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Road Vehicles — Aerosol separator performance test for internal combustion engines —

Part 4:
Laboratory fractional efficiency test method

Véhicules Routiers — Essai de performance du séparateur d'aérosols pour les moteurs à combustion interne —

Partie 4: Méthode d'essai de l'efficacité fractionnelle en laboratoire

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 34, *Propulsion, powertrain and powertrain fluids*.

A list of all parts in the ISO 17536 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Engine crankcase blowby is composed of combustion exhaust gases, which have escaped to the crankcase via piston ring seals, and lube oil aerosols generated by thermal and mechanical action within the engine. These gases are vented from the crankcase to prevent a build-up of high pressure. The constituents of vented engine blowby gases are recognized as an undesirable contaminant and technology for their containment is therefore evolving.

The device used to separate oil aerosols from the blowby typically releases cleaned gases to atmosphere or into the air inlet prior to the engine or turbo compressor (if present). The latter has led to the requirement for a pressure control device to isolate the engine from turbo inlet suction.

It is the purpose of this document to define standardized and repeatable test procedures for the evaluation of blowby oil aerosol separators and filtering devices using this laboratory fractional efficiency test method.

Road Vehicles — Aerosol separator performance test for internal combustion engines —

Part 4: Laboratory fractional efficiency test method

1 Scope

This document defines standardized and repeatable test procedures for the evaluation of blowby oil aerosol separators and filtering devices and specifies laboratory fractional separation efficiency in both open and closed crankcase ventilation systems.

Filter life is not evaluated in this document.

The conditioned portion of this test only applies to filters that can meet the Dp stability requirements referenced in ISO/TS 17536-2.

Conformance of a device to legislation is outside of the scope of this document.

Due to limited precision using current equipment, this document is not suitable for filters above an efficiency of 99 %.

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.

ISO 17536-1:2015, *Road vehicles — Aerosol separator performance test for internal combustion engines — Part 1: General*

ISO/TS 17536-2, *Road vehicles — Aerosol separator performance test for internal combustion engines — Part 2: Laboratory test method*

3 Terms, definitions, and abbreviated terms

For the purposes of this document, the terms and definitions given in ISO 17536-1 and the following apply.

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

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

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

3.1 Terms and definitions

3.1.1
fractional separation efficiency
ability of the separator to remove particles of a specified size expressed as a percentage

3.1.2
particle instrument
instrument for sizing and/or counting aerosol particles

Note 1 to entry: Recommended particle instruments are LSAS's, or other instruments demonstrating they can measure results to within 5 % of an LSAS.

3.2 Abbreviated terms

PSD particle size distribution

PSE particle size removal efficiency

PSL polystyrene latex, referring to commercially available particles of various specific sizes

LSAS light scattering aerosol spectrometer

4 Measurement accuracy

The measurement accuracy of this document shall be in accordance with ISO 17536-1:2015, Clause 3.

5 Test materials and conditions

5.1 Absolute filter, wall flow trap and leakage

The provisions related to the absolute filter (if present), the downstream wall flow trap (if present) and leakage shall be in accordance with ISO 17536-1.

5.2 Test temperature

The volume directly outside of the unit under test (UUT) and internal temperature of the efficiency test shall be either:

— Condition A: 80 °C ± 3 °C

— Condition B: 23 °C ± 5 °C

The condition that is run shall be documented in the test report (see Annex B).

5.3 Test conditions

All test measurements shall be performed under the following stable conditions:

a) Flow rate: Air flow rate and mass oil flow are specified by the customer or by the test requestor.

b) Clean condition: The user should run a clean pressure loss test as specified in ISO/TS 17536-2. The clean pressure loss test is conducted before any oil aerosol is allowed to enter the unit under test (UUT).

c) If gravimetric efficiency (per ISO/TS 17536-2) and fractional efficiency tests are being performed simultaneously, once the oil flow has been started for a test the air flow and oil flow shall not be interrupted until the completion of the fractional efficiency test.

d) The conditioned fractional efficiency is measured after reaching the condition specified in ISO/TS 17536-2.

NOTE Aerosol size distribution is not specified in this document, however two possible distributions are as follows. D50: 0,85 µm to 0,9 µm (same as ISO/TS 17536-2) or to the customer's specification.

6 Test procedure

6.1 General

Performance tests shall be performed on a complete aerosol separator assembly. The tests shall consist of a fractional efficiency test and a conditioned fractional efficiency test (when applicable). If a gravimetric efficiency test, conditioned gravimetric efficiency test, pressure loss, crankcase pressure control test (when pressure regulator is present), or a drain interval test (when applicable) will be performed, it shall be done in accordance with ISO/TS 17536-2.

6.2 Test equipment

NOTE The definitions of the following terms related to the test equipment are defined in ISO 17536-1; upstream particle instrument, particle instrument calibration, maximum particle concentration and particle instrument flow.

6.2.1 The duct material shall be electrically conductive and electrically grounded (metal duct), have a smooth interior finish, and be sufficiently rigid to maintain its shape at the operating pressures. The background air shall be tested with a particle instrument.

6.2.2 The test bench used to determine fractional efficiency shall be the same as one of the benches that are shown in Annex C.

6.2.3 Use an aerosol generator which is capable of dosing oil mist over the range of sizes required as per customer specification.

6.2.4 An upstream wall flow trap should be used between the oil mist generator and the inlet duct to eliminate any oil wall flow to the inlet duct. Use a wall flow trap conforming to ISO 17536-1.

6.2.5 Use an inlet piezometer tube conforming to ISO 17536-1. The cross-section shall be the same as the aerosol separator inlet. In the case of non-uniform flow conditions caused by special inlet ducts, special precautions may be required.

6.2.6 Use a manometer or other differential pressure measuring device with the specified accuracy described in ISO 17536-1.

6.2.7 A downstream wall flow trap should be used between the unit under test and the outlet piezometer tube described in 6.2.5 (if present) to eliminate any oil wall flow. Use a wall flow trap conforming to ISO 17536-1.

6.2.8 Use an outlet duct conforming to ISO 17536-1. The cross-section shall be the same as the aerosol separator outlet. In the case of non-uniform flow conditions caused by special inlet ducts, special precautions may be required.

6.2.9 Use an air flow rate measuring system having the accuracy described in ISO 17536-1. The device needs to be calibrated to the environmental conditions inside the inlet duct at the test conditions used.

6.2.10 Use an air flow rate control system with a refresh rate greater than or equal to 2 Hz capable of maintaining the indicated flow rate to within 5 % of the selected value.

6.2.11 Use compressed air/blower/exhauster for controlling air flow through the system, which has adequate flow rate and pressure characteristics for the oil separators to be tested.

6.2.12 If the unit under test has a pressure regulator or bypass, the use of a blower/exhauster on the downstream of the system can be used to regulate the pressure on the outlet of the unit under test. Devices with pressure regulators shall have air pushed through the inlet, because the pressure regulator device regulates the amount of vacuum allowed on the system.

6.3 Aerosol generator

6.3.1 Aerosol concentration shall be measured by particle counting. The concentration shall be documented in the test report.

6.3.2 The test oil shall be documented for surface tension, density and viscosity. The temperature of the aerosol flow shall be measured at the filtration system inlet. Run test at conditions specified in 5.3. Periodically check these parameters.

6.4 Aerosol sampling system

6.4.1 The design criterion for the sampling system should be to provide a particle transport of >95 % for 3 µm diameter particles from the sample probe inlet within the test duct to the inlet of the particle instrument.

This shall be verified by experimental measurement or by numerical calculation of particle transport based upon the geometry of the sampling system, the sampling flow rate, and particle deposition associated with diffusion, sedimentation, turbulent flow, and inertial forces, as described in Reference [1].

6.4.2 The use of a sampling system is allowed to optimize particle transport from the inlet probe to the particle instrument. The sampling system shall meet the following criteria:

6.4.2.1 The portion of the sampling line in the duct shall block less than 25 % of the duct cross-sectional area.

6.4.2.2 Isokinetic sampling (to within +0 % to -10 %) shall be maintained on both upstream and downstream probes for the requestors specified flow rate of the UUT.

6.4.2.3 Flow through the sampling system shall be measured to within 5 % with volumetric devices (e.g. orifice plates and variable area flowmeters).

Sampling air flow should be considered in total flow rate (e.g. 3 l/min sampling at 30 l/min rated flow).

6.4.2.4 Combined particle losses in the system should be <5 % for 3 µm diameter particles, based on particle transport modelling.

6.4.2.5 The upstream and downstream sampling systems shall be of equal length and equivalent geometry.

6.4.2.6 Where the upstream sampling system flow rate is greater or equal to 20 % of the system air flow rate, compensation of the downstream particle count system flow rate shall account for the flow through the particle sizer to maintain UUT constant flow rate.

6.4.2.7 Where the downstream sampling system flow rate is greater than or equal to 20 % of the system air flow rate, compensation of the downstream particle count system flow rate shall account for the flow through the particle sizer to maintain UUT constant flow rate.

6.4.2.8 Position of auxiliary components (i.e. wall flow trap) shall not change PSD, will need to verify by measurement.

6.4.2.9 User shall verify the dilution ratio and ensure that the dilution does not change the particle distribution.

6.4.2.10 Ground all metal tubing and/or use grounded plastic tubing (carbon or embedded wire). The upstream and downstream sample lines should be nominally identical in geometry and shall use the minimal length of tubing possible.

6.4.2.11 The inlet nozzles of upstream and downstream sample probes shall be sharp edged (<15° included angle) and of appropriate entrance diameter to maintain isokinetic sampling within +0 to -10 % at the test airflow rate.

6.5 Particle sizing and counting monitor(s)

Permissible instruments used to measure the size and concentration of the aerosol shall meet the following criteria:

6.5.1 Shall measure particle diameters between 0,3 um and 5 um particles and group them into at least 8 channels per decade.

6.5.2 At least 90 % of all observed counts shall register between 0,7 µm to 1,3 µm when the particle instrument is challenged with monodisperse 1,0 µm diameter PSL particles.

6.5.3 Shall have at least 50 % counting efficiency at 0,3 um.

6.5.4 Shall have less than 10 % coincidence loss during the measurement.

6.5.5 Shall measure no more than 10 counts per min over the 0,30 µm to 5 µm range with a HEPA filter mounted at the inlet of the counter.

6.5.6 The particle instrument shall be periodically calibrated according to manufacturer specifications.

6.5.7 The particle instrument shall be calibrated to measure oil particles.

NOTE Particle counters often are calibrated for dust, which can give erroneous results when used for this test.

7 Apparatus qualification testing

7.1 Test stand verification

7.1.1 Apparatus qualification tests shall verify quantitatively that the test rig and sampling procedures are capable of providing reliable particle size efficiency measurements. The tests shall be performed in accordance with Table 1.

Table 1 — System qualification measurement requirements

Parameter	Requirement
100 % efficiency test: based on HEPA filter test	>99 %
Correlation ratio test	See Clause 9, Table 7

Table 1 *(continued)*

Parameter	Requirement
Duct leakage: ratio of leak rate to test airflow rate	 <1,0 %
Particle instrument zero count check: based on HEPA filter attached to the instrument's inlet	<10 counts per min over the 0,30 µm to 10 µm range
Particle instrument sizing accuracy check: based on sampling of aerosolized monodisperse PSL spheres of known size	Relative maximum shall appear in the appropriate sizing channel

7.2 Concentration limit of the particle instrument

7.2.1 A series of initial efficiency tests shall be performed over oil aerosol concentrations to determine a total concentration level for the PSE tests that does not overload the particle instrument(s). The lowest total concentration level shall be less than 1 % of the instrument's stated total concentration limit. The tests shall be performed following the procedures of 8.1 through 8.5 on a device using a range of upstream aerosol concentrations. The tests shall be performed at 10 %, 50 %, 100 % and 200 % of rated flow.

7.2.2 The aerosol for these tests shall be generated using the same system and procedures as described in Clause 8 for fractional efficiency tests.

7.2.3 The tests shall be performed over a sufficient range of total challenge concentrations to demonstrate that the particle instrument(s) is not overloaded at the intended test concentration.

7.3 100 % efficiency test and development of purge time

7.3.1 An initial efficiency test shall be performed using a HEPA filter as the test device to ensure that the test duct and sampling system are capable of providing a >99 % efficiency measurement. The test procedures for determination of PSE given in Clause 9 shall be followed, and the test shall be performed at 10 %, 50 %, and 100 % of test systems flow rate range.

7.3.2 The computed PSE values shall be greater than 99 % for all particle sizes.

7.3.3 One parameter affecting the efficiency during the 100 % efficiency test is the purge time. The purge time is too short if, after switching from the upstream to the downstream line, residual particles from the upstream sample are counted during the downstream sampling and yield an efficiency of <99 %. In this case, the purge time shall be increased and the 100 % efficiency test repeated.

7.4 Correlation test

7.4.1 A test shall be performed without a test device in place to check the adequacy of the overall duct, sampling, measurement, and aerosol generator.

7.4.2 The test procedures, given in 9.6, for determination of the correlation ratio shall be followed.

7.4.3 The correlation ratio for each particle size shall meet the requirements specified in Table 7.

7.5 Test duct air leakage test

7.5.1 Air leakage from the test duct shall not exceed 1 % of the airflow rate of test filter.

7.5.2 The leak rate of the test duct shall be evaluated by a method similar to that delineated in ANSI/ASME N510. The test duct shall be sealed immediately upstream of the aerosol injection location.