SLOVENSKI STANDARD
kSIST-TP FprCEN/TR 17420:2019

01-september-2019

Železniške naprave - Zunanja konstrukcija tramvajskih in lahkih železniških vozil glede varnosti pešcev

Railway applications - Vehicle end design for trams and light rail vehicles with respect to pedestrian safety

Bahnwendungen â Fahrzeugkopfgestaltung von StraÃen- und Stadtbahnen im Hinblick auf den Passantenschutz

Applications ferroviaires - Conception de l'extrémité des véhicules pour tramways et métros légers en ce qui concerne la sécurité des piétons

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ICS:

45.140	Oprema za podzemne vlake, tramvaje in lahka tirna vozila	Metro, tram and light rail equipment

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Railway applications - Vehicle end design for trams and light rail vehicles with respect to pedestrian safety

Applications ferroviaires - Conception de l'extrémité des véhicules pour tramways et métros légers en ce qui concerne la sécurité des piétons

Bahnwendungen â¿¿ Fahrzeugkopfgestaltung von StraÃ¿en- und Stadtbahnen im Hinblick auf den Passantenschutz

This draft Technical Report is submitted to CEN members for Vote. It has been drawn up by the Technical Committee CEN/TC 256.

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kSIST-TP FprCEN/TR 17420:2019

Contents

Page

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https://standards.iteh.ai/catalog/standards/sist/dd708876-5d75-40e3-9e35-a2d03c9e5/ksist-tp-fprcen-tr-17420-2019

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European foreword

This document (FprCEN/TR 17420:2019) has been prepared by Technical Committee CEN/TC 256 “Railway applications”, the secretariat of which is held by DIN.

This document is currently submitted to the Vote on TR.

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1 Scope

This document is applicable to tram vehicles according to prEN 17343. Tram-Train vehicles, on track machines, infrastructure inspection vehicles and road-rail machines according to prEN 17343 and demountable machines/machinery are not in the Scope of this Technical Report.

This document describes passive safety measures to reduce the consequences of collisions with pedestrians. These measures provide the last means of protection when all other possibilities of preventing an accident have failed, i.e.:

— design recommendations for the vehicle front to minimize the impact effect on a pedestrian when hit,

— design recommendations for the vehicle front end for side (lateral) deflections in order to minimize the risk of being drawn under the vehicle on flat ground (embedded track),

— design recommendations for the vehicle body underframe to not aggravate injuries to a pedestrian/body lying on the ground,

— recommendations to prevent the pedestrian from being over-run by the leading wheels of the vehicle.

The following measures to actively improve safety are not in the Scope of this document:

— colour of front;

— additional position lights;

— additional cameras;

— driver assistance systems;

— additional acoustic warning devices, etc.;

— view of the driver / mirrors;

— consequences for pedestrian injuries due to secondary impact with infrastructure (side posts, concrete ground, poles, trees, etc.).

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The recommendations of this document only apply to new vehicles.

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 15663:2017+A1:2018, *Railway applications – 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:

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

kSIST-TP FprCEN/TR 17420:2019

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

3.1
tram vehicle
urban rail vehicle designed to run on a tram network

[SOURCE: prEN 17343:2019, 3.1.6.1.2.3]

3.2
collision scenario
collision scenario derived from accident analysis that is applicable for design and assessment

3.3
head injury criterion
HIC
measure of the likelihood of head injury stemming from impact or acceleration

Note 1 to entry: The head injury criterion (HIC) should not exceed a value of 1 000 over any time interval of up to 15 ms. The HIC is calculated using the following formula:

$$HIC = \left(t_2 - t_1\right)\left[\frac{\int_{t_1}^{t_2} A_R dt}{\left(t_2 - t_1\right)}\right]^{2,5}$$

where

t_1 represents the start of the time interval,

t_2 represents the end of the time interval,

HIC_{15} is the maximum value of HIC for $(t_2 - t_1) \le 15$ ms,

A_R is the resultant acceleration

$$A_R = \sqrt{A_X^2 + A_Y^2 + A_Z^2}$$

where

A_X, A_Y and A_Z represent the accelerations in g in X, Y and Z directions.

Note 2 to entry: The 15 ms time frame relates to the original biomechanical testing used to establish the HIC as an injury criterion commonly accepted for impacts against fixed surfaces.

Note 3 to entry: This criterion can be used to assess the safety regarding vehicles, personal protective gear and sports equipment.

3.4
light rail vehicle
urban rail vehicle designed to be line of sight operated and/or to be operated on segregated lines by signalization

Note 1 to entry: German: Light Rail-Fahrzeug.

Note 2 to entry: Light rail vehicle is a generic term used to distinguish a vehicle from heavy rail vehicles.

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kSIST-TP FprCEN/TR 17420:2019

[SOURCE: prEN 17343:2019, 3.1.6.1.2.1, modified — The end of the original definition "signal-controlled segregated lines" was replaced with "segregated lines by signalization" and Note 1 to entry" was added.]

3.5
tram system
urban rail system operated on infrastructure shared with road traffic and/or its own infrastructure

[SOURCE: prEN 17343:2019, 3.1.2.2, modified — The original Notes to the definition were not reproduced here.]

3.6
rescue mannequin
life size model of a person used in tests to simulate what happens to people when a vehicle gets into an accident (with a pedestrian)

3.7
anthropomorphic test device
ATD
model or mannequin of a person used in tests

3.8
pedestrian
walking, standing or lying person

Note 1 to entry: In this context, person can refer to an adult or a child.

Note 2 to entry: Any recommendations defined in this document for walking or standing persons will also improve the impact effect on cyclists (self-propelled or on e-bikes), skaters, persons in wheel chairs, or children in baby buggies, etc. Persons on e-scooters, motorbikes, etc. are not considered.

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3.9
pedestrian deflector
technical device that pushes the pedestrian out of the path of the tramway in case of a collision

3.10
pedestrian anti-crush mechanism
PACM
mechanism like a trap basket / drop down tray

3.11
front cover
front fairings
outside front panels of the tram vehicle structure below the windscreen, i.e. streamlining

3.12
tram-train vehicle
vehicle designed to operate on urban and/or regional networks, in track-sharing operation and interfacing with road traffic

[SOURCE: prEN 17343:2019, 3.1.6.1.3, modified — The current definition was substantially reworded.]

kSIST-TP FprCEN/TR 17420:2019

3.13
tram width
TW
overall width of the car body excluding additionally fixed equipment like mirrors and cameras

4 Symbols and abbreviations

ATD	Anthropomorphic Test Device
IIV	Infrastructure Inspection Vehicle
LRV	Light Rail Vehicle
OTM	On-Track Machine
PACM	Pedestrian Anti-Crush Mechanism (fr: dispositif anti-écrasement d'un piéton)

5 Front end design of tram vehicles and light rail vehicles

5.1 Objective / concept

The objectives of this technical report are to provide protection for pedestrians by reducing the risk of severe injuries, of being trapped under the vehicle, of being hit by underfloor equipment, and of being run over by the wheels of the vehicle. All tram vehicles and light rail vehicle should have a design that enables a pedestrian's body to be deflected rather than be run over during an impact. The pedestrian is considered to have been deflected onto the side once the pedestrian has been moved out of the path of the vehicle.

5.2 Sequence of an impact

The entire sequence of an impact can be divided into three phases. All three phases can cause severe injuries to the involved pedestrian:

— Phase 1 is considered as primary impact. A pedestrian, standing or walking in front of a moving tram, comes in contact with the vehicles front end. It is assumed that the pedestrian is moving perpendicular to the direction of the tram. Consequently, the tram hits the pedestrian at his side.

— Phase 2 is considered as secondary impact. Once being hit by the tram the pedestrian is thrown forward or to the side. As a consequence, the pedestrian impacts on the infrastructure (e.g. pavement, track, side poles).

— Phase 3 is considered as tertiary impact. As a consequence of Phase 2 the pedestrian might lay on the track, be overrun by the tram and collide again with the lower parts of the tram.

This technical report focuses on the consequences of the primary and tertiary impact. The consequences of a secondary impact are out of the scope of this technical report. Due to the recommendations given in this technical report, the consequences for the pedestrian in the primary impact and the risk to be run over by the wheels of the vehicle should be minimized (see 7.3).

5.3 Reference collision scenarios

The following reference collision scenarios with pedestrians should be considered:

— Type A: Collision with a passing pedestrian in the front area of the vehicle;

— Type B: Collision with a lying pedestrian on the ground in front of the vehicle.

kSIST-TP FprCEN/TR 17420:2019

Collision type A covers the effects of a primary impact and influences the effects of the downstream phases.

The tertiary impact is regarded to be identical to the collision type B.

6 Reference collision scenario type A

6.1 Introduction

The general approach is to achieve compliance with the geometrical requirements defined in 6.3.

If it is not possible to comply with all geometric parameters, numerical simulations can be carried out to demonstrate the ability to limit the risk of severe injuries and to encourage lateral ejection. Nevertheless, the criteria for h_S in the impact surface and for the avoidance of sharp edges in the extended impact zone should still be fulfilled in this case (from 6.3).

The recommendations of this section focus on the side impact against a pedestrian at the front end (i.e. passing pedestrian). Two categories of pedestrians are identified:

— a 6-year-old child, 1,10 m in height;

— a medium-sized adult, 1,75 m in height (50th percentile/average size).

If the requirements are fulfilled for these two categories, the design characteristics of the front end will also be beneficial to the impact effect in collisions with other sizes of pedestrians.

6.2 Impact surfaces

6.2.1 General

The impact surface is part of the front face of a tram predestined for contact with pedestrians in case of a collision and with the most likely possibility of severe injuries. This region should be used for evaluation of the geometric requirements. The impact surface is divided into two zones:

— centre zone;

— intermediate zone.

The impact surface is defined as the front surface of the tram up to a height of 1,75 m from the ground (the average height of an adult). The width of the impact surface is 50 % of the maximum tram width centred to the tram centre line (see Figure 1),

The projection surface from the front view is used to define the impact surface.

Based on the current requirements for visibility the impact surface is not assumed to interfere with the A-pillars of the tram front. If the impact surface overlaps the A-pillars nevertheless, then the impact surface may be reduced to the width between the A-pillars at a height of 1,75 m from the ground, minus 100 mm on each side.

6.2.2 Extended impact surface

The extended impact surface is defined in analogy to the impact surface with the exception that the width is 75 % of the maximum tram width.

The impact surface is displayed in Figure 1:

kSIST-TP FprCEN/TR 17420:2019

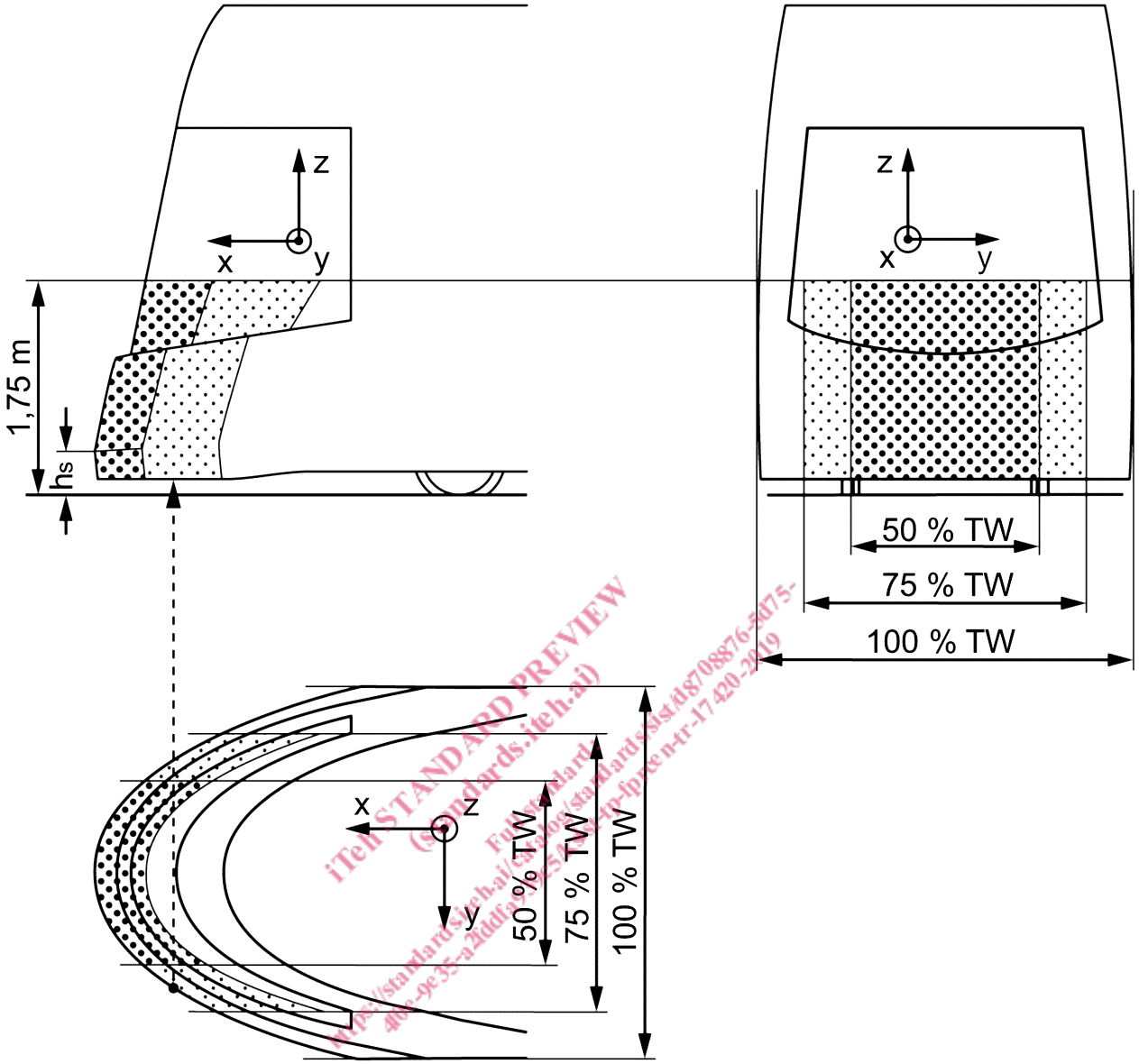

Figure 1 — Impact surface

6.3 Geometric criteria to reduce the severity of injuries

6.3.1 General

If the compliance with the geometric recommendations given in this chapter is proven, the HIC value is assumed to stay below 1 000. In this case, any additional numerical analyses (according to 6.4) for this proof are not mandatory but monitoring of this value is recommended.

6.3.2 Objective of the desired kinematics

In order to limit severe injuries, in particular to the head, the body kinematic to be favoured is either to block the shoulder and the torso as quickly as possible while limiting the rotation of the torso or to progressively impact-the pedestrian starting from the lower legs up to the torso and shoulders.