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Second edition
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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
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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.

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 of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

This second edition cancels and replaces the first edition (ISO 19438:2003), which has been technically revised.

The main changes are as follows:

— revised validation procedure;

— added requirement to measure final test system conductivity;

— revised test report to include initial and final test system conductivity;

— Replaced Annex D “Summary of the International interlaboratory trial (round robin) to validate ISO 19438 protocol” with “Effect of dust cake filtration on filter capacity”.

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.

Introduction

This document establishes a standard test procedure for measuring the filtration efficiency, retention capacities and resistance to flow of fuel filters. This test is intended to differentiate filters according to their functional performance but is not intended to represent performance under actual field operating conditions. Test conditions are steady-state and the dynamic characteristics of the fuel systems are not represented. Other test protocols are in development to evaluate performance under cyclic flow and vibration.

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

1 Scope

This document specifies a multi-pass filtration test, with continuous contaminant injection and using the on line particle counting method, to evaluate 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 document is applicable to filter elements having a rated flow between 50 l/h and 800 l/h; however, by agreement between the filter manufacturer and customer, and with some modifications, the procedure is permitted for application to fuel filters with higher flow rates.

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

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

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

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

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

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 11943:2021, *Hydraulic fluid power — Online automatic particle-counting systems for liquids — Methods of calibration and validation*

ISO 12103-1, *Road vehicles — Test contaminants 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, ISO 11841-2 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

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

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

3.1
multi-pass 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

Note 1 to entry: It is 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* (3.7) or cumulative *overall efficiency* (3.4) of a given percentage

Note 1 to entry: It is expressed in micrometres(c) [µm(c)], which signifies throughout this document 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 (3.5) at 99 % efficiency

Note 1 to entry: It is expressed in micrometres(c) [µm(c)], which signifies throughout this document 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 document for fluid power system components are in accordance with ISO 1219-1.

5 Test apparatus and materials

5.1 Test apparatus

5.1.1 Test rig

The test rig, shown diagrammatically in Figure 1 (to which the numbers in parentheses throughout this document 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 bypassed 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:

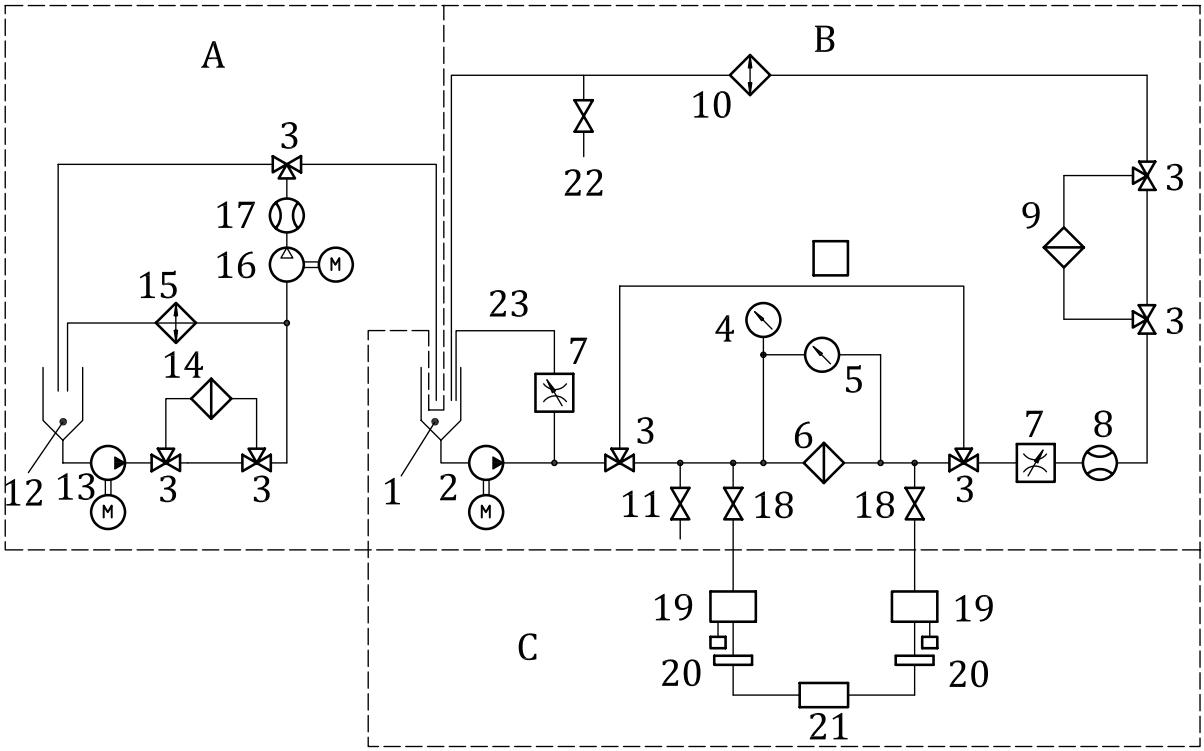
a) an initial system contamination level of less than 1 000 particles/ml having a size greater than 10 µm(c);

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

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 12103-1 A.3 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 it 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 instead 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 12103-1 A.3 medium 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 18 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 formula:

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

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) the particle count obtained for a given size at each sample interval does not deviate more than 15 % from the average particle count from all sample intervals for that size, and

b) the average of all cumulative particle counts per millilitre is within the range of acceptable counts in accordance with ISO 11943:2021, Table C.2.

7.3.8 Contaminate the fluid to the maximum gravimetric level to be tested using ISO 12103-1 A.3 medium 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 18 µm(c), with online dilution, at 10 min sample intervals.

