TECHNICAL SPECIFICATION

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

Part 5: Engine fractional efficiency test method and upstream distribution sampling method

Véhicules Routiers — Norme d'essai de performance des filtres des circuits fermés de ré-aspiration des gaz de carter moteur —

Partie 5: Méthode d'essai d'efficacité fractionnaire moteur et méthode d'échantillonnage de la distribution amont

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

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.

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

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 either define standardized and repeatable test procedures for the evaluation of blowby oil aerosol separators and filtering devices using this engine fractional efficiency test method and/or determining the size distribution of the blowby aerosol from the engine.

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

Part 5:
Engine fractional efficiency test method and upstream distribution sampling method

1 Scope

This document defines standardized and repeatable test procedures by using internal combustion engines for the evaluation of blowby oil aerosol, and aerosol separators and filtering devices by specifying the engine blowby sampling procedure and engine fractional efficiency test in both open and closed crankcase ventilation systems running at steady state. Due to sampling requirements, measuring efficiency when there are transient flow conditions is not in scope.

Separator life is not evaluated in this document.

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

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

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:

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

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

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

3.2 Abbreviated terms

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

4 Measurement accuracy

The measurement accuracy of this document shall be in accordance with ISO 17536-1.

5 Test materials and test conditions

5.1 Test oil and aerosol

The engine oil shall be documented for make, type, viscosity, cleanliness, and density.

The aerosol produced by the engine shall be measured using a calibrated particle size measurement device.

Mass aerosol distribution shall be displayed in Particle Size (μm) versus mass percent less than stated size.

The test conditions, engine aerosol size distribution, and fractional efficiency shall be documented. See Annex A, Figures A.1, A.2 and A.3 for a sample test reporting structure.

5.2 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.

5.3 Test conditions

Flow rate for efficiency tests shall be recorded in volumetric flow. All engine efficiency tests shall be documented with actual on-engine blowby temperature, absolute pressure, and humidity.

5.4 Aerosol Sampling System

5.4.1 The design criterion for the sampling system shall 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 counter.

NOTE This can 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. Aerosol Measurement: [1] is a possible reference for developing a good aerosol sampling system.

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

5.4.2.1 The portion of the sampling line in the duct shall block less than 25 % of the duct cross-sectional area[1)].

5.4.2.2 Isokinetic sampling (to within +0 to −10 %) shall be maintained on both upstream and downstream probes for nominal flow rates.

5.4.2.3 Flow through the sampling system shall be measured to within 5 % with volumetric devices (e.g., orifice plates and variable area flowmeters)[2)].

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1) Taken from: ASTM D1099-97 Standard Practice for Sampling Steam pg. 4 [3].

2) Taken from: ISO 21501-1:2009, *Determination of particle size distribution — Single particle light interaction methods — Part 1: Light scattering aerosol spectrometer* [4].

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

5.4.2.5 The airflow rate of the upstream and downstream sampling system shall be <20 % of the system airflow rate. This requirement excludes low flow conditions (i.e. idle or low RPM). The operator should try and minimize airflow rate of the upstream system as much as possible as pulling too much air from the system air flow rate could affect separator performance.

5.4.2.6 The auxiliary pump and associated flow control and flow measurement devices of the sampling lines shall be downstream of secondary probes.

5.4.2.7 Because a correlation test will be used, the operator does not need to provide equal dilution to both the upstream and downstream samples.

5.4.2.8 All metal tubing should be grounded. The upstream and downstream sample lines are to be nominally identical in geometry. The use of a short length (50 mm [2 in.] maximum) of straight, flexible, metal tubing to make the final connection to the aerosol particle counter is acceptable.

5.4.2.9 The inlet nozzles of upstream and downstream sample probes shall be sharp edged and of appropriate entrance diameter to maintain isokinetic sampling within +0 to −10 % at the test airflow rate.

5.5 Particle Counter(s) sizing and counting monitor(s)

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

a) If you are only measuring upstream particle distribution, the operator shall measure particle diameters between 0,3 µm and 10 µm particles and group them into at least 4 channels per decade.

b) If the operator is using this technical specification to measure efficiency, an 8-channel particle counter (or greater) shall be used. The operator shall measure particle diameters between 0,3 µm and 10 µm as long as 8.7.4.3 is met.

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

d) Shall have at least 50 % counting efficiency at 0,3 um[3].

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

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

g) The particle counter shall be periodically calibrated according to manufacturer specifications.

h) Shall be able to handle the high air temperatures seen by the raw or conditioned blowby gas coming off an engine.

6 Test procedure

6.1 General

A fractional efficiency test shall be performed on a complete aerosol separator assembly.

3) Taken from ISO 21501-1.

6.2 Test equipment

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

6.2.1 If the user is measuring efficiency, the setup arrangement to determine the efficiency is shown in Annex B, Figure B.1. Use an engine to supply blowby to the crankcase ventilation system. If the user is only measuring the distribution from an engine, the arrangement is shown in Annex B, Figure B.2.

6.2.2 Use a wall flow trap between the engine and the inlet tube described in ISO 17536-1 to eliminate any oil flow to the inlet tube.

NOTE The piezometer can be contaminated without the use of the wall flow trap.

6.2.3 Use an inlet piezometer tube conforming to Figure B.3. The cross-section shall be the same as the aerosol separator inlet.

6.2.4 Use a manometer or other differential pressure measuring device with the specified accuracy.

6.2.5 Orientation of the unit under test shall be as in application.

6.2.6 Use a wall flow trap similar to the one shown in ISO 17536-1 between the unit under test and the outlet piezometer tube described in 6.2.3 to eliminate any oil flow to the piezometer, if applicable.

6.2.7 Use an outlet piezometer tube conforming to Figure B.3. The cross-section shall be the same as the aerosol separator outlet. In the case of non-uniform flow conditions caused by special inlet tubes, special precautions may be required.

6.2.8 Use an air flow rate measuring system having the accuracy described in ISO 17536-1. Use a system that is capable of holding the RPM and torque described in ISO 17536-1. Make sure that the isokinetic sampling tubes meet the specs given in 5.4

6.2.9 If an engine is not capable of generating the blowby flow rate requested, use compressed air/blower/exhauster for inducing air flow through the system, which has adequate flow rate and pressure characteristics for the separators to be tested. Pulsation of flow rate shall be so low that it is not measurable by the flow rate measuring system.

6.2.10 If the components downstream of the unit under test and the environment have a pressure drop greater than 500 Pa, and it is proven that this pressure drop affects the particle size upstream and/or downstream of the UUT, a blower/exhauster on the downstream of the system shall be used to regulate the outlet pressure of the unit under test.

6.2.11 Grounding is required for all test apparatus to reduce the effects of static charge and to improve the consistency of the test results. Grounding of metallic and non-metallic surfaces, housings, transport tubes, injectors and associated hardware is recommended.

6.2.12 All tubing up to the point of the downstream sampling device (if present) should be insulated, or heated, or any other method that will keep the blowby gas above the dew point to eliminate condensation without changing the particle size distribution. If no separator is being tested, the tubing should be insulated up to the point of the sampling device (in cases where the operator is only measuring the engine distribution).

NOTE If the temperature of the blowby gas not maintained, the aerosol distribution could shift due to the presence of water droplets in the airstream.

6.2.13 Tubing should be the shortest length and have as few bends as possible.

6.2.14 The blank duct should be smooth, conductive metal tubing that includes the minimum bends and area changes required to replace the separator housing and connect the inlet and outlet piezometers in the same positions as when the device to be tested is installed.

6.3 Concentration Limit of the Particle Counter

6.3.1 To confirm you do not have coincidence error, either use a particle counter that automatically determines when you have coincidence error, or watch your total counts to make sure they are below the manufacturer's limit specification.

6.4 100 % Efficiency Test and Development of Purge Time

6.4.1 An initial efficiency test should 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 efficiency given in Clause 8 shall be followed, and the test should be performed at two engine conditions, idle and a loaded condition.

6.4.2 The computed efficiency values shall meet the requirements specified in 6.8, Table 1.

6.4.3 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.

6.5 Correlation Test

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

6.5.2 The test procedures for determination of the correlation ratio given in 8.4 shall be followed.

6.5.3 The correlation ratio for each particle size shall meet the requirements specified in 6.8, Table 1.

6.6 Particle Counter(s) Zero

The zero count of the particle counter(s) shall meet the requirements specified in 6.8, Table 1

6.7 Particle Counter(s) Sizing Accuracy

The sizing accuracy of the particle counter(s) shall be checked by sampling an aerosol containing monodisperse polystyrene spheres of known size. A relative maximum particle count shall appear in the particle counter sizing channel that encompasses the PSL diameter.

6.8 Summary of Qualification Test Requirements

Qualification test criteria shall conform to Table 1.

Table 1 — System Qualification Measurement Requirements

Parameter	*Requirement*
100 % Efficiency Test: Based on HEPA filter test	> 99 %
Correlation Ratio Test	0,30 to 1,0 µm: 0,90 to 1,10 1,0 to 3,0 µm: 0,80 to 1,20 3,0 to 10 µm: 0,70 to 1,30
Particle Counter Zero Count Check: Based on HEPA filter attached to the instrument's inlet	< 10 counts per minute over the 0,30 µm to 10 µm range
Particle Counter Sizing Accuracy Check: Based on sampling of aerosolized monodisperse PSL spheres of known size	Relative maximum shall appear in the appropriate sizing channel

6.9 Apparatus validation and maintenance

Maintenance items and schedules should conform to Table 2.

Table 2 — Apparatus Maintenance Schedule

Maintenance Item (Section Reference)	*Daily*	*Monthly*	*Biannually*	*After a Change in separator type or engine*	*Comment*
Correlation ratio measurement (6.5)		X		X	
Particle counter zero check (6.6)		X			
Particle counter(s) primary calibration using PSL					NOTE 1
Overloading test of particle counter(s) (6.3.1)			X		
Flow rates, pressure drops, temperature, relative humidity, etc.		NOTE 3			NOTE 2
Cleaning of test duct and components					NOTE 4

NOTE

1) Calibration performed annually.

2) In accordance with manufacturer's recommendations but at least annually.

3) Monthly visual inspection for proper installation and operation.

4) Cleaning intervals of the test duct, engine, aerosol sampling lines, and other test components is discretionary.

7 Test Procedures

7.1 General

The purpose of these tests is either to determine the fractional efficiency of an aerosol separator while attached to an engine or to just to measure the size distribution of the aerosol coming from the engine.

Due to the fact that the engine aerosol generated varies in distribution and concentration, if the user is running the separator efficiency test procedure, it shall be done with a pair of particle counters that are used to sample the upstream and downstream flow nearly simultaneously. There is a finite measurable delay for particle transport from the upstream sample probe to the downstream sample probe. It is possible to improve data quality by starting the downstream sample count after a delay equal to the

