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

Part 2: Laboratory test method

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

Partie 2: Méthode d'essai de laboratoire

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Introduction

The 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 the atmosphere or alternatively returns the cleaned product to the combustion process by feeding into the engine air intake prior to the turbo compressor (if present). The latter has led to the requirement for a pressure control device to isolate the engine crankcase from air intake pressure.

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 gravimetric test method.

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

Part 2: Laboratory 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 gravimetric separation efficiency and system pressure tests in both open and closed crankcase ventilation systems. This document has a limitation of 0 % to 99 % for aerosol gravimetric efficiency.

NOTE Gravimetric efficiencies >99 % may be difficult to measure due to long test durations and absolute filter weight measurements.

Filter life is not evaluated in this document.

This test method only applies to devices that have a defined tubular inlet, outlet and drain that can be connected to the test equipment. For devices that lack such connections, for example, one that is built into a valve cover, see Annex A.

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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*

3 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 http://www.electropedia.org/

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

3.1
standard flow
flow rate corrected to standard conditions

Note 1 to entry: See 5.3 for details.

4 Measurement accuracy

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

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5 Test materials and test conditions

5.1 Test oil

The test oil to be used shall be an oil of such appropriate viscosity and surface tension that the particle size of 50 % cumulative mass of the generated aerosol exhibits more than 0,85 µm and less than 0,90 µm. The test oil shall meet the aerosol distribution by mass given in Annex B. The challenge aerosol size distribution shall be plotted in Figure C.1.

5.2 Absolute filter, wall flow trap and leakage

The provisions related to the absolute filter, the downstream wall flow trap and leakage shall be in accordance with ISO 17536-1:2015, Clause 4.

5.3 Standard conditions

The standard condition for temperature, humidity and pressure is 20 °C, 0 % RH and 101,3 kPa (1 013 mbar). Airflow differential pressure, inlet and outlet pressure and pressure loss shall be corrected to that standard condition.

5.4 Test temperature

5.4.1 Efficiency tests

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

Condition A: 80 °C ± 3 °C

Condition B: 23 °C ± 5 °C

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The condition that is run shall be documented in the test report (see Table C.1).

5.4.2 Differential pressure, pressure loss and crankcase pressure control tests

The flow rate for pressure loss and crankcase pressure control tests shall be corrected to standard flow. The pressure loss and crankcase pressure control tests shall be conducted with air entering the aerosol separator at a temperature of 23 °C ± 5 °C.

6 Test procedure

6.1 General

Performance tests shall be performed on a complete aerosol separator assembly. The tests shall consist of a pressure loss test, gravimetric efficiency test, conditioned gravimetric efficiency test, crankcase pressure control test (when a pressure regulator is present) and drain interval test (when applicable).

6.2 Test equipment

NOTE The definitions of the following terms related to the test equipment are defined in ISO 17536-1:2015, Clause 2: upstream particle counter, particle counter calibration, maximum particle concentration and particle counter flow.

6.2.1 Typical arrangements to determine the differential pressure or pressure loss to air flow, efficiency and crankcase pressure control are shown in Annex D.

Use an aerosol generator which is capable of dosing oil mist over the range of delivery rates required according to the customers' specification.

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The aerosol generator shall be validated as follows.

— Fill the aerosol generator to a pre-determined level.

— Simultaneously start the aerosol generator and timer.

— At a time interval relative to a mass oil flow of >1 g, determine the amount of aerosol dispersed and particle size distribution. Continue mass oil flow determinations of the aerosol until the desired oil flow deviates by <5 % and shall be >30 min. Continue feeding aerosol until the particle distribution does not meet the Annex B specification (to understand time capability to deliver a distribution as specified in Annex B).

— Adjust the aerosol generator until the average delivery rate is within ±5 % of the desired rate and deviation in the delivery rate from the average is not more than ±5 % for the entire designated test duration.

— After verifying the delivery rate, verify the aerosol delivered from the aerosol generator for the entire test duration is within the Annex B specifications.

6.2.2 An upstream wall flow trap should be used between the oil mist generator and the inlet tube to eliminate any oil wall flow to the inlet tube. Use a wall flow trap conforming to ISO 17536-1:2015, Annex I.

6.2.3 Use an inlet piezometer tube conforming to ISO 17536-1:2015, Figure B.2. The cross-section shall be the same as the aerosol separator inlet. In the case of non-uniform flow conditions caused by special inlet tubes, special precautions may be required.

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6.2.4 Use a manometer or other differential pressure measuring device with the specified accuracy described in ISO 17536-1:2015, Clause 3.

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6.2.5 Setup test with no UUT present, e.g. straight pipe.

6.2.6 A downstream wall flow trap should be used between the unit under test and the outlet piezometer tube described in 6.2.3 to eliminate any oil wall flow. Use a wall flow trap conforming to ISO 17536-1:2015, Annex I.

6.2.7 Use an outlet tube conforming to ISO 17536-1:2015, Figure B.2. 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 17536-1:2015, Clause 3. The flow rate for differential pressure and crankcase pressure control tests shall be standard flow, which is the volume flow rate corrected to standard conditions, as specified in 5.3.

6.2.9 Use an air flow rate control system with a refresh rate greater than 2 Hz capable of maintaining the indicated flow rate to within 5 % of the selected value at a minimum data record frequency of 2 Hz during a steady-state and variable air flow operation.

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

6.2.11 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 negative vacuum allowed on the system.

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6.2.12 Grounding is required for all test apparatus to reduce the effects of static charges 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.

6.3 Pressure loss test

6.3.1 The purpose of this test is to determine the pressure loss across the unit under test which will result when air is passed through under predetermined conditions. Airflow differential pressure is measured with a clean aerosol separator at least four equally spaced air flows or agreed upon between the customer and supplier.

6.3.2 Set up the UUT as shown in ISO 17536-1:2015, Figure B.1, Figure D.1 or Figure D.3. Seal all joints to prevent air leaks. Connect the piezometer tubes to the inlet and outlet of the unit under test. The piezometer tube shall be sized to the size of the inlet and outlet of the UUT.

Care should be taken to understand the product components that may affect the flow path during a pressure loss test, e.g. pressure regulators.

6.3.3 Record the inlet temperature, barometric pressure and relative humidity.

6.3.4 Measure and record the differential pressure and upstream absolute pressure of the unit under test versus the air flow rate at a minimum of four equally spaced air flows or flow rates agreed upon between the customer and supplier.

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6.3.5 Record the inlet temperature, barometric pressure and relative humidity.

6.3.6 Recorded differential pressure readings shall be corrected to standard conditions in accordance with Annex E. See Formulae (E.4) and (E.5).

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6.3.7 For pressure loss determination, use the formula given in ISO 17536-1:2015, Annex A.

6.3.8 Plot the pressure loss as shown in Figure C.2 or equivalent.

6.4 Gravimetric efficiency test

6.4.1 The purpose of the gravimetric efficiency test is to determine the gravimetric separation efficiency of a device in two conditions:

a) new state;

b) conditioned state, as specified in 6.5.

The test duration for a gravimetric efficiency test shall be a minimum of 30 min and the minimum mass gained on the absolute filter shall be 0,1 g. Additional time may be needed to achieve the absolute filter weight gain requirement. The weight changes of the component parts and the absolute filter during the test duration are used to calculate the new and conditioned state gravimetric efficiency.

High efficiency separators shall not exceed 3 h for 6.4.1, a) as the new state is no longer maintained. For such separators, 6.5 and 6.6 shall be performed to complete an efficiency evaluation on the product and shall meet the above minimum requirements of 30 min and 0,1 g on the absolute filter.

NOTE The higher efficiency separators can require additional time to achieve the specified absolute filter weight gain requirement.

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6.4.2 The mass oil flow is agreed upon by the user and manufacturer.

Care should be taken to understand that mass oil flow may affect the challenge aerosol size distribution.

6.4.3 Weigh and record the unit under test.

6.4.4 Weigh and record the drainage vessel (if present).

6.4.5 Weigh the absolute filter as specified in ISO 17536-1:2015, 4.1.2 and record the mass before assembly within the absolute filter housing.

6.4.6 Weigh the downstream wall flow trap of the unit under test as specified in ISO 17536-1:2015, 4.2.1.

6.4.7 Setup the test stand as shown in Figure D.2 or Figure D.4 for all aerosol separators. Seal all joints to prevent air leakage. The orientation of the unit under test shall be as in application.

Care should be taken to understand the product components that may affect the flow path during a pressure loss test, e.g. pressure regulators.

6.4.8 Record the UUT external air temperature, pressure and relative humidity.

6.4.9 Start the air flow through the test stand as specified in 5.4.1 and stabilize at the test flow as specified in 6.2.8. Record the differential pressure.

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6.4.10 Set the feed rate to the pre-determined oil flow. Start the aerosol generator.

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6.4.11 The differential pressure shall be compensated for the increased differential pressure that the tubing and downstream wall flow trap between the unit under test and the piezometer introduces, since the downstream wall flow trap will be in this area. The downstream wall flow trap is present to protect the downstream piezometer from contamination of liquid oil wall flow. The pressure loss of the downstream wall flow trap shall be subtracted from the overall pressure loss.

6.4.12 Every 10 min, record the differential pressure at the air test flow and the elapsed test time.

6.4.13 Record the differential pressure at the end of the test before interrupting either the air flow rate or mass oil flow to remove the absolute filter.

6.4.14 Stop the aerosol generator and continue to run the air flow rate for 15 s to 30 s as this will evacuate the test stand of aerosol.

6.4.15 Stop the air flow rate.

6.4.16 Record the UUT external air temperature, pressure and relative humidity.

6.4.17 Weigh the unit under test. Note any evidence of seal leakage or unusual conditions. The increase in mass of the unit under test is the mass measured minus the mass recorded in 6.4.3.

NOTE Carefully weigh all components so as not to lose any oil or mass.

6.4.18 Remove the absolute filter. Repeat 6.4.5 and determine the difference in mass. The change is the increase in mass of the absolute filter. The difference is the aerosol penetration of the unit under test. The minimum mass gained on the absolute filter shall be 0,1 g.

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6.4.19 Reweigh the downstream wall flow trap. The increase in mass of the downstream wall flow trap is the mass minus the mass recorded in 6.4.6.

6.4.20 Reweigh the drainage vessel. The increase in mass of the drainage vessel is the mass minus the mass recorded in 6.4.4.

6.4.21 Calculate the aerosol efficiency, E_a, E_T and P_L, by using ISO 17536-1:2015, 5.3.2, Formulae (2), (3) and (4), respectively.

6.4.22 Report the results as shown in Table C.2 or equivalent.

6.5 Conditioning of the separation device before a conditioned gravimetric efficiency test

6.5.1 After the gravimetric efficiency as specified in 6.4, condition the oil separator prior to running 6.6. The conditioning portion shall use aerosol as specified in Annex B. The goal of this test is to condition the oil separator to a condition that is representing the majority of the time on an engine.

6.5.2 Perform the steps prescribed in 6.4.2 to 6.4.20 to run this test.

6.5.3 After introducing a total oil mass numerically in grams equal to at least 50 % of the volume of the media, verify that the unit under test is continuously draining. Once the unit under test is continuously draining, the pressure loss shall not change more than 100 Pa over a 3 h period.

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6.5.4 Once the separation device has reached a conditioned state according to 6.5.3. Calculate the total mass challenged, Δm_T, found respectively in ISO 17536-1:2015, 5.3.2. Document the total amount of aerosol challenged as specified in ISO 17536-1 to the UUT during conditioning, both 6.4 and 6.5 in Table C.3. Proceed to 6.6.

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6.5.5 If the unit under test is an inertial separator, test using 6.4 until the oil drainage is observed. This efficiency shall be used to document the 6.6 condition for an inertial separator.

6.5.6 If the unit under test is a combination of separator technologies or methods, 6.5.1 to 6.5.4 shall be used to condition a combination separator.

6.6 Conditioned gravimetric efficiency test

6.6.1 The purpose of the gravimetric efficiency test is to determine the gravimetric separation efficiency of a device in two conditions as stated in 6.4.1.

The test duration for a gravimetric efficiency test shall be a minimum of 30 min and the minimum mass gained on the absolute filter shall be 0,1 g. Additional time may be needed to achieve the absolute filter weight gain requirement. The weight changes of the component parts and the absolute filter during the test duration are used to calculate the new and conditioned state gravimetric efficiency.

NOTE The higher efficiency separators may require additional time to achieve the specified absolute filter weight gain requirement.

6.6.2 Perform the steps prescribed in 6.4.2 to 6.4.20 to run this test

6.6.3 Calculate the aerosol efficiency, E_a, E_T and P_L, by using ISO 17536-1:2015, 5.3.2, Formulae (2), (3) and (4), respectively.

6.6.4 Report the results as shown in Table C.3 or equivalent.

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