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

Part 1:
General

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

Partie 1: Généralités

Reference number
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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 on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 34, *Propulsion, powertrain and powertrain fluids*.

ISO 17536 consists of the following parts, under the general title *Road vehicles — Aerosol separator performance test for internal combustion engines*:

— *Part 1: General*

— *Part 3: Method to perform engine gravimetric test* [Technical Specification]

The following parts are under preparation:

— *Part 2: Laboratory gravimetric test method* [Technical Specification]

— *Part 4: Laboratory fractional test method*

— *Part 5: Method to perform engine fractional test* [Technical Specification]

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 need to be 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 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.

The engine test methods presented in ISO 17536 are general guidelines for performing an engine test.

Annexes A to I specify general and common provisions for aerosol separator performance test.

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

Part 1:
General

1 Scope

This part of ISO 17536 specifies general conditions, defines terms and establishes the basic principles for blowby oil aerosol separator performance tests by laboratory or engine and gravimetric or fractional test method.

2 Terms, definitions, symbols and units

2.1 Terms and definitions

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

2.1.1
blowby
aerosol produced from engines and released through a crankcase vent

2.1.2
oil carryover
total amount of liquid oil captured in the downstream wall flow trap

2.1.3
filter element
replaceable part of the crankcase system, consisting of the filter material and carrying frame

2.1.4
crankcase ventilation system
device which separates oil and particles from the engine blowby before venting to either the engine (closed crankcase ventilation, CCV) or the environment (open crankcase ventilation, OCV)

2.1.5
differential pressure
difference in static pressure measured immediately upstream and downstream of the unit under test

2.1.6
pressure loss
measure of the loss of aerodynamic energy caused by an aerosol separator at the observed air flow rate due to different flow velocities at the measuring point:

Note 1 to entry: It is expressed as the differential pressure corrected for any difference in the dynamic head at the measuring points

Note 2 to entry: For further information, see Annex A.

2.1.7
wall flow trap
device to capture oil that is flowing along the walls

Note 1 to entry: The wall flow trap design is drawn in Figure I.2.

2.1.8
absolute filter
filter downstream of the unit under test to retain the contaminant passed by the unit under test

2.1.9
piezometer tube
duct that has a hole or holes drilled in the wall to obtain a pressure reading

Note 1 to entry: For further information, see Figure B.2.

2.1.10
separator efficiency
ability of the aerosol separator or the unit under test to remove contaminant under specified test conditions

2.1.11
optical diameter
optical equivalent diameter
$D_{o,i}$
diameter of a particle of the type used to calibrate an optical sizing instrument that scatters the same amount of light as the particle being measured

Note 1 to entry: Optical diameter depends on the instrument, the type of particle used to calibrate the instrument (usually polystyrene latex spheres), and the optical properties of the particle being measured.

2.1.12
aerodynamic diameter
aerodynamic equivalent diameter
D_{ae}
diameter of a sphere of density 1 g/cm^3 with the same terminal velocity due to gravitational force in calm air, as the particle being measured

Note 1 to entry: Annex C provides additional information about aerodynamic diameter.

Note 2 to entry: Aerodynamic diameter depends on the instrument, the type of particle used to calibrate the instrument (usually polystyrene latex spheres), and the properties of the particle being measured.

2.1.13
pressure regulator
device between the outlet of the aerosol separator and air intake to regulate the crankcase pressure in high vacuum conditions

2.1.14
mass oil flow
mass amount of oil per unit time

2.1.15
relief valve
device to direct a portion of the flow around a separation device due to a pressure difference, usually venting to the atmosphere

2.1.16
bypass valve
device to direct a portion of the flow around a separation device due to pressure difference, usually venting downstream of the bypassed separation device

2.1.17
challenge aerosol
output from the aerosol generator or engine which corresponds to the distribution in testing and with the amount of the mass feed rate

Note 1 to entry: The aerosol distribution by mass is prescribed in ISO/TS 17536-2.

2.1.18
particle size
polystyrene latex equivalent size expressed as a diameter in micrometers

2.1.19
isokinetic sampling
sampling in which the flow in the sampler inlet is moving at the same velocity and direction as the flow being sampled

Note 1 to entry: Annex D provides additional information about isokinetic sampling.

2.1.20
particle counter
instrument for sizing and/or counting aerosol particles

Note 1 to entry: Recommended particle counters are optical particle counters (in accordance with ISO 21501-1) or other counters demonstrating good correlation in measuring particle sizes such as aerodynamic particle counters.

2.1.21
coefficient of variation
COV
standard deviation of a group of measurements divided by the mean

2.1.22
unit under test
UUT
either a single aerosol separator element or a complete crankcase ventilation system

2.1.23
open crankcase ventilation
OCV
aerosol separator system that is attached to the crankcase and is vented to the environment

2.1.24
closed crankcase ventilation
CCV
aerosol separator system that is attached between the crankcase and the engine

2.1.25
aerosol separator
device that separates oil from the blowby stream or test stand airstream

2.1.26
high efficiency particulate air filter
HEPA filter
filter having 99,95 % efficiency at most penetrating particle size (class H13 in accordance with EN 1822), or 99,97 % (or higher) fractional efficiency at 0,3 µm using dispersed oil particulate (DOP) aerosol as defined by IEST RP-CC001 recommended practice

2.1.27
inertial separator
device that separates oil from the blowby stream using inertia

2.1.28
combination separator
device that separates oil from the blowby stream using inertia as well as a filter element

2.1.29
rated air flow
flow rate specified by the user or manufacturer

Note 1 to entry: The rated air flow is usually used as the test air flow.

2.1.30
test air flow
measure of the quantity of air pushed or drawn through the aerosol separator per unit time

2.1.31
aerosol generator
laboratory equipment that can produce a simulated blowby particle distribution from oil and compressed air

Note 1 to entry: The aerosol distribution by mass is prescribed in ISO/TS 17536-2.

2.1.32
drainage vessel
device that captures the separated oil from the crankcase separation system, not to include oil carryover

Note 1 to entry: Filter life is not used in all parts of ISO 17536. Life reference is given in Annex E.

2.1.33
mass feed rate
mass amount of challenge aerosol or liquid subjected to the unit under test per unit time

Note 1 to entry: Filter life is not used in all parts of ISO 17536. Life reference is given in Annex E.

2.2 Symbols and units

Quantity	Symbol	Unit
Volume flow rate	q_V	l/min
Velocity	v	m/s
Density	ρ	kg/m^3
Mass flow rate	q_m	g/h
Pressure	p	Pa
Differential pressure	Δp_d	Pa
Pressure loss	Δp_l	Pa
Mass	m	g
Time	t	s
Speed	N	rev/min
Torque	T	N-m

3 Measurement equipment accuracy

Air flow rate to within ± 5 % of reading.

Differential pressure to within ± 25 Pa of reading.

Temperature to within ± 1,5 °C of reading.

Mass to within 0,1 g except for absolute filter mass and downstream wall flow trap.

Mass to within 0,01 g for absolute filter mass and downstream wall flow trap.

Relative humidity (RH) with an accuracy of ± 2 % RH.

Barometric pressure to within ± 3 hPa.

Crankcase pressure to within ± 25 Pa of reading

RPM to within ± 0,5 % of maximum engine speed

Torque within ± 2 % of operating torque

Leak rate shall be < 1 % of the air flow rate.

The measurement equipment shall be calibrated at regular intervals to ensure the required accuracy.

4 Absolute filter, wall flow trap and leakage

4.1 Absolute filter

4.1.1 Absolute filter material

Separation efficiency of the absolute filter shall be equal to or greater than 97 % for the challenge aerosol based on the calculation in Annex F. The absolute filter shall be stable up to temperatures equal or greater than 105 °C, and resistant to oil, all kind of fuels, water, and other components of blowby.

The validation of absolute filter media efficiency is given in Annex F.

NOTE The use of an absolute filter with a backing will minimize fibre loss.

4.1.2 Absolute filter mass measurement method

The absolute filter shall be weighed, at least to the nearest 0,01 g, after the mass has stabilized. Weigh stabilization may be achieved for water removal and minimal volatile content loss by storage in a ventilated oven at a constant temperature of 65,5 °C. Other temperatures may be used to meet customer requirements. Alternatively, place absolute filter in an ambient temperature and humidity controlled enclosure.

The absolute filter shall be weighed in the same environment as at the beginning of the test. Heated weighing should be in an enclosed heated chamber.

NOTE See Annex F for the validation process and 4.1.3 for process control.

4.1.3 Absolute media measurement process validation

Using the method of choice, the absolute pad weight method shall be performed once each day for three days and have no more than ± 0,03 g variation between measurements.

4.2 Wall flow trap

NOTE An example of the wall flow trap design is given in Figure I.2.

4.2.1 Weight measurement

The wall flow trap shall be weighed, to the nearest 0,01 g, after the mass has stabilized.

The wall flow trap should be weighed in the same environment as at the beginning of the test. Heated weighing should be in an enclosed heated chamber.

4.2.2 Validation of wall flow trap liquid oil efficiency

Arrange two wall flow traps in series. Challenge the wall flow trap with a high mass flow rate to determine gravimetric efficiency according to the test procedure given in the corresponding clauses in the relevant part of ISO 17536. Wall flow trap efficiency from the validation setup shall be equal to or greater than 97 % for the challenge aerosol with a minimum of 1 g gained in the upstream wall flow trap.

Challenge the wall flow trap with a high mass flow rate to determine gravimetric efficiency test.

The wall flow trap efficiency, E_t, shall be calculated as shown in Formula (1):

$$E_t = \frac{\Delta m_C}{\Delta m_C + \Delta m_D} \times 100 \qquad (1)$$

where

Δm_C is the mass increase of upstream wall flow trap;

Δm_D is the mass increase of downstream wall flow trap.

4.2.3 Validation of wall flow trap aerosol efficiency

Conduct a test similar to the method explained in Annex F, to obtain an aerosol efficiency value using the specified challenge aerosol. The test setup shall consist of an oil mist generator, wall flow trap, and an absolute filter to measure the aerosol. The absolute filter shall meet the requirements in 4.1.1. A minimum of 3 g shall be subjected to the wall flow trap during this efficiency test. The wall flow trap shall meet an efficiency of less than 1 %.

4.3 Leakage

It is important to minimize leakage into the test system to obtain good data. Depending on where the leakage occurs, it can cause major errors in particle counting.

As a minimum all connections and joints should be checked for visual leakage using soap bubbles or smoke. Any known soap solution can be used for the test. Preferably, the soap solution (foam) will be applied using a brush at all connections and joints. Leaks are especially important on the clean side of the oil separator.

Leakage shall be evaluated according to Annex G.

5 Principles for aerosol separator performance tests

5.1 General

Performance tests shall be performed on a complete aerosol separator assembly. The tests may consist of one or more of the following: laboratory gravimetric test (see ISO/TS 17536-2), an engine gravimetric test (see ISO/TS 17536-3), a laboratory fractional test method (see ISO/TS 17536-4) and an engine fractional method (see ISO/TS 17536-5).

For performance tests which require pressure reading to be measured, either static or differential, this shall be done in accordance with Annex A.

The test equipment used to measure pressure readings shall be as specified in Annex B.

5.2 Test equipment

5.2.1 Grounding

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.