TECHNICAL SPECIFICATION

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Performance test method for diesel engine soot-removal devices in lubricating oils — Initial filtration efficiency

Essai de performance de filtration pour moteurs diesel — Séparation des impuretés dans l'huile pour lubrification

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ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of normative document:

— an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;

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An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

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

ISO/TS 23556 was prepared by Technical Committee ISO/TC 70, *Internal combustion engines*, Subcommittee SC 7, *Tests for lubricating oil filters*.

Performance test method for diesel engine soot-removal devices in lubricating oils — Initial filtration efficiency

IMPORTANT — The test method specified in this Technical Specification has not been proven by a round robin exercise.

1 Scope

This Technical Specification specifies a multipass soot-filtration test method using batch thermal gravimetric analysis (TGA), continuous online Fourier Transformation Infrared (FTIR), or other approved soot-measuring techniques for evaluating the initial filtration efficiency of single-stage, multiple-stage, centrifugal and other soot-removal devices (SRD) for internal combustion engines submitted to a constant flow rate of test liquid. The test procedure determines time-weighted average initial soot-removal efficiency for soot-removal devices. This test method is intended for application to SRDs having a rated flow between 0,5 l/min and 75 l/min.

2 Normative references

The following referenced documents are indispensable for the application 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 1219-1, *Fluid power systems and components — Graphic symbols and circuit diagrams — Part 1: Graphic symbols for conventional use and data-processing applications*

ISO 3968, *Hydraulic fluid power — Filters — Evaluation of differential pressure versus flow characteristics*

ISO 4405, *Hydraulic fluid power — Fluid contamination — Determination of particulate contamination by the gravimetric method*

ISO 11841-1, *Road vehicles and internal combustion engines — Filter vocabulary — Part 1: Definitions of filters and filter components*

ISO 11841-2, *Road vehicles and internal combustion engines — Filter vocabulary — Part 2: Definitions of characteristics of filters and their components*

DHD-1:2001, *Global Performance Specification of Diesel Engine Oil*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11841-1, ISO 11841-2 and the following apply.

3.1
soot-removal device
SRD
device intended to remove soot from lubricating oil

NOTE SRDs include single-stage, multiple-stage, centrifugal and other devices.

3.2
soot contaminant
carbon-based contaminant produced to simulate soot generated from a diesel engine

3.3
multipass test
test that consists of recirculating treated fluid through the soot-removal device

3.4
base upstream gravimetric level
upstream contaminant concentration if no contaminant is recirculated

3.5
soot-removal device efficiency
ability of the soot-removal device to retain particles, expressed as the time-weighted average of soot mass that has been captured by the SRD relative to the mass offered to it

3.6
total circuit volume
total volume of the circuit with a straight section of pipe plus the volume contained in the soot-removal device

NOTE For installation, see Clause 9, No. 2).

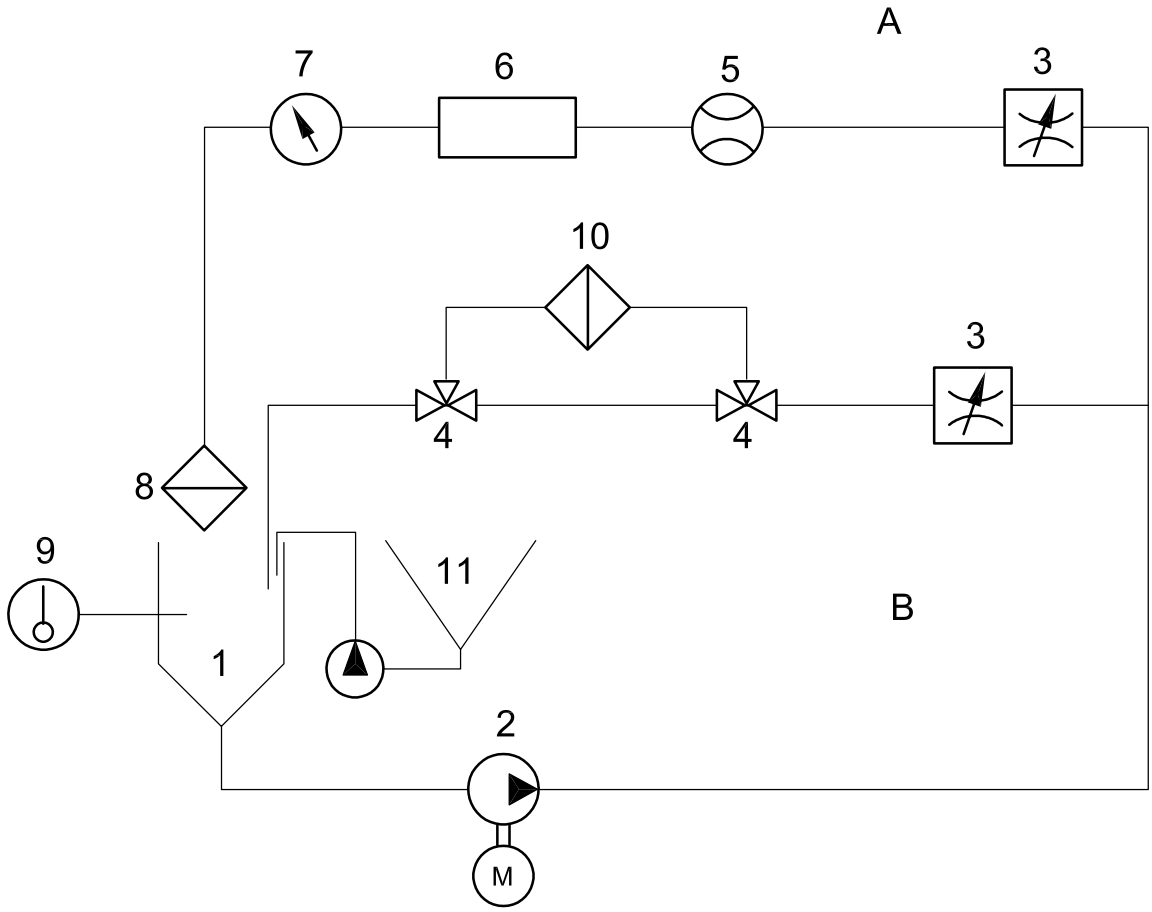
4 Symbols (and abbreviated terms)

The graphical symbols used in this Technical Specification are in accordance with ISO 1219-1.

5 Test equipment

5.1 Test rig

A diagram of the test rig is shown Figure 1. It shall comprise a filter test circuit as described in 5.2.



Key

A test loop
B clean-up loop
1 reservoir incorporating a thermostatically controlled heater
2 variable speed test pump
3 throttling valves
4 three-way valves
5 flow meter
6 soot content measurement device
7 pressure gauge
8 soot-removal device (test filter or centrifuge)
9 thermocouple
10 clean-up filter
11 contaminant injection reservoir

Figure 1 — Diagram arrangement of test rig for centrifugal and bypass filters

5.2 Filter test circuit

This consists of the following:

5.2.1 Reservoir (1), constructed with a conical bottom having an included angle of not more than 90 degrees;

5.2.2 Oil pump (2), which does not exhibit excessive flow pulses;

5.2.3 Device, such as a head to accommodate single-stage, multi-stage, centrifugal or other soot-removal devices, which can be bypassed or replaced by a straight section of pipe;

5.2.4 System clean-up filter (10), capable of providing an initial system contamination level of less than 25 mg/l, according to Annex A;

5.2.5 Online soot meter (6), capable of measuring a maximum of 6 wt% soot;

5.2.6 Pressure tappings, in accordance with ISO 3968;

5.2.7 Piping, sized to ensure that turbulent mixing conditions exist throughout the filter test circuit;

5.2.8 Thermal Gravimetric Analysis (TGA), or online instrumentation capable of measuring soot content;

5.3 Timer, capable of measuring hours and minutes;

5.4 Contaminant injection system, capable of injecting the soot slurry at a constant gravimetric level and flow rate. It consists of a reservoir (11), an injection pump, and an injection flow meter.

6 Test materials

6.1 Test contaminant

The contaminant shall have a carbon base and conform to the specifications given in Annex B. The soot test contaminant should be obtained from approved suppliers.

6.2 Test fluid

6.2.1 Heavy-duty applications

The oil shall have a kinematic viscosity of 14,4 $mm^2/s \pm 1,9$ mm^2/s at 100 °C.

6.2.2 Automotive applications

The oil shall have a kinematic viscosity of 10,9 $mm^2/s \pm 1,6$ mm^2/s at 100 °C.

7 Accuracy of measuring instruments and test condition variations

The measuring instruments shall be capable of measuring to the levels of accuracy in Table 1. The last column in the table gives the limits within which the test conditions shall be maintained.

Table 1 — Instrument accuracy and test condition variation

Test parameter	Units	Measurement accuracy	Allowed test condition variation
Flow rate	l/min	± 2 %	± 5 %
Pressure	kPa	± 5 %	± 10 %
Temperature	°C	± 2 °C	± 5 °C
Volume	l	± 5 %	± 10 %

8 Test rig validation

This validation procedure reveals the effectiveness of the test and injection system to maintain constant operating conditions, especially the soot concentration upstream of the SRD test.

1) Validate the filter test circuit at the minimum flow rate at which the circuit will be operated.

2) Install a straight section of pipe in place of a soot-removal device during the validation procedure.

3) Perform validation of the system at the recommended contamination level for the flow loop.

4) Dilute soot contaminant so the soot content is approximately 8 wt%.

5) Verify soot content using TGA or other approved soot measurement techniques.

6) Fill test rig with 12 l of clean oil and circulate oil at 2 l/min until operating temperature is stabilized.

7) Start injecting test contaminant at 4 ml/min.

8) Record soot content every 4 h.

9) Perform step 5) for 52 h and plot using the test data calculations in Annex E.

10) Soot concentration shall maintain $\pm$ 10 % of the predicted soot weight percentage limit for the validation period.

9 Multipass test procedure

This includes the following steps:

1) Install the soot-removal device in the test rig as shown in Figure 1.

2) For flows of less than 60 l/min, adjust the total circuit volume to be numerically equal to one-half of the value of the minimum flow volume per minute through the filter, with a minimum of 12 l. For flows higher than 60 l/min, adjust the total circuit volume to be numerically equal to one-quarter of the volume on the minimum flow volume per minute through the filter.

3) Total circuit volume shall include sump, piping and the soot-removal housing.

4) Determine soot content for slurry.

5) Ensure that the test oil meets the requirements defined in Annex C.

6) Circulate test oil through the clean-up filter until gravimetric level is less than 25 mg/l, determined in accordance with Annex A.

7) Circulate test oil until the sump temperature is 105 °C.

8) Add a minimum of 14,5 l test contaminant into contaminant injection reservoir (11), circulate, and heat to at least 80 °C.

9) Bypass clean-up filter.

10) Adjust reservoir (1) volume to be as shown in Clause 9, No. 2).

11) Adjust throttle valves (3) to the required flow rate and pressure.

12) Adjust flow rate to obtain approximately 90 % of the system flow through the SRD (A) and a maximum of 10 % through the bypass section (B).

NOTE Bypass section B is used to adjust the flow rate and the system pressure to meet the required testing parameters.

13) For centrifugal SRDs, adjust upstream pressure to 345 kPa or as defined by the user and record it.

14) Start test.

15) Extract an initial sample as a reference/control sample.

16) Begin slurry injection at 4 ml per min.

17) If using TGA, extract a sample after 4 h and every 4 h thereafter before the SRD and determine soot content.

18) Online soot measurements shall be taken at a minimum of every 30 min.

19) Terminate test after 52 h if the soot-removal device reaches a terminal differential pressure as specified by the user, or if the flow rate has been reduced by more than 50 % of the initial flow rate.

20) Plot the sump weight percentage soot content in hours, in accordance with Annex D.

21) Report SRD soot-removal data and calculate TWA efficiency, as described in Annex E.

Annex A
(normative)

Method to determine oil cleanliness

Steps include:

1) Obtain 250 ml of test oil.
2) Dry 5 µm membrane filters in an oven at 70 °C.
3) Weigh filters to nearest 0,1 mg.
4) Filter oil in accordance with ISO 4405.
5) Calculate the mg/l for the clean oil sample.

Annex B
(normative)

Specification for test soot slurry

This includes:

— Description: An amorphous black solid in the form of a slurry.

— Composition: Elemental carbon and metals.

— Particle size distribution: The average particle size for the soot slurry shall be 0,2 µm ± 0,1 µm.

— Weight percentage: The soot content shall be 16 wt% ± 1 wt% as determined by thermal gravimetric analysis (TGA).

— Coefficient of viscosity: The coefficient of viscosity shall be 400 cps ± 100 cps.

— Metal content: The metal content shall be 30 ppm or less.

Annex C
(normative)

Test oil requirements

C.1 For heavy-duty applications, the test oil shall meet Global DHD-1:2001 viscosity grade 15W-40 or the current Global DHD performance specification for diesel engine oil.

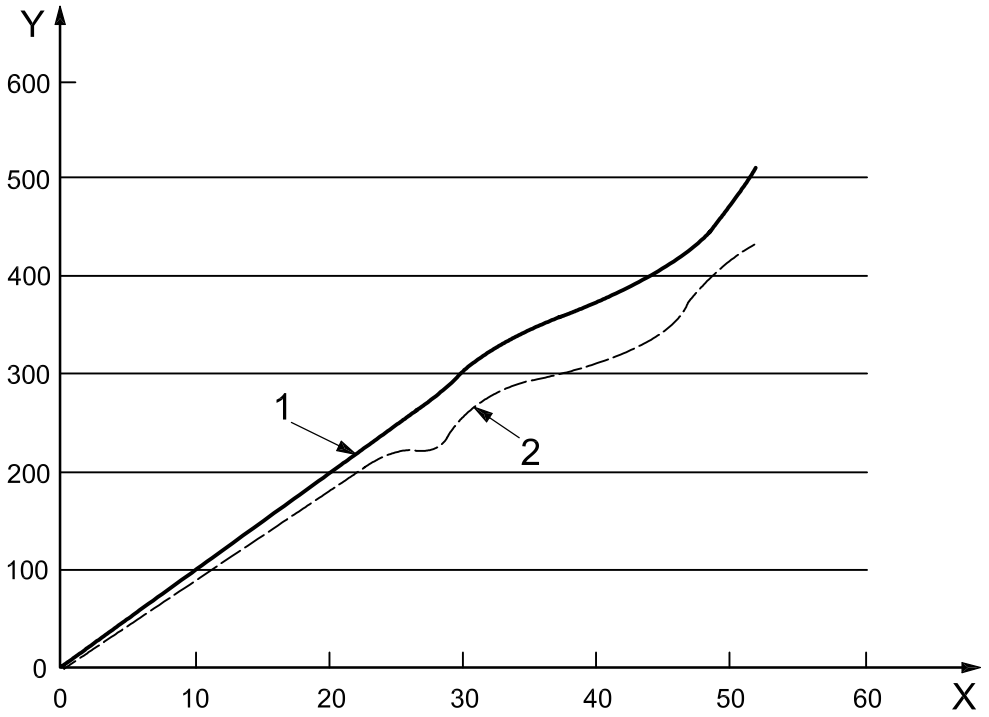
NOTE Global DHD-1:2001 has been jointly developed by the Association des Constructucteurs Européens d'Automobiles (ACEA), the Engine Manufacturers Association (EMA) and Japan Automobile Manufacturers Association, Inc. (JAMA).

C.2 For automotive applications, the test oil shall meet International Lubricant Standardization and Approval Committee (ILSAC) GF-2 viscosity grade SAE 5W30.

Annex D
(normative)

Test data presentation

Plot the theoretical soot levels and the measured soot concentration as a function of time (hours).



Key

X time (h)

Y soot concentration (wt%)

1 measured soot concentration

2 theoretical soot concentration

Figure D.1 — Test data presentation

Annex E
(normative)

Test data calculations

The test report and time weighted average calculation shall be carried out using the following equations:

$$V_T = V_I + 60 * T \quad \text{(E.1)}$$

$$V_{Inj} = T * Q_I * 60 \quad \text{(E.2)}$$

$$S_T = V_{Inj} * S_s \quad \text{(E.3)}$$

$$S_M = V_T * S_{srd} \quad \text{(E.4)}$$

$$E_i = \left(S_T - S_M\right) / S_T * 100 \quad \text{(E.5)}$$

Time Weighted Average (TWA) Efficiency $= \sum \left(t_i * E_i\right) T$

where

V_T is total volume, l;

V_I is initial volume, l;

V_{Inj} is injected volume, l;

Q_I is injection flow rate, ml/min;

T is time, hours;

S_T is soot content, g;

S_s is slurry soot content;

S_M is measured soot content, g;

S_{srd} is soot-removal device/sump soot content;

E_i is efficiency;

t_i is time increments, hours.

Annex F
(normative)

Test report

ISO/TS 23556 Test Report

Date:	**Soot-Removal Device:**
Slurry Concentration:	**Slurry Concentration Test Method:**
Slurry Injection Rate:	
Slurry Tank Temp (°C):	**Sump Tank Temp (°C):**
System Pressure:	**System Flow Rate:**

Time, hrs	4	8	16	24	28
Theoretical Soot Content					
Measured Soot Content					
Efficiency, %					

Time, hrs	32	36	44	48	52
Theoretical Soot Content					
Measured Soot Content					
Efficiency, %					

TWA Efficiency

Figure F.1 — Test report

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