   1) a load of 65 kN for each double wheel;

   2) a contact surface of 700 $cm^2$ for a double wheel with a width of approximately 200 mm.

There shall be neither deflection of the floor nor any significant permanent deformation of the under-frame as a result of the tests.

### 7.6 Attachment of containers and swap bodies

#### 7.6.1 General

ISO containers and swap bodies shall be attached to rail vehicles using devices that engage with the load units ISO corner castings or corner plates. Devices currently used for this purpose include spigots and twistlocks.

### 7.6.2 Strength requirements for the container/swap body retention devices

The container or swap body retention devices and their attachment to the vehicle shall be capable of withstanding the accelerations indicated in Table 24, applied to the maximum gross container or swap body mass. The resulting force shall be applied at the base plane of the container or swap body when restrained by the quantity of devices in the table, these being assumed to share the load evenly.

**Table 24 — Strength requirements for the container/swap body retention devices**

| | Direction | Acceleration | Number of restraining locations |
|---|---|---|---|
| Proof loads | Longitudinal | 2 $g$ | Restrained at any two locations |
| | Transverse | 1 $g$ | Restrained at any two locations |
| | Vertical downward | 2 $g$ | Restrained at four locations |
| | Vertical upward | 1 $g$ | Restrained at any two locations |



Spigots cannot restrain the vertical upward load case and therefore the spigot installation shall withstand, without undergoing deformation that would render it unfit for use, an upward vertical load of 150 kN applied along the spigot centreline.

## 7.7 Special wagons for the conveyance of containers

### 7.7.1 Resistance tests on the securing equipment

#### 7.7.1.1 In the longitudinal direction of the wagon

The wagon loaded with containers to the maximum permissible capacity shall be impacted according to Clause 8.

At least one of these containers or swap bodies shall have the maximum permissible mass for an individual container.

Speeds shall be increased until the acceleration measured on the containers reaches 2 $g$ (measurement taken with frequencies exceeding 16 Hz eliminated). The characteristics of the filter used shall be specified in the test report.

The container with a maximum permissible mass shall be secured by two devices only, on which the measurements are taken.

The permissible stresses in the securing devices shall not exceed the values indicated 6.2.2. Furthermore, no residual strain or significant permanent deformation shall result from the test.

#### 7.7.1.2 In the vertical direction

Resistance tests on the securing equipment under a vertical load of 150 kN shall be applied at the uppermost point of the equipment (simulation of an erroneous manoeuvre during transhipment of loads). After maintaining this load for a certain time, the device shall not present any deformation or anomaly rendering it unusable.

#### 7.7.2 Wagons equipped with impact damping systems, test for checking the efficiency of the damping device

The wagon fully or party loaded with large containers is impacted, as specified under 8.1, with the following loads:

— maximum permissible load;

— a quarter of the maximum permissible load.

In both cases, the accelerations measured on the large containers shall not exceed 2 *g* (measured taken with frequencies exceeding 16 Hz eliminated). The characteristics of the filter used shall be specified in the test report.



### 7.8 Strength of side doors

#### 7.8.1 Strength of sliding doors at covered wagons

##### 7.8.1.1 General

With the door in position and locked a horizontal cross force shall be applied from the inside of the wagon outwards. This force reproduces the forces produced transversally by a shift in the load as well as by pressure differences resulting from the high speed passing of passenger trains in tunnels. This force shall be applied in the following conditions.

##### 7.8.1.2 Transverse load

— At the centre of the door and over a 1 $m^2$ area, increasing up to 8 kN;

— at each link point using square plates with a side length of 300 mm, increasing up to 5 kN.

No damage or significant permanent deformation shall be found, either on the door itself (wall and framework) or on the locking, sliding or guiding components as a result of the tests.

##### 7.8.1.3 Diagonal force (optional)

With the door removed and secured at two of its corners, either at the top or bottom, a gradual tensile or thrust force shall be applied to one of the free corners until a value of 10 kN is reached; care should be taken to ensure that the door does not twist.

No significant permanent deformation shall result from the test.

##### 7.8.1.4 Stresses due to the load

— In the case of sliding sides less than 2,5 m in length, the tests may be carried out in accordance with 7.8.1.2 (8 kN and 5 kN);

— in the case of sliding sides with a length of between 2,5 m and 5 m, a force of 20 kN shall be applied at the centre of the side on a square of 1 m side;

— in the case of sliding sides with a length of between 5 m and 7 m, a force of 15 kN shall be applied to each at a distance from the two ends of the side equal to 1/4 of its length and at a height of 1 m, over a square surface of 1 m side;

— in the case of sliding sides with a length exceeding 7 m, a force of 20 kN shall be applied to each at a distance from the two ends of the side equal to 1/4 of its length and at a height of 1 m, over a square surface of 1 m side;

— a force of 10 kN shall be applied to the lower cantrail of the sliding side, between two articulated points, directly above the floor of the wagon, over a surface 200 mm in height and 300 mm in width.



#### 7.8.1.5 Stresses caused by trains passing

A force shall be applied on external articulation points of the sliding panel (near the end wall) over a surface 200 mm in height and 300 mm in width, directly above the floor of the wagon and in the roof area, as near as possible to the upper articulation point:

— of 11,5 kN on each side for two-axle wagons and bogie wagons fitted with more than two sliding panels on each side;

— of 14 kN on each side for bogie wagons fitted with two sliding panels.

The upper force may be applied to the vertical end of the sliding panel, but as near as possible to the upper articulation point.

No deterioration shall be found in the locking, running and guide mechanisms of the sliding sides. It shall be possible to move the panels without any difficulty.

Residual deformation is tolerated when it does not exceed a limit of half the distance between the inner face of an open side and the most projecting point of a closed side.

#### 7.8.1.6 Two-leaved door

— At the centre of each door leaf simultaneously and over an area of 1 $m^2$, for each door increasing up to 8 kN;

— at each link point using square plates with a side length of 300 mm, increasing up to 5 kN.

The value of the significant permanent deformation shall not exceed 2 mm on the door itself and no damage or significant permanent deformation shall be found on the bridges or closing elements as a result of the tests.

### 7.8.2 Strength of the side doors at high-sided open wagons

Application of a horizontal force of 20 kN at the height of the door locking bar or 1 m above the floor and in the centre-line of the opening. The significant permanent deformation shall not exceed 1 mm on the door itself, and no deterioration or significant permanent deformation of the bridges or closing elements shall result from the test.

## 7.9 Strength of drop sides and ends at flat wagons and interchangeable flat/open wagons

Ends which drop down over the buffers or onto brackets forming an integral part of the headstock, and sides which lower onto raised loading platforms shall be able to withstand the following stresses imposed by a lorry:

— a load of 65 kN on each wheel;

— supporting surface for a double wheel, extending over a surface area of 700 $cm^2$ with a width of approximately 200 mm.

There shall not be any appreciable residual deformation.

In addition to the above tests the static tests according to 6.2.4 are also to be carried out.

For the end flaps made of aluminium alloy, additional dynamic tests should be considered.

## 7.10 Strength of stanchions

### 7.10.1 General

At these tests the permissible stresses indicated in 6.2.2 shall not be exceeded either on the stanchion or on its fastening. Furthermore, no residual strain or significant permanent deformation shall result from the test.

### 7.10.2 Strength of the side stanchions

Two side stanchions (pivoting or removable), fitted to the wagon and positioned opposite each other, shall be subjected to a force of:

— 35 kN at 500 mm acting from inside the wagon from the centre of the borehole (swivelling stanchions); and

— 35 kN at 500 mm from the upper fixation flange (removable stanchion)

in a horizontal direction towards the outside.

High strengths posts shall withstand a moment of:

— 42 kNm in transverse direction;

— 15 kNm in longitudinal direction.

### 7.10.3 Strength of the end stanchions

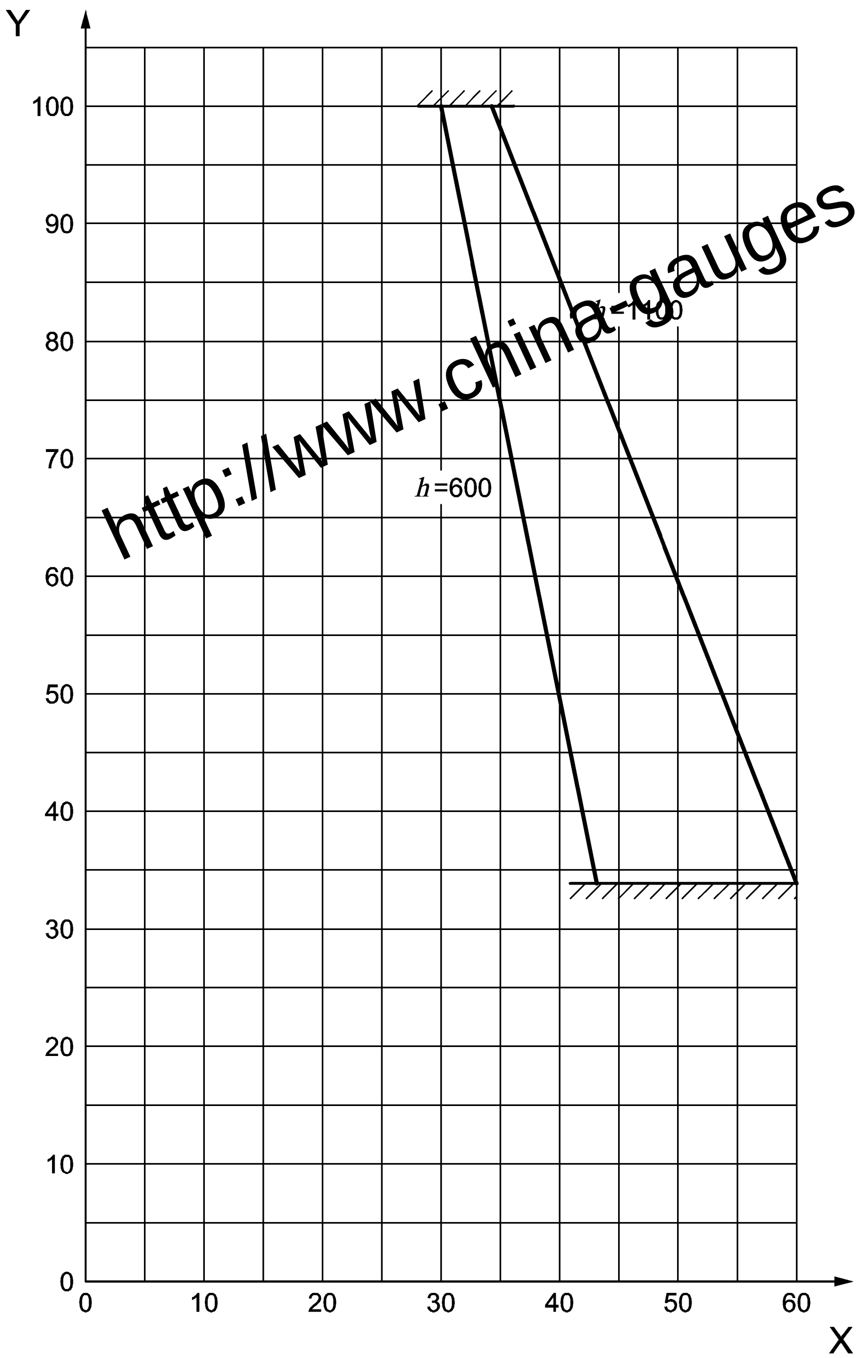
An end stanchion fitted to the wagon shall be subjected to a force of 80 kN directed from inside the wagon towards the outside in a horizontal direction, applied 350 mm above the top surface of the floor.

## 7.11 Strength of lockable partitions of sliding wall wagons

When the partition is locked a force which corresponds to a buffing impact on a load of 5 t at a speed of 13 km/h and which simulates the stresses produced by a palletized load shall be applied:

— to a square surface area of 1 m side length, 600 mm and 1 100 mm above the top of the floor. The forces and deformation of the partition shall be measured. The force shall be increased until the deformation corresponds to that in the diagram given in Figure 16. There shall be no damage to the locking mechanism;

— to the seat of the lower lock via a pressure plate measuring 100 mm × 100 mm. A force increasing up to 50 kN shall be applied. There shall be no damage and no significant permanent deformation as a result of the test.






**Key**

Y force, in kilonewtons (kN)

X deflection, in millimetres (mm)

*h* height above top of the floor

**Figure 16 — Strength diagram**

The following alternative procedure applies to prove the strength of lockable partitions of sliding wall wagons:

a) The testing wagon shall be laden with the maximum permissible load. The testing load shall be equally allocated to the partitions surface that means with maximum payload/number of partitions per partitions surface.

b) The testing load shall be placed on timber pallets on the floor without insets between the pallets and the floor.

c) Buffing tests shall carried out with the speeds:

   1) 7 km/h (one time);

   2) > 9 km/h (one time);

   3) > 12 km/h (two times).

d) The impact-receiving wagon shall be a four-axle wagon loaded to a total weight of 80 t.



After the buffing tests the partitions and the locking devices shall not exhibit any visible deformation and the function of the locking and operating devices shall be faultless.

# 8 Buffing impact testing

## 8.1 General

Buffing impact tests with empty wagons are carried out in order to test the inertia effects (in particular the connection between the wagon frame and the bogies, and the response of the superstructures).

Buffing impact tests on loaded wagons are carried out in order to test the effect of a load on the superstructures and particularly on the end faces.

With regard to load protection, the accelerations acting on the vehicle are measured in the centre of the loading area in buffing tests with both empty and loaded wagons.

## 8.2 Implementation

### 8.2.1 General

The partner wagon shall be a four-axle wagon loaded to a total weight of 80 t.

Only friction spring (e.g. Ringfeder) or butyl buffers are approved reference buffers. These should possess Category A technical characteristics as specified in [A1⟩ EN 15551:2022 ⟨A1].

NOTE In case of a test on wagons equipped with automatic coupling, an elastic system of the automatic coupler should exhibit class 2 characteristics in accordance with UIC 524 on the partner wagon.

The side buffers or the elastic system of the automatic coupler of the wagon tested should be identical with those adopted for the same type of wagons.

In the case of tank wagons intended for the transportation of dangerous loads according to class 2 of RID, the side buffers of the wagon tested shall belong to Category A even though buffers from Category C are required to equip wagons of this type in accordance with [A1⟩ EN 15551:2022 ⟨A1].

The moving wagon impacts the stationary wagon, un-braked on straight track (no matter if it is the tested wagon or the partner wagon).

### 8.2.2 Buffing tests with empty wagons

The tests are conducted at increasing speeds up to 12 km/h. The acceleration curve $x^* = f(v)$ is to be recorded for the speed range of 8 km/h to 12 km/h taking account of 6.2.1. For certain wagons where a normal buffing impact might damage the special equipment on the wagon, the impact speed may be limited to 7 km/h.

A difference in buffer height of 50 mm can be tolerated.

In the case of refrigerator vans the test is also carried out with the vans fully loaded with refrigerant or with a corresponding load.

In the case of mechanically refrigerated vans the test is carried out with the machinery equipment in operation so as to ascertain its correct functioning during and after buffing.



### 8.2.3 Buffing tests with loaded wagons

For these tests, the vehicle tested should be carrying its maximum permissible load. Care should be taken to ensure that the buffing heights of the test wagon and the impacted wagon remain as identical as possible. They should be measured at the beginning and at the end of the tests.

A vertical displacement of the buffers of 50 mm is still permissible.

The various loads used for this test are as follows:

a) With covered wagons, wagons with opening roof, insulated, refrigerator or mechanically refrigerated wagons:

   1) sacks of gravel or another suitable load which will fully take up the useful volume[4];

   2) tests with insulated, refrigerator or mechanically refrigerated vans with suspended load are carried out only to meet particular requirements.

b) With high speed open wagons:

   1) UIC standard ballast or some other type of load which will ensure that the centre of gravity is at the same height with the maximum permissible load[4].

c) With special wagons for the transport of special products (gravity discharging wagons, strip coil wagons, etc.):

   1) products normally carried in these vehicles or, if possible, a load having the same characteristics (consistence, centre of gravity, etc.) [4].

d) With tank wagons:

   1) if possible, the products normally carried in these wagons, or where applicable water; the filling ratio stipulated by RID (ullage area and load) is to be observed in each case.

The following recommendations should be taken into consideration when the density of the product differs greatly from that of water:

[4] For these tests it is recommended that after each buffing, an inverse buffing effect be exerted so as to restore the load to its original position.

e) If the density of the product is substantially higher than 1, observance of the filling ratio produces a total load ($m$) which is less than the maximum total load ($M$). In this case the essential buffing speed of the impacting wagon is to be multiplied by the coefficient $K$:

$$K = \sqrt{\frac{M(80\,\text{t} + m)}{m(80\,\text{t} + M)}}$$

f) If the density of the product is substantially lower than 1, the maximum load makes it impossible to observe the filling ratio. In this case the measurements may not take into account the secondary effects generated by movement of the liquid. Only the first part of the signal is to be taken into account.

The tests are in each case to be carried out with non-pressurized containers.

In the case of container wagons without long stroke shock absorbers for linear trains and with spigots/twistlocks and car carrying wagons, this test is limited to a speed of 7 km/h.



### 8.2.4 Procedure for the tests

Taking into account the characteristics and requirements with regard to the test setup and measuring and evaluation techniques (see Clause 6 and Table 25), preliminary tests should be executed with increasing buffing speed and with the largest possible number of strain gauges for determining the following:

— the curve of the variation in force behind the buffers as a function of the impact speed;

— the strain gauge locations exhibiting the highest stresses and also those revealing any residual strains;

— the work diagrams of both buffers on the test wagon during three impacts at a speed of ca. 9 km/h;

— the acceleration curve $x^* = f(v)$ in the speed range of 8 km/h to 12 km/h[5].

These preliminary tests are continued until one of the two parameters – speed or force – reaches its maximum limiting value, as defined in Table 26[6].

With this limiting value, 40 identical buffing impacts are then executed. This number can be reduced if residual strains development is stable and below prescribed limits.

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[5] Respectively up to the limiting speed corresponding to an individual buffer force of 1 500 kN.

[6] Recommendations regarding the category of buffers, to be selected as a function of the type of wagon, are given in Technical Document DT 85 of ERRI-B12, Annex B 3.0.

**Table 25 — Instrumentation characteristics for impact test**

| | **Impact speed** $V_A$ | **Buffer force** $F_p$ | **Buffer stroke** $S_p$ | **Acceleration** $X^*$ | **Strain** |
|---|---|---|---|---|---|
| Transmission / frequency behaviour of the measuring chain | | Transmission of measuring signals up to a frequency of 1 kHz in the case of a drop in amplitude of 1 dB max. | | | |
| Position of sensor / location of measuring points | Immediately before buffing impact of impact wagon upon stationary wagon | Pressure gauge between base plate of buffer and headstock / frame end of test wagon | Two displacement transducers per buffer (above and below the buffer between the base plate and the buffer head) | Centre of test wagon body, where possible at or beneath the centre of the loading area | In keeping with specific plan of measuring points |
| Maximum value of measured variable | 20 km/h | 2 000 kN (force per buffer – dynamic) | 160 mm | 200 m/s² | 3 ‰ |
| Accuracy of measurement instrumentation | ±1 % | ±5 % | ±2 % | ±2,5 % | ±2,5 % |
| Limiting frequency for filtering [a] | Unfiltered | $f \geq 100$ Hz [b] | $f \geq 100$ Hz [b] | F = 32 Hz | Unfiltered |
| Observations | In specific studies also additional measurement of the speed of the impacted wagon after the buffing impact | Static calibration of force sensor | RMS-formation in the case of the electrical measuring signals from the two displacement transducers per buffer | Influence upon the measuring signal from natural oscillation of the fastening component is to be ruled out | The specific characteristics of the strain gauge in use are to be indicated in the test report |

[a] Filtering is basically to be carried out with low-pass filters with Butterworth characteristics and a roll off of ≥ 24 dB/octave (4th order) and - 3 dB at the case at the limiting frequency; the roll off is to be indicated in the test report.

[b] Filtering of the buffer force and buffer stroke shall, however, be synchronized; the filter frequency shall be indicated in the test report.

The preliminary tests and the series of buffing tests should be conducted under the conditions given in Table 26[7)].

**Table 26 — Conditions for preliminary tests and serial buffing tests**

| **Limit values** | | **Preliminary tests** | **Serial tests [b]** |
|---|---|---|---|
| **Force per buffer [a]** | **Impact speed** | | |
| 1 500 kN [c d] | 12 km/h | Ten impacts with progressively increasing speeds up to 12 km/h; of which three impacts at approx. 9 km/h.<br>If however an individual buffer force of 1 500 kN [c] is reached at a speed of v < 12 km/h, the speed shall not be increased beyond this value. | 40 impacts with the limiting speed determined in the preliminary tests:<br>— either 12 km/h; or<br>— speed corresponding to an individual buffer force of 1 500 kN [c e f] |

[a] The permissible tolerance on the buffer force at one end of the wagon is ± 200 kN, but the total force on both buffers should not exceed 3 000 kN.

[b] If the individual buffer force in the preliminary tests does not exceed 1 000 kN, the tests series with 40 buffing impacts may be dispensed with.

[c] If the wagon tested is equipped with buffers of Category C of [A1⟩ EN 15551:2022 ⟨A1], the limiting value of the buffer force may, subject to the agreement of the railway concerned, be reduced to 1 300 kN.

[d] The test wagon is to be equipped with higher capacity buffers when the buffer force already reaches 1 000 kN for an impact speed of < 9 km/h or the acceleration values measured with respect to the loading area do not meet the damage prevention requirements insofar as limit values that have been prescribed for the acceleration have been exceeded.

[e] If requested by the railway, buffing tests with a force above 1 500 kN and a speed of up to 12 km/h are carried out at the end of the tests.

[f] For wagons with hydrodynamic long-stroke shock absorbers the limiting value of the buffer force is reduced to 1 000 kN.



7) Unless otherwise stated in the specifications. In particular, with certain wagons for which gravity shunting, pushing off and impacting other wagons are subject to restrictions, the buffing speed may be limited to 7 km/h.

### 8.2.5 Special case of wagons

#### 8.2.5.1 Special case of wagons F-II of which the underframe has a compressive strength of 1 200 kN

The wagons concerned are car-carrying wagons and combined transport wagons without long stroke shock absorbers.

Preliminary tests are to be carried out in both loading conditions and with the following speeds:

— 7 km/h with maximum load;

— 12 km/h in tare condition.

Depending on the buffer force measured, the procedure is as indicated in Table 27.

**Table 27 — Test procedure**

| **Maximum impact speed**<br>km/h | **Individual buffer force *F***<br>kN | **Further action** |
|---|---|---|
| 7 loaded<br>and<br>12 empty | $F < 600$ [a] | No test series |
| | $660 \leq F < 900$ [b] | Performance of a test series of 40 impacts under the most unfavourable loading and speed conditions when residual stresses occur in the underframe. |
| | $F > 900$ [b] | Equip wagon with more powerful buffers and repeat preliminary tests. |

[a] The permissible upper and lower limit of the individual buffer force on one wagon end is ± 100 kN, but the total buffer force shall not exceed 1 200 kN.

[b] The permissible upper and lower limit of the individual buffer force on one wagon end is ± 100 kN, but the total buffer force on both buffers is not to exceed 1 800 kN.

For the series of 40 buffing impacts, the following measurements are to be taken after every fifth impact:

— stresses at the moment of impact;

— residual strains after the impacts, using a strain gauge bridge;

— variation in length of the loading functional dimensions after the impacts.

#### 8.2.5.2 Special case of freight wagon with automatic coupler

The tests with freight wagons according category F-I are carried out at increasing speeds up to 12 km/h. For wagons according category F-II the test speed may be limited to 7 km/h.

#### 8.2.5.3 Tank wagons equipped with crashworthy buffers according to RID

To ensure that the wagon fulfils the requirements of the RID the structure shall be tested to show that the load peaks induced in the energy absorption elements can be transferred into the structure without any major plastic deformations and without any significant structural collapse.

This objective can be demonstrated by the static test using the equation in 6.3 and the buffing test at 12 km/h.

### 8.3 Assessment of the results

The different buffing tests should not give rise to any significant permanent deformation. The stresses occurring at certain critical points of the bogie/underframe, under-frame/body and superstructure connections should be recorded.

The test-results obtained for wagons with side-buffers shall satisfy the following conditions:

— the cumulative residual strains arising from the preliminary tests and from the series of 40 buffing impacts should be less than 2 ‰ and should be stabilized before the thirtieth impact of the series. This does not apply however to those structural components covered by special provisions;

— the variations in leading dimensions shall not impair the operating safety of the wagon.

## 9 Validation programme

### 9.1 Objective

The objective of the validation programme is to prove that the design of the freight wagon body structure and associated specific equipment withstands the maximum loads consistent with the operational requirements and achieves the required service life under normal operating conditions. It shall be demonstrated by calculation and/or testing, that no significant permanent deformation or fracture of the structure as a whole, or of any individual element, will occur under the load cases defined in Clause 5 for wagon body or in Clause 7 for associated specific equipment and under buffing test load defined in Clause 8. The content of the validation programme depends on the degree of originality in the design and changes of its application (including but not limited to intensity of usage and years in service). This clause gives a solution for the definition of validation programme for evolved design or application.

**Table 28 — Summary of validation programme**

| | Complete structural analysis | Local or global comparative structural analysis | Tests specified in this standard | Fatigue and/or service tests |
|---|---|---|---|---|
| **New design** | N/A | N/A | yes | only required if tests specified in this standard do not show sufficient fatigue strength |
| **Evolved design and/or new application**<br>**Identical design and new application** | no | yes | no or reduced test programme | only required if other methods do not show sufficient fatigue strength |
| **Evolved design, similar application** | no | yes | no or reduced test programme | no |
| NOTE A new design is a product (vehicle or component part) that is newly created and has no direct connection with any existing similar product. An evolved design is a product (vehicle or component part) that is based on an existing similar product and has direct connection with that existing product. | | | | |



## 9.2 Validation programme for new design of vehicle body structures – Testing

### 9.2.1 Tests specified in this standard

The characteristic vehicle body structures and associated specific equipment of the railway vehicle shall be tested as specified in this standard.

### 9.2.2 Fatigue testing

It is not normal practice to carry out laboratory dynamic fatigue tests on full vehicle body structures but in some circumstances this may be appropriate if tests specified in this standard do not show sufficient fatigue strength.

Fatigue tests may be performed on specific structural details to demonstrate sufficient fatigue strength.

### 9.2.3 Service testing

In order to evaluate the fatigue strength, on track service tests can be used to directly measure operating stresses and check fitness for purpose when tests specified in this standard have not shown sufficient fatigue strength. Strain gauges shall be applied at significant positions of the structure of the fully equipped railway vehicle (with normal design payload $m_3$) to capture the structural response for representative service conditions. These positions shall cover all critical areas according to the results of the structural analyses and/or static test.

Based on these measurements an assessment of the fatigue strength in the significant measurement positions and critical areas shall be performed as final step of the proof of fitness for purpose.

## 9.3 Validation programme for evolved design of vehicle body structures



### 9.3.1 General

If a new vehicle body structure is evolved from a proven design the test programme may be reduced as indicated in 9.3.

### 9.3.2 Structural analyses

Where a vehicle body is a development of an earlier design for which the safety has been demonstrated and similar service conditions apply, then earlier data may be used, supported by comparative evidence. Areas of significant change shall be re-analysed. Where the global load path is maintained and the stresses remain below the acceptable limits it is sufficient to demonstrate the acceptability of the changes only by analysis.

### 9.3.3 Testing

#### 9.3.3.1 General

Tests shall be performed if it has not been possible to validate the design as indicated in 9.3.2.

#### 9.3.3.2 Tests specified in this European Standard

A test programme shall be carried out that considers the areas of structural changes and the associated loads.

#### 9.3.3.3 Fatigue testing

Fatigue tests may be performed as indicated in 9.2.2.

#### 9.3.3.4 Service testing

When analysis or static testing have not shown compliance with this standard and if the application on a new track imposes significantly different loading conditions, on-track service tests can be used to measure operating stresses and check fitness for purpose. The number of strain gauges may be reduced in comparison with the measurements of the original design.

Based on these measurements an assessment of the fatigue strength in the significant measurement positions and critical areas shall be performed as final step of the proof of fitness for purpose.

[A1) *Deleted annex* (A1]

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[1] EN 10025 (all parts), *Hot rolled products of structural steels*

[2] UIC 524:1978, *Wagons — Technical specifications governing spring devices for wagons fitted with automatic couplers belonging to the UIC and OSJD member railways*

[3] UIC 844-3:2001, *Technical specification for the supply of plywood panels, glued together and protected by phenolic resin, for the walls of covered wagons*

[4] UIC 577, *Wagon stresses*

[5] UIC 573, *Technical conditions for the construction of tank wagons*

[6] ERRI B12/RP17, *Programme of tests to be carried out on wagons with steel underframe and body structure (suitable for being fitted with the automatic buffing and draw coupler) and on their cast steel frame bogies*

[7] ERRI B12/RP60, *Regulations for proof tests and maximum permissible stresses*

[8] RID Regulations concerning the International Carriage of Dangerous Goods by Rail[8)]

8) Can be purchased from www.otif.org.

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