SLOVENSKI STANDARD
SIST EN 17507:2021

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Cestna vozila - Prenosni sistemi za merjenje emisij (PEMS) - Ocenjevanje delovanja

Road Vehicles - Portable Emission Measuring Systems (PEMS) - Performance Assessment

Straßenfahrzeuge - Mobile Abgasmesssysteme (PEMS) - Leistungsbewertung

Véhicules routiers - Systèmes portatifs de mesure des émissions (PEMS) - Vérification de la performance

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43.180	Diagnostična, vzdrževalna in preskusna oprema	Diagnostic, maintenance and test equipment

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Road vehicles - Portable Emission Measuring Systems (PEMS) - Performance assessment

Véhicules routiers - Systèmes portatifs de mesure des émissions (PEMS) - Vérification de la performance

Straßenfahrzeuge - Mobile Abgasmesssysteme (PEMS) - Leistungsbewertung

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European foreword

This document (EN 17507:2021) has been prepared by Technical Committee CEN/TC 301 “Road vehicles”, the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 2022, and conflicting national standards shall be withdrawn at the latest March 2022.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

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Introduction

The intention of this document is to determine the measurement uncertainty of mobile vehicle exhaust emission testing equipment (e.g. Portable Emissions Measurement Systems, PEMS) under consideration of applicable legal requirements (e.g. European Legislation on Light-Duty Real Driving Emission measurement, RDE).

The specific aims include the following:

— To be able to assess PEMS (for gaseous and particle number emissions) under various operating environments with the intention of predicting PEMS performance and uncertainty over the whole range of conditions used. For the time being, it focusses on light-duty-vehicle application and serves as a basis for assessing the uncertainty of heavy-duty emission measurement using PEMS.

— To be able to evaluate the deviation of gaseous PEMS under various light-duty on-road test conditions and heavy-duty PEMS test conditions against known analyser systems under standard laboratory conditions for the specified gas, which is traceable to national or international primary standards.

— To be able to evaluate the deviation of Particle Number (PN) - PEMS under various light-duty on-road test conditions and heavy-duty PEMS test conditions against a known analyser system under standard laboratory conditions for the same sample, which is traceable to national or international primary or secondary standards.

— To define the means for demonstrating that the PEMS equipment is stable and the measurement quality is sufficient between PEMS equipment service intervals.

— To provide input to the development of future specifications and quantified information about instrument and process accuracy to help improve the accuracy and robustness of PEMS systems and on-road measurements.

— To set a framework for determining the measurement uncertainty by analysing available data and providing a method for data evaluation.

In particular, the derivation of the uncertainty according to all parts of the document allows the following:

— The instrument measurement uncertainty can be evaluated.

— The instrument measurement uncertainty on-road can be reported as a part of the measurement result following ISO 10012:2003.

— The results of an investigation based on this document provides information about the suitability of the equipment for the intended use.

— Transparency with respect to the instrument measurement uncertainty of currently available equipment.

— Transparency with respect to the testing processes for the measurement uncertainty.

— Assessment of the statistical significance of the difference of measurement results.

1 Scope

This document defines the procedures for assessing the performance of test equipment that is used for the on-road measurement of tailpipe emissions of light-duty vehicles, on the basis of a common test procedure that simulates the range of conditions experienced during on-road tests.

This document prescribes:

— the tests to be conducted, and

— a procedure to determine, for any type of PEMS equipment, an appropriate uncertainty margin to reflect its performance over those conditions.

The key test variables are as follows (but not limited to the ones mentioned):

a) temperature, humidity and pressure (including step-wise or gradual changes),

b) acceleration and deceleration (longitudinal and lateral),

c) vibration, inclination and shock tests,

d) instrument positioning on a vehicle,

e) combinations of (a) to (d),

f) cross-interferences,

g) signal-processing, data treatment and time alignment, and

h) calculation methods (excluding the regulatory post-processing of data).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN ISO 29463 (all parts), *High-efficiency filters and filter media for removing particles in air (ISO 29463 (all parts))*

ISO 27891:2015, *Aerosol particle number concentration - Calibration of condensation particle counters*

ISO/IEC Guide 98-3:2008, *Uncertainty of measurement - Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

3 Terms, definitions and symbols

3.1 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at https://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

3.1.1
analyser
component of a Measurement Module(s) for detecting the gaseous or particle emission concentrations

Note 1 to entry: The type is defined by the specific analyser model and the applied analytical principle or the combination of multiple analytical principles.

3.1.2
filtered air
air filtered with a high efficiency filter according to EN ISO 29463-1, class 35H

3.1.3
inspection decision
result of an inspection

3.1.4
inspection
inspection process
conformity evaluation by observation and judgement accompanied as appropriate by measurement, testing or gauging

3.1.5
limit of error
maximum permissible error
extreme value of measurement error, with respect to a known reference quantity value, permitted by specifications or regulations for a given measurement, measuring instrument, or measuring system

3.1.6
measurement standard
realization of the definition of a given quantity, with stated quantity value and associated measurement uncertainty, used as a reference

3.1.7
measuring and test equipment
device used for making measurements, alone or in conjunction with one or more supplementary devices

3.1.8
measuring system
set of one or more measuring instruments and often other devices, including any reagent and supply, assembled and adapted to give information used to generate measured quantity values within specified intervals for quantities of specified kinds

3.1.9
measurement uncertainty
non-negative parameter characterizing the dispersion of the quantity values being attributed to a measurand, based on the information used

3.1.10
module
discrete or integrated sub-component within a PEMS, which supports the analyser(s) with the necessary supplementary components to fulfil the necessary requirements for each pollutant being measured

3.1.11
Portable Emission Measurement System
PEMS
system that can measure exhaust emissions from a vehicle on the road, allowing real-world testing

Note 1 to entry: For regulatory purposes, a PEMS comprises all the components necessary to monitor, process and report the real-driving emissions of the regulated pollutants in accordance with the relevant regulation. The PEMS used for emissions regulatory purposes typically integrate Measurement Module(s) (for example, for gaseous, particulate and exhaust-mass-flow). Additional accessories to fulfil the regulatory monitoring and processing functions are also included (for example, a weather station, Global Navigation Satellite System (GNSS) and, if required, connection to the vehicle networks).

3.1.12
uncertainty budget
statement of a measurement uncertainty, of the components of that measurement uncertainty, and of their calculation and combination

3.2 Symbols and abbreviations

A	Accuracy
c	concentration
CLD	Chemiluminescence Detector
CPC	Condensation Particle Counter
D	Drift
d	distance or diameter
DMA	Differential Mobility Analyser
E	Specific mass emission
ECU	Engine Control Unit
EFM	Exhaust Flow Meter
FS	Full Scale
GMD	Geometric Mean Mobility Diameter
GRR	Gauge Repeatability Reproducibility
GSD	Geometric Standard Deviation
GUM	Guide to the Expression of Uncertainty in Measurement
i	index
k	k-factor
LSL	Lower Limit of Specification

m	mass
MFC	Mass Flow Controller
MPE	Maximum Permissible Error
NDIR	Non-Dispersive Infra-Red
NDUV	Non-dispersive Ultra Violet
NMC	Non-Methane Cutter
NMHC	Non-Methane Hydrocarbons
p	pressure
P	Precision
PAS	Photoacoustic Spectroscopy
PEMS	Portable Emission Measurement Systems
PMP	Particle Measurement Programme
PN	Particle Number from exhaust emission according to relevant legal definition
PSD	Power Spectral Density
PSU	Power Supply Unit
Q	flow
R&R	Repeatability and Reproducibility
RDE	Real Driving Emissions
RE	Resolution (of measurement system)
RH	Relative Humidity
SOC	State of Charge
T	Temperature
t_e	time at end of test
t	time
TOL	Tolerance
u	uncertainty
u_{AV}	Uncertainty contribution of operator
u_{Bi}	Uncertainty contribution of bias

u_{CAL}	Uncertainty contribution of calibration
u_{EVO}	Uncertainty contribution of repeatability at the object
u_{EVR}	Uncertainty contribution of repeatability on standards
U_{IAI}	Uncertainty contribution of interdependence
u_{MP}	Uncertainty contribution by measurement procedure
U_{MP}	Extended measurement uncertainty contribution by measurement procedure
u_{MS}	Uncertainty contribution by measurement system
U_{MS}	Extended measurement uncertainty contribution by measurement system
u_{RE}	Uncertainty contribution by resolution
USL	Upper Limit of Specification
VDE	Verband der Elektrotechnik, Elektronik und Informationstechnik (Association for Electrical, Electronic & Information Technologies)
VDI	Verein Deutscher Ingenieure (Association of German Engineers)
VIM	Vocabulary of Metrology
VPR	Volatile Particle Remover
Δc	Concentration offset
Δt_e	Test duration
Δt	Time offset
	Sensor or monitoring device for indicated entity (e.g. temperature sensor)
	Controlling device for indicated entity (e.g. pressure controller or release valve)

3.3 List of subscripts

act	actual value (value that would be displayed by a perfect instrument)
amb	ambient, referring to ambient conditions
cur	current value
drift	concerning drift
err	error
gas	gas
i	index
j	index
m	mass (e.g. for flow)
meas	measured value
mono	monodisperse
poly	polydisperse
rd	relative density
ref	reference, referring to values of a reference device (if used)
s	sample
set	set value
span	span
T	Test duration
true	true value
V	Volume
zero	zero

4 Document structure including requirements, responsibilities and results

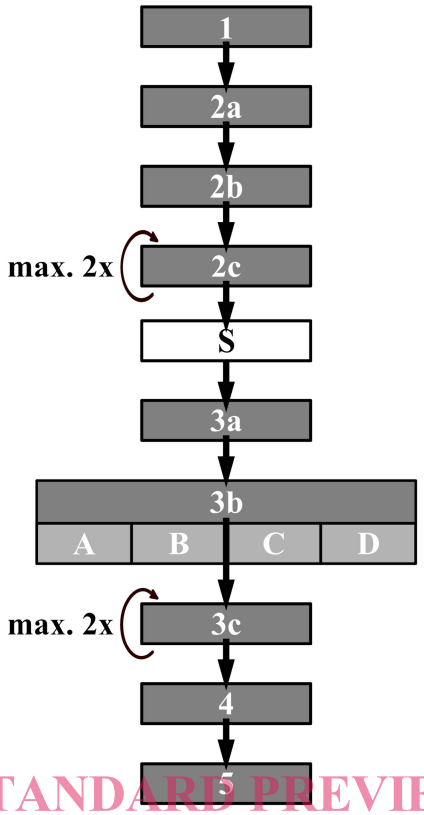
The whole document is structured according to the following table. This table also includes recommendations, which party should be responsible to conduct the tests and evaluate the uncertainty following the procedures which are described in this document.

Table 1 — Document structure

#	Requirement	Responsible party	Result
5	On-road testing process using PEMS	---	---
6	PEMS requirements and specifications of PEMS	PEMS manufacturers	PEMS technical specifications and test procedures for each type of PEMS component under ideal laboratory conditions
7	PEMS performance testing	PEMS manufacturers	PEMS performance test procedure for the evaluation of each type of PEMS component under simulated boundary conditions of use (in the laboratory)
8	Motivation and methods for uncertainty evaluation	---	---
9	Uncertainty evaluation of on-road testing (Type A – experimentally)	---	---
9.3	Determination of the combined measurement uncertainty I – PEMS validation	Individual PEMS User	Combined measurement uncertainty of the **PEMS validation**
9.4	Determination of the measurement uncertainty of the measurement II – on-road measurement process	PEMS User Community	Combined measurement uncertainty of the **on-road measurement process**
10	Uncertainty evaluation of on-road testing (Type B – non experimentally)	Individual PEMS User	Combined measurement uncertainty of the PEMS validation

5 On-road testing process using PEMS

The basis for this document is a common understanding of the on-road inspection process including all influencing parameters. The general description of the test procedure is defined in the relevant regulations. However, the following process chart (Figure 1) summarizes the most important steps.



Key

1	vehicle and equipment set-up	3b	on-road test (e.g. RDE test) consisting of multiple phases (e.g. A, B, C, D)
2a	pre-test; consisting of leak check, PN zero check, zero calibration, span calibration, EFM-function check	3c	post-test; similar to 2c
2b	validation test	4	evaluation of results
2c	post-test; consisting of PN zero check, zero drift check (relative to pre-test), span drift check (relative to pre-test)	5	results of test, power specific or distance specific mass emissions
3a	pre-test; similar to 2a	S	soak time of the vehicle (typically) between 6 to 56h, PEMS stays installed on the vehicle

Figure 1 — Example of general on-road measurement process (based on the European Legislation on Light-Duty Real Driving Emission measurement, RDE)

The final result of the exhaust emission measurement is the distance specific mass of an emission component limited by the relevant regulations. These results are given in the unit g/km or mg/km for gaseous species, or in the unit 1/km for particle number for light-duty vehicles. Therefore, the uncertainty has to be derived with respect to these final values.

As the applicable testing scheme may vary due to legally defined procedures, this process is taken as a minimum reference for the description of errors, their dependencies and propagation. If the testing procedure does significantly deviate from this process, the approach of uncertainty assessment shall be reassessed accordingly based on the recommendations of this document.