

DIN EN 17019

ICS 17.100

Entwurf

Einsprüche bis 2016-10-12
Ersatz für
E DIN 8113:2009-02

**Wägung von Fahrzeugen während der Fahrt –
Anforderungen;
Englische Fassung FprEN 17019:2016**

Weigh-in-Motion of road vehicles –
Requirements;
English version FprEN 17019:2016

Pesage en marche des véhicules routiers –
Exigences;
Version anglaise FprEN 17019:2016

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Gesamtumfang 76 Seiten

DIN-Normenausschuss Maschinenbau (NAM)

Nationales Vorwort

Dieser Norm-Entwurf beinhaltet die Englische Fassung der vom Technischen Komitee CEN/SS F05 „Messgeräte“ im Europäischen Komitee für Normung (CEN) ausgearbeiteten FprEN 17019:2016.

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Dieser Europäische Norm-Entwurf wurde erarbeitet von der FiWi Arbeitsgruppe (FEHRL Institute zur Achslastmessung im rollenden Verkehr, WIM - Weighing in Motion Initiative) und basiert auf der 1999 vom COST 323 Managementausschuss veröffentlichten Europäischen Spezifikation zur WIM von Straßenfahrzeugen (WIM of Road Vehicles COST 323). Die statistischen Grundlagen sind in [Jacob, 2002] nachzulesen und den technischen Quellen zu entnehmen, auf die in [Jacob et al., 2002] verwiesen wird.

Die nationalen Interessen werden vom Ausschuss NA 060-37-01 AA „Wägetechnik“ im Fachbereich „Wägetechnik“ des DIN-Normenausschusses Maschinenbau (NAM) wahrgenommen.

Der nationale Norm-Entwurf DIN 8113:2009-02 wird mit dem Erscheinen des vorliegenden Dokuments ersatzlos zurückgezogen.

Weigh-in-Motion of road vehicles - Requirements

Pesage en marche des véhicules routiers - Exigences

Wägung von Fahrzeugen während der Fahrt -
Anforderungen

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European foreword

This document (FprEN 17019:2016) has been prepared by Technical Committee CEN/SS F05 “Measuring Instruments”, the secretariat of which is held by CCMC.

This document is currently submitted to the Formal Vote.

This European Standard has been prepared by the FiWi (FEHRL institutes WIM initiative) working group and is based on the European Specification on WIM of Road Vehicles (COST323, 1999) published in 1999 by the COST323 Management Committee. The statistical background may be found in (Jacob, 2002) and the technical references in (Jacob et al., 2002).

This standard was prepared to deal with aspects related to:

- scope, normative references, terminology and symbols (Clauses 1 to 3);
- site selection, operating conditions and environmental requirements (Clauses 4 and 5);
- accuracy classification (Clause 6);
- system calibration and testing (Clauses 7 to 11);

The informative Annexes A, B, C, D and E provide respectively:

- comparison with the OIML R134-1 international recommendation;
- standard test plans and simplified acceptance procedures;
- guidelines for system calibration;
- guidelines for data and test result presentation, and computer tools for accuracy assessment;
- comments and explanations of the main clauses.

Introduction

This standard comprises comprehensive and detailed requirements based on a scientific and technical background developed in the COST323 action (Jacob, O'Brien and Jehaes, 2002). The procedure for assessing the accuracy of a WIM system is flexible and general. It may use almost any test plan, depending on the context and means available. The whole standard is based on a statistical approach of the accuracy assessment, with tolerances which are the boundaries of confidence intervals, and a level of confidence, reflecting the probability that an individual measure lays in the specified tolerances or in the confidence interval. This level of confidence can be specified by the users, depending on the application.

However, several users and WIM manufacturers expressed the need to have a simplified procedure for common tests and applications, easier to implement and to understand. Therefore a simplified procedure adapted to standard test plans and with a fixed level of confidence of 95 % was developed. Wherever possible, the detailed clauses of this standard were simplified to allow common users to easily assess a WIM system accuracy.

When a simplified approach is available, the section concerned is duplicated as follows:

- Section title – Detailed procedure,
- Section title – Simplified procedure,

and they are numbered with consecutive numbers at the same level.

The clauses of the simplified procedure may be applied instead of those of the detailed procedure, if respecting the conditions of application.

The simplified procedure mainly applies for the check of the accuracy of a WIM system (Clause 10). The condition is to fix the confidence level at 95 %. The acceptance test can be done using approximate analytical formula (Annex B, B.3.1) or one of the four standard test plans proposed (Annex B, B.1) and charts (Annex B, B.2).

More in details:

- Clauses 1 to 5, 7 to 9 and 11 are common to the detailed and simplified procedures;
- in Clause 6 (Accuracy classes tolerances) the simplified procedure only deals with fixed accuracy classes referred by a letter and a number (e.g. B(10)) as stated in 6.2, while the detailed procedure also includes interpolated classes (6.1 and 6.3.4);
- the detailed procedure to check the accuracy by testing is given in 10.1, 10.3, 10.5 and 10.7, while the simplified procedure is described in 10.2, 10.4, 10.6 and 10.8, using the standard test plans given in the Annex B.

1 Scope

1.1 This standard specifies the requirements for installation, calibration, performance and accuracy assessment, and test methods for Weigh-in-Motion (WIM) systems, that are used to determine gross weights, axle and group-of-axle loads for road vehicles when they are weighed in motion.

1.2 This standard applies to:

1.2.1 WIM systems installed on road infrastructure (including bridges), but not to the WIM systems installed on-board of vehicles;

1.2.2 High speed WIM (HS-WIM) systems, i.e. systems installed in one or more traffic lane(s) of a road, and operated automatically under normal traffic conditions, and to low speed WIM (LS-WIM) systems, i.e. systems installed in a controlled weighing area, and operated under controlled conditions;

1.2.3 WIM systems using either scales which are able to weigh standard masses statically, or other sensors which may measure the loads indirectly;

1.2.4 on-site full WIM system performance assessment and model (type) approval, but excludes laboratory (product) tests or tests on parts of systems (e.g. sensors only).

1.6 The scope of this standard covers all WIM applications, except trade.

NOTE For load enforcement of road vehicles, this standard or the OIML (International Organization for Legal Metrology) international recommendation R 134-1 and 134-2 (OIML, 2004 and 2006) applies, depending on the national requirements and legislation.

1.7 WIM systems used for trade are dealt with in the OIML recommendations R134-1 and R134-2 (OIML, 2006 and 2004). These OIML recommendations apply to WIM systems installed in controlled weighing areas, on a specified apron and where the vehicle speed is controlled. They mainly apply to WIM systems composed of scales, which are capable of weighing standard masses statically. The OIML recommendations are limited to the highest accuracy classes (0,2 to 10), with tolerances for 100 % of the measurements.

This standard applies to any WIM system, which may be installed either in a controlled weighing area, or on a road open to traffic. These systems may use road sensors and bridge WIM.

This standard covers type approval testing, initial and in service testing.

This standard specifies the required performance and ability of WIM systems in general, but does not aim to standardize products.

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.

ISO 3534-1:2006, *Statistics — Vocabulary and symbols — Part 1: General statistical terms and terms used in probability*

ISO 3534-2:2007, *Statistics — Vocabulary and symbols — Part 2: Applied statistics*

ISO/IEC Guide 99:2007, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

3 Terms, definitions, symbols and abbreviations

For the purposes of this document, the terms and definitions given in the Glossary of WIM terms of the COST 323 final report (Jacob et al., 2002), in ISO 3534-1 and ISO 3534-2, in ISO/IEC Guide 99:2007 and the following apply.

3.1 Terms and definitions taken from the Vocabulary of International Metrology

3.1.0

quantity

property of a phenomenon, body, or substance, to which a magnitude can be assigned

3.1.1

measurement

process of experimentally obtaining information about the magnitude of a quantity

3.1.2

measurand

quantity intended to be measured

3.1.3

measurement method/procedure

generic description of a logical sequence of operations used in a measurement / detailed description of a measurement according to one or more measurement principles and to a given measurement method

3.1.4

measurement result

information about the magnitude of a quantity, obtained experimentally

3.1.5

measurement uncertainty

parameter that characterizes the dispersion of the quantity values that are being attributed to a measurand, based on the information used

3.1.6

standard (measurement) uncertainty

measurement uncertainty expressed as a standard deviation

3.1.7

calibration

(a) operation establishing the relation between quantity values provided by measurement standards (French “*étalon*”) and the corresponding indications of a measuring system, carried out under specified conditions and including evaluation of measurement uncertainty; or

(b) operation that establishes the relation, obtained by reference to one or more measurement standards (French “*étalon*”), that exists under specified conditions, between the indication of a measuring system and the measurement result that would be obtained using the measuring system

3.1.8

(metrological) traceability

property of a measurement result relating the result to a stated metrological reference through an unbroken chain of calibrations of a measuring system or comparisons, each contributing to the stated measurement uncertainty

3.1.9

verification

confirmation through examination of a given item and provision of objective evidence that it fulfils specified requirements

3.1.10

influence quantity

quantity which, in a direct measurement, is not the quantity being measured, but whose change affects the relation between the indication of the measuring system and the measurement result

3.1.11

Correction

modification applied to a quantity value obtained from measurement, to compensate for a systematic effect

3.1.12

(measurement) precision

closeness of agreement between quantity values obtained by replicate measurements of a quantity, under specified conditions

3.1.13

measuring instrument

device or combination of devices designed for measurement of quantities

3.1.14

measuring transducer

device that provides at its output a quantity having a determined relation to the quantity at its input

3.1.15

measuring system

set of measuring instruments and other devices or substances assembled and adapted to the measurement of quantities of specified kinds within specified intervals of values

3.1.16

sensor

element of a measuring system that is directly affected by the phenomenon, body, or substance carrying the quantity to be measured

3.1.17

detector

device or substance that indicates the presence of a phenomenon, body, or substance when a threshold value of an associated quantity is exceeded

3.1.18

adjustment

set of operations carried out on a measuring system in order that it provide prescribed indications corresponding to given values of the quantity to be measured

3.1.19

measuring interval

set of values of the quantities of the same kind that can be measured by a given measuring system, with specified measurement uncertainty under defined conditions

3.1.20

steady state condition

operating condition of a measuring system in which the possible variation with time of the quantity being measured is such that a calibration of the measuring system carried out with a measurand constant with time remains valid

3.1.21

rated operating condition

condition that shall be fulfilled during measurement in order that a measuring system perform as designed

3.1.22

limiting condition

extreme condition that a measuring system is required to withstand without damage, and without degradation of specified metrological characteristics when it is subsequently operated under its rated operating conditions

3.1.23

reference condition

condition of use prescribed for evaluating the performance of a measuring system or for comparison of measurement results

3.1.24

resolution

smallest change, in the value of a quantity being measured by a measuring system, that causes a perceptible change in the corresponding indication

3.1.25

stability

ability of a measuring system to maintain its metrological characteristics constant with time

3.1.26

drift

change in the indication of a measuring system, generally slow and continuous, related neither to a change in the quantity being measured nor to a change of an influence quantity

3.1.27

instrumental uncertainty

component of measurement uncertainty attributed to a measuring instrument and determined by its calibration

3.1.28

accuracy class

class of measuring instruments that meet stated metrological requirements which are intended to keep instrumental uncertainty within specified limits under specified operating conditions; or

class of measuring instruments that meet stated metrological requirements which are intended to keep errors (3.1.32) within specified limits under specified operating conditions

3.1.29

true value (of a quantity)

quantity value consistent with the definition of a quantity. Also an accepted reference to which a measurement (result) is compared to assess an error

3.1.30

accuracy of a measurement

closeness of agreement between a quantity value obtained by measurement and the true value of the measurand

Accuracy of a measuring system:

ability of a measuring system to provide a quantity value close to the true value of a measurand

3.1.31

trueness

closeness of agreement between the average that would ensue from an infinite number of quantity values obtained under specified measurement conditions and the true value of the measurand

3.1.32

error

difference of quantity value obtained by measurement and true value of the measurand

3.1.33

random error

difference of quantity value obtained by measurement and average that would ensue from an infinite number of replicated measurements of the same measurand carried out under repeatability conditions

3.1.34

systematic error

difference of average that would ensue from an infinite number of replicated measurements of the same measurand carried out under repeatability conditions and true value of the measurand

3.1.35

maximum permissible error

one of the two extreme values of the error permitted by specifications or regulations for a given measuring system

3.1.36

intrinsic error (of a measuring system)

error of indication when determined under reference conditions

3.1.37

bias (of a measuring system)

systematic error of indication of a measuring system

3.2 Specific statistical and metrological terms and definitions

3.2.1

confidence interval

interval which contains the true value of a quantity value represented by a random variable, with a given probability, π , or a minimum required probability π_0

3.2.2

confidence level

probability, π , that an interval contains the true value of a quantity value represented by a random variable

3.2.3

tolerance – tolerance interval

width of an interval (δ) in which an error shall lie with a minimum required probability. $[-\delta; +\delta]$ is called the tolerance interval

3.2.4

outlier(s)

value(s) in a series of measurement results of a given quantity value which has(ve) a much lower probability of occurrence than expected according to the sample size and distribution

Note 1 to entry: An outlier is suspected of being an erroneous measurement, and can be eliminated under certain conditions.

3.2.5

performance or acceptance test

test to determine whether an equipment is capable of performing its specified functions or meet a given accuracy class under specified operating conditions

3.2.6

correction factor

numerical factor by which a quantity value obtained from measurement is multiplied, to compensate for a systematic effect

3.2.7

calibration factor

numerical factor by which a quantity value obtained from measurement is multiplied, to fit a true value

3.3 Terms and definitions related to vehicles

3.3.1

axle

set of two or more wheels with centres lying approximately on a common axis oriented transversely to the nominal direction of motion of the vehicle

3.3.2

wheelbase

distance between the first and last axle of a vehicle, a portion of vehicle or a bogie or group of axles (3.3.4)

3.3.3

single axle

axle that is spaced more than 2,2 m from its nearest neighbouring axle of the same vehicle, unless an alternative definition is agreed ¹

3.3.4

Group of axles

set of axles on the same vehicle spaced, each from the next one, less than 2,2 m, centre to centre, unless an alternative definition is agreed ²

¹ In vehicle engineering, a single axle is an axle not linked to another axle by a common suspension.

² In vehicle engineering, a tandem (resp. tridem) axle is a set of two (resp. three) axles linked by a common suspension.

3.3.5

tandem axle

group of two axles, with a wheelbase less than the value specified in 3.3.4

3.3.6

tridem axle

group of three axles, with wheelbases less than the value specified in 3.3.4

3.3.7

axle of a group

one axle of a vehicle that belongs to a group of axles (see 3.3.4)

3.3.8

Gross vehicle weight (GVW)

force due only to the external force of gravity acting vertically downward on the total mass of a vehicle, including all connected components

Note 1 to entry: Its magnitude is the total vehicle mass multiplied by the acceleration due to gravity ($g = 9,8 \text{ m/s}^2$).

3.3.9

wheel load

portion of the gross weight imposed upon the weighing device by the tyre(s) of a stationary wheel at the time of weighing, expressed in units of mass, due only to the vertically downward force of gravity acting on the mass of the static vehicle

3.3.10

axle load

sum of all the wheel loads of an axle of a vehicle

3.3.11

axle group load

sum of all the axle loads of the axles which belong to a group of axles (see 3.3.4)

3.3.12

dynamic (impact) tyre force

component of the time-varying force applied perpendicular to the road surface by the tyre(s) of a wheel of a moving vehicle

3.3.13

dynamic (impact) wheel/axle/group of axles/vehicle force

force applied to the pavement by the moving tyre(s) of a wheel/axle/group of axles/vehicle

Note 1 to entry: For the purposes of this standard, the WIM system is adjusted or calibrated to indicate the magnitude of the vertically downward, measured dynamic forces in units of mass. The indicated mass is converted to units of force by multiplying it by the acceleration due to gravity: $g = 9,8 \text{ m/s}^2$.

3.3.14

impact factor

ratio of an impact force to the corresponding wheel/axle/group of axles load or gross vehicle weight

3.3.15

reference (or test) vehicle

vehicle which has accepted true values of the quantities to be measured, e.g. axle loads, gross weight, axle spacing, length

Note 1 to entry: Axle loads and gross weight are commonly measured statically on approved scales.

3.4 Terms and definitions related to WIM systems

3.4.1

wheel load scale

device on which the whole wheel imprint is applied and which measures a wheel load

3.4.2

axle load scale

device on which all the wheel imprints of an axle are applied at once and which measures the combined wheel loads of an axle

Note 1 to entry: If verified to appropriately small maximum permissible errors in relation to the intended tolerance of a WIM system, an axle load scale is commonly used for generating static axle load reference values.

3.4.3

weigh-bridge

weighing device on which a complete stationary vehicle may be weighed at once

Note 1 to entry: If verified to appropriately small maximum permissible errors in relation to the intended tolerance of a WIM system, a weigh-bridge is commonly used for generating gross weight reference values.

3.4.4

strip sensor

sensor installed perpendicular to the direction of travel of a road, with a longitudinal extent (in the traffic direction) of a few centimetres, but smaller than a tyre imprint length

3.4.5

Weigh-In-Motion (WIM)

process of estimating the gross weight of a moving vehicle, and the portion of that weight that is carried by each of its wheels or axles, by measurement and analysis of dynamic vehicle tyre forces

3.4.6

Weigh-In-Motion system (station)

set of mounted sensor(s) and electronics with software which measures dynamic vehicle tyre forces and vehicle presence of a moving vehicle with respect to time and provides data for calculating wheel and/or axle load and gross weight estimates, as well as other parameters such as speed, axle spacing and silhouettes

3.4.7

Bridge WIM (B-WIM)

WIM using an instrumented bridge as an axle or vehicle scale

Note 1 to entry: The strains measured in some of the bridge elements are used to estimate, through software, the gross weights and axle loads of a vehicle crossing the bridge.

3.4.8

Low Speed WIM (LS-WIM)

weighing a (generally slowly) moving vehicle, on a specific area usually outside the traffic flow, on a horizontal, straight, and even pavement surface under controlled conditions, such as constant and limited speed (e.g. ≤ 10 km/h or 15 km/h) in order to minimise dynamic effects

3.4.9

High Speed WIM (HS-WIM)

weighing a vehicle in motion in the traffic flow, at its actual speed

3.5 List of symbols and abbreviations

3.5.1 Symbols

A(5), B+(7), B(10), C(15), D+(20), D(25), E(30)...: main accuracy classes for WIM systems (see Clause 6).

δ : tolerance for a given quantity; $[-\delta; \delta]$ is a tolerance interval. δ concerns relative errors and is expressed as a %.

δ_c : tolerance (in %) of a gross vehicle weight, which defines the accuracy classes (see Clause 6).

$\delta_{\min}$: minimum tolerance (in %) which ensures, for a given sample and specified test conditions, that an individual random error lies in the tolerance interval $[-\delta_{\min}; \delta_{\min}]$ with a minimum required probability π_0 .

m : sample mean of individual relative errors.

n : sample size of a set of individual relative errors.

π : probability that an individual random error lies in a tolerance interval; or probability that a confidence interval contains a true value of a quantity.

π_0 : minimum required probability π .

E1, E2, E3: environmental repeatability and reproducibility test conditions (see Clause 7).

R1, R2, R3, R4: sample repeatability and reproducibility test conditions (see Clause 7).

s : sample standard deviation of individual relative errors.

V_m : mean traffic speed.

W : Measured load (may be a vehicle gross weight, an axle load or a group-of-axles load).

W_s : Static or reference load (of a vehicle, an axle load or a group of axles).

W_d : In-motion or dynamic (measured by a WIM system) load (of a vehicle, an axle load or a group of axles).

x, x_i : individual relative errors in a set of measurements; $x = 100 \times (W_d - W_s) / W_s$ (in %).

3.5.2 Abbreviations

APL: Analyseur de Profil en Long, the APL index which gives an account of the pavement profile consists of 3 ratings, in short, medium and long wavelengths.

IRI: International Roughness Index; give an account of the pavement profile unevenness; higher the index, rougher the pavement.

ISWIM: International Society for Weigh in motion.

WIM: weigh in motion.

B-WIM: bridge weigh-in-motion.

HS-WIM: high speed weigh-in-motion.

LS-WIM: low speed weigh-in-motion.

MS-WIM: multiple sensor weigh-in-motion.

4 Site selection criteria³

4.1 Road geometry

4.1.1 The road section between 50 m upstream and 25 m downstream of the system shall meet the geometrical characteristics given in the Table 1 (4.3), first line “Geometry”. In addition it shall not contain any bumps or other type of sudden local change in slope.

4.1.2 The WIM system shall be installed away from any area of expected frequent acceleration or deceleration, (e.g. close to traffic lights, toll station, slip roads), in order to weigh vehicles travelling at uniform speed.

4.1.3 Areas where the number of lanes changes shall be avoided.

4.2 Pavement characteristics

4.2.1 The criteria for rutting, deflection and evenness are given in Table 1.

4.2.2 The pavements shall also meet the following criteria:

- no hard spots in the underlying courses or under the wearing course (toll slabs, service tunnels, etc.);
- thickness of bonded layers greater than 10 cm;
- good mechanical bonding between courses, in particular of bituminous concrete on granular materials stabilized by hydraulic binders. The sensors shall be installed in homogeneous layers, not in a joint;
- surfacing shall be deterioration-free in the area of sensor installation;
- pavement shall be homogeneous across each traffic lane, ruling out the presence of joints of coated materials within the length of a sensor.

4.2.3 Road sensors shall not be installed on a bridge or on any structure subject to dynamic effects, except for Bridge WIM systems (see 4.4).

4.3 WIM site classes (not for B-WIM)

To be qualified in one of the classes of Table 1, the pavement of the WIM site shall meet all the relevant criteria of column I, II or III of the class, depending on the pavement type and on the parameter measurement method.

³ The performance of any WIM system depends on the site characteristics: road geometry and road evenness. Three WIM site classes are defined in 4.3.

Except for Bridge WIM, it is not recommended to install a WIM system on a site which does not meet at least class III specification.

The recommended site class/WIM system accuracy pairings, according to the current technology and knowledge, are given in Table E.1 of Annex E.

Table 1 — Classification and criteria of WIM sites

			WIM site classes		
			I Excellent	II Good	III Acceptabl e
Geometry		Longitudinal slope (%)	≤ 1	≤ 2	≤ 2
		Transverse slope (%)	≤ 3	≤ 3	≤ 3
		Radius of curvature (m)	≥ 1 000	≥ 1 000	≥ 1 000
Deflection (quasi-static) (13 000 kg - axle)	Semi-rigid pavements	Mean deflection (10 ⁻² mm)	≤ 15	≤ 20	≤ 30
		Left/Right difference (10 ⁻² mm)	±3	±5	±10
	All bitumen pavements	Mean deflection (10 ⁻² mm)	≤ 20	≤ 35	≤ 50
		Left/Right difference (10 ⁻² mm)	±4	±8	±12
	Flexible pavements	Mean deflection (10 ⁻² mm)	≤ 30	≤ 50	≤ 75
		Left/Right difference (10 ⁻² mm)	±7	±10	±15
Deflection (dynamic) (5 000 kg - load)	Semi-rigid pavements	Deflection (10 ⁻² mm)	≤ 10	≤ 15	≤ 20
		Left/Right difference (10 ⁻² mm)	±2	±4	±7
	All bitumen pavements	Mean deflection (10 ⁻² mm)	≤ 15	≤ 25	≤ 35
		Left/Right difference (10 ⁻² mm)	±3	±6	±9
	Flexible pavements	Mean Deflection (10 ⁻² mm)	≤ 20	≤ 35	≤ 55
		Left/Right difference (10 ⁻² mm)	±5	±7	±10
Rutting (3 m beam)		Rut depth max. (mm)	≤ 4	≤ 7	≤ 10
Evenness	IRI a index	Index (m/km)	0 to 1,3	1,3 to 2,6	2,6 to 4
	APL b	Rating (SW, MW, LW)	9 to 10	7 to 8	5 to 6

NOTE The rutting and deflection values are given for a temperature below or equal to 20 °C and suitable drainage conditions.

a International Roughness Index.

b The APL (Analyseur de Profil en Long) is a device which measures the longitudinal profile; it consists of two single wheel trailers operating at 72 km/h, towed by a car. The rating quantifies the logarithm of the energy dissipated in one of the wavelength ranges: SW = Small Wavelengths (0,7 m to 2,8 m), MW = Medium Wavelengths (2,8 to 11,3 m), LW = Large Wavelengths (11,3 to 45,2 m). The scale is from 10 (lowest energy, excellent evenness) to 1 (highest energy, poorest pavement surface).

4.4 Particular requirements for bridges

4.4.1 B-WIM systems shall be installed on structures such as bridges, culverts or any other structure which behaves in a similar way.

4.4.2 Braking or accelerating of vehicles on the structure due to junctions close to the site or any other reason shall be avoided since non-constant speed over the structure significantly decreases the accuracy of the calculated weights.

If a B-WIM system is installed in location where acceleration, deceleration, stopping or lane changing is possible, then the system shall identify results of the vehicles during which measurement any of these events occurred.

4.4.3 Detection of vehicles, axles and their velocity can be done with any type of axle detectors, with strain sensors or with any other device if the results provide sufficiently accurate input for other B-WIM calculations.

4.4.4 A B-WIM system shall provide a means to compare the measured and the calculated responses of the bridge to the crossing of a specific vehicle in order to verify the results.

5 Operating conditions and environmental requirements

5.1 General conditions

5.1.1 WIM system specification shall contain a description of its rated operating conditions consisting at least of ranges for:

- traffic intensity;
- vehicle speeds;
- temperature;
- humidity;
- electromagnetic conditions;
- mechanical condition.

5.1.2 Traffic intensity range consists of the minimum (zero by default) and maximum numbers of heavy vehicles that can be recorded by the WIM system per hour and per day.

5.1.3 Speed range extends from the minimum to the maximum speed of passing vehicles.

5.1.4 The supplier shall specify the maximum and minimum ambient temperature in which its system will operate with its claimed performance. It should be specified whether the WIM system is designed for condensing or non-condensing humidity.

5.1.5 One of three electromagnetic environment classifications should be specified as described below:

- EM1, locations with electromagnetic disturbances corresponding to those likely to be found in residential, commercial and light industrial buildings;
- EM2, locations with electromagnetic disturbances corresponding to those in other industrial buildings or roadside locations;
- EM3, locations where the electrical power is supplied by a battery of a car or a generator with possible sudden peaks or reduction in the power supply.

5.1.6 One of three mechanical condition classifications should be specified as described below:

- M1, locations with vibrations and shocks of low significance, e.g. office conditions;
- M2, locations with significant levels of vibration and shock, e.g. road side conditions with passing vehicles;
- M3, locations with high levels of vibration and shocks, e.g. equipment directly mounted on machines or vehicles.

5.1.7 A vehicle record made by a WIM system shall contain at least:

- unique registration number;
- location;
- traffic lane and direction;
- date and time stamp (yy-mm-dd + hh:mm:ss:cc);
- axle load;
- gross vehicle weight;
- numbers of axles and axle distances (centre to centre);
- wheelbase;
- vehicle speed;
- vehicle class according to a specified system (e.g. as in the Annex E, E.11).

The vehicle length (bumper to bumper) is generally measured by other sensors than the weighing sensors, and therefore is not required here. However, if available, it should be given by the WIM system.

5.2 Sensors requirements

5.2.1 Climatic conditions

5.2.1.1 The supplier shall specify the upper temperature limit and the lower temperature limit from any of the values below, and indicate whether the instrument is designed for condensing or non-condensing humidity as well as the intended location for the instrument, i.e. open or closed.

Upper temperature limits: 30 °C, 40 °C, 55 °C, 70 °C.

Lower temperature limits: -5 °C, -10 °C, -25°C, -40 °C.

The specified limits shall comply with the extreme temperatures encountered on site.

5.2.1.2 Salt and water ingress: the sensors shall continue to function normally when subject, on a regular basis, to water and salt exposure (in areas where snowfalls and/or ice may occur).

If the road structure is not well drained, the deflection may increase after rainfall.

5.2.2 Traffic conditions and mechanical resistance

5.2.2.1 The sensors shall survive if they are crossed by tanks (up to 60 t) and other tracked vehicles, or by a deflated tyre. In cold climate areas, the sensors shall also survive under studded tyres and snow-clearing devices. This requirement may be waived for portable systems used temporarily over short time periods.

5.2.2.2 The sensors shall always remain fixed in place under heavy traffic flow, until their removal or the pavement replacement, for safety reasons. This particularly concerns portable WIM sensors and sensors glued or bonded to the pavement surface.

5.3 Electronics requirements

5.3.1 The electronic devices and components shall operate within the temperature limits stated by the supplier as defined in 5.2.1.1.

5.3.2 Relative humidity in the range of 0 to 90 % (not condensing) shall be supported, unless there is another user specification.

5.3.3 The system and all its parts shall be protected against lightning as well as against any external electrical or magnetic field.

NOTE In any cases, it is better not to install systems under high voltage power line, or close to radio transmission towers and railways tracks.

6 Accuracy class tolerances with respect to the weights

6.1 General clauses – Detailed procedure

6.1.1 A WIM system shall be checked following a well-defined procedure or test programme and can then be classified into one of several accuracy classes according to the test results. These accuracy classes are defined with respect to the (static) reference weight; but in some special cases another reference may be adopted, such as independently measured impact forces.

6.1.2 The principle adopted for this classification consists of assessing the tolerance δ , i.e. the width of an interval in which any individual measurement lies, with a minimum specified probability (level of confidence) π_0 chosen by the user.

In order to be checked with a test using reference vehicles (7.4.3), the specified level of confidence π_0 shall depend on the test conditions, i.e. the sample size and the repeatability or reproducibility conditions (see 10.4).

The level of confidence shall be mentioned for any reference to an accuracy class, otherwise the level of 95 % shall be at least assessed by default.

NOTE A system meets an accuracy class δ (see 6.3) if any individual measurement W_d (of a single axle, axle of a group, group of axles or gross weight) has a probability π higher than a minimum specified value π_0 of being within the interval $[W_s(1-\delta); W_s(1+\delta)]$, where W_s is the corresponding static load, or any other accepted reference value. It also means that statistically a proportion π of a large sample of WIM data should be within this same interval. Reversely, it may be said that given an individual measurement W_d , the confidence interval $[W_d/(1+\delta); W_d/(1-\delta)]$ contains the true value W_s with a probability π higher than a minimum specified value π_0 . Hence the customer risk (that an individual measurement fails outside the previous interval) is lower than $(1-\pi_0)$.

6.1.3 Individual measurements are required to assess the accuracy of a system, and shall be given by it. If a WIM system delivers only statistics during the operational period of use, detailed data should be provided for calibration and accuracy tests (see Clause 10).

6.2 General – Simplified procedure

The accuracy of a WIM system is defined by a set of tolerances δ (see 6.3, Table 1), such that, for each criterion (single axle load, axle of a group, group of axles and gross weight), the probability that an individual measured value W falls in the tolerance interval $[W_s(1-\delta); W_s(1+\delta)]$, is greater than or equal to 95 %. W_s is the true value, i.e. the corresponding static load, or other accepted reference value (as defined in 6.4).

NOTE if an individual value W is measured, the associated 95 % confidence interval is $[W/(1+\delta); W/(1-\delta)]$, i.e. this interval contains the true value W_s with a probability ≥ 95 %.

E.g.: For a tolerance δ of 10 % (gross weight in accuracy class B(10)), the probability (before the measurement) that an individual measurement W falls in the tolerance interval $[0,9 W_s; 1,1 W_s]$ is 95 %. After an individual measurement which gives a result W , and if W_s is unknown, the 95 % confidence interval $[0,909 W; 1,111 W]$ can be found, which contains W_s with a probability of 95 %. This interval is neither centred on W_s nor on W .

6.3 Accuracy classes

6.3.1 The tolerances for a load of a single axle, a group of axles, an axle belonging to a group and a gross weight are distinguished. Additional classes may be obtained, either by interpolation or extrapolation using the formulas of 6.3.4.1 or 6.3.4.2, or the curves of Figure 1.

The standard classes are designated by numbers $\delta_c = 5, 7, 10, 15, 20, 25$, which are the tolerances for the gross weights. The use of classes A(1), A(2)...A(5) or designated by any integer δ (e.g. C(13) if $\delta = 13$) is allowed if needed, with the letter of the closest standard class with a tolerance $\delta_c \geq \delta$.

The accuracy class of any WIM system is the lowest class obtained for all the relevant criteria.

6.3.2 The weighing intervals for axle loads and gross vehicle weights are given in Table 3, and the maximum scale divisions are given in Table 4. The WIM system shall meet all requirements specified in this standard in these weighing intervals.

6.3.3 If a WIM system does not provide axle of group loads, the accuracy requirements for this axles do not apply; in this case any reference to an accuracy class shall be complemented with the mention “except for axles of a group”.

6.3.4 Tolerance extrapolation and interpolation

6.3.4.1 If more classes are needed, beyond E(50), the tolerances for each criterion may be extrapolated by:

Group of Axles (GA): $\delta = 1,047 \delta_c + 2,16$ for $\delta_c \geq 50$

Single Axles (SA): $\delta = 1,133 \delta_c + 2,67$ for $\delta_c \geq 50$

Axles of a Group (AoG): $\delta = 1,133 \delta_c + 7,67$ for $\delta_c \geq 50$

where δ_c is the tolerance for the gross weight, and the accuracy class name is E(δ_c). These values shall be incremented in steps of 5 (%). The δ values obtained with the above formula shall be rounded up/down to the closest integer (see Table 2).

6.3.4.2 If interpolated classes from 0 to 50 (between the figures given on the line for gross weight in Table 2) are used, the tolerances for each criterion may be interpolated by:

Group of Axles (GA): $\delta = \delta_c/0,7$ for $\delta_c < 7$, $\delta = \delta_c + 3$ for $7 \leq \delta_c < 30$,

$\delta = 1,2 \delta_c - 3$ for $30 \leq \delta_c < 35$, and $\delta = \delta_c + 4$ for $35 \leq \delta_c < 50$