Weigh-in-Motion of Road Vehicles

Simplified Requirements

Wägung von Fahrzeugen während dem Fahrt —

Pesage en marche des véhicules routiers

ICS:

Descriptors:
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Foreword

This document (prEN XXX-2:2013) has been prepared by Technical Committee CEN/TC xxx “xxx”, the secretariat of which is held by CCMC.

This document is currently submitted to the CEN Enquiry.

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 complements the main standard “Weigh-in-motion of Road Vehicles” prEN XXX-1-2013 by providing some simplified procedures. It uses and refer to this main standard and does not duplicates its content.

This standard was prepared to deal with aspects related to:

- Scope, normative references, terminology and symbols (chapters 1 to 3);
- Site selection, operating conditions and environmental requirements (chapters 4 and 5);
- Accuracy classification (chapter 6);
- System calibration and testing (chapters 7 to 10);

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

This standard provides simplified and minimum requirements of practical use for common users, and shall be used in conjunction with the main standard prEN XXX-1-2013.

Keywords

1 Scope

The scope is the sale as in the main standard “Weigh-in-motion of Road Vehicles” prEN XXX-1-2013.

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.

prEN XXX-1:2013, Weigh-in-motion of Road Vehicles.


3 Terms, definitions, symbols and abbreviations

As in the main standard “Weigh-in-motion of Road Vehicles” prEN XXX-1-2013.

4 Site Selection Criteria

If users or suppliers want to specify or to refer to a site class, they shall use the standardized site classification given in prEN XXX-1-2013, chapter 4.

5 Operating Conditions and Environmental Requirements

A WIM system specification should 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 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.

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

5.3 The supplier must 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.
5.4 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.

5.5 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.

5.6 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 loads
- 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 prEN XXX-1-2013, Annex E, E.11).

and, not mandatory but if possible:

- Vehicle Length

6 Accuracy Class Tolerances

6.1 Tolerances

The accuracy of a WIM system is defined by a set of tolerances \( \delta \) (see 6.2, 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 \([W_a(1-\delta);W_a(1+\delta)]\), is greater than or equal to 95%. \( W_a \) is the true value, i.e., the corresponding static load, or other accepted reference value (as defined in prEN XXX-1-2013, section 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 $\geq 95\%$.

E.g.: For a tolerance $\delta$ of 10% (gross weight in accuracy class B(10)), the probability (before the measurement) that an individual measurement $W$ falls in the tolerance interval $[0.9W_s;1.1W_s]$ is 95%. After an individual measurement which gives a result $W$, and if $W_s$ is unknown, the 95% confidence interval $[0.909W;1.111W]$ can be found, which contains $W_s$ with a probability of 95%. This interval is neither centred on $W_s$ nor on $W$.

6.2 Accuracy Classes

An accuracy class is named by the tolerance $\delta$ for the gross weight. The main accuracy classes are named also by letters: A(5), B+(7), B(10), C(15), D+(20), D(25), E(30), E(35), etc.

The tolerances $\delta$ for each accuracy class and criterion are given in Table 1.

<table>
<thead>
<tr>
<th>Criterion (type of measurement)</th>
<th>Accuracy Classes - Tolerance interval width $\delta$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gross weight ($\delta_c$)</td>
<td>5</td>
</tr>
<tr>
<td>2. Group of axles</td>
<td>7</td>
</tr>
<tr>
<td>3. Single axle</td>
<td>8</td>
</tr>
<tr>
<td>4. Axle of a group</td>
<td>10</td>
</tr>
</tbody>
</table>

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

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”.

NOTE It is allowed to use intermediate classes such as A(1), A(2),… B(11), B(12)… where the tolerance on the gross weight is given in parentheses as an integer. The corresponding tolerances for the other criteria are interpolated as explained in prEN XXX-1-2013, section 6.2.4.

The WIM system shall meet all requirements specified in this standard for at least the range of axle and gross vehicle weights listed in Table 2. The scale divisions for axle and gross weights shall not be greater than those listed in Table 3.

<table>
<thead>
<tr>
<th>Table 1 — Measurement intervals</th>
<th>Table 3 —Maximum scale divisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axle loads</td>
<td>1000</td>
</tr>
<tr>
<td>Vehicle weights</td>
<td>3500</td>
</tr>
<tr>
<td></td>
<td>Axle loads</td>
</tr>
<tr>
<td></td>
<td>Vehicle weights</td>
</tr>
</tbody>
</table>

6.3 Other tolerances

The minimum rate of detection (percentage of vehicle detected by the system) is 90% 1.

A record is complete if all the quantities listed in clause 5.6 are recorded. The minimum rate of complete registration is 80%.

1 It does not mean that any detected vehicles can be eliminated from a sample, up to 10% of the sample size.
The tolerance on the axle spacing is 20% with a maximum error of 0.3 m, and on the wheelbase is 10% with a maximum error of 1 m. These criteria, for both axle spacing and wheelbase, apply for a minimum of 95% of the measurement.

7 On Site System Checks, Calibration and Test Condition

7.1 General

A newly developed WIM system shall pass a type (model) approval before it can be claimed to be capable of achieving a specified accuracy (see chapter 8 and prEN XXX-1-2013, chapter 8).

A newly installed WIM system, or a modified WIM system, shall pass an initial verification (see 9.1 and prEN XXX-1-2013, chapter 9), if the supplier or user wishes to claim any accuracy of its data, or to fulfil a contractual agreement on the accuracy between the vendor and the client.

Any WIM system shall periodically pass an in-service verification (see 9.2 and prEN XXX-1-2013, chapter 9) if the user wishes to claim any accuracy of its data over time.

NOTE In any case initial and in-service verifications are highly recommended.

7.2 Calibration Methods

Any WIM system must be calibrated prior to a type approval or an initial verification test.

NOTE There are various calibration methods for WIM systems which may be used, separately or combined, depending on the users’ requirements and means, which are described in prEN XXX-1-2013, section 7.4 and Annex C.

7.3 Definitions of Test Conditions

Depending on the environmental (climatic) conditions and the sample of reference vehicles used for a test, the test repeatability or reproducibility conditions are defined as follows.

NOTE The minimum required conditions depend on the accuracy class to be assessed and are specified in section 7.4.

7.3.1 Environmental conditions

(E1) Limited environmental variability (environmental repeatability): the test is carried out over a couple of hours, a day or a few consecutive days, such that the temperature, climatic and environmental conditions do not vary significantly during the measurements;

(E2) Extended environmental variability (limited environmental reproducibility): the test time period extends at least over a full week or several days spread over a month, such that the temperature, climatic and environmental conditions vary during the measurements, but no seasonal effect has to be considered;

(E3) Full environmental variability (full environmental reproducibility): the test time period extends over a whole year or more, or at least over several days spread all over a year, such that the temperature, climatic and environmental conditions vary during the measurements and all the site seasonal conditions are encountered.

7.3.2 Vehicle Sample conditions

(R1) Minimum or no reference vehicle variation (full repeatability conditions): only one vehicle passes several times at the same speed, the same load and the same lateral position;

(R2) One reference vehicle with variations (extended repeatability conditions): only one vehicle but it passes several times at different speeds (according to the traffic lane conditions), different loads (e.g. fully loaded, half-loaded and empty), and with small lateral position variations (according to the real traffic paths);
(R3) **Small set of reference vehicles (limited reproducibility conditions):** a small set of vehicles (typically 2 to 10), representative of the whole traffic composition expected on the site (silhouettes and gross weights), is used, each of them passing several times, at different speeds, different loads, and with small variations in lateral position;

(R4) **Large set of reference vehicles from the traffic flow (full reproducibility conditions):** a large sample of vehicles (i.e. some tens to a few hundred) taken from the traffic flow and representative of it, pass on the WIM system and are statically weighed before or after it.

### 7.4 Minimum Required Test Conditions

Minimum test conditions are required, combining environmental and sampling conditions (section 7.3.1 and 7.3.2), according to the accuracy class to be assessed as shown in Table 4. The choice of the reference vehicles should be based on the most common types in the traffic flow or the target vehicles of the user. The bogie axles should be equipped, as far as possible, with air suspensions, in order to minimise gross errors in the static reference axle loads.

<table>
<thead>
<tr>
<th>Accuracy class</th>
<th>A(5) or B+(7)</th>
<th>B(10)</th>
<th>C(15)</th>
<th>D+(20) or D(25)</th>
<th>E(30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type Approval Test</td>
<td>R4 &amp; E3 (200)</td>
<td>R4 &amp; E3 (200)</td>
<td>R3 &amp; E2 (60)</td>
<td>R3 &amp; E2 (60)</td>
<td>R2 &amp; E2 (30)</td>
</tr>
<tr>
<td>Initial verification</td>
<td>R3 &amp; E2 (60)</td>
<td>R2 &amp; E1 (30)</td>
<td>R2 &amp; E1 (30)</td>
<td>R1 &amp; E1 (10)</td>
<td>R1 &amp; E1 (10)</td>
</tr>
<tr>
<td>In-service verification</td>
<td>R3 &amp; E2 (60)</td>
<td>R2 &amp; E1 (30)</td>
<td>R2 &amp; E1 (30)</td>
<td>R1 &amp; E1 (10)</td>
<td>R1 &amp; E1 (10)</td>
</tr>
</tbody>
</table>

R2: two significantly different loads (≥ 15 runs/load) and various speeds  
R3: two vehicles and one load per vehicle (≥ 15 runs/vehicle), or 3 vehicles and 2 significantly different loads per vehicles (10 runs/vehicle and load case).

### 8 Type (Model) Approval

See prEN XXX-1-2013, chapter 8.

### 9 Initial and In-Service Verifications of a WIM System

#### 9.1 Initial Verification

After installation, modifications, repair or part replacement, a WIM system must be (re)calibrated. At that point, an initial verification is required if an accuracy class for the system is to be claimed. For such a verification, the tolerances given in Table 1 (section 6.2) are reduced by a multiplicative factor $k = 0.8$.

#### 9.2 In-Service Verification

If the system is checked using repeated runs of reference vehicles during its operation life, the tolerances given in the Table a are used.

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2 E.g. if the same data is used for the (re)calibration and accuracy classification, which is NOT recommended

3 The data used for accuracy classification being different from that used for (re)calibration
10 Procedure to Check the Accuracy of a WIM System by testing

10.1 General Rules

This section specifies the accuracy assessment of a WIM system while in situ testing, using either repeated runs of reference vehicles, and/or the use of single runs of reference vehicles from the traffic flow.

Reference vehicles shall be pre- or post-weighed on an approved static scale, weigh-bridge or low speed WIM system. The clauses of prEN XXX-1-2013, section 6.4, apply. The standard deviations of the static axle loads, based on repeated weighings of the same vehicle, shall be less than 1/3 of those measured in motion.

Minimum test conditions are required with respect to the accuracy class to be assessed, as described in section 7.4. However, vendors and users may agree to use more extensive test plans than the minimum required. If some tests are carried out with a test plan below the minimum required, the obtained accuracy class cannot be claimed with respect to this standard.

Some examples of test plans are given in prEN XXX-1-2013, Annex B, B.1.

10.2 Confidence Level

The confidence level of the interval defined in section 6.1 is 95%.

10.3 Test Results Analysis

10.3.1 Any system failure or malfunction shall be reported.

10.3.2 Before the analysis, the numbers $n$ of recorded gross weights, groups of axles, single axles and axles of a group must be counted. The number of gross weights should be equal to or exceed the value specified in the Table 4 of the section 7.4.

10.3.3 The outliers properly identified by relevant statistical tests shall be accounted for and counted as missing data after elimination, if agreed with the users.

10.3.4 It is highly recommended to check that the results are Normally distributed (e.g. follow a Gaussian law), both because non-Normality often reveals some dysfunction, and because the Normality is assumed for the accuracy class acceptance procedure.

10.3.5 The procedure for assessing WIM system accuracy is described below:

1) For each entity (gross weight, single axle, group of axles and axles of a group) the individual relative errors with respect to the static load (weight) or the accepted reference values are calculated:

$$x_i = \frac{(W_{di} - W_{si})}{W_{si}} \times 100 \quad \text{(in %)}$$

where $W_{di}$ and $W_{si}$ are the in-motion measured value and the static (reference) values respectively.

2) The sample statistics: number $n$, mean $m$ and standard deviation $s$, of each sub-population of $x_i$ (same entity) are calculated.

3) For each criterion (gross weight, group of axle, single axle, axle of a group), the tolerance $\delta$ of the proposed accuracy class is taken from Table a (for an initial verification, $\delta$ is replaced by $k_\delta$ - clause 9.1). Then a statistical procedure agreed between the involved parties shall be applied to assess the proposed accuracy class (see 10.4)
10.4 Decision Procedures (Not mandatory)

Two decision procedures are given in prEN XXX-1-2013, Annex B, B.3. They use the sample statistics of the test results (10.3.5) and the tolerance of the accuracy class to be assessed for each criterion. A more general procedure is given prEN XXX-1-2013, section 10.4.
Bibliography


