SLOVENSKI STANDARD
SIST EN 13104:2004

01-junij-2004

Železniške naprave - Kolesne dvojice in podstavni vozički – Pogonske osi - Konstrukcijska metoda

Railway applications - Wheelsets and bogies - Powered axles - Design method

Bahnanwendungen - Radsätze und Drehgestelle - Treibradsatzwellen - Konstruktions- und Berechnungsrichtlinie

Applications ferroviaires - Essieux montés et bogies - Essieux-axes moteurs - Méthode de conception

Ta slovenski standard je istoveten z: EN 13104:2001

ICS:

45.040	Materiali in deli za železniško tehniko	Materials and components for railway engineering

SIST EN 13104:2004 **en**

EUROPEAN STANDARD

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EN 13104

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English version

Railway applications - Wheelsets and bogies - Powered axles - Design method

Applications ferroviaires - Essieux montés et bogies - Essieux-axes moteurs - Méthode de conception

Bahnanwendungen - Radsätze und Drehgestelle - Treibradsatzwellen - Konstruktionsverfahren

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

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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of an identical text or by endorsement, at the latest by October 2001, and conflicting national standards shall be withdrawn at the latest by October 2001.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 Directives.

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

Railway axles were among the first train components to give rise to fatigue problems.

Many years ago, specific methods were developed in order to design these axles. They were based on a feedback process from the service behaviour of axles combined with the examination of failures and on fatigue-tests conducted in the laboratory, so as to characterise and optimise the design and materials used for axles.

A European working party under the aegis of UIC[1]) started to harmonise these methods at the beginning of the 1970's. This led to an ORE[2]) document applicable to the design of trailer stock axles, subsequently incorporated into national standards (French, German, Italian).

This method was successfully extrapolated in France for the design of powered axles and the French standard also applies to such axles. Consequently this method was converted into a UIC leaflet.

The bibliography lists the relevant documents used for references purposes. The method described therein is largely based on conventional loadings and applies the beam theory for the stress calculation. The shape and stress recommendations are derived from laboratory tests and the outcome is validated by many years of operations on the various railway systems.

This standard is largely based on this method which has been improved and its scope enlarged.

1 Scope

This standard:

- defines the forces and moments to be taken into account with reference to masses, traction and braking conditions;
- gives the stress calculation method for axles with outside axle-journals;
- specifies the maximum permissible stresses to be assumed in calculations, for steel grade EA1N defined in prEN 13261:1998;
- describes how to obtain the maximum permissible stresses for other steel grades;
- determines the diameters for the various sections of the axle. The preferred shapes and transitions are identified to ensure adequate service performance.

This standard is applicable to:

- solid and hollow powered axles for railway rolling stock;
- solid and hollow non-powered axles of motor bogies;
- solid and hollow non-powered axles of locomotives[3]);
- axles defined in prEN 13261:1998;
- all gauges[4]).

This standard is applicable to axles fitted to rolling stock intended to run under normal European conditions. Before the use of this standard, if there is any doubt as to whether the railway operating conditions are normal, it is necessary to determine whether an additional design factor has to be applied to the maximum permissible stresses. The calculation of wheelsets for special applications (e.g. tamping/lining/levelling machines) may be made according to the submitted standard, for the load case of free running and running in train formation. This standard is not applicable for workload cases. They are calculated separately.

For light rail and tramway applications other standards or documents, agreed between the customer and supplier, may be applied.

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[1]) UIC: Union Internationale des Chemins de fer

[2]) ORE: Office de Recherches et d'Essais de l'UIC

[3]) In France the interpretation of the term “locomotive” is locomotive, locomoteur or locotracteur.

[4]) If the gauge is not standard, some formulae need to be adapted.

2 Normative references

This European Standard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

prEN 13260:1998 Railway applications - Wheelsets and bogies - Wheelsets - Product requirements

prEN 13261:1998 Railway applications - Wheelsets and bogies - Axles - Product requirements

3 Symbols and abbreviated terms

For the purposes of this European Standard, the symbols and abbreviated terms of table 1 apply:

Table 1

Symbol	Unit	Description
m_1	kg	Mass on journals per wheelset (bearings and axle boxes masses are included)
m_2	kg	Wheelset mass and masses on the wheelset between rolling planes (brake disc, gear wheel, etc.)
$m_1 + m_2$	kg	For the wheelset considered, mass applied on the rails
g	m/s^2	Acceleration due to gravity
P	N	Half the vertical force per wheelset applied on the rail $\frac{(m_1 + m_2)g}{2}$
P_0	N	Vertical static force per journal when the wheelset is loaded symmetrically $\frac{m_1 g}{2}$
P_1	N	Vertical force on the more heavily loaded journal
P_2	N	Vertical force on the less loaded journal
P'	N	Part of P braked by any mechanical braking system
Y_1	N	Wheel/rail horizontal force perpendicular to the rail on the side of the more heavily loaded journal
Y_2	N	Wheel/rail horizontal force perpendicular to the rail on the side of the less loaded journal
H	N	Force balancing the forces Y_1 and Y_2
Q_1	N	Vertical reaction on the wheel situated on the side of the more heavily loaded journal
Q_2	N	Vertical reaction on the wheel situated on the side of the less loaded journal
F_i	N	Forces exerted by the masses of the unsprung elements situated between the two wheels (brake disc(s), gear wheel, etc.)
F_f	N	Maximum force input of the brake-shoes of the same shoeholder on one wheel or interface force of the pads on one disc
M_x	Nmm	Bending moment due to the masses in motion
M'_x , M'_z	Nmm	Bending moments due to braking
M'_y	Nmm	Torsional moment due to braking

(continued)

Table 1 (concluded)

Symbol	Unit	Description
M''_x , M''_z	Nmm	Bending moments due to tractive force
M''_y	Nmm	Torsional moment due to tractive force
MX , MZ	Nmm	Sum of bending moments
MY	Nmm	Sum of torsional moments
MR	Nmm	Resultant moment
$2b$	mm	Distance between vertical force input points on axle journals
$2s$	mm	Distance between wheel rolling circles
h_1	mm	Height above the axle centreline of centre of gravity of masses carried by the wheelset
y_i	mm	Distance between the rolling circle of one wheel and force F_i
y	mm	Abscissa for any section of the axle calculated from the section subject to force P_1
Γ		Average friction coefficient between the wheel and the brake-shoe or between the brake pads and the disc
σ	N/mm^2	Stress calculated on one section
K		Fatigue stress concentration factor
R	mm	Nominal radius of the rolling circle of a wheel
R_b	mm	Brake disc radius
d	mm	Diameter for one section of the axle
d'	mm	Bore diameter of a hollow axle
D	mm	Diameter used for determining K
r	mm	Radius of transition fillet or groove used to determine K
S		Security coefficient
G		Centre of gravity
R_{fL}	N/mm^2	Fatigue limit under rotating bending up to 10^7 cycles for smooth specimens
R_{fE}	N/mm^2	Fatigue limit under rotating bending up to 10^7 cycles for notched specimens
a_q	m/s^2	Unbalanced transverse acceleration
f_q		Thrust factor

4 General

The major phases for the design of an axle are the following:

a) identification of the forces to be taken into account and calculations of the moments on the various sections of the axle;

b) selection of the diameters for axle-body and journals - on the basis of such diameters, calculation of the diameters for the other sections;

c) the options taken are verified in the following manner:

- stress calculation for each section;
- comparison of such stresses with the maximum permissible stresses.

The maximum permissible stresses are mainly defined by:

- the steel grade;
- whether the axle is solid or hollow;
- the type of transmission of motor power.

An example data sheet is given in annex A (informative).

5 Forces and moments to be taken into consideration

5.1 Type of forces

Three types of forces have to be addressed:

- masses in motion;
- braking force and moments;
- tractive force and moments.

5.2 Effects due to masses in motion

The forces generated by masses in motion are concentrated along the vertical symmetry plane (y,z) (see figure 1) intersecting the axle centreline.

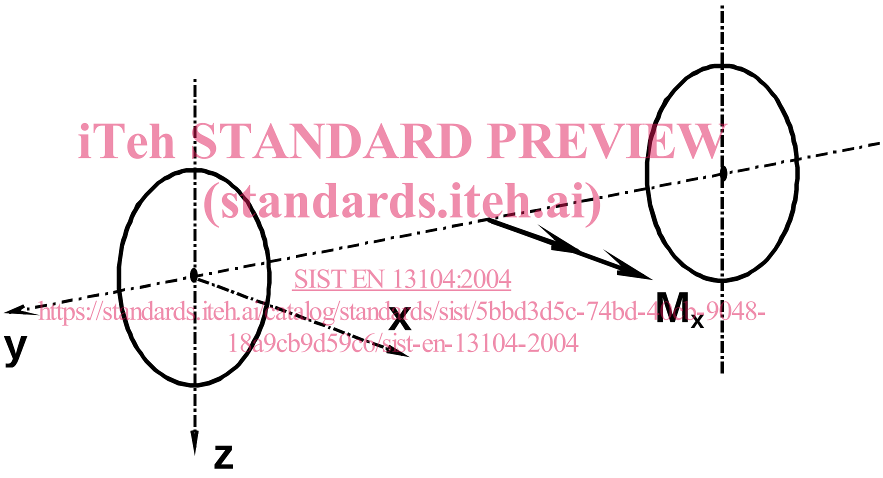


Figure 1

Unless otherwise defined by the customer, the masses $(m_1 + m_2)$ to be taken into account for the main railway applications are defined in table 2. For particular applications, e.g. suburban vehicles, other definitions for masses are necessary, in accordance with the specific operating requirements.

Table 2

Type of rolling stock units	Mass $(m_1 + m_2)$
Tractive units with no passenger accommodation, luggage areas and postal vans	For the axle considered, the proportion of the wagon mass under maximum permissible loading in service
Tractive stock including passenger accommodation, luggage areas and vans	
1 – Main line vehicles[1])	Mass in service + 1,2 × payload, "mass in service" is defined as: the vehicle mass without passengers, tanks full with water, sand, fuel, etc.; "payload" is defined as: the mass of a passenger, which is estimated at 80 kg including hand luggage; – 1 passenger per seating place; – 2 passengers per m² in corridors and vestibules; – 2 passengers per attendant's compartment; – 300 kg per m² in luggage compartments.
2 – Suburban vehicles[1]) [2])	Mass in service + 1,2 × payload, "mass in service" is defined as: the vehicle mass without passengers, tanks full with water, sand, fuel, etc.; "payload" is defined as: the mass of a passenger, which is estimated at 70 kg (little or no luggage); – 1 passenger per seating place; – 3 passengers per m² in corridor areas; – 4 or 5passengers per m² in vestibule areas[2]); – 300 kg per m² in luggage compartments.

[1]) The payloads to be taken into account to determine the mainline and suburban vehicles broadly reflect the normal operating conditions of the member railways of the International Union of Railways (UIC). If and when operating conditions significantly differ from the above framework, masses may be modified, for example, by increasing or decreasing the number of passengers per m² in corridors and vestibules.

[2]) These vehicles are sometimes associated with classes of passenger travel, i.e. 1st or 2nd class.

The bending moment M_x in any section is calculated from forces P_1, P_2, Q_1, Q_2, Y_1, Y_2 and F_i as shown in Figure 2. It represents the most adverse condition for the axle, i. e.:

- asymmetric distribution of forces
- the direction of the forces F_i due to the masses of unsprung components selected in such a manner that their effect on bending is added to that due to the vertical forces.

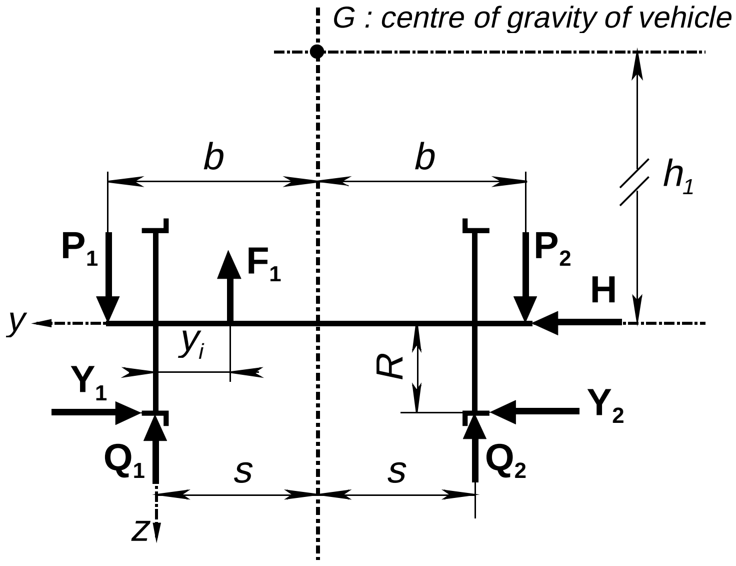


Figure 2

Table 3 shows the values for the forces calculated from m_1.

The formulae coefficient values are applicable to standard gauge axles and classical suspension. For very different gauges, metre gauge for example, or new system of suspension, pendular system for example, other values shall be considered (see informative annex B).

Table 3

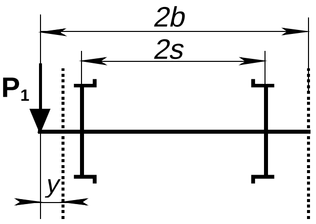
For all axles defined in the scope of this standard	$P_1 = (0{,}625 + 0{,}0875 h_1 / b) m_1 g$ $P_2 = (0{,}625 - 0{,}0875 h_1 / b) m_1 g$ $Y_1 = 0{,}35 m_1 g$ $Y_2 = 0{,}175 m_1 g$ $H = Y_1 - Y_2 = 0{,}175 m_1 g$
For all axles	$Q_1 = \frac{1}{2s}[P_1(b+s) - P_2(b-s) + (Y_1 - Y_2)R - F_i(2s - y_i)]$ $Q_2 = \frac{1}{2s}[P_2(b+s) - P_1(b-s) - (Y_1 - Y_2)R - F_i y_i]$

Table 4 shows the formulae to calculate M_x for each zone of the axle and the general outline of M_x variations along the axle.

Table 4

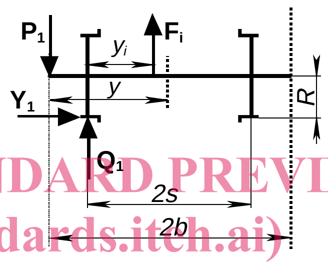
<table>
<tr><th>Zone of the axle</th><th>M_x [1])</th></tr>
<tr><td>Between loading plane and rolling plane</td><td>

$M_x = P_1 y$



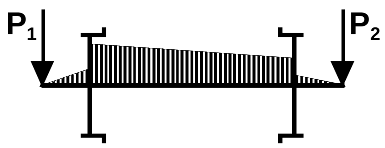
</td></tr>
<tr><td>Between rolling planes</td><td>

$M_x = P_1 y - Q_1 (y - b + s) + Y_1 R - F_i (y - b + s - y_i)$



F_i : Force(s) situated on the left of the section considered

</td></tr>
<tr><td>General outline of M_x variations</td><td>



</td></tr>
<tr><td colspan="2">[1]) For a non-symmetric axle the calculations shall be carried out after alternately applying the load to the two journals to determine the worst case.</td></tr>
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