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**Železniške naprave - Udobnost vožnje potnikov - 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: ENV 12299:1999**

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**ICS:**

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

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Railway applications - Ride comfort for passengers -  
Measurement and evaluation

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

Bahnanwendungen - Fahrkomfort für Fahrgäste - Messung  
und Auswertung

This European Prestandard (ENV) was approved by CEN on 29 August 1997 as a prospective standard for provisional application.

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

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## Foreword

This European Prestandard has been prepared by Technical Committee CEN/TC 256 "Railway applications", the secretariat of which is held by DIN.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to announce this European Prestandard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

This ENV takes into account the documents listed below for the following:

UIC 513	Evaluation of Mean Comfort indices and definition of filters
ISO 2631	Definitions
BRR TR DOS 018 5/86	Comfort on Curve Transitions Comfort on Discrete Events
UIC 518	Selected testing procedures and track characteristics
List of normative clauses and annexes	Clauses 1, 2, 3, 4 Normative Annexes A, B, C, D
List of informative clauses and annexes	Foreword, Introduction, Clauses 5, 6 Informative Annexes E, F, G, H, K, L, M, N, P, Q, R, S

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## Introduction

### a) General

The comfort of passengers in a railway vehicle is influenced by a number of different factors (temperature, noise, vibration etc). This European Prestandard considers only that part of the comfort influenced by the dynamic behaviour of the vehicle. This is described as Ride Comfort or as Comfort.

This European Prestandard summarizes the relevant works on the matter:

- taking into account, in mandatory form, the effects on Ride comfort for passengers of vibration exposure measured on the carbody floor (the simplified method for Mean Comfort evaluation);
- taking into account, (as recommendation), the vibration exposure measured on the interfaces (the complete method for Mean Comfort evaluation);
- taking into account, (as recommendation), the effects on Ride comfort for passengers of:
  - discrete events (Comfort on Discrete Events);
  - running on curve transitions (Comfort on Curve Transitions).

The standard is published as European Prestandard (ENV), due to

- the lack of experience in the application of the Mean Comfort measurement and evaluation criteria, based on UIC-leaflet 513, up to now experimentally approved in UIC, both for the normative part ( $N_{MV}$ ) and for the informative part ( $N_{VA}$ ,  $N_{VD}$ );
- the lack of experience in the application of the recommended  $P_{DE}$ ,  $P_{CT}$  comfort indexes, up to now based on the technical experience in studies and direct tests given mainly in Great Britain and in indirect tests performed by Italy, Germany and Switzerland.

Railway transport exposes passengers to vibrations related to the dynamic movements of the carbody.

The movements of the carbody 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 - upper arms
  - seat - hip
  - seat - back
  - floor - feet

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The type of transmission is whole-body transmission (see 3.4), which acts on the whole body through the interfaces (see 3.3 ).

The effect produced by the carbody movements considered in this ENV is:

- discomfort (effect on comfort, see 3.2), associated with relatively low levels of acceleration.

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

- health risk effect: physical damage and psychological deterioration.

This ENV applies to passengers in good health.

**b) Inclusions and exclusions**

The following table lists the items included or excluded from this ENV:

**Table 1**

Item	included	excluded
Effects of movements	<ul style="list-style-type: none"> <li>- on comfort</li> </ul>	<ul style="list-style-type: none"> <li>- on health</li> <li>- on activities</li> </ul>
Transmission	<ul style="list-style-type: none"> <li>- on whole body through interfaces</li> </ul>	<ul style="list-style-type: none"> <li>- on single body part</li> <li>- on whole surface</li> </ul>
Type of vehicles	<ul style="list-style-type: none"> <li>- railway vehicles designed for carrying passengers</li> </ul>	<ul style="list-style-type: none"> <li>- other types of railway vehicles, e.g. locomotives, freight wagons</li> </ul>
Test procedure	<ul style="list-style-type: none"> <li>- definitions</li> <li>- reference system</li> <li>- requirements</li> <li>- measurement and evaluation rules</li> <li>- report rules</li> </ul>	<ul style="list-style-type: none"> <li>- notes or attributes related to service quality and/or passenger expectation</li> <li>- limiting values</li> </ul>
Position of passenger	<ul style="list-style-type: none"> <li>- standing</li> <li>- seated</li> </ul>	<ul style="list-style-type: none"> <li>- lying</li> <li>- performing specific actions</li> </ul>
Type of measurement	<ul style="list-style-type: none"> <li>- indirect measurements               <ul style="list-style-type: none"> <li>- simplified measurements of Mean Comfort</li> <li>- complete measurements of Mean Comfort<sup>1)</sup></li> <li>- evaluation of Comfort on Discrete Events<sup>1)</sup></li> <li>- evaluation of Comfort in Curve Transitions<sup>1)</sup></li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>- direct measurements</li> <li>- combined measurements</li> </ul>
<sup>1)</sup> informative		

### c) Characteristics of railway vehicle movements

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

- range of frequencies from 0 to 2 Hz for Comfort on Curve Transitions and for Discrete Events, from 0,4 to 80 Hz for Mean Comfort evaluation. For the latter, with a large part in the sub-range:
  - 0,4 up to 3,0 Hz in the lateral direction,
  - 0,4 up to 20 Hz in the vertical direction;
- relatively low level of amplitude;
- different properties, depending on the type of evaluation: stationary (Mean Comfort), non-stationary (Discrete Events), quasi-static (mean lateral acceleration on Discrete Events), dynamic with relevant transient components (peak-to-peak on Discrete Events, Comfort on Transitions), highly non-linear (on Curves, on Discrete Events), linear (Mean Comfort).

### d) Ride comfort for passengers

The Ride comfort for passengers is the complex sensation, produced on the passenger by the carbody movements of the railway vehicle, transmitted to the whole body through the interfaces.

This sensation is classified as:

- average sensation, based on the vibration applied on a long-time basis (at least some minutes),
- instantaneous sensation: a sudden modification of the average sensation, due to a short-basis event (change of mean lateral acceleration value, roll movement at significant speed, lateral jerk with possible oscillation).

Both the first and the second type of sensation are taken into account in the Mean Comfort evaluation.

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

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### e) Direct and indirect measurements (standards.iteh.ai)

The quantification of Ride comfort for passengers is performed through indirect measurements, i.e. measuring and post-processing the relevant parameters (see 3.5). Other types of tests and evaluation, such as direct tests based on the direct assessment of the perceptions of tested passengers, and combined tests, including both direct and indirect tests, are not quantified in this European Prestandard.

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**f) Simplified and complete measurements for Mean Comfort**

The indirect measurements are classified as simplified or complete if the measurements are taken respectively on relevant points of the carbody floor or also on the interfaces.

**g) Summary table of procedures**

The evaluation of Ride comfort for passengers is taken into account in this European Prestandard by:

- normative procedure for the quantification of Mean Comfort through indirect simplified measurements, described in the normative part, see 4.1 to 4.2,
- informative procedure for the quantification of Mean Comfort through indirect complete measurements, described in the informative part, see Annex E,
- informative procedure for the quantification of Comfort on Curve Transitions through indirect simplified measurements, described in the informative part, see Annex K,
- informative procedure for the quantification of Comfort on Discrete Events through indirect simplified measurements, described in the informative part, see Annex M.

The use of an informative procedure in addition is appropriate in situations where these aspects are of particular interest, as for example for the evaluation of behaviour of tilting vehicles running in curves.

Table 2 presents an overview of different characteristics for measurement and evaluation procedures.

**Table 2**

Characteristics	Mean Comfort simplified	Mean Comfort complete	Comfort on Curve Transitions	Comfort on Discrete Events
Comfort index	$N_{mv}$	$N_{vd}$	$P_{CT}$	$P_{DE}$
Procedure	normative	informative	informative	informative
Measuring parameter	accelerations	accelerations	lateral acceleration; roll speed	lateral acceleration
Measuring position	floor	floor floor and interfaces	floor	floor

A table of possible applications, and the list of corresponding information needed, is given in 6.2.

## 1 Scope

This European Prestandard specifies a method for quantifying the effects of carbody movements on Ride comfort for passengers ("Comfort")<sup>1)</sup>.

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; this document can be used as a guide for other railway vehicles, for example locomotives, metros, trams, etc.

The standard applies to passengers in good health.

## 2 Normative references

This European Prestandard 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 prestandard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

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 8002	Mechanical vibrations - Land vehicles - Method for reporting measured data
UIC 513 E <sup>2)</sup>	Guidelines for evaluating passenger comfort in relation to vibration in railway vehicles - 1st edition 01-07-94
UIC 518 VE <sup>2)</sup>	Testing and approval of railway vehicles from the point of view of their dynamic behaviour - Safety - Track fatigue - Ride quality - 1st edition 01-07-95
B 153 - Rp 10 <sup>2)</sup>	Vibratory comfort: Drawing up weighting curves
B 153 - Rp 12 <sup>2)</sup>	Influence of the low frequency components on the evaluation of comfort
B 153 - Rp 13 <sup>2)</sup>	Tests on comfort in standing position
B 153 - Rp 17 <sup>2)</sup>	Comfort in seated position
C 116 - Rp 3 and Rp 6 <sup>2)</sup>	Geometry of the contact between wheelset and track - Part 1: Methods of measurement and analysis - Part 2: Equivalent conicity values for wheelsets in service

## 3 Definitions

For the purpose of this standard, the following definitions apply:

### 3.1 Passengers

People travelling in a railway vehicle, without specific activities related to the transport.

### 3.2 Comfort

This is the complex sensation produced during the application of oscillations and/or inertia forces, via whole-body transmission (see 3.4) caused by the railway vehicle's carbody movements.

It is defined and measured through Comfort indexes<sup>3)</sup> as:

- Mean Comfort: a mean feeling, continuously adjusted, as evaluated through measurement following the procedures indicated in clause 4 and Annexes A, B, C, D for Comfort index  $N_{mv}$  and the procedure indicated in Annexes E, F, G, H for Comfort indices  $N_{va}$ ,  $N_{vd}$ .

<sup>1)</sup> The quantification of Ride Quality and the corresponding evaluation rules will be covered by a separate European Standard.

<sup>2)</sup> To be purchased from: UIC, Direction Générale, 16, rue Jean Rey, F - 75015 Paris

<sup>3)</sup> The base of the derivation of the comfort indexes is experimental.

- Comfort on Curve Transition: discomfort, due to a perceived curve entry or reverse transition, quantified by the recommended procedure indicated in Annex K and Annex L, as Comfort index  $P_{CT}$ .
- Comfort on Discrete Events: discomfort, due to a perceived transient oscillation on straight track, curves and curve transitions, quantified by the recommended procedure indicated in Annex M and Annex N, as Comfort index  $P_{DE}$ .

### 3.3 Interfaces

They are the contact parts between the carbody and the passenger with the function of sustaining and guiding the passenger and of transmitting the weight of the same to the carbody itself.

In standing position:

- floor - feet

In seated position:

- headrest - neck
- arm rest - upper arms
- seat - hip
- seat - back
- floor - feet.

### 3.4 Whole-body transmission

This is an action transmitted to the whole body through the interfaces.

### 3.5 Indirect measurements/tests

This is a measurement or test or part of test based on measurement and post-processing of the relevant parameters (acceleration and roll speed measured in the carbody).

### 3.6 Characteristics of indirect measurements/tests

- Complete measurements: composed of measurements at the positions defined in G.3.2:
  - measurements on interfaces (see 3.3),
  - measurements on carbody floor, near to the seat.
- Simplified measurements: composed of measurements on the carbody floor at the positions defined in A.3.2 .

## 4 Mean Comfort - Simplified method

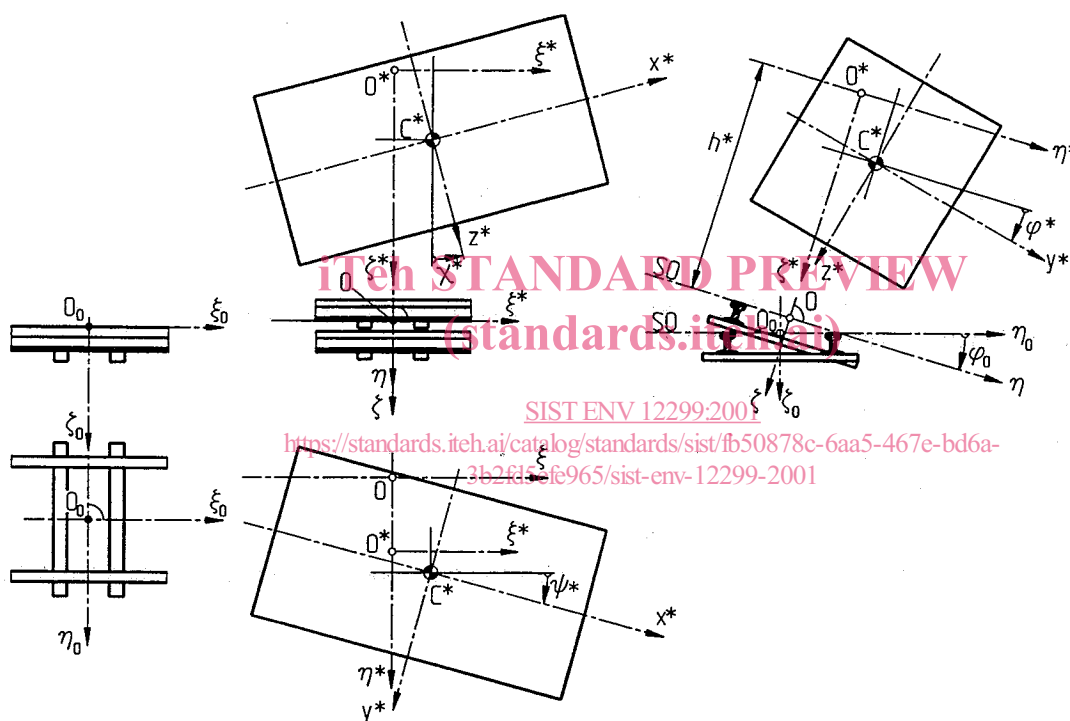
NOTE: Two methods are available for the assessment of the passenger perception of Mean Comfort:

- A simplified method based on measurement of acceleration on the floor ( $N_{MV}$ ).
- A complete method based on measurement of acceleration at the interface between passengers and the vehicle ( $N_{VA}$ ,  $N_{VD}$ ).

The complete method is more highly correlated with the passenger's perception of comfort than the simplified method. For a general assessment of the ride comfort of a railway vehicle, the simplified method shall be used. For the full assessment of the ride comfort of railway vehicles (with a view to the passenger's perception of comfort), it is recommended that the complete method is used where practical.

### 4.1 Reference system

The general reference system of the railway vehicle is defined, with reference to the horizontal plane (see figure 1), according to ERRI C 116 - Rp 3 and is given here for general information.



#### Legend

##### Track

$O_0, \xi_0, \eta_0, \zeta_0$

fixed track axis system

$O, \xi, \eta, \zeta$

mobile track axis system

##### Carbody

$O^*, \xi^*, \eta^*, \zeta^*$

mobile carbody axis system

$C^*, x^*, y^*, z^*$

carbody axis system

##### Rotation of carbody axis system

$\varphi^*$

roll angle

$\chi^*$

pitch angle

$\psi^*$

yaw angle

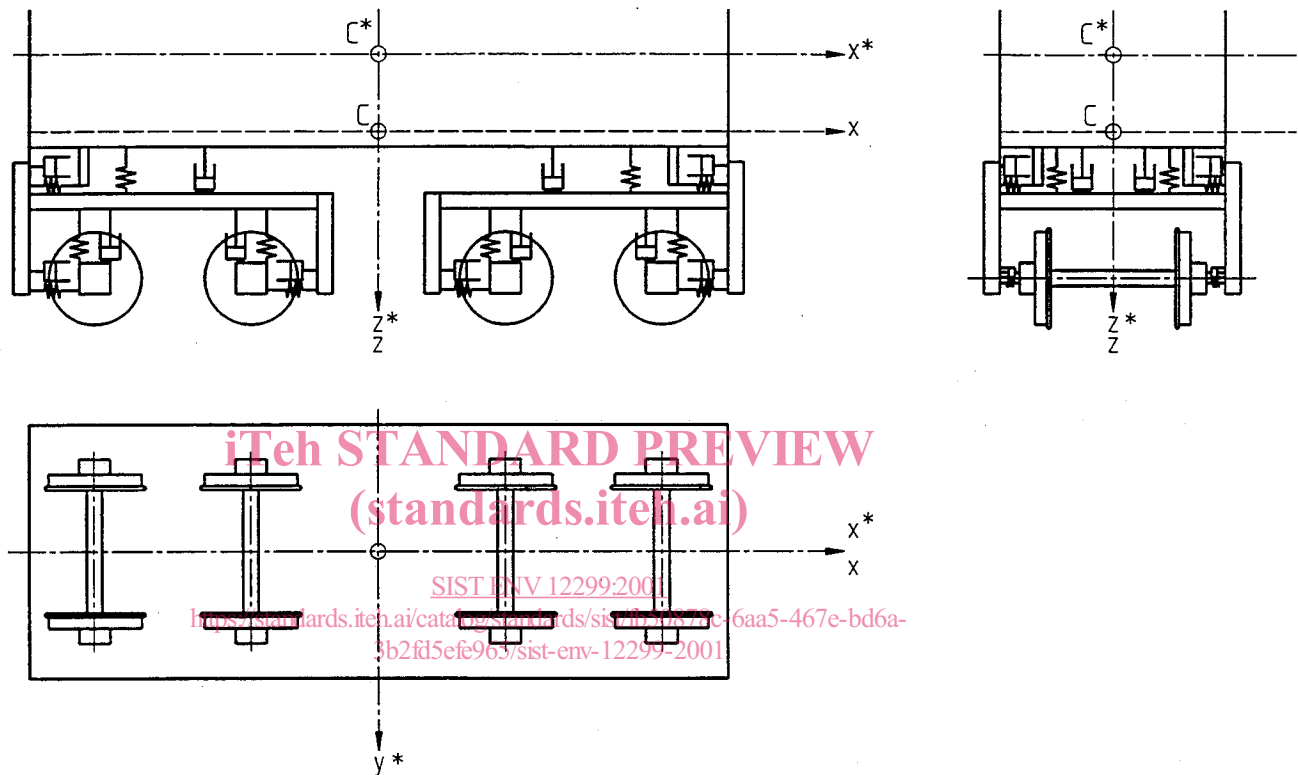
Figure 1 : General reference system

The local reference system (see figure 2 ) for the carbody and relevant parameters, is defined through:

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

Axis:

- $z$ -axis: vertical downwards perpendicular to floor plan,
- $x$ -axis: longitudinal, in travelling sense, on floor plan,
- $y$ -axis: lateral, right-oriented in travelling sense, on floor plan.



#### Legend

$C, x, y, z$

carbody axis system for comfort evaluation

$C^*, x^*, y^*, z^*$

see figure 1

**Figure 2 : Local reference system**

## 4.2 Measurement and evaluation rules

### 4.2.1 General

NOTE: Application of the simplified method

This formula is a simplification of a more general but more complicated expression. The application of this formula is constrained by two conditions:

- 1) The lateral acceleration at track level shall be lower than  $1 \text{ m/s}^2$  (this excludes high speed running on track with many curves and tilting coaches).
- 2) The longitudinal vibration shall not be excessive (excluding soft seat backs and ride with traction induced longitudinal vibration).

The object is to define:

- the conditions for carrying out running tests to assess Mean Comfort evaluated using the simplified method,
- the parameters to be measured and the method to be used to obtain the assessment values.

NOTE: This clause is based on UIC 513 produced by ERRI B153 Committee. It gives a simplified procedure to assess the Mean Comfort. The complete procedure, recommended but not obligatory, is presented in Annex E.

Clause 4 and Annexes A, B, C, D constitute an application document for the railway field covering the measurement, analysis and evaluation of vibration, taking into account that mechanical vibration in a railway vehicle presents certain specific characteristics.

Application of clause 4, on the basis of the measurement of certain accelerations, will permit an evaluation to be made of Mean Comfort in a defined vehicle under defined service conditions. The minimum of information needed for the application of the method is contained in Annex C.

**Application of this method will give a comfort index for the vehicle-track system. The separate influence of the vehicle and track cannot be assessed without further information on vehicle characteristics and track layout and roughness characteristics<sup>4)</sup>.**

Application of this method under the prescribed conditions may assist in the identification of causes of discomfort. This method is applicable to the vibration generally encountered on railway vehicles. Correct evaluation of comfort on the basis of this procedure requires rigorous observation of the procedures which it contains.

### 4.2.2 Base of the method

Mean Comfort is perceived in different ways by different people. It is therefore impossible to specify an unique assessment system which is valid for everybody.

As a result of this, the evaluation of Mean Comfort made in this standard is based on the relationship between the accelerations measured in a vehicle and the Mean Comfort rating given by a representative group of passengers for periods of 5 min.

NOTE: The method is demonstrated and validated in the reports of ERRI B153 Committee, particularly in:

Rp10	Vibratory comfort: Drawing up weighting curves
Rp12	Influence of the low frequency components on the evaluation of comfort
Rp13	Tests on comfort in standing position
Rp17	Comfort in seated position
DT219 (B153)	Dépouillement statistique d'essais de confort pour le compte du comité B153 (exists only in french)

### 4.2.3 Evaluation method

The evaluation method consists of the following:

- measuring the acceleration on the floor of the vehicle;
- principles to be taken into account for these measurements are given in Annex A;

<sup>4)</sup> The definition of this further information is not at the present time available. Therefore a list of possible applications of this ENV and an indication of the necessary supporting data is given in table 3 (recommended)

- signal processing in accordance with Annex B, including:
  - frequency weighting,
  - calculation of rms-values for time intervals of 5 s,
  - calculation of the cumulative distribution for a total time interval of five minutes,
  - calculation of the 95% probability sample,
  - calculation of Mean Comfort index  $N_{MV}$  at each measuring point indicated in Annex A.

The duration of the measurements shall be a multiple of five minutes. The minimum required is four zones of five minutes, each zone travelled at constant speed, which allows this method to be applied.

NOTE: No guidance is given by ERRI B153 for the combination of the  $N_{MV}$  values of the individual zones.

#### 4.2.4 Test conditions

The general test conditions are described in following subclauses. The detailed conditions may vary depending on the application. The test conditions used must be given in the test report.

##### 4.2.4.1 Test speed

Mean comfort is evaluated at normal service speed for the tested vehicle on the test section; tests at different speeds are non-mandatory.

##### 4.2.4.2 Selection of test sections

The choice of the test section has to be done in such a way that operating conditions representative of the tested vehicle are taken into account, for instance, high speed line, normal speed line, sharply curved track.

NOTE: For each type of section so defined according to ERRI B153 it should be necessary to take at least four zones of five minutes, each of them being issued from a continuous record.

##### 4.2.4.3 Track geometry and quality

A test section shall be selected in which the track geometry and quality correspond to that specified for the running speed required.

The test track is characterized according to Annex C.

The track characteristics of the sections used shall be specified in the test report (see 4.2.7).

##### 4.2.4.4 Wheel-rail contact geometry

The running behaviour of the vehicle is influenced by the wheel-rail contact geometry. For applications needing the assessment of separate influence of the vehicle, the wheel-rail contact parameters have to be quantified.

To determine numerical value of the equivalent conicity, the actual wheel profiles of the test vehicle are combined with theoretical rail profile normally used in the test zones (including inclination and gauge).

For a better interpretation of the results, it can be useful to determine equivalent conicity taking into account actual rail profiles of the test zone giving low and high conicity values.

NOTE: Advice for the calculation is given in ERRI C116 Rp3 and Rp6.

Representative conicity ranges, both on straight and in curves of radius  $\geq 2500$  m listed below:

- 0,1 to 0,4 where speed  $v \leq 200$  km/h,
- 0,1 to 0,3 where speed  $v > 200$  km/h.

The characteristics of the wheel-rail contact geometry have to be noted in the test report.