SLOVENSKI STANDARD

oSIST prEN 12299:2006

01-oktober-2006

Železniške naprave - Parametri za določanje udobnosti potnikov med vožnjo - Meritve in vrednotenje

Railway applications - Ride comfort for passengers - Measurement and evaluation

Bahnanwendungen - Fahrkomfort für Fahrgäste - Messung und Auswertung

Applications ferroviaires - Confort de marche des voyageurs - Mesurage et évaluation

Ta slovenski standard je istoveten z: **prEN 12299**

ICS:

13.160	Vpliv vibracij in udarcev na ljudi	Vibration and shock with respect to human beings
45.060.20	Železniški vagoni	Trailing stock

oSIST prEN 12299:2006 **en**

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

DRAFT
prEN 12299

July 2006

ICS

Will supersede ENV 12299:1999

English Version

Railway applications - Ride comfort for passengers - Measurement and evaluation

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

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

CEN members are the national standards bodies of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

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.

Warning : This document is not a European Standard. It is distributed for review and comments. It is subject to change without notice and shall not be referred to as a European Standard.

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

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

Ref. No. prEN 12299:2006: E

Contents

Page

Foreword 6

1 Scope 7

2 Normative references 7

3 Terms and definitions 7
3.1 Definitions 7
3.2 Reference system 8
3.3 List of symbols 9

4 General description 11
4.1 General 11
4.2 Passenger exposure to vibrations 12
4.3 Application 12
4.4 Characteristics of railway vehicle motions 13
4.5 Ride comfort for passengers 13
4.6 Direct and indirect measurements 13
4.7 Summary table of procedures 13
4.8 Application of comfort indices 14

5 Mean comfort and continuous comfort 15
5.1 General 15
5.2 Base of the method 16
5.3 Methodology 16
5.4 Test conditions 16
5.4.1 General 16
5.4.2 Selection of test sections 16
5.4.3 Test speed 17
5.4.4 Wheel-rail contact geometry 17
5.4.5 Vehicle condition 17
5.5 Parameters to be measured 17
5.5.1 General 17
5.5.2 Location of measuring points 17
5.5.3 Filtering 18
5.6 Definition of intermediate quantities 18
5.6.1 Symbols and indices 18
5.6.3 R.m.s.-values of weighted accelerations 19
5.6.3 95^{th} and 50^{th} percentiles 20
5.7 Definition of comfort indexes 20
5.7.1 Continuous comfort 20
5.7.2 Mean comfort standard method 21
5.7.3 Mean comfort complete method 21
5.8 Test report 21

6 Comfort on curve transitions 21
6.1 General 21
6.2 Base of the method 22
6.3 Methodology 22
6.4 Test conditions 22
6.4.1 General 22
6.4.2 Selection of test sections 23
6.4.3 Test speed 23
6.4.4 Wheel-rail contact geometry 23
6.4.5 Vehicle condition 23
6.5 Parameters to be measured 23
6.5.1 General 23
6.5.2 Location of measuring points 23
6.5.3 Filtering 23

6.6 Definition of intermediate quantities 23
6.6.1 Symbols and indices 23
6.6.2 Averaging procedure 24
6.6.3 Identification of transition intervals 25
6.6.4 Intermediate quantities 25
6.7 Definition of comfort index P_{CT} 25
6.8 Test report 26
6.9 Example diagrams 26
7 Comfort on discrete events 28
7.1 General 28
7.2 Base of the method 28
7.3 Methodology 28
7.4 Test conditions 29
7.4.1 General 29
7.4.2 Selection of test sections 29
7.4.3 Test speed 29
7.4.4 Wheel-rail contact geometry 29
7.4.5 Vehicle condition 29
7.5 Parameters to be measured 29
7.5.1 General 29
7.5.2 Location of measuring points 29
7.5.3 Filtering 29
7.6 Definition of intermediate quantities 30
7.6.1 Symbols and indices 30
7.6.2 Averaging procedure 30
7.6.3 Intermediate quantities 30
7.7 Definition of comfort index P_{DE} 31
7.8 Test report 31
7.9 Example diagrams 31
8 Guide for the interpretation of the results (informative) 32
8.1 General 32
8.2 Mean Comfort 32
8.3 Continuous Comfort 32
8.4 Comfort on curve transitions 33
8.5 Comfort on discrete events 33
Annex A (normative) Reference system 34
Annex B (normative) Measurement techniques 36
B.1 General 36
B.2 Measuring equipment 36
B.3 Seat measuring devices and their applications 37
Annex C (normative) Weighting curves 40
C.1 General 40
C.2 Filter functions 40
C.3 Tolerances 42
C.4 Diagrams 44
Annex D (informative) Presentation of test report 47
D.1 General 47
D.2 Aim of test 47
D.3 Test performer 47
D.4 References 47
D.5 Test conditions 47
D.6 Measurements and processing 48
D.7 Report on mean comfort and continuous comfort 49
D.8 Report on comfort in curve transitions 53
D.9 Reporting on comfort on discrete events 53
Annex E (normative) Guidelines for application to vehicle assessment with respect to Mean Comfort Standard Method 55
E.1 General 55
E.2 Track geometric quality 55

E.3 Possible modifications of the methods for mean comfort evaluation 56
E.4 Test conditions 56
E.5 Test report 57
Annex F (informative) Guideline for the application of direct tests 58
Annex G (informative) Workflow for numerical integration 59
Annex H (informative) D e t e r m i n i n g quantities 60
Bibliography 62

Bilder

Figure 1 — Locations of measuring points Passenger coach (Conventional or articulated)....18
Figure 2 — Location of measuring points Double-Deck train (Conventional or articulated) 18
Figure 3 — Interpretation of the terms, $|\ddot{y}_{1s}|_{\max}$ and $|\dddot{y}_{1s}|_{\max}$ in the P_{CT} in formula....26
Figure 4 — Figure 4 — Interpretation of the term $|\dot{\varphi}_{1s}|_{\max}$ in the P_{CT} formula....27
Figure 5 — Relevant time intervals on curve transition 27
Figure 6 — Interpretation of $|\ddot{y}_{2s}(t)|$ and $\ddot{y}_{pp}(t)$ for calculation of P_{DE} 31
Figure A.1 — Local reference system for a carbody....34
Figure A.2 — Local reference systems for a person in a seated position....35
Figure A.3 — Local reference system for a person in standing position 35
Figure B.1 — Seat pan measuring device (for y- and z-direction)....37
Figure B.2 — Seat pan measuring device....38
Figure B.3 — Seat back measurement device....38
Figure C.1 — Tolerances for W_b 42
Figure C.2 — Tolerances for W_c 43
Figure C.3 — Tolerances W_d 43
Figure C.4 — Tolerances for W_p 44
Figure C.5 — Magnitude of the alternative frequency weighting W_b for vertical vibration along the z-axis on the floor and seat pan 44
Figure C.6 — Magnitude of the frequency weighting W_c for horizontal vibration along the x-axis, for the seat back....45
Figure C.7 — Magnitude of the frequency weighting W_d for horizontal vibration along the x- or y-axis on the floor, or along the y-axis on the seat pan 45
Figure C.8 — Magnitude of the frequency weighting W_p for lateral acceleration for P_{CT} and P_{DE}, and for roll velocity for P_{CT} evaluation....46
Figure D.1 — Continuous Comfort - Collection of five-minute periods (selected periods marked grey)50
Figure D.2 — Example of Continuous Comfort and statistical distribution for a five-minute period....51
Figure D.3 — Example of weighted (bold line) and un-weighted (thin line) power spectral density of floor level acceleration in x, y and z directions (Duration: 307,2 s / Sampling rate: 400 Hz / FFT : 2048 points)....52

Figure D.4 — of time series for P_{DE} evaluation 54

Tabellen

Table 1 — Items considered by this standard 12
Table 2 — Motion quantities and measurement position of estimation of ride comfort.....14
Table 3 — Motion Specification of different comfort indices for estimations of ride comfort and Vehicle assessment with respect to ride comfort.....14
Table 4 — Guidance to use the different comfort indices for other applications.....15
Table 5 — Constants for P_{CT} comfort index.....25
Table 6 — Constants for P_{DE} comfort index.....31
Table 7 — Scale for the N_{MV} comfort index 32
Table 8 — Preliminary scale for the $C_{Cy}(t)$ and $C_{Cz}(t)$ comfort indexes 32
Table C.1 — Weighting curves 40
Table C.2 — Parameters and transfer functions of the frequency weightings 40
Table C.3 — Tolerances on weighting curves 42
Table H.1 — Determining quantities for Mean Comfort 60
Table H.2 — Determining quantities for Comfort in curve transitions and discrete events.....61

Foreword

This document (prEN 12299:2006) 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 CEN Enquiry.

This document will supersede ENV 12299:1999.

1 Scope

This European Standard specifies methods for quantifying the effects of car body motions on ride comfort for passengers and vehicle assessment with respect to ride comfort. The effect considered is:

— discomfort, associated with relatively low levels of acceleration and roll velocity.

Other effects, not included in the standard, are associated with higher acceleration levels:

— health risk effect: physical damage and psychological deterioration.

The scope of the standard is limited to public railway services; the standard includes railway vehicles designed for carrying passengers travelling on railway lines, including secondary and suburban lines. However, this standard can be used as a guide for other railway vehicles, for example locomotives, metros, trams, etc.

The standard applies to passengers in good health.

This standard applies to measurements of motions, but can also be used for simulations.

2 Normative references

The following referenced documents are indispensable for the application 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 14363:2005, *Railway applications — Testing for the acceptance of running characteristics of railway vehicles — Testing of running behaviour and stationary tests*

ISO 2631-1, *Mechanical vibration and shock — Evaluation of human exposure to whole-body vibration — Part 1: General requirements*

ISO 5348, *Mechanical vibration and shock — Mechanical mounting of accelerometers*

ISO 5353, *Earth-moving machinery, and tractors and machinery for agriculture and forestry — Seat index point*

ISO 8002, *Mechanical vibrations — Land vehicles — Method for reporting measured data*

ISO 8041, *Human response to vibration — Measuring instrumentation*

3 Terms and definitions

3.1 Definitions

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

3.1.1
passengers
people travelling in a railway vehicle, without specific activities related to the transport

3.1.2
ride comfort
the complex sensation produced during the application of oscillations and/or inertia forces, via whole-body transmission caused by the railway vehicle's car body motions

3.1.3
interfaces
the contact parts between the car body or seat and the passenger with the function of sustaining and guiding the passenger and of transmitting the weight of the same to the car body itself, e.g. floor-feet

3.1.4
mean comfort
a mean feeling, continuously adjusted, as evaluated through measurement on a long-time basis (at least some minutes)

3.1.5
continuous comfort
a level of accelerations, ISO frequency weighted continuously evaluated as a set of root mean square values in vertical, lateral and longitudinal direction over a short time interval (typical 5 s)

3.1.6
comfort on curve transition
discomfort, due to a perceived curve transition

3.1.7
comfort on discrete event
discomfort, due to a perceived transient oscillation

3.1.8
whole-body transmission
a motion transmitted to the whole body through the interfaces between car body and passenger

3.1.9
indirect measurement
measurement of motion environment by different motion quantities, such as acceleration or roll velocity

3.1.10
direct measurement
measurement of actual passenger reactions, for example by asking passengers to fill in a questionnaire

3.1.11
vehicle assessment with respect to ride comfort
identifying the vehicle's contribution to the ride comfort by relating the measured ride comfort to the condition of the track (geometry, irregularities, turnout, bridges, etc.) and operation condition (speed, cant deficiency, etc.)

3.2 Reference system

The local reference system for a carbody is defined through:

Origin: on carbody floor, in the central position between the two body-bogie centre pivots (existing or ideally defined)

Axis:

— x-axis: longitudinal, in travelling sense, on floor plan;

— y-axis: lateral, right-oriented in travelling sense, on floor plan;

— z-axis: vertical downwards perpendicular to floor plan.

Roll motions (φ) are defined as rotation around the x-axis.

For human body reference system, right hand system is used with vertical direction defined upwards.

— A more detailed definition of the reference system is given in Annex A.

3.3 List of symbols

Parameter	Direction for measurements	Symbol
Accelerations on running gear [m/s^2]		
Wheel set *i*	Lateral	$\ddot{y}_i$
Accelerations in vehicle body [m/s^2]		
Body centre	Longitudinal	$\ddot{x}^*_M$
Leading end of passenger compartment	Lateral	$\ddot{y}^*_{EI}$
Over leading bogie	Lateral	$\ddot{y}^*_I$
Body centre	Lateral	$\ddot{y}^*_M$
Over trailing bogie	Lateral	$\ddot{y}^*_{II}$
Trailing end of passenger compartment	Lateral	$\ddot{y}^*_{EII}$
Leading end of passenger compartment	Vertical	$\ddot{z}^*_{EI}$
Over leading bogie	Vertical	$\ddot{z}^*_I$
Body centre	Vertical	$\ddot{z}^*_M$
Over trailing bogie	Vertical	$\ddot{z}^*_{II}$
Trailing end of passenger compartment	Vertical	$\ddot{z}^*_{EII}$
Weighted accelerations [m/s^2]		
Seat back, weighted W_c	Longitudinal	$\ddot{x}^*_{D,Wc}$
Vehicle body, weighted W_d	Longitudinal	$\ddot{x}^*_{P,Wd}$
Vehicle body, weighted W_d	Lateral	$\ddot{y}^*_{P,Wd}$
Vehicle body, weighted W_p	Lateral	$\ddot{y}^*_{P,Wp}$
Seat pan, weighted W_b	Vertical	$\ddot{z}^*_{A,Wb}$
Vehicle body, weighted W_b	Vertical	$\ddot{z}^*_{P,Wb}$
Seat back, weighted W_c, rms	Longitudinal	$a^{w_c}_{XD}$
Floor, weighted W_d, rms	Longitudinal	$a^{w_d}_{XP}$
Floor, weighted W_d, rms	Lateral	$a^{w_d}_{YP}$
Seat pan, weighted W_b, rms	Vertical	$a^{w_b}_{ZA}$
Floor, weighted W_b, rms	Vertical	$a^{w_b}_{ZP}$

Parameter	Direction for measurements	Symbol
Seat back, weighted W_c, rms, 95 percentile	Longitudinal	$a_{XD95}^{w_c}$
Weighted W_d, rms, 50 percentile	Longitudinal	$a_{XP50}^{w_d}$
Floor, weighted W_d, rms, 95 percentile	Longitudinal	$a_{XP95}^{w_d}$
Weighted W_d, rms, 50 percentile	Lateral	$a_{YP50}^{w_d}$
Seat pan, weighted W_d, rms, 95 percentile	Lateral	$a_{YA95}^{w_d}$
Floor, weighted W_d, rms, 95 percentile	Lateral	$a_{YP95}^{w_d}$
Weighted W_b, rms, 50 percentile	Vertical	$a_{ZP50}^{w_b}$
Seat pan, weighted W_b, rms, 95 percentile	Vertical	$a_{ZA95}^{w_b}$
Floor, weighted W_b, rms, 95 percentile	Vertical	$a_{ZP95}^{w_b}$
One-second average	Lateral	$\ddot{y}_{1s}$
Two-second average	Lateral	$\ddot{y}_{2s}(t)$
Peak to peak	Lateral	$\ddot{y}_{pp}(t)$
One-second average, maximum absolute value	Lateral	$\lvert\ddot{y}_{1s}\rvert_{\max}$
Two-second average, absolute value	Lateral	$\lvert\ddot{y}_{2s}(t)\rvert$
Jerk in vehicle body [m/s^3]		
One-second average	Lateral	$\dddot{y}_{1s}(t)$
One-second average, maximum absolute value	Lateral	$\lvert\dddot{y}_{1s}\rvert_{\max}$
Angular velocity in vehicle body [rad/s]		
Body	Roll	$\dot{\varphi}^*(t)$
Weighted W_p	Roll	$\dot{\varphi}_{Wp}^*(t)$
One-second average	Roll	$\dot{\varphi}_{1s}(t)$
One-second average, maximum absolute value	Roll	$\lvert\dot{\varphi}_{1s}\rvert_{\max}$
Comfort indexes [-]		
Mean comfort standard method	-	N_{MV}
Mean comfort standard method, partial index	Longitudinal	N_{MVx}

Parameter	Direction for measurements	Symbol
Mean comfort standard method, partial index	Lateral	N_{MVy}
Mean comfort standard method, partial index	Vertical	N_{MVz}
Mean Comfort Complete Method, seated	-	N_{VA}
Mean Comfort Complete Method, standing	-	N_{VD}
Continuous comfort	Longitudinal	C_{Cx}
Continuous comfort	Lateral	C_{Cy}
Continuous comfort	Vertical	C_{Cz}
Comfort on Curve Transitions	-	P_{CT}
Comfort on Discrete Events	Lateral	P_{DE}

4 General description

4.1 General

The comfort of passengers in a railway vehicle is influenced by a number of different factors (temperature, noise, vibration etc.). This European Standard considers only that part of the comfort influenced by the vibrations and motions of the vehicle. This is described as ride comfort or as passenger comfort. The standard can also be used for vehicle assessment with respect to ride comfort.

This European Standard defines as the standard method:

— The standard method for Mean Comfort evaluation, taking into account the effects of vibration exposure measured on the car body floor.

This European Standard also defines several methods for special applications:

— taking into account the short time effects of vibration exposure measured on the car body floor as Continuous Comfort for the longitudinal, lateral, and vertical direction;

— taking into account the vibration exposure measured on the seat or other interfaces on ride comfort as the complete method for Mean Comfort evaluation;

— taking into account the effects of:

  — discrete events (Comfort on Discrete Events) and

  — running on curve transitions (Comfort on Curve Transitions) on ride comfort.

— taking into account the vibration exposure measured on the car body floor for the purpose of vehicle assessment with respect to ride comfort. Annex E provides guidance for vehicle assessment with respect to ride comfort.

4.2 Passenger exposure to vibrations

Railway transport exposes passengers to vibrations related to the dynamic motions of the car body.

The motions of the car body transmit their effects to the human body through the following interfaces:

— in the standing position:

  — floor – feet

— in the seated position:

  — headrest – neck

  — arm rest – arms

  — seat – hip

  — backrest – back

  — floor – feet

The type of transmission is whole-body transmission which acts on the whole body through the interfaces.

4.3 Application

The following Table 1 lists the items included or excluded from this EN standard:

Table 1 — Items considered by this standard

Item	Included	Excluded
Effects of vibration exposure	- on ride comfort - on vehicle assessment with respect to ride comfort	- on health - on activities - on motion sickness
Vibration transfer	- on whole body through interfaces - through floor interface	- on single body part - on whole surface
Type of vehicles	- railway vehicles designed for carrying passengers	
Test procedure	- definitions - reference system - requirements - measurement and evaluation rules - report guidance	- notes or attributes related to service quality and/or passenger expectation - limiting values
Posture and activities of passenger	- standing - seated	- laying - performing specific actions (reading, writing etc.)
Type of measurement	- indirect measurement, i.e. measurement of motion environment by different motion quantities	- direct measurements (by asking test subjects) - combined measurements

4.4 Characteristics of railway vehicle motions

The basic typical motion characteristics, referred to the type of measurement and evaluation, are:

— Different properties, depending on the type of evaluation:

  — quasi-stationary (Mean Comfort)

  — non-stationary (Comfort on Curve Transitions and Comfort on Discrete Events).

— The frequency range of motions expected in rail vehicles includes, in the lateral direction:

  — up to 15 Hz: due to track profile, car body swing-roll and yaw in the lower frequencies, and suspensions characteristics and car body modes in the higher ones;

— The frequency range of motions expected in rail vehicles includes, in the vertical direction:

  — up to 40 Hz: due to track profile and geometry, suspensions characteristics, wheel defaults, car body modes;

— Range of frequencies from 0 Hz to 2 Hz for Comfort on Curve Transitions and for Discrete Events.

4.5 Ride comfort for passengers

The ride comfort for passengers is the complex sensation, produced on the passenger by the car body motions of the railway vehicle, transmitted to the whole body through the interfaces.

This sensation is classified as:

1. average sensation, based on the vibration applied on a long-time basis (several minutes);

2. instantaneous sensation: a sudden modification of the average sensation, due to a short-basis event (change of mean lateral acceleration level with possible oscillation, roll motion at significant velocity and lateral jerk);

3. quasi-static lateral acceleration due to curving.

The first type of sensation is taken into account in the Mean Comfort evaluation.

The second and the third type of sensation are taken into account in the Comfort on Curve Transitions and in Comfort on Discrete Events.

4.6 Direct and indirect measurements

The quantification of ride comfort for passengers is performed through indirect measurements, i.e. measuring and post-processing the relevant motion quantities. Other types of tests and evaluation, such as direct tests based on the assessment of the perceptions of tested passengers, and combined tests, including both direct and indirect tests, are not defined in this European Standard. However, some guidance for direct tests is given in Annex F.

4.7 Summary table of procedures

The evaluation of ride comfort for passengers is taken into account in this European Standard by:

— procedure for the quantification of comfort index “Mean Comfort” by the Standard method (N_{MV}), see clause 5 and Annex H;

— procedure for the quantification of comfort index “Mean Comfort” by the Complete method (N_{VA} , N_{VD}), see clause 5 and Annex H;

— procedure for the quantification of comfort index “Comfort on Curve Transitions” (P_{CT}), see clause 6 and Annex H;