SLOVENSKI STANDARD
SIST-TS CEN/TS 13103-2:2020

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Železniške naprave - Kolesne dvojice in podstavni vozički - 2. del: Metode za načrtovanje osi z notranjim uležajenjem

Railway applications - Wheelsets and bogies - Part 2: Design method for axles with internal journals

Bahnanwendungen - Radsätze und Drehgestelle - Teil 2: Konstruktionsleitfaden für innengelagerte Radsatzwellen

Applications ferroviaires - Essieux montés et bogies - Partie 2: Méthode de conception pour les essieux-axes à fusées intérieures

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ICS:

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

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European foreword

This document (CEN/TS 13103-2:2020) has been prepared by Technical Committee CEN/TC 256 “Railway applications”, the secretariat of which is held by DIN.

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1 Scope

This document:

— 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 inboard axle journals;

— specifies the maximum permissible stresses to be assumed in calculations for steel grade EA1N, EA1T and EA4T defined in EN 13261;

— describes the method for determination of the maximum permissible stresses for other steel grades;

— determines the diameters for the various sections of the axle and recommends the preferred shapes and transitions to ensure adequate service performance.

This document is applicable for axles defined in EN 13261.

This document applies only for heavy rail vehicles.

The calculation of wheelsets for special applications (e.g. railbound construction and maintenance machines) can be made according to this document only for the load cases of free-rolling and rolling in train formation.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 13260, *Railway applications — Wheelsets and bogies — Wheelsets — Product requirements*

EN 13261, *Railway applications — Wheelsets and bogies — Axles — Product requirements*

EN 15313, *Railway applications - In-service wheelset operation requirements - In-service and off-vehicle wheelset maintenance*

EN 15663, *Railway applications - Definition of vehicle reference masses*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

3.1
powered axle
vehicle axle that is driven by a vehicle's engine. For the purpose of this standard, the following solid and hollow axles are considered as "powered axles":

— powered axles for railway rolling stock;

— non-powered axles of motor bogies;

— non-powered axles of locomotives

3.2
non-powered axle
solid and hollow axle of railway rolling stock used for the transportation of passengers and freight that is not considered as a powered axle as defined in 3.1

3.3
technical specification
document, describing specific parameters and/or product requirements as an addition to the requirements of this standard

3.4
guiding axle
first axle (i.e. leading) of a train set

4 Symbols and abbreviations

For the purposes of this document, the symbols and abbreviations in Table 1 apply.

Table 1 — Symbols and abbreviations

Symbol	Unit	Description
m_1	kg	Mass on journals (including bearings and axle boxes)
m_2	kg	Wheelset mass and masses on the wheelset between rolling circles according to EN 13262 (brake disc, gear wheel etc.)
$m_1 + m_2$	kg	For the wheelset considered, proportion of the mass of the vehicle on the rails
g	m/s²	Acceleration due to gravity
P	N	Half the vertical force per wheelset 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 heavily-loaded journal
P'	N	Proportion 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 heavily-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 heavily-loaded journal
F_i	N	Forces exerted by the masses of the unsprung elements situated between the two wheels (brake disc(s), pinion, 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	N·mm	Bending moment due to the masses in motion
M'_x, M'_z	N·mm	Bending moments due to braking
M'_y	N·mm	Torsional moment due to braking
M''_x, M''_z	N·mm	Bending moments due to traction

M''_y	N·mm	Torsional moment due to traction
MX , MZ	N·mm	Sum of bending moments
MY	N·mm	Sum of torsional moments
MR	N·mm	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 vehicle 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 Q_1
Γ		Average friction coefficient between the wheel and the brake shoe or between the brake pads and the disc
σ	N/mm²	Stress calculated in one section
K		Fatigue stress correction factor
R	mm	Nominal wheel radius (Nominal wheel diameter / 2)
R_b	mm	Brake 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/mm²	Fatigue limit under rotating bending up to 10^7 cycles for unnotched test pieces
R_{fE}	N/mm²	Fatigue limit under rotating bending up to 10^7 cycles for notched test pieces
a_q	m/s²	Unbalanced transverse acceleration
f_q		Thrust factor

5 General

The major phases for the design of an axle are:

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

b) selection of the diameters of the axle body and journals and - on the basis of these diameters - calculation of the diameters for the other parts of the axle;

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

  — stress calculation for each section;

  — comparison of these 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 of a data sheet with all these phases is given in Annex A.

6 Forces and moments to be taken into consideration

6.1 Types of forces

Three types of forces are to be taken into consideration as a function of the:

— masses in motion;

— braking system;

— traction.

6.2 Influence of 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.

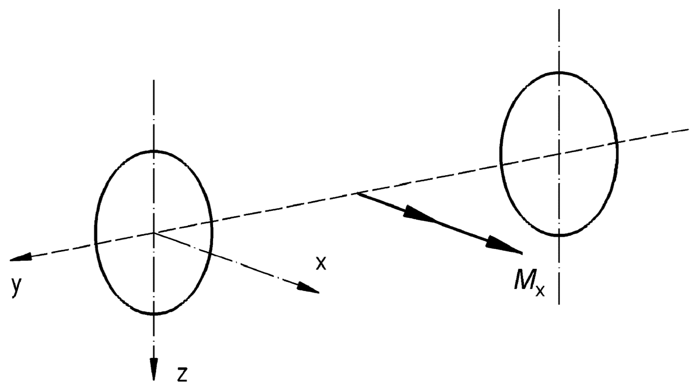

Figure 1 — Definition of centrelines and of moments due to masses in motion

The bending moment M_x is due to the vertical forces parallel to the Z axis.

Unless otherwise defined in the technical specification, the masses $(m_1 + m_2)$ to be taken into account for the main types of rolling stock are defined in Table 2. For particular applications, other definitions for masses are necessary, in accordance with the specific operating requirements.

Table 2 — Masses to take into account for the main types of rolling stock

Type of rolling stock	Mass $(m_1 + m_2)$
Freight wagons Traction units with no passenger accommodation, luggage areas and postal vans	Design mass in working order + Normal design payload (Maximum payload), Design mass in working order and Normal design payload are defined in EN 15663.
Coaches and traction units including accommodation for passengers, luggage or post	Design mass in working order + 1,2 × Normal design payload,
1 – High speed and long distance trains	Design mass in working order is defined in EN 15663. Normal design payload is defined in EN 15663 on which the standing passengers shall be: 160 kg/m² (2 passengers per m²) in standing and catering areas.
2 – Passenger vehicles other than high speed and long distance trains	Design mass in working order is defined in EN 15663. Normal design payload is defined in EN 15663 on which the standing passengers shall be: — 210 kg/m² (3 passengers per m²) in corridor areas; — 350 kg/m² (5 passengers per m²) in vestibule areas, 280 kg/m² (4 passengers per m²) may be used for specific services (e.g. 1st class area) as described in the technical specification.

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 force equilibrium for right hand curving, i.e.:

— asymmetric distribution of forces;

— the direction of the forces F_i due to the masses of the non-suspended components selected in such a manner that their effect on bending is added to that due to the vertical forces;

— the value of the forces F_i results from multiplying the mass of each non-suspended component by 3 g.

Left hand curving force equilibrium shall be also considered and the formulae and the forces in Figure 2 adapted.

Both cases, left-hand and right hand curving, shall be calculated to cover the worst case for the axle design.

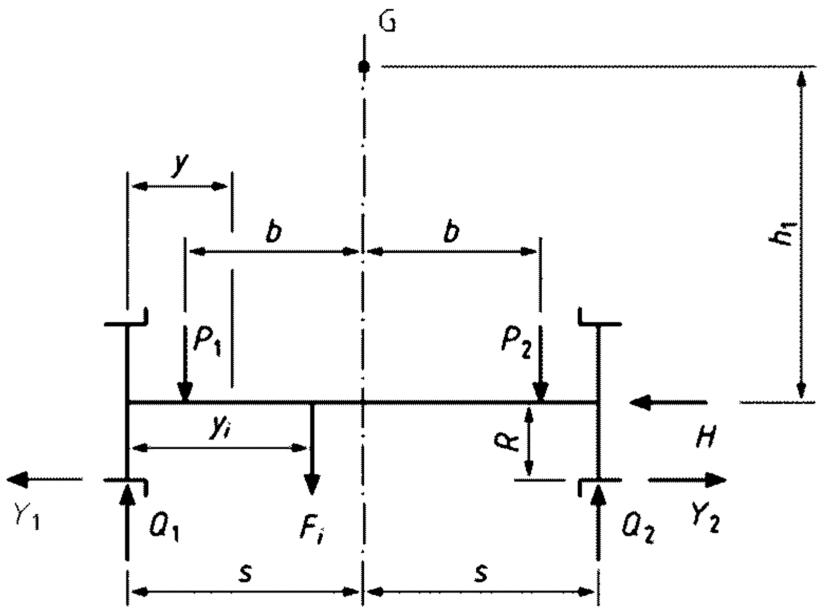

Figure 2 — Forces for calculation of bending moment

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

The formulae coefficient values are applicable to standard gauge axles and classical suspension. For specific designs (different gauges, e.g. metric gauge, or a new system of suspension, e.g. tilting system), other values shall be considered.

NOTE These specific designs will be taken into account in a future version.

Table 3 — Formulae for calculation of forces for main line vehicles[a]

Load case 1: Straight track	$P_1 = 0,8\, m_1 g$ $P_2 = 0,8\, m_1 g$ $Y_1 = 0$ $Y_2 = 0$ $H = 0$
Load case 2: Curve	$P_1 = (0,5625 + 0,0375\, h_1 / b) m_1 g$ $P_2 = (0,5625 - 0,0375\, h_1 / b) m_1 g$ $Y_1 = 0,135\, m_1 g$ $Y_2 = 0,21\, m_1 g$ $H = Y_2 - Y_1 = 0,075\, m_1 g$