INTERNATIONAL STANDARD

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Diesel fuel and petrol filters for internal combustion engines — Filtration efficiency using particle counting and contaminant retention capacity

Filtres à carburant, essence ou diesel, pour moteurs à combustion interne — Efficacité de filtration par comptage des particules et capacité de rétention

Reference number
ISO 19438:2003(E)

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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.

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 19438 was prepared by Technical Committee ISO/TC 22, *Road vehicles*, Subcommittee SC 7, *Injection equipment and filters for use on road vehicles*.

It is intended that ISO 19438 replace ISO/TS 13353:2002 when that document is reviewed after three years.

This corrected version of ISO 19438:2003 incorporates the following corrections:

— in the test report in Annex B, under the headings “Presentation of test results… Initial filtration efficiency — Elapsed time: 6,00 min…” and “… Initial filtration efficiency — Elapsed time: 15,00 min…”, the particle size “⩾ 3 µm(c)” has been corrected to "⩾ 13 µm(c)”;

— in Figure D.4, the curve labelled at left of the legend as “LATOUR T2” has been corrected to read “LATOUR T1”;

— an explanation that the barred values in the table are discarded outliers has been inserted in the title of Table D.2;

— ISO/TS 13353 has been added to the bibliography;

— typographical errors have been corrected.

Introduction

An interlaboratory trial was conducted using ISO 19438 by six laboratories in 2002. Typical filters were evaluated and results for filtration efficiencies and retention capacities analysed to deduce repeatability, reproducibility and coefficient of variation of the method. Initial filtration efficiency results were found to closely correlate to those obtained through the method specified in ISO/TS 13353, thus making the method given in that Technical Specification redundant.

A summary of the results is given in Annex D.

Diesel fuel and petrol filters for internal combustion engines — Filtration efficiency using particle counting and contaminant retention capacity

1 Scope

This International Standard specifies a multi-pass filtration test, with continuous contaminant injection and using the on-line particle counting method, for evaluating the performance of diesel fuel and petrol filters for internal combustion engines submitted to a constant flow rate of test liquid. The test procedure determines the contaminant capacity of a filter, its particulate removal characteristics and differential pressure. This International Standard is applicable to filter elements having a rated flow of between 50 l/h and 800 l/h; however, by agreement between filter manufacturer and customer, and with some modification, the procedure is permitted for application to fuel filters with higher flow rates.

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 1219-1:1991, *Fluid power systems and components — Graphic symbols and circuit diagrams — Part 1: Graphic symbols*

ISO 2942:1994, *Hydraulic fluid power — Filter elements — Verification of fabrication integrity and determination of the first bubble point*

ISO 3968:2001, *Hydraulic fluid power — Filters — Evaluation of differential pressure versus flow characteristics*

ISO 4021:1992, *Hydraulic fluid power — Particulate contamination analysis — Extraction of fluid samples from lines of an operating system*

ISO 11171:1999, *Hydraulic fluid power — Calibration of automatic particle counters for liquids*

ISO 4405:1991, *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*

ISO 11943:1999, *Hydraulic fluid power — On-line automatic particle-counting systems — Method of calibration and validation*

ISO 12103-1:1997, *Road vehicles — Test dust for filter evaluation — Part 1: Arizona test dust*

3 Terms and definitions

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

3.1
multipass test
test which requires the recirculation of filtered fluid through the filter element

3.2
base upstream gravimetric level
upstream contaminant concentration if no contaminant is recirculated

3.3
filtration efficiency
ability of the filter to retain particles expressed as the percentage of particles of a given size retained by the filter under test

3.4
overall efficiency
efficiency calculated from the average upstream and downstream particle counts obtained during the entire test

3.5
filter rating
particle size corresponding to an initial efficiency or cumulative overall efficiency of a given percentage

NOTE It is expressed in micrometres(c) [µm(c)], which signifies throughout this International Standard that a particle size measurement is carried out using an automatic particle counter calibrated in accordance with ISO 11171.

3.6
filter reference rating
filter rating at 99 % efficiency

NOTE It is expressed in micrometres(c) [µm(c)], which signifies throughout this International Standard that a particle size measurement is carried out using an automatic particle counter calibrated in accordance with ISO 11171.

3.7
initial efficiency
efficiency at first data points calculated from 4 min, 5 min and 6 min particle counts

4 Symbols

Graphical symbols used in this International Standard for fluid power system components are in accordance with ISO 1219-1.

5 Test equipment and materials

5.1 Test equipment

5.1.1 Test rig

The test rig, shown diagrammatically in Figure 1 (to which the numbers in parentheses throughout this International Standard refer), shall comprise the following.

5.1.1.1 Filter test circuit, including the components specified in 5.1.1.1.1 to 5.1.1.1.7.

5.1.1.1.1 Reservoir (1), constructed with a conical bottom having an included angle of not more than 90° and where the oil entering is diffused below the fluid surface.

5.1.1.1.2 Oil pump (2), which does not alter the contaminant particle size distribution and does not exhibit pressure pulsation with an amplitude greater than 10 % of the average pressure at the filter inlet.

5.1.1.1.3 Device, such as a filter head to accommodate spin-on filters, which connects the test filter (6) and which can be by-passed or replaced by a straight section of pipe.

5.1.1.1.4 System clean-up filter (9), capable of providing an initial system contamination level of less than 15 particles/ml having a size greater than 10 µm(c).

5.1.1.1.5 Sampling valves, in accordance with ISO 4021, for turbulent sampling upstream and downstream of the test filter, for on-line particle counting (18) and for gravimetric analysis (11).

5.1.1.1.6 Pressure tappings, in accordance with ISO 3968.

5.1.1.1.7 Piping, sized to ensure that turbulent mixing conditions exist throughout the filter test circuit.

5.1.1.2 Contaminant injection circuit, including the components specified in 5.1.1.2.1 to 5.1.1.2.3.

5.1.1.2.1 Reservoir (12), constructed with a conical bottom having an included angle of not more than 90° and where the oil entering is diffused below the fluid surface.

5.1.1.2.2 Oil pump (13), of centrifugal or other type, which does not alter the contaminant particle size distribution.

5.1.1.2.3 System clean-up filter (14), capable of providing either of the following conditions:

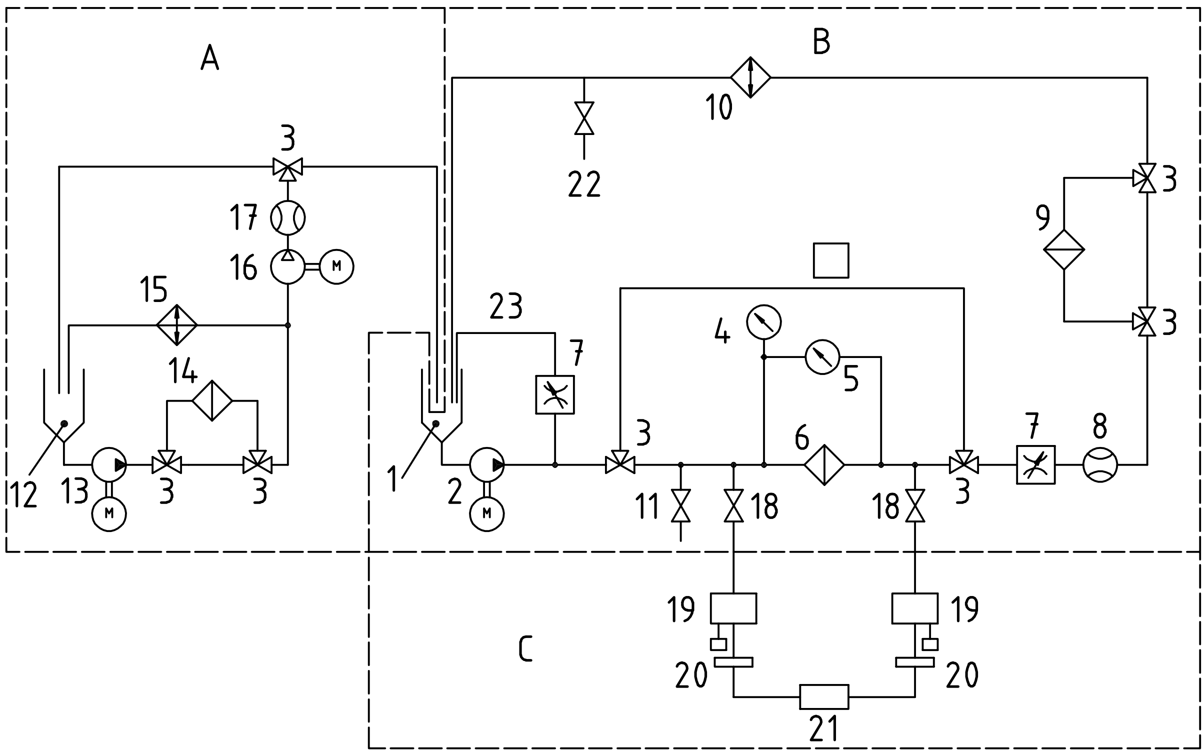
a) an initial system contamination level of less than 1 000 particles/ml having a size greater than 10 µm(c);

b) a gravimetric level less than 2 % of the calculated level at which the test is being conducted, measured using the double membrane gravimetric method in accordance with ISO 4405.

5.1.1.2.4 Piping, sized to ensure that turbulent mixing conditions exist throughout the contaminant injection circuit.

While injection flows lower than 0,25 l/min may be used if validated, an injection flow of 0,25 l/min is recommended.

Injection flows higher than 0,25 l/min shall not be used to minimize the effect of fluid extraction on filter capacity.



Key

1 reservoir incorporating thermostatically controlled heater
2 test pump
3 three-way ball valve
4 pressure gauge
5 differential pressure gauge
6 test filter
7 throttle valve (for flow regulation)
8 flow meter
9 clean-up filter
10 heat exchanger
11 sampling valve
12 reservoir incorporating thermostatically controlled heater
13 circulation pump
14 clean-up filter
15 heat exchanger
16 injection pump
17 flow meter
18 sampling valve
19 dilution system
20 particle counter sensor
21 particle counter
22 sampling valve
23 by-pass flow circuit

A contaminant injection circuit
B filter test circuit
C dilution and counting system

Figure 1 — Diagrammatic arrangement of test rig

5.1.2 On-line dilution and particle counting system

The on-line dilution and particle counting system shall be in accordance with ISO 11943 and include the components specified in 5.1.2.1 to 5.1.2.4.

5.1.2.1 On-line sample delivery pipework, sized to maintain a fluid velocity that prevents silting at a flow rate of 0,125 l/min. For tests with sampling flows > 10 % of the total filter flow rate, the amount of dust discarded in the sampling flow will be significant. This amount shall be evaluated and deducted from the retained capacity. Lower flow rates may be used provided they are validated.

5.1.2.2 Dilution system (19), comprising appropriate reservoir, pump, clean-up filters, flow meters and flow regulation valves.

5.1.2.3 **Two optical particle sensors** (20), connected to a particle counter (21) having a minimum of five channels.

5.1.2.4 **Timer**, capable of measuring minutes and seconds.

5.2 Test materials

5.2.1 Test contaminant

5.2.1.1 Contaminant grade

The contaminant shall be in accordance with the specification of ISO 12103-A3 medium grade test dust.

5.2.1.2 Contaminant preparation

The test dust shall be pre-dried in quantities no larger than 200 g for at least 1 h at (105 ± 5) °C and cooled to room temperature. Maintain in a desiccator until required for use.

5.2.2 Test fluid

The test fluid shall have a petroleum base and conform to the specifications given in Annex A.

6 Accuracy of measuring instruments and test conditions

The measuring instruments shall be capable of measuring to the levels of accuracy given 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 condition	Unit	Measurement accuracy	Allowed test condition variation
Flow			
Filter Test Flow	l/min	± 2 %	± 5 %
Sampling Flow	ml/min	± 1,5 %	± 3 %
Injection Flow	ml/min	± 2 %	± 5 %
Pressure	Pa	± 5 %	—
Temperature	°C	± 1 °C	2 °C
Volume	l	± 5 %	± 10 %
Base upstream gravimetric level	mg/l	—	± 10 %
Conductivity	pS/m	± 10 %	See 8.3.4
Viscosity [a]	mm^2/s	± 5 %	—

[a] The viscosity of the test liquid should be checked at regular intervals to ensure that the test is conducted at a liquid temperature which corresponds to a viscosity of 15 ± 1 mm^2/s.

7 Test rig validation

7.1 General

These validation procedures reveal the effectiveness of the test rig in maintaining contaminant entrainment or preventing contaminant size modification or both.

7.2 Validation of the on-line dilution and particle counting system

Proceed in accordance with ISO 11943 to validate the on-line dilution system and in accordance with ISO 11171 to validate the particle counter.

7.3 Validation of filter test circuit

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

7.3.2 Install a straight section of pipe in place of a test filter during the validation procedure.

7.3.3 Adjust the total circuit volume so that it is numerically equal to half the value of the minimum flow volume per minute through the filter, with a minimum of 6 l. The total circuit volume should include sump, piping and filter. A by-pass flow loop should be utilized for low flow test conditions.

7.3.4 Contaminate the fluid to the calculated gravimetric level of 5 mg/l using ISO 12103-A3 test dust.

NOTE This contamination level is below the coincidence limit of automatic particle counters.

7.3.5 Circulate the fluid in the test system for 1 h while obtaining downstream cumulative counts at 5 µm(c), 10 µm(c) and 20 µm(c), without on-line dilution, at 10 min sample intervals.

7.3.6 Calculate and record the on-line count (C_o) in particles per millilitre, using the equation:

$$C_o = \frac{N_c}{V}$$

where

N_c is the cumulative count for the selected sample period, in number of particles;

V is the volume of fluid, in millilitres, passed through the particle counter sensor during the sample period.

7.3.7 The validation shall be accepted only if

a) each particle count obtained at 5 µm(c), 10 µm(c) and 20 µm(c) does not deviate by more than 10 % from the average particle count for these sizes,

b) the average for all particles per millilitre at channels $\geqslant$ 5 µm(c) is not less than 6 000 and not greater than 7 300,

c) the average for all particles per millilitre at channels $\geqslant$ 10 µm(c) is not less than 815 and not greater than 1 015, and

d) the average for all particles per millilitre at channel $\geqslant$ 20 µm(c) is not less than 77 and not greater than 106.

7.3.8 Contaminate the fluid to the maximum gravimetric level to be tested using ISO 12103-A3 test dust.

7.3.9 Circulate the fluid in the test system for 1 h while obtaining downstream cumulative counts at 5 µm(c), 10 µm(c) and 20 µm(c), with on-line dilution, at 10 min sample intervals.

7.3.10 The validation test shall be accepted only if each particle count obtained at 5 µm(c), 10 µm(c) and 20 µm(c) does not deviate by more than 10 % from the average particle count for these sizes.

7.4 Validation of contaminant injection circuit

7.4.1 Validate the contaminant injection circuit at the maximum volume and the maximum gravimetric level to be used.

7.4.2 Add the required quantity of contaminant in slurry form to the injection circuit fluid and circulate for a time sufficient to completely disperse the contaminant.

NOTE All systems might not disperse contaminant at the same rate. A period of 10 min to 20 min could be necessary for complete dispersion.

7.4.3 Extract fluid samples at the point where the injection fluid is discharged into the filter test circuit reservoir at 30 min intervals over 2 h and analyse each sample gravimetrically. These samples should be taken at the intended test injection flow rate.

7.4.4 The validation test shall be accepted only if the gravimetric level of each sample is within ± 5 % of the average of the four samples and if this average is within ± 5 % of the gravimetric value selected in 7.3.1.

8 Preliminary preparation

8.1 Test filter assembly

8.1.1 Ensure that the test fluid cannot by pass the filter element to be evaluated.

8.1.2 Subject the test filter element to a fabrication integrity test in accordance with ISO 2942:1994 using MIL-H-5606 fluid prior to the multi-pass test or following it, if the element is not readily accessible as in the spin-on configuration.

8.1.3 If the integrity test has been made prior to the multi-pass test and if the test filter element fails to meet the test pressure agreed between the purchaser and the manufacturer, the element shall be disqualified from further testing. If the integrity test has been made after the multi-pass test and if the element fails, the test result shall be disqualified.

8.2 Contaminant injection circuit

8.2.1 Using 50 mg/l as the base upstream gravimetric level, calculate the predicted test time, T_e, in minutes, from the equation:

$$T_e = \frac{F_c}{G \times Q} = \frac{F_c}{50 \times Q}$$

where

F_c is the estimated capacity of the filter element, in milligrams;

G is the base upstream gravimetric level, in milligrams per litre;

Q is the test flow rate, in litres per minute.

