SLOVENSKI STANDARD
SIST EN 12663:2001

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Železniške naprave - Konstrukcijske zahteve za vagonske koše železniških vozil

Railway applications - Structural requirements of railway vehicle bodies

Bahnanwendungen - Festigkeitsanforderungen an Wagenkästen von Schienenfahrzeugen

Applications ferroviaires - Prescriptions de dimensionnement des structures de véhicules ferroviaires

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45.060.20	Železniški vagoni	Trailing stock

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EUROPEAN STANDARD
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Railway applications - Structural requirements of railway vehicle bodies

Applications ferroviaires - Prescriptions de dimensionnement des structures de véhicules ferroviaires

Bahnanwendungen - Festigkeitsanforderungen an Wagenkästen von Schienenfahrzeugen

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Contents

Foreword

This European Standard 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of an identical text or by endorsement, at the latest by January 2001, and conflicting national standards shall be withdrawn at the latest by January 2001.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Introduction

The structural design of railway vehicle bodies depends 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 of the vehicle body.

The loading requirements for the vehicle body structural design and testing 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 designer freedom to optimise his design whilst maintaining requisite levels of safety.

This European Standard defines no specific arithmetical techniques in order not to affect the developments in analysis methods and permit innovative developments by vehicle designers and operators. Changes due to advances in scientific knowledge and technology will be taken into account at suitable intervals through revisions and/or supplements.

1 Scope

This European Standard defines minimum structural requirements for railway vehicle bodies.

This European Standard specifies the loads vehicle bodies shall be capable of sustaining, identifies how material data shall be used and presents the principles to be used for design verification by analysis and testing.

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

These structural requirements should not be confused with operating requirements. It is the responsibility of the operator to decide as to which structural category railway vehicles shall be designed. Some vehicles may not fit into any of the defined categories; the structural requirements for such railway vehicles should be specified by the operator using the principles presented in this European Standard.

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

2 Definitions

For the purpose of this European Standard, the following definitions apply:

2.1 Railway vehicle body

It comprises the main load carrying structure above the suspension units. It includes 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.

2.2 Operator of railway vehicles

The organisation which has the responsibility for defining the technical requirements for the railway vehicle in order that it will perform the intended operation in consideration of acceptance criteria.

2.3 Designer of railway vehicles

The organisation which has responsibility for designing the railway vehicle to satisfy the technical requirements of the operator.

2.4 Vehicle masses

2.4.1 Mass of the vehicle body in working order m_1

The mass in working order m_1 consists of the completely assembled vehicle body with all mounted parts. This includes the full operating reserves of water, sand, fuel, foodstuffs etc. and the overall weight of staff.

2.4.2 Maximum payload m_2

The maximum payload m_2 is to be determined dependent on the type of vehicle. For freight vehicles, it corresponds to the allowed mass of the goods. For passenger rolling stock, it depends on the number of seats for passengers and on the number of passengers per m^2 in the standing areas. These values are fixed by the operator, taking into account any statutory regulations, and give the mass for the payload and the number of passengers which are allowed to be transported in these vehicles.

Typical weights for passengers:

- long distance	80 kg per passenger with luggage;
- commuter/suburban	70 kg per passenger.

Typical passenger densities in standing areas :

- long distance	2 to 4 passenger per m^2;
- commuter/suburban	5 to 10 passengers per m^2.

Typical luggage area loading:

-	300 kg per m^2.

2.4.3 Mass of the bogie or running gear m_3

The mass of one bogie or running gear m_3 is the mass of all equipment below and including the body suspension. The mass of linking elements between vehicle body and bogie or running gear shall be apportioned between m_1 and m_3.

2.5 Coordinate system

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

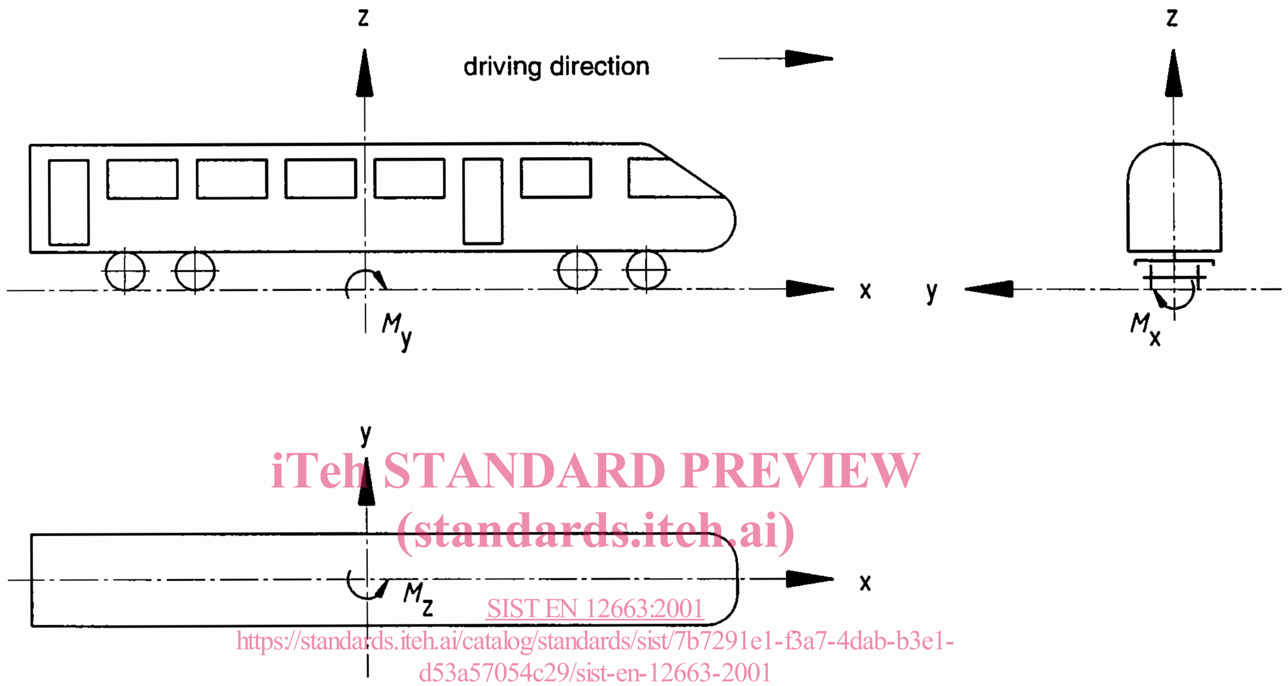

Figure 1 - Vehicle coordinate system

3 Structural requirements

3.1 General

Railway vehicle bodies shall withstand the maximum loads consistent with their operational requirements and achieve the required service life under normal operating conditions with an adequate probability of survival.

The capability of the railway vehicle body to not sustain permanent deformation and fracture shall be demonstrated by calculation and/or testing (see clause 6). The assessment shall be based on the following criteria:

a) Exceptional loading defining the maximum loading which shall be sustained and a full operational condition maintained;

b) Acceptable margin of safety, such that if the exceptional load is exceeded, catastrophic fracture or collapse will not occur;

c) Stiffness, such that the deformation under load and the natural frequencies of the structure meet limits as determined by the operational requirements;

d) Service or cyclic loads being sustained for the specified life without detriment to the structural safety.

The operator shall supply data defining the expected service conditions. In conjunction with the operator, it is the task of the designer to identify all significant load cases in a meaningful way from these data and to ensure that the design satisfies them.

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 and/or tested.

The requirements of this European Standard are based on the use of metallic materials and requirements defined in 3.4.2, 3.4.3 and 3.6 and clauses 5 and 6 are specifically applicable only to such materials. If different (non-metallic) materials are being used, then the basic principles of this standard shall still be applied. The designer shall ensure that he has suitable data to represent the performance of the materials. He shall adopt methods and requirements such that they are applied in a manner consistent with the current state of knowledge.

The load cases used as the basis of vehicle body design shall comprise the relevant cases listed in clause 4.

All formal parameters are expressed as SI basic units and units derived from SI basic units. The gravitational acceleration g is -9,81 m/s^2.

3.2 Categories of railway vehicles

3.2.1 Structural categories

For the application of this European Standard, all railway vehicles are classified in categories.

The classification of the different categories of railway vehicles is based only upon the structural requirements of the vehicle bodies. It is the responsibility of the operators to decide as to which category railway vehicles shall be designed. There will be differences between operators. This is to be expected and should not be considered as conflicting with this European Standard. Some railway vehicles may not fit into any of the defined categories. The structural requirements for such railway vehicles should be specified by the operator using the principles presented in this standard.

Due to the specific nature of their construction and different design objectives there are two main groups, namely freight vehicles (F) and passenger vehicles including locomotives (P). The two groups may be subdivided further into categories according to their structural requirements.

The choice of category from the clauses below shall be based on the structural requirements as defined in the tables in clause 4. These structural requirements should not be confused with the operating requirements. The track gauge is also not a determinant for the choice of category.

3.2.2 Freight vehicles

All vehicles 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 excluded from hump and loose shunting.

3.2.3 Passenger vehicles and locomotives

To this group belong all types of railway vehicles intended for the transport of passengers, ranging from main line vehicles, suburban and urban transit stock to tramways. Also included are locomotives and power units.

Passenger vehicles are divided into five structural design categories into which all vehicles may be allocated. The five categories are listed below, with an indication of the types of vehicle generally associated with each:

Category P-I	e.g. Coaches and locomotives;
Category P-II	e.g. Fixed units;
Category P-III	e.g. Underground and rapid transit vehicles;
Category P-IV	e.g. Light duty metro and heavy duty tramway vehicles;
Category P-V	e.g. Tramway vehicles.

3.3 Uncertainties in railway design parameters

3.3.1 Loads

All loads used as the basis for vehicle body design shall incorporate any necessary allowance for uncertainties in their values. The loads specified in clause 4 include this allowance.

3.3.2 Material

For design purposes, the minimum material property values as defined by the material specification shall be used. Where the material properties are affected, for example, by

- rate of loading;
- time (e.g. by material ageing);
- environment (moisture absorption, temperature etc.);
- welding or other manufacturing processes

appropriate new minimum values shall be determined.

Similarly, the S-N curve used to represent the fatigue behaviour of material shall incorporate the above effects and shall represent the lower bound of data scatter as defined in 5.2.

3.3.3 Uncertainty factors

The following factors introduce uncertainty into the design process:

a) Dimensional tolerances

It is normally acceptable to base calculations on the nominal component dimensions. It is necessary to consider minimum dimensions only if significant reductions in thickness (due to wear etc.) are inherent in the operation of the component. Adequate protection against corrosion will be an integral part of the vehicle specification. The loss of material by this cause may normally be neglected.

b) Manufacturing process

The performance characteristics exhibited by material in actual components may differ from those derived from test samples. Such differences are due to variations in the manufacturing processes and workmanship, which cannot be detected in any practicable quality control procedure.

c) Analytical accuracy

Every analytical procedure incorporates approximations and simplifications. It is incumbent on the designer to be consciously conservative in the application of analytical procedures to the design.

The uncertainties described in a) and b) may be allowed for by incorporating a safety factor into the design process. This "uncertainty factor" designated S shall be applied when comparing the calculated stresses to the permissible stress.

3.4 Demonstration of static strength and structural stability

3.4.1 Requirement

It shall be demonstrated by calculation and/or testing, that no permanent deformation or fracture of the structure as a whole, or of any individual element, will occur under the prescribed design load cases. The requirement shall be achieved by satisfying 3.3.2 and, if the design is also limited by the conditions of 3.4.3 and 3.4.4 these shall be satisfied as well.

3.4.2 Yield or proof strength

Where the design is verified only by calculation, S_1 shall be 1,15 for each individual load case. S_1 may be taken as 1,0 subject to agreement between designer and operator where:

- the design load cases are to be verified by test or
- the uncertainties mentioned in 3.3.3 can be shown to be very low or
- the superposition of load cases is demonstrated by calculation (see 4.4).

Under the static load cases as defined in 4.1 to 4.5, the ratio of permissible stress to calculated stress shall be greater than or equal to S_1.

$$\frac{R}{\sigma_\mathrm{c}} \geq S_1$$

where:

R is the material yield (R_el) or 0,2% proof stress, (R_p02) in N/mm^2

σ_c is the calculated stress, in N/mm^2.

In determining the stress levels in ductile materials, it is not necessary to take into account features producing local stress concentration. If the analysis does incorporate local stress concentrations, then it is permissible for the theoretical stress to exceed the material yield or 0,2% proof limit. The areas of local plastic deformation associated with stress concentrations shall be sufficiently small so as not to cause any significant permanent deformation when the load is removed.

3.4.3 Ultimate strength

It is necessary to provide a margin of safety between the maximum design load and the failure load. This is achieved by introducing a safety factor, S_2, such that the ratio between material ultimate stress and calculated stress shall be greater than or equal to S_2[1]).

$$\frac{R_\mathrm{m}}{\sigma_\mathrm{c}} \geq S_2$$

where:

R_m is the material ultimate stress, in N/mm^2;

σ_c is the calculated stress, in N/mm^2.

Usually S_2=1,5, but the factor may be reduced when at least one of the following conditions is fulfilled:

a) there are alternative load paths;

b) for parts of the structure which are specifically designed to collapse in a controlled manner;

c) the calculations are sufficiently detailed to give high confidence in the performance of the critical areas of the structure.

The treatment of stress concentration as indicated in 3.4.2 also applies in this case. However, the effect of stress concentration shall be considered in more detail for brittle materials where local plastic yielding, as a mechanism for stress redistribution at the concentration, does not occur.

A reduction in the value of S_2 shall be agreed between the operator and designer.

3.4.4 Stability

Local instability, in the form of elastic buckling, is permissible provided alternative load paths exist and the yield or proof criteria are met.

The vehicle structure shall have a margin of safety against instability leading to general structural failure. This is to be achieved by ensuring that the ratio of the critical buckling stress to the calculated stresses shall be greater than or equal to S_3:

$$\frac{\sigma_\mathrm{cb}}{\sigma_\mathrm{c}} \geq S_3$$

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[1]) S_2 incorporates the uncertainty factor S_1

where:

σ_{cb} is the critical buckling stress, in N/mm^2;

σ_c is the calculated stress, in N/mm^2.

Usually S_3=1,5, but the factor may be reduced if the structure is specifically designed to collapse in a controlled manner. A reduction in the value of S_3 shall be agreed between the operator and designer.

3.5 Demonstration of stiffness

Stiffness limits ensure that the vehicle body remains within its required space envelope and unacceptable dynamic responses are avoided.

The required stiffness may be defined in terms of an allowable deformation under a prescribed load or as a minimum frequency of vibration. The requirements may apply to the complete vehicle body or to specific components or sub-assemblies.

Any additional specific requirements shall be agreed between the operator and designer.

3.6 Demonstration of fatigue strength

3.6.1 General

The structures of railway vehicle bodies are subjected to a very large number of dynamic loads of varying magnitude during their operational life.

The effects of these loads are most apparent at critical features in the vehicle body structure. Examples of such features are:

a) Points of load input (including equipment attachments);

b) Joints between structural members (e.g. welds, bolted connections);

c) Changes in geometry giving rise to stress concentrations (e.g. door and window corners).

The identification of these critical features is essential. This is achieved by the designer's experience in conjunction with the results of structural analysis or tests. Detailed examination of local features may be necessary.

It is possible to demonstrate the fatigue strength by two different calculation methods:

a) Endurance limit approach (see 3.6.2.1);

b) Cumulative damage approach (see 3.6.2.2).

The nature and quality of the available data influence the choice of method to be used as described in 3.6.2. The methods to be used shall be agreed between designer and operator.

Provided the dynamic load cases which are being examined in the fatigue analysis already include allowance for any uncertainty and provided the minimum material properties are used as described in 5.2, no additional safety factors are necessary in these calculations.

Test methods to demonstrate the fatigue performance or to verify the calculations results are described in 6.3.

3.6.2 Methods of calculation

3.6.2.1 Endurance limit approach

This approach is acceptable where the material data show that an endurance limit exists. The endurance limit is a stress level at which, provided all dynamic stress cycles remain below it, no fatigue damage will occur.

The required fatigue strength is demonstrated provided the stress, due to all appropriate combinations of the fatigue load cases defined in 4.6 to 4.8, remains below the endurance limit.

3.6.2.2 Cumulative damage approach

This approach should be used when it is inappropriate to maintain the stress level below the endurance limit for all relevant load combinations, or when no material endurance limit can be defined.