SLOVENSKI STANDARD
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Specifikacija in preverjanje porabe energije železniških vozil

Specification and verification of energy consumption for railway rolling stock

Spezifikation und Überprüfung des Energieverbrauchs von Schienenfahrzeugen

Spécification et vérification de la consommation d'énergie pour le matériel roulant ferroviaire

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Specification and verification of energy consumption for railway rolling stock

Spécification et vérification de la consommation d'énergie pour le matériel roulant ferroviaire

Spezifikation und Überprüfung des Energieverbrauchs von Schienenfahrzeugen

This draft European Standard is submitted to CENELEC members for enquiry.
Deadline for CENELEC: 2018-04-06.

It has been drawn up by CLC/SC 9XB.

If this draft becomes a European Standard, CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

This draft European Standard was established by CENELEC in three official versions (English, French, German).
A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Contents

Page

Figures

Tables

European foreword

This document (prEN 50591:2017) has been prepared by CLC/TC 9X “Electrical and electronic applications for railways” with contribution of UNIFE-UIC TECREC 100_001.

This document is currently submitted to the CEN Enquiry.

The following dates are proposed:

— latest date by which the existence of this document has to be announced at national level	(doa)	dor + 6 months
— latest date by which this document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	dor + 12 months
— latest date by which the national standards conflicting with this document have to be withdrawn	(dow)	dor + 36 months (to be confirmed or modified when voting)

This document will supersede CLC/TS 50591:2013.

Main changes in this standard compared to CLC/TS 50591:2013 are the adoption of existing CLC/TS 50591 enquiry comments, harmonisation with results from European Lighthouse Project Roll2Rail and the inclusion of an HVAC energy quantification method. Since separate methods for traction and HVAC energy quantification are described, the document structure had to be revised.

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

For the relationship with EU Directive(s) see informative Annex ZZ, which is an integral part of this document.

1 Scope

The main purpose of this standard is the support of rolling stock procurement, especially in light of life cycle cost (LCC) assessment.

This European Standard is applicable to the specification and verification of energy consumption of railway rolling stock. It establishes a criterion for the energy consumption of rolling stock to calculate the total net energy consumed, either at current collector or from the fuel tank, over a predefined service profile, in order to ensure that the results are directly comparable or representative of the real operation of the train. For this purpose, this document takes into account the energy consumed and regenerated by the rolling stock.

This European Standard provides the framework that gives guidance on the generation of comparable energy performance values for trains and locomotives on a common basis and thereby supports benchmarking and improvement of the energy efficiency of rail vehicles.

This European Standard does not cover specification for comparison of energy consumption with other modes of transportation, or even for comparison between diesel and electric traction, covering only the energy consumption of the railway rolling stock itself.

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 13129:2016, *Railway applications — Air conditioning for main line rolling stock — Comfort parameters and type tests*

EN 15663:2017, *Railway applications — Vehicle reference masses*

EN 50163:2004, *Railway applications — Supply voltages of traction systems*

EN 50463-1:2013, *Railway applications — Energy measurement on board trains — Part 1: General*

EN 50463-2:2013, *Railway applications — Energy measurement on board trains — Part 2: Energy measuring*

EN 50463-3:2013, *Railway applications — Energy measurement on board trains — Part 3: Data handling*

EN 50388:2012, *Railway Applications — Power supply and rolling stock — Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

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

Note 1 to entry: When possible, the following definitions have been taken from the relevant chapters of the International Electrotechnical Vocabulary (IEV), IEC 60050. In such cases, the appropriate IEV reference is given. Certain new definitions or modifications of IEV definitions have been added in this standard in order to facilitate understanding. Expression of the performance of electrical and electronic measuring equipment has been taken from EN 60359:2002.

3.1.1
traction auxiliaries
equipment needed to operate the traction equipment and the train in normal operation mode, but not producing tractive or dynamic braking efforts themselves (e.g. cooling fans, oil and water pumps, compressor, air supply for brakes, HVAC for the leading driver's cabin, TCMS and signalling equipment)

3.1.2
comfort systems
all equipment consuming energy for passenger comfort belonging neither to the traction equipment nor to traction auxiliaries, mainly for the provision of a comfortable environment (e.g. lighting, heating, air conditioning, toilets, information and entertainment systems, laptop supplies)

Note 1 to entry: Comfort systems are split in two groups for use in this standard: Heating, Ventilation and Air Conditioning (HVAC) and Other comfort functions.

3.1.3
consist
group of vehicles which are not separated during normal operation or a single vehicle

3.1.4
contact line
CL
conductor system for supplying electric energy to a traction unit through current-collecting equipment

[SOURCE: IEC 60050-811:1991, 811-33-01:1991, modified]

3.1.5
diesel multiple unit
DMU
train having a fixed composition powered by one or several diesel engines having a fixed composition

3.1.6
hybrid vehicle
vehicle that can store energy in an on-board energy storage system (ESS) and is driven by using the stored energy as well as power from a primary power source

3.1.7
primary power source
PPS
subsystem in a hybrid system the primary purpose of which is to supply energy to other subsystems in the hybrid system by either consuming the fuel stored on-board or taking in energy from external sources

3.1.8
state of energy
SoE
remaining energy to be discharged, normally expressed as a percentage of full energy

[SOURCE: EN 62864-1:2016, modified]

3.1.9
energy storage system
ESS
physical system which is comprised of energy storage technologies such as batteries, double-layer capacitors, flywheel, etc. and other equipment to connect the storage technologies to traction equipment, including control, cooling and monitoring systems

[SOURCE: EN 62864-1:2016, modified]

3.1.10
electric traction system
railway electrical distribution network (infrastructure) used to provide energy for rolling stock

3.1.11
electric multiple unit
EMU
train having a fixed composition and getting its traction power from an electric traction system

3.1.12
heating, ventilation and air conditioning
HVAC
system to help maintain good indoor air quality through adequate ventilation with filtration and providing thermal comfort

3.1.13
infrastructure
fixed installations of the railway system (e.g. tracks, power supply, signalling, communication)

3.1.14
net energy
difference between the energy taken (consumed) from the contact line, fuel tank and/or energy storage system by the traction unit, and the energy fed back (regenerated) into the contact line or energy storage system (ESS) by the traction unit. For ESS, the difference in state of energy (SoE) is used and it is defined, under which conditions recharging of the energy storage system is performed after the service profile

3.1.15
rolling stock
general term covering all railway vehicles or consist of vehicles

Note 1 to entry: Rolling stock may be fitted with traction equipment.

3.1.16
service profile
outline of the expected range and variation in the mission with respect to parameters such as time, loading, speed, distance, stops, tunnels, etc., in the commercial exploitation of the train

3.1.17
single-train run
run of one train over a part of infrastructure, without inclusion of effects of other trains

3.1.18
traction equipment
equipment on-board of the train directly needed to produce tractive or dynamic braking effort (e.g. transformers, converters, motors, gearboxes, internal combustion engines, fuel cells, energy storage systems)

3.1.19
traction unit
railway vehicle or a fixed composition of vehicles with traction ability (e.g. locomotive, multiple traction unit)

3.1.20
train
consist with traction unit ready for in-service operation

3.1.21

vehicle

smallest part in a train, intended as a single vehicle (e.g. freight wagons, passenger coaches, locomotives)

3.2 Abbreviations

For the purposes of this document, the following abbreviations apply.

All the abbreviations are listed in alphabetical order:

AC	Alternating Current
DC	Direct Current
DMU	Diesel Multiple Unit
EMU	Electric Multiple Unit
ESS	Energy Storage System
HVAC	Heating, Ventilation and Air Conditioning System
LCC	Life Cycle Cost

4 General

Energy is an integral quantity. This means that the cumulated energy is the decisive factor. Realistic train operation always has to take place under the constraints of infrastructure and operational requirements.

The following train modes are used in the standard.

— **In-service mode with commercial operation**

This mode covers the normal operation of a train, including several passenger loads or a locomotive hauling a trailer consist of freight wagons. The train is moving or at standstill with passengers and the HVAC system is running in its normal operation mode.

— **In-service mode without commercial operation**

In this mode the train is at standstill, the HVAC system is in operation as for commercial operation and there is no passenger in the train. This situation is quite frequent, for example when the train is waiting between two commercial runs.

— **Parking mode**

A train is in parking mode when it is stationary in depot areas, with active power supply, without staff or passengers being on board. Usually, the HVAC system runs with reduced settings for temperature and airflow.

In this standard the preconditioning (pre-heating or pre-cooling) and cleaning are not considered separately. The corresponding hours shall be counted in the In-service mode without commercial operation.

The train is switched OFF the remaining time of each day, therefore without any energy consumption.

In order to keep different characteristics, requirements and procedures manageable, the energy consumption of the whole train is subdivided into the following three different energy categories, which are handled separately:

1) Traction and Auxiliaries (in service mode with commercial operation, without HVAC);

2) Traction and Auxiliaries (in service mode without commercial operation and in parking mode, without HVAC);

3) HVAC.

This European Standard incorporates infrastructure and operational conditions into so-called “service profiles” for the train. The service profile for traction and auxiliaries is assessed via train runs along a line for in service and stationary at the depot for out of service operation, whereas HVAC is assessed via a reference point matrix for different operational modes.

The energy consumption over such service profiles shall be used as an input when assessing LCC. This requires a well-defined and harmonized methodology for specification and verification of the energy consumption. The selected approach has two steps:

a) simulation of the energy consumption of the train for the three energy categories mentioned above;

b) verification of the simulation by undertaking measurements.

It is important to note that two different sorts of service profiles for traction and auxiliaries may be chosen:

1) user defined service profiles based on data from a real railway line, normally one or several lines out of the railway network where the train will be operated;

2) standardized service profiles, for the following categories:

— suburban (passenger service);

— regional (passenger service);

— intercity (passenger service);

— high speed (passenger service);

— freight mainline service.

Definitions of relevant values for the standardized service profiles (2) and their parameters are given in Annex A and Annex B of this European Standard. The standard service profiles are characterized by definitions of standard values for the identified service types being typical (i.e. representative) – yet not real – of the type of railway service.

This means that it may not be possible to validate these on a real world track unless some adjustments of the verification results are undertaken to take into account the differences between the simulation and verification. However, these standardized service profiles are intended to be a common basis against which various trains can be simulated and simulation results compared.

For the assessment of HVAC energy consumption, standard weighting factors for the reference points are given in Annex C.

5 Traction and Auxiliaries (in service with commercial operation, without HVAC)

5.1 General

This section is focused on traction energy in service mode on a single train run for a train travelling from origin to destination location including standstill times on the way by means of the representative driving cycles. It includes energy related to traction auxiliaries (control, cooling and leading driver’s cab HVAC which is necessary for safe train driving) and other comfort functions, e.g. as toilets, passenger infotainment systems, WIFI.

It excludes energy related to HVAC for the passenger saloon and for the inactive driver’s cab, Auxiliary equipment rarely used are also expressly omitted (e.g. windscreen wiper, sanding, defrosters).

For the traction and auxiliary energy in service, the defined timetable for the operation over a specified line plays an important role. This European Standard is therefore not a direct specification of detailed driving styles. Instead it provides a framework which allows freedom for the user to propose sound solutions integrating a given mix of energy efficient technologies and driving styles.

5.2 Operational requirements

5.2.1 General

The information in this section is applicable for both simulation and verification of energy consumption.

5.2.2 Train data

5.2.2.1 Train and propulsion system

The specification shall include the train and its mechanical losses, the propulsion chain (electric, diesel-electric or diesel-mechanic) and all auxiliaries which are essential to operate the propulsion chain including control circuits for traction and signalling.

5.2.2.2 Load conditions

EN 15663:2017 shall be used for reading and understanding this clause.

The gross mass, and therefore the load, of a train have a significant influence on its energy consumption. The mass of the train shall be specified as follows depending on the train category:

a) Passenger trains:

The train weight shall be taken as the design mass in working order plus the mass of 50 % of seated passengers according to EN 15663:2017 (ID S05, this identification number refers to the infrastructure parameter S05 in Table A.3).

b) Freight trains:

The train weight shall be taken as the locomotive weight in design mass in working order plus a trailer consist, which shall be homogeneous, i.e. shall consist of only one wagon or coach type. The following values shall be specified for the trailer consist as a load:

1) total mass of the trailer consist [t] (ID S06);

2) rotating masses in terms of dynamic mass [t] (ID S07);

3) length of the trailer consist [m] (ID S08);

4) running resistance [kN] of the trailer consist versus speed [km/h] over the whole speed range (ID S09).

The parameters used to characterize load conditions are defined in Table A.3.

5.2.3 Infrastructure conditions

5.2.3.1 Longitudinal profile

The longitudinal profile shall be defined by the following parameters:

1) total distance of selected route or reference track from selected origin location to selected destination location [km] (ID I01);

2) height [m], as an absolute value (above sea level) (ID I02);

3) gradient [‰], as difference in height divided by difference of distance in longitudinal direction (ID I03).

ID I02 and ID I03 are correlated. It shall be ensured and documented that the integral of gradients along the track results in the correct difference of height between origin and destination location.

The parameters used to characterize longitudinal profile are defined in Table A.1.

5.2.3.2 Maximum speed profile

The maximum speed profile [km/h] shall be defined by the following parameters: maximum speed profile at every location along the selected route or reference track (ID I04).

The speed profile shall include the following criteria:

1) maximum speed for which the line, relevant to the profile, is planned;

2) permanent speed reductions due to curves, according to the required capabilities of the specified train.

   EXAMPLE Tilting trains may have a higher permitted speed in some sections along the route than other trains.

3) non-permanent speed reductions due to signalling, according to conditions during verification runs or service operation of the train.

   EXAMPLE Speed restrictions imposed by the changeover between two tracks shall already be included in the speed profile.

4) rules for safe operation.

   EXAMPLE If the operation rules require the target speed to be reached 100 m before a permanent speed restriction, this shall be included in the profile.

The parameters used to characterize speed profile are defined in Table A.1.

5.2.3.3 Curves

The curves shall be defined by the following parameters: location and radius of each curve along the selected route or reference track [m] (ID I05).

The parameters used to characterize curves are defined in Table A.1.

5.2.3.4 Tunnels

The tunnels shall be defined by the following parameters:

— location and length [m] of each tunnel along the selected route or reference track (ID I06);

— location and cross section area [m^2] of each tunnel along the selected route or reference track (ID I07).

Short tunnels with a length of less than 20 m and road bridges over the railway are negligible.

The parameters used to characterize tunnels are defined in Table A.1.

In addition, the tunnel surface and ventilation shafts or cross vents may have a significant impact on tunnel drag and thus energy consumption in case of long tunnels, these data should be provided as well.

5.2.4 Timetable and driving style

5.2.4.1 Timetable

A single-train run shall be specified. The sensitivity of energy consumption versus travelling time is high. Therefore, the requirements on precision of the timetable are high as well.

The timetable shall be defined by the following parameters: