INTERNATIONAL RECOMMENDATION

OIML R 91-2

Edition 202x (E)

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Traffic speed meters

Part 2: Test procedures

Cinémomètres pour la mesure de la vitesse des véhicules

Partie 2: les procédures d'essai

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ORGANISATION INTERNATIONALE DE METROLOGIE LEGALE

INTERNATIONAL ORGANIZATION OF LEGAL METROLOGY

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Foreword

The International Organization of Legal Metrology (OIML) is a worldwide, intergovernmental organization whose primary aim is to harmonize the regulations and metrological controls applied by the national metrological services, or related organizations, of its Member States. The main categories of OIML publications are:

- **International Recommendations (OIML R),** which are model regulations that establish the metrological characteristics required of certain measuring instruments and which specify methods and equipment for checking their conformity. OIML Member States shall implement these Recommendations to the greatest possible extent;
- **International Documents (OIML D),** which are informative in nature and which are intended to harmonize and improve work in the field of legal metrology;
- **International Guides (OIML G),** which are also informative in nature and which are intended to give guidelines for the application of certain requirements to legal metrology; and
- **International Basic Publications (OIML B),** which define the operating, rules of the various OIML structures and systems.

OIML Draft Recommendations, Documents and Guides are developed by Technical Committees or Subcommittees which comprise representatives from the Member States. Certain international and regional institutions also participate on a consultation basis. Cooperative agreements have been established between the OIML and certain institutions, such as ISO and the IEC, with the objective of avoiding contradictory requirements. Consequently, manufacturers and users of measuring instruments, test laboratories, etc. may simultaneously apply OIML publications and those of other institutions.

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Additionally, the OIML publishes or participates in the publication of **Vocabularies (OIML V)** and periodically commissions legal metrology experts to write **Expert Reports (OIML E)**. Expert Reports are intended to provide information and advice, and are written solely from the viewpoint of their author, without the involvement of a Technical Committee or Subcommittee, nor that of the International Committee of Legal Metrology. Thus, they do not necessarily represent the views of the OIML.

This publication – reference OIML R 91-2, Edition 20xx – was developed by Project Group 3 of OIML Technical Subcommittee TC 7/SC 4 – *Speed meters*. It was approved for final publication by the International Committee of Legal Metrology at its xxth meeting in October 202x. It supersedes the previous edition of R 91 dated 1990.

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1 Introduction

This OIML Recommendation R 91-2 covers the preparation of the test program, selection of test procedures and setting of test levels for speed meters.

This recommendation is used for the type evaluation of speed meters.

2 Test program

The test program shall be prepared to prove that the speed meter or its parts fulfil general, performance and durability requirements from OIML R 91-1 for type evaluation.

The test program shall first determine which test procedures are necessary and which test levels shall apply.

It shall cover:

a. Requirements from OIML R 91-1:202x.
b. Influence factors and disturbance tests according to OIML D 11 [1], and
c. Software tests according to OIML D 31 [2].

3 Requirements from OIML R 91-1

Metrological requirements are stated in OIML R 91-1, clause 6 and technical requirements are stated in OIML R 91-1, clause 7.

4 Metrological field test

4.1 General conditions

This test is for stationary speed meters and for moving speed meters in stationary mode. The metrological field test for moving speed meters in moving mode is described in 7.7.1.

All conditions shall be within rated operating conditions of the EUT and of the reference speed meter.

Installation of the EUT shall be done according to the user manual.

Tests shall contain conditions to test minimal, typical and maximal distances from the EUT to the measured vehicles. If intervals of alignment parameters (azimuth, elevation, side distance and height) are specified by the manufacturer at least three different installation conditions shall be tested.

If the EUT can be used to measure approaching and departing vehicles, both driving directions shall be tested.

The EUT and the reference speed meters shall be installed, configured and triggered such that their corresponding measurement sections are overlapping as much as possible and are aligned centrally. If a perfect matching of the measurement sections is not possible the test laboratory shall ensure by other means that the speed comparison is valid even in worst-case scenarios (drivers braking and/or accelerating). Such means might include an estimation of the influence of a worst-case scenario or the detection and exclusion of worst-case scenarios by the use of secondary reference speed meters which cover other measurement sections than the reference speed meter.

4.2 Choice of test sites

It is recommended that the metrological field tests should be completed in real traffic conditions. It might be necessary to perform measurements at several test sites to include all of the following aspects:

a. The speed of the vehicles shall cover the interval from the minimum specified speed to the maximum legal speed limit on motorways.

b. The occurrence of all types of vehicles: cars, motorcycles, small trucks, vehicles with trailers, and long vehicles such as busses or trucks.

c. A motorway with at least two lanes in the same driving direction, where overtaking occurs regularly during measurements.

d. A road with at least two lanes with traffic in opposite directions (departing and approaching traffic).

On all test sites the traffic on the road shall generally go smoothly, and shall not be prone to congestion or very small distances between vehicles. The vehicles shall generally not brake abruptly or accelerate close to the site of measurement.

The roads at all test sites, shall be straight or have a curve radius larger than the specified minimum curve radius of the EUT. Additional field or simulation tests are required for speed meters that have a specified minimum curve radius lower than the road used for the metrological field test.

4.3 Traffic condition during measurement

The traffic should not be congested during the measurement, which shall be the case when the average speed of the vehicles is above 80 % of the normal (uncongested) average speed and when the average temporal distance between vehicles driving on the same lane is above 1.8 s.

4.4 Number of measurements

In case of automatic measurements, a total number of at least 500 valid measurements shall be performed. In case of manual measurements, a total number of at least 100 valid measurements shall be performed. Lower numbers of measurements are possible if measurements take long (as might be the case when testing average speed meters) and if this is justified by a statistical analysis of errors.

Larger numbers of measurements might be necessary when several installation conditions or specific scenarios are tested.

The scenario of testing and number of valid measurements has to be indicated in the report.

4.5 Reference speed meter

The reference speed meter shall preferably perform automatic measurements. Justified exceptions are possible, for example, when the reference speed meter is moving (as might be the case when testing average speed meters).

The expanded measurement uncertainty ($k = 2$) of the reference speed meter for single measurements shall not exceed 0.6 km/h at speeds up to and including 100 km/h and 0.6 % of the speed value at speeds above 100 km/h.

If these uncertainties cannot be met, larger measurement uncertainties can be used, if the added uncertainty is compensated for in the maximum permissible error (see guarded acceptance in clause 8.3.2 of OIML G 1-106 [3]) and in the possible statistical analysis of errors (see clause 4.7).

4.6 Maximum permissible error

The MPE defined in R 91-1, 6.4 shall be respected in all measurements. In the following two cases the EUT shall be considered in accordance with the relevant MPE, even if some measurements have a negative error below the lower MPE value:

a. The EUT is an along-the-road speed meter and the error would be within the relevant MPE if the cosine error would be corrected.

b. The EUT uses the mathematical operation "rounding toward zero (truncating)" to obtain integer speed values and the error would be within the relevant MPE if "rounding to the nearest integer" would have been implemented.

The simple acceptance decision rule (also known as shared risk decision rule) shall be used to decide on conformity. Measurements on vehicles for which either the EUT or the reference speed meter gives no valid speed value shall be ignored.

4.7 Statistical analysis of errors (optional)

A statistical analysis of errors for a sequence of measurements is recommended. For this purpose, the errors are subdivided into bins according to the reference speed values. The recommended series of intervals, which serve as bins are: [0 km/h, 50 km/h], [50 km/h, 100 km/h], [100 km/h, 150 km/h], [150 km/h, 200 km/h], etc. Intervals of smaller or larger sizes may be used, depending on the circumstances. The mean value m and the standard deviation σ are than calculated within each bin. A factor z is chosen which is a measure of confidence (the recommended value is $z = 5$). The EUT shall be considered in accordance with the relevant MPE if the interval $[m - z\,\sigma, m + z\,\sigma]$ is fully within the MPE defined in R 91-1, 6.4.

4.8 Assignment to image evidence

If the speed meter records image evidence (photo or video) for the identification of vehicles, the timing and markings of the image evidence must be correct for all measurements. There must be no doubt about the correct assignment of the measured values to the vehicle visible on the image evidence, in particular in the case of overtaking procedures or when the distance from the EUT to the measured vehicles is near the minimal or maximal specified value.

If the measurements at speed values ~~inside the legal interval~~below the legal speed limit give rise to any suspicion that the correct assignment might not be guaranteed at speeds above the legal speed limit, additional field measurements in a protected environment are necessary.

4.9 Testing at speeds above the legal limit up to the maximum specified speed~~Speed measurements outside the legal interval~~

When metrological field tests are performed on public roads with a legal speed limit, the range of speeds from the legal speed limit up to the maximum specified speed must be checked by additional tests:~~The metrological performance of the EUT outside the legal speed interval shall be tested either:~~

a. Preferably, by performing additional field measurements in a protected environment (for example, on a race circuit), or ~~.~~

b. b~~B~~y performing metrological laboratory tests using a validated complete traffic simulator.

5 Metrological laboratory tests by traffic simulation

5.1 General conditions

Metrological laboratory tests are ~~optional, but can be~~ used to test, in a reproducible and safe environment, the behaviour of the EUT in various specific and well-defined situations. For type evaluation tests, the metrological laboratory tests cannot fully replace metrological field tests. For verifications, however, the metrological laboratory tests can replace metrological field tests.

These simulation tests are for stationary speed meters and for moving speed meters in stationary mode. The ego speed meter of moving speed meters shall be tested using a separate simulation test (see also 7.7).

All conditions shall be within rated operating conditions. The ambient temperature shall be within the interval 23 °C ± 5 °C and the relative humidity shall be within the interval 50 % RH ± 30 % RH.

5.2 Characteristics of the traffic simulator

The traffic simulator used for the metrological laboratory test shall be a device that is independent of the EUT. If necessary, the simulator shall be provided by the manufacturer and/or the EUT shall feature special tools provided by the manufacturer.

The traffic simulator shall generate a signal such as an electrical pulse sequence, light pulses or an electromagnetic radiation pattern, that corresponds to a vehicle driving at a known and configurable speed.

If possible, the use of a complete traffic simulator is recommended (see Figure 1). A partial traffic simulator as illustrated in Figure 2 may be used, if the parts of the measurement chain of the EUT, that are not covered by the partial traffic simulator, are tested by an appropriate additional test. The partial traffic simulator shall introduce an analogue or digital signal as early as possible into the measurement chain.

The expanded measurement uncertainty ($k = 2$) of the simulated reference speed shall not exceed 0.25 km/h at speeds up to and including 100 km/h and 0.25 % of the speed value at speeds above 100 km/h. The traffic simulator shall be validated by comparing the results of a measurement series on the road with the results of a simulation of a measurement series using the same EUT and simulating the same conditions as were present on the road.

Figure 1 – Complete traffic simulator for the example of a Doppler-radar based speed meter. The simulator introduces the same type of signal in the speed meter as a vehicle (microwave radiation in this case).

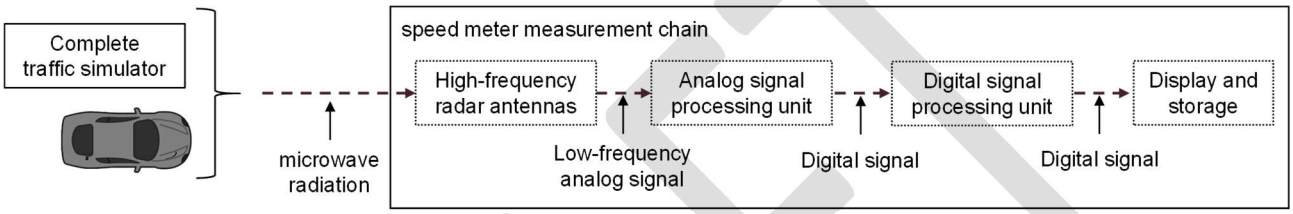
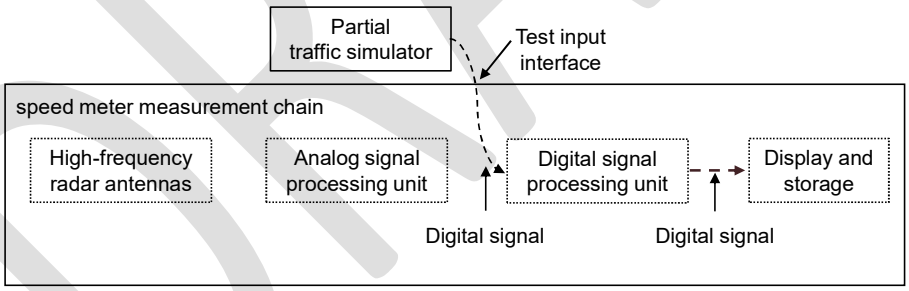


Figure 2 – Example of a partial traffic simulator for a Doppler-radar based speed meter, which introduces a digital signal. Parts of measurement chain, which are not tested by the partial traffic simulator, shall be tested by other appropriate additional tests or means.



5.3 Dynamic performance test ~~(optional)~~

The purpose of the dynamic performance test is to simulate the conditions of the metrological field test as closely as possible, including a possible distribution and variation of the measurement angle and possible vehicle-shape related effects. The simulator used for the dynamic performance test shall be validated by comparing the results of the simulation to the results of the metrological field test using the same device in the same measuring interval.

The simulator shall be configured such that one of the installation conditions tested in the metrological field tests is simulated. If the EUT can be used to measure approaching and departing vehicles, both driving directions shall be tested.

The simulated speed values shall be randomly chosen from a uniform distribution covering the full specified measuring interval and the acceleration values shall be randomly chosen from a uniform distribution covering the interval between −1.5 m/s^2 and 1.5 m/s^2. The relevant simulated reference speed is the speed on the identical measurement section as used by the EUT.

A total number of at least 500 valid simulation measurements shall be performed. To decide on conformity the same MPE and statistical methods as in the metrological field test shall be used.

5.4 Speed linearity test ~~(optional)~~

The purpose of the speed linearity test is to determine errors of indication under reference simulation (i.e. with minimized influence ~~factors~~quantities) and to determine errors and faults caused by influence factors and disturbances. The reference simulation conditions shall include:

a. a constant nominal measurement angle ~~of 0°~~ (if applicable),

b. as type of vehicle an isolated, cuboid car with length 5 m,

c. no acceleration (constantly 0 m/s^2),

d. a straight trajectory of the vehicles.

Before the actual test, the mathematical operation used by the EUT to obtain the indicated integer speed values from the higher resolution values ~~given at the test interface~~ is checked. The high-resolution speed values can be read from the test interface or in test mode and shall be used ~~F~~for the evaluation of errors of indication during the speed linearity test~~, the high-resolution speed values from the test interface of the EUT shall be used or the rounding shall be compensated~~.

The speed linearity test shall be carried out before and after the influence factor and disturbance tests at least at 10 speed values within the specified measuring interval. The EUT shall give valid speed values for each simulated vehicle. The EUT shall respect the linearity error limit specified in R 91-1, 6.5. During the influence factor and disturbance tests the repeated simulation of one single speed value is sufficient (see R 91-2, 6.3) and the acceptance criteria are given in table 1.

5.5 Distance linearity test ~~(optional)~~

The purpose of the distance linearity test is to reveal the accuracy of the distance measurements of the EUT under static conditions. The simulated vehicle shall be in standstill (speed 0 km/h) and the measurement angle shall be 0°.

The distance linearity test shall be carried out at least at 10 distances of the specified distance interval. The EUT shall give valid distance values for each simulated vehicle. The EUT shall respect the error limits specified by the manufacturer.

5.6 Angle linearity test ~~(optional)~~

The purpose of the optional angle linearity test is to reveal the accuracy of the angle measurements of the EUT under static conditions. The simulated vehicle shall be in standstill (speed 0 km/h) and the distance shall be a typical value within the specified distance interval.

The angle linearity test shall be carried out at least at 10 angles of the specified angle interval. The EUT shall give valid angle values for each simulated vehicle. The EUT shall respect the error limits specified by the manufacturer.

6 Influence factors and disturbance tests

Test procedures for influence factors and disturbances are defined in OIML D 11 [1], clauses 9 – 14, including the referenced IEC and ISO publications. Details about the tests which go beyond those defined in OIML D 11 [1], clauses 9 – 14 shall be done according to the test levels specified by the manufacturer in the documentation for type approval but checked and finally approved by testing laboratory by overviewing documentation and sample of the speed meter.

Nevertheless, the test laboratory should take into consideration and re-evaluate the manufacturer's specification based on:

- simulation technique to be used;
- point of use and principle of installation of the EUT (see R 91-1, clause 5);
- installation instructions and further detailed specifications by the manufacturer

before the final test plan is prepared.

6.1 Evaluation method

Table 1 and 2 include severity levels and evaluation criteria for influence factor and disturbance tests. The following abbreviations are used in the tables (based on definitions given in OIML D11 [1]):

~~Following table represents evaluation method environmental conditions:~~*Note 1:*

I Influence factor

D Disturbance

MPE ~~Maximum permissible error defined in OIML R 91-1, 6.4 and the l~~Linearity error limit defined in OIML R91-1, 6.5 ~~are~~is respected during the presence of the influence factor~~ (in relation to OIML D 11 [1] MPE)~~. The evidence files produced for every measurement must not be corrupt and the photographic documentation must be of the same quality as without the influence factor (if camera is part of EUT).

NSFa No significant fault occurred after the disturbance. The EUT shall continue to operate as intended after the test (manual intervention allowed).

NSFd No significant fault occurred during the disturbance. The EUT shall continue to operate as intended after the test without manual intervention.~~If no measurement result is displayed and no evidence file is produced under a certain test level with evaluation method NSFd, the test level shall be lowered to the closest test level index to check whether a significant fault occurs.~~

n/a not applicable (test not useful for traffic speed meters).

RF amp. radio frequency amplitude.

~~Note 2: Battery voltage variation (28, 29) shall also be performed during 1 Dry heat (operating) and 3 Cold (operating)~~

Table 1 – Climatic and mechanical influence factors and disturbances ~~Influence factors and disturbances~~

#	Influence quantity exposure	Table(s) from OIML D 11 [1]	Severity level	Evaluation	
1	Dry heat (operating)	6	3	I	MPE
2	Dry heat (storage)	6	4	D	NSFa
3	Cold (operating)	7	2	I	MPE
4	Cold (storage)	7	3	D	NSFa
5	Damp heat, cyclic (condensing)	9	H1 – n/a H2 – 1 H3 – 2	I~~D~~	~~NSFd~~MPE
6	Water (optional)	10	2	D	NSFd
7	Atmospheric pressure ~~(optional)~~	11,12	~~I~~ ~~MPE~~n/a		
8	Sand and dust (optional)	13	1	D	NSFd
9	Salt mist (optional)	14	2	D	NSFd
10	Vibration (random)	15,~~16~~	M2 – 1 M3 – 2	I	MPE
11	Mechanical shock	17	M2 – 1 M3 – 2	D	NSFa

#	Influence quantity exposure	Table(s) from OIML D 11 [1]	Severity level	Evaluation	
~~12~~	~~DC mains voltage variation~~	~~18~~		~~I~~	~~MPE~~
~~13~~	~~Ripple on DC mains power~~	~~19~~		~~D~~	~~NSFd~~
~~14~~	~~AC mains voltage variation~~	~~20~~		~~I~~	~~MPE~~
~~15~~	~~AC mains frequency variation~~	~~21~~		~~I~~	~~MPE~~
~~16~~	~~DC mains voltage dips, short interruptions and reductions~~	~~22~~		~~D~~	~~NSFd~~
~~17~~	~~AC mains voltage dips, short interruptions and voltage reduction~~	~~23~~		~~D~~	~~NSFd~~
~~18~~	~~AC mains harmonics~~	~~24~~		~~D~~	~~NSFd~~
~~19~~	~~VLF and LF disturbances on AC and DC mains~~	~~25~~		~~D~~	~~NSFd~~
~~20~~	~~Bursts (transients) on AC and DC mains~~	~~26~~		~~D~~	~~NSFd~~
~~21~~	~~Surges on AC and DC mains power~~	~~27~~		~~D~~	~~NSFd~~
~~22~~	~~Bursts (transients) on signal, data and control lines~~	~~28~~		~~D~~	~~NSFd~~
~~23~~	~~Surges on signal, data and control lines~~	~~29~~		~~D~~	~~NSFd~~
~~24~~	~~Mains power frequency magnetic field~~	~~30~~		~~D~~	~~NSFd~~
~~25~~	~~Conducted (common mode) currents generated by RF EM fields~~	~~31~~		~~D~~	~~NSFd~~
~~26~~	~~RF electromagnetic fields~~	~~32,33,34~~		~~D~~	~~NSFd~~
~~27~~	~~Electrostatic discharge~~	~~35~~		~~D~~	~~NSFd~~
~~28~~	~~Low voltage of internal battery~~	~~36~~		~~I~~	~~MPE~~
~~29~~	~~Voltage variations of a road vehicle battery~~	~~37~~		~~I~~	~~MPE~~
~~30~~	~~Electrical transient conduction along supply lines of external 12 V and 24 V batteries (pulses 2a, 3a, 3b)~~	~~38~~		~~D~~	~~NSFd~~
~~31~~	~~Electrical transient conduction along supply lines of external 12 V and 24 V batteries (pulse 2b)~~	~~38~~		~~D~~	~~NSFd~~
~~32~~	~~Electrical transient conduction via lines other than supply lines for external 12 V and 24 V batteries~~	~~39~~		~~D~~	~~NSFd~~
~~33~~	~~Battery voltage variations during cranking~~	~~40~~		~~D~~	~~NSFd~~
~~34~~	~~"Load dump" test~~	~~41~~		~~D~~	~~NSFd~~

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~~*Note 1:*~~

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Table 2 – Electromagnetic influence factors and disturbances

#	Influence quantity exposure	Table(s) from OIML D 11 [1]	Severity level			Evaluation	
			E2		E3		
			AC	DC	Vehicle DC		
12	DC mains voltage variation	18	n/a	1 [(a)]	n/a	I	MPE
13	Ripple on DC mains power	19	n/a	2	n/a	D	NSFd
14	AC mains voltage variation	20	1	n/a	n/a	I	MPE
15	AC mains frequency variation	21	1	n/a	n/a	I	MPE
16	DC mains voltage dips, short interruptions and (short term) voltage variations	22	n/a	1 [(b)]	n/a	D	NSFd
17	AC mains voltage dips, short interruptions and reductions	23	2	n/a	n/a	D	NSFd
18	AC mains frequency harmonics	24	3	n/a	n/a	D	NSFd
19	VLF and LF disturbances on AC and DC mains	25	2	n/a	n/a	D	NSFd
20	Bursts (transients) on AC and DC mains	26	3	3 [(c)(d)]	n/a	D	NSFd
21	Surges on AC and DC mains power lines	27	3	3 [(c)(d)]	n/a	D	NSFd
22	Bursts (transients) on signal, data and control lines	28	3 [(e)]	3 [(e)]	n/a	D	NSFd
23	Surges on signal, data and control lines	29	3 [(e)]	3 [(e)]	n/a	D	NSFd
24	AC mains power frequency magnetic field	30	5	n/a	n/a	D	NSFd
25	Conducted (common mode) currents generated by RF electromagnetic fields	31	RF amp. 20 V	n/a	n/a	D	NSFd
26	RF electromagnetic fields	32, 33, 34	RF amp. 20 V/m	RF amp. 20 V/m	RF amp. 20 V/m	D	NSFd
27	Electrostatic discharges	35	3	3	3	D	NSFd
28	Low voltage of internal battery	36	n/a	1	n/a	I	MPE
29	Voltage variations of a road vehicle battery	37	n/a	n/a	C or F [(f)]	I	MPE
30	Electrical transient conduction along supply lines of external 12 V and 24 V batteries	38	n/a	n/a	IV	D	NSFd
31	Electrical transient conduction via lines other than supply lines for external 12 V and 24 V batteries	39	n/a	n/a	IV	D	NSFd
32	Battery voltage variations during cranking	40	n/a	n/a	III	D	NSFd
33	Load dump test	41	n/a	n/a	A[(g)]	D	NSFd

Notes:

(a) This test must be done at the operative DC voltage limits declared by the manufacturer
(b) For speed meters connected to a dedicated DC power source, which is not used for other equipment in the installation this test is not applicable.
(c) When the manufacturer provides a dedicated AC/DC power source, the instrument must be tested as AC powered instrument. However, if the distance between such power source and the instrument is greater than 3 m (for burst) or 10 m (for surge) then the disturbance has to be applied in the DC input of the instrument.
(d) Applicable only when the typical distance between the DC power source and the instrument is greater than 3 m (for burst) or 10 m (for surge).
(e) For fixed speed meters installed outdoor where the cables between the components of the speed meters (cameras, indicating display, illuminator, etc.) are running outdoor these tests have to be applied in the such cables only when the distance between the components are greater than 3 m (for bursts) or 10 m for (Surge)
(f) Code C for 12 V vehicle batteries and code F for 24 V vehicle batteries.
(g) The choice to use load dump pulse A or B depends whether the instrument will be installed in a vehicle with or without protection (see ISO 16750-2 [4]). Because this circumstance is unknown for authorities it is recommended to assume the worst case (i.e. without protection).

~~I Influence factor~~

~~D Disturbance~~

~~MPE Maximum permissible error defined in OIML R 91-1, 6.4 and the linearity error limit defined in OIML R91-1, 6.5 are respected during the presence of the influence factor (in relation to OIML D 11 [1] MPE)~~

~~NSFa No significant fault occurred after the disturbance~~

~~NSFd No significant fault occurred during the disturbance. If no measurement result is displayed and no evidence file is produced under a certain test level with evaluation method NSFd, the test level shall be lowered to the closest test level index to check whether a significant fault occurs.~~

~~*Note 2:* Battery voltage variation (28, 29) shall also be performed during 1 Dry heat (operating) and 3 Cold (operating)~~

~~6.1~~6.2 Reference conditions

Reference conditions are the following:

a. Ambient temperature : 23 °C ± 5 °C, and
b. Relative humidity : 50 % RH ± 30 % RH.

During each test at reference conditions, the temperature and the relative humidity shall not vary by more than 5 °C and 30 % RH, respectively, within the reference intervals. ~~AC mains voltage and frequency (if appropriate) shall be maintained at their nominal values.~~

~~6.2~~6.3 Traffic s~~S~~imulation during influence factor and disturbance ~~tests before and after disturbances and during influence factors~~

~~The EUT shall pass the speed linearity test as specified in clause 5.4 before and after the presence of the disturbances and during the presence of influence factors.~~

For the influence factor and disturbance tests a traffic simulator must be available, which allows the determination of errors and faults. A complete traffic simulator is recommended. If necessary, the simulator shall be provided by the manufacturer and/or the EUT shall feature special tools provided by the manufacturer. The traffic simulator shall be designed to simulate at least 10 velocity values inside the EUT's measurement range.

The simulated speed during the influence factor and disturbance tests can be constantly the same or changing. The EUT shall be configured such, that evidence files are produced at all simulated speed values. For the evaluation of errors and faults the high-resolution speed values shall be used (see also clause 5.4).

The time interval between two simulated vehicles shall be adapted to the change of the tested influence quantity (e.g. 30 s during changing temperature and 5 s during scanning RF frequency).

~~6.3 Simulation tests during the presence of disturbances~~

~~During the presence of disturbances, it is recommended to repeatedly simulate a reference speed value of 100 km/h and to determine the faults. The intrinsic error shall be determined at reference simulation conditions (see clause 5.4**Error! Reference source not found.**). No significant fault shall occur (see clauses 6.18.1 and 6.18.2 of R 91-1).~~

~~6.4 Characteristics of the traffic simulator~~

~~The use of a simulation technique is mandatory, whereby a complete traffic simulator is recommended.~~

As few parts of the traffic simulator as possible shall be exposed to the influence factor/disturbance, the other parts being held at reference conditions.

If there is the possibility that parts of the traffic simulator are damaged or influenced by the influence factor/disturbance, the use of a partial traffic simulator is possible. Parts of measurement chain, which are not tested by the partial traffic simulator, shall be tested by other appropriate additional tests or means.

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~~6.5~~6.4 ~~Checking facilities~~Additional guidance on carrying out the tests

During the influence factor and disturbance tests, the EUT shall be powered with nominal voltage and according to the installation conditions specified by the manufacturer. For speed meters intended to be power by AC mains via a dedicated AC/DC converter (considered as a part of the EUT), the tests shall be performed on the AC mains and the frequency shall be at nominal value. If no dedicated AC/DC converter is part of the EUT, the EUT is considered DC powered and corresponding tests shall be carried out.

For battery powered speed meters, the tests on battery voltage variation (#28 and #29 in table 2) shall also be performed during tests #1 Dry heat (operating) and #3 Cold (operating).

If the EUT incorporates checking facilities, it might occur that the EUT does not show a measurement result or not produce an evidence file at certain test levels. This behaviour is OK as long as it is ensured that the acceptance criterion is met at lower amplitudes where the checking facility does not intervene. Additional tests at lower amplitudes might be necessary.

The test procedures for dry heat (operating), cold (operating) and DC/AC voltage variations shall also include the testing of the corresponding checking facilities. The test report shall state if and how the checking facilities were tested.

~~6.6~~6.5 Acceleration test

Accelerations in the interval between −1.5 m/s^2 and 1.5 m/s^2 are typically present during metrological field tests and are additionally tested during the dynamic performance test using simulation. ~~considered as influence factors. No additional influence factor test is required, as the vehicles simulated in the speed dynamic test have accelerations in this interval.~~

Accelerations in the intervals [−5 m/s^2, −1.5 m/s^2] and [1.5 m/s^2, 5 m/s^2] need to be specifically tested with all other influence quantities minimized. ~~are considered as disturbances. A corresponding disturbance test using the evaluation criteria NSFd shall be conducted.~~ The use of a partial traffic simulator is sufficient for this test. The integer speed values from the EUT shall be used to calculate the errors. The errors shall fulfil the MPE for stationary measurements (clause 6.4 of R91-1).

For this test it is particularly important to evaluate the simulated reference speed on a measurement section, which overlaps as much as possible with the measurement section of the EUT.

~~6.7~~6.6 Further ~~disturbance~~ influence quantity tests

Further possible ~~disturbances~~ influence quantities are speed-meter-specific and include rain (or snow), small curve radii of the road, existence of pulsed light sources, dense traffic, or exotic target vehicles (with respect to length, height, shape, surface reflectivity, etc.).

Corresponding specific field or simulation tests with all other influence quantities minimized shall be performed if there is any suspicion that the EUT might be so sensitive to such influence quantities~~disturbances~~ that the MPE's given in clause 6.5 of R 91-1 for stationary measurements and 6.15.1 of R 91-1 for moving measurement ~~a significant fault~~ might not be fulfilled under all possible circumstances~~occur during the disturbance~~.

~~6.8~~6.7 Installation and alignment of sensor and camera

The installation and alignment of sensor and camera shall be observed, at all allowed positions to install, to prove that means of identification of the measured vehicle are assigned to the correct vehicle.

7 Tests specific to certain categories of speed meters

7.1 Doppler-radar based speed meters

Specific test procedures shall be performed to determine:

a. carrier frequency or interval of modulated frequencies,
b. antenna pattern test to determine beam width and secondary beams and angles of the measurement beam ~~angles of the measurement beam~~,
c. equivalent isotropic radiated power [EIRP] (optional),
d. minimum and maximum of distance measurement, if applicable,
e. accuracy of angle measurement, if applicable, and
f. accuracy of the aiming device, if applicable.

7.2 Range-finding based speed meters

Specific test procedures shall be performed to determine:

a. that vehicle shape does not significantly affect the speed measurement,
b. pulse repetition rate or another characteristic of the time intervals between the pulses,
c. the beam width~~-~~, secondary beams and relevant characteristics of the field of view (divergence etc.)~~or the relevant characteristics of the field of view~~,
d. the exit angle of the measurement beam, if applicable, and
~~d.~~e. influence of curve radius

7.3 Average speed meters

Specific test procedures shall be performed to determine:

a. robustness of time synchronisation mechanism,
b. minimum and maximum area of trigger point/determination, and
c. minimum distance between entry and exit point.

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7.4 Fixed-distance speed meters

Specific test procedures shall be performed to determine:

a. accuracy of trigger point, and
b. minimum and maximum distance between trigger points.

7.5 Image based speed meters

a. accuracy of trigger point,
b. minimum and maximum distance between trigger points, and
c. minimum illumination and fog.

7.6 Across-the-road speed meters

a. accuracy of aiming device, if applicable, and
b. influence of curve radius.

7.7 Moving speed meters

7.7.1 Moving metrological field test

Moving speed meters shall be tested on the road under real traffic conditions. Installation of the EUT shall be done on a test vehicle according to the user manual. As a reference an ego speed meter installed on a second vehicle shall be used (called reference vehicle hereafter). The expanded measurement uncertainty (k = 2) of the reference speed meter shall not exceed 1 km/h at speeds up to and including 100 km/h and 1 % of the speed value at speeds above 100 km/h.

The EUT shall perform at least 200 valid measurements of the reference vehicle under various traffic conditions. There shall also be measurements in curved streets as the EUT shall give no valid speed value when the measurement is done outside specified limits. The reference vehicle shall generally not brake abruptly or accelerate strongly during the measurements. Appropriate means shall be taken to ensure that the measurements of the EUT are compared to the synchronous reference speed value.

The MPE defined in R 91-1, 6.15.1 shall be respected for each driving direction (if applicable).

7.7.2 Metrological field test of the ego speed meter

The metrological performance of the ego speed meter of the EUT shall be tested on the road. Installation of the EUT shall be done on a test vehicle according to the user manual. A suitable reference for the speed of the test vehicle shall be used. The expanded measurement uncertainty (k = 2) of the reference shall not exceed 0.2 km/h at speeds up to and including 100 km/h and 0.2 % of the speed value at speeds above 100 km/h.

If the mentioned uncertainty cannot be met, a larger measurement uncertainty can be used, if the added uncertainty is compensated for in the maximum permissible error (see guarded acceptance in clause 8.3.2 of OIML G 1-106 [3]).

The MPE defined in clause R 91-1, 6.15.3 shall be respected for all tested speed values.

7.7.3 Traffic simulation for moving speed meters

~~Separate t~~Traffic simulators shall be used to test the metrological performance of the moving speed meter in stationary mode and of the ego speed meter. ~~Moving speed meters shall also be tested simulating both ego~~

~~speed and moving speed at the same time.~~ Influence factor and disturbance tests should be performed separately on the moving speed meter in stationary mode and on the ego speed meter using these simulators.

8 Software examinations

Software examinations are performed according to documentation review and functional observation of the EUT.

Note: National regulations may require higher levels for the validation and examination steps.

8.1 Software evaluation methods

Evaluation methods for software requirements are defined in OIML D 31 [2], clause 7 *Type Evaluation*.

8.2 Software examination level

The speed meter software requirements shall be examined according to the Examination level A according to OIML D 31 [2] – normal examination level.

8.3 Evaluation requirements and method

Requirements from 1 to 7 are mandatory.

8.3.1 General requirements [mandatory]

#	Requirement	OIML D 31 [2]	Evaluation methods
1	Software identification	6.2.1	AD + VFTSw
2	Correctness of algorithms and functions	6.2.2	AD + VFTM

8.3.2 Software protection [mandatory]

#	Requirement	OIML D 31 [2]	Evaluation methods
3	Evidence and prevention of intervention	6.2.3	AD + VFTSw
4	Prevention of misuse	6.2.4	AD + VFTSw
5	Demands on the user	6.2.5	AD + VFTSw

8.3.3 Support of hardware features [mandatory]

#	Requirement	OIML D 31 [2]	Evaluation methods
6	Detection of significant defects	6.2.6.1	AD + VFTSw
7	Durability protection	6.2.6.2	AD + VFTSw
8	Time stamps	6.2.7	AD + VFTSw

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8.3.4 Specification and separation of legally relevant parts and specification of interfaces [optional]

#	Requirement	OIML D 31 [2]	Evaluation methods
9	Separation of components	6.3.2.1	AD
10	Separation of modules	6.3.2.2	AD
11	Shared indication	6.3.3	AD + VFTM/ VFTSw
12	Storage of data	6.3.4	AD + VFTSw
13	The measurement data stored shall be accompanied by all relevant information necessary for future legally relevant use	6.3.4.2	AD + VFTSw
14	The stored measurement data shall be protected by software means to guarantee the authenticity, integrity and correctness of the information concerning the speed measurement	6.3.4.3	AD + VFTSw
15	Automatic storing	6.3.4.4	AD + VFTSw
16	Transmission via communication lines	6.3.5	AD + VFTSw
17	The measurement data transmitted shall be accompanied by all relevant information necessary for future legally relevant use.	6.3.5.2	AD + VFTSw
18	The transmitted data shall be protected by software means to guarantee the authenticity, integrity and, if necessary correctness of the information concerning the speed of measurement.	6.3.5.3	AD + VFTSw
19	Transmission delay or interruption	6.3.5.4	AD + VFTSw
20	Compatibility of operating systems and hardware	6.3.6.2	AD + VFTSw
21	Hardware interfaces not equipped with a protective software interface shall not be able to inadmissibly influence the legally relevant software part.	6.3.6.2	AD + VFTSw
22	If a secure boot process is needed to ensure protection of the legally relevant software part, the following requirements apply.	6.3.6.3.1	AD + VFTSw
23	The combination of the legally relevant software part and the operating system shall ensure that there are enough resources for the operation of the legally relevant application.	6.3.6.4	AD + VFTSw
24	Protection during use	6.3.6.5	AD + VFTSw

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#	Requirement	OIML D 31 [2]	Evaluation methods
25	Communication with the legally relevant software part shall be made via protective interfaces.	6.3.6.6	AD + VFTSw
26	Identification and traceability	6.3.6.7	AD + VFTSw
27	The manufacturer shall identify the hardware and software environment that is suitable. Minimum resources and a suitable configuration necessary for correct functioning shall be declared by the manufacturer.	6.3.6.8	AD + VFTSw
28	Technical means shall be provided in the legally relevant software to prevent operation, if the minimum resources or a suitable configuration are not met.	6.3.6.9	AD + VFTSw

8.3.5 Maintenance and re-configuration [optional]

#	Requirement	OIML D 31 [2]	Evaluation methods
29	Verified update	6.3.8.3	AD
30	Traced update	6.3.8.4	AD + VFTSw

Note 1: AD stands for Analysis of the documentation and evaluation of the design according to OIML D 31 [2], 7.3.2.1.

Note 2: VFTM stands for Verification by functional testing of metrological functions according to OIML D 31 [2], 7.3.2.2.

Note 3: VFTSw stands for Verification by functional testing of software functions according to OIML D 31 [2], 7.3.2.3.

9 Bibliography

[1] OIML D 11:2013 *General requirements for measuring instruments - Environmental conditions*

[2] OIML D 31:2023 *General requirements for software-controlled measuring instruments*

[3] OIML G 1-106:2012 *Evaluation of measurement data - The role of measurement uncertainty in conformity assessment*

[4] ISO 16750-2:2023 *Road vehicles — Environmental conditions and testing for electrical and electronic equipment, Part 2: Electrical loads*

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