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Methods of test for full-flow lubricating oil filters for internal combustion engines —

Part 12: Filtration efficiency using particle counting, and contaminant retention capacity

Méthodes d'essai des filtres à huile de lubrification à plein débit pour les moteurs à combustion interne —

Partie 12: Efficacité de filtration par comptage des particules et capacité de rétention des contaminants

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 part of ISO 4548 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 4548-12 was prepared by Technical Committee ISO/TC 70, *Internal combustion engines*, Subcommittee SC 7, *Tests for lubricating oil filters*.

ISO 4548 consists of the following parts, under the general title *Methods of test for full-flow lubricating oil filters for internal combustion engines*:

— *Part 1: Differential pressure/flow characteristics*

— *Part 2: Element by-pass valve characteristics*

— *Part 3: Resistance to high differential pressure and to elevated temperature*

— *Part 4: Initial particle retention efficiency, life and cumulative efficiency (gravimetric method)*

— *Part 5: Cold start simulation and hydraulic pulse durability test*

— *Part 6: Static burst pressure test*

— *Part 7: Vibration fatigue test*

— *Part 9: Inlet and outlet anti-drain valve tests*

— *Part 10: Life and cumulative efficiency in the presence of water in oil*

— *Part 11: Self-cleaning filters*

— *Part 12: Filtration efficiency using particle counting, and contaminant retention capacity*

Annexes A and C form a normative part of this part of ISO 4548. Annex B is for information only.

Introduction

ISO 4548 establishes standard test procedures for measuring the performance of full-flow lubricating oil filters for internal combustion engines. It has been prepared in separate parts, each part relating to a particular performance characteristic.

Together the tests provide the information necessary to assess the characteristics of a filter, but if agreed between the purchaser and the manufacturer, the tests may be conducted separately.

Methods of test for full-flow lubricating oil filters for internal combustion engines —

Part 12: Filtration efficiency using particle counting, and contaminant retention capacity

1 Scope

This part of ISO 4548 specifies a multi-pass filtration test with continuous contaminant injection and using the on-line particle counting method for evaluating the performance of full-flow lubricating oil filters for internal combustion engines.

The test procedure determines the contaminant capacity of a filter, its particulate removal characteristics and differential pressure.

This test is intended for application to filter elements having a rated flow between 4 l/min and 600 l/min and with an efficiency of less than 99 % at a particle size greater than 10 μm.

NOTE Several test flow loops built into one test rig, or several test rigs, would be required to cover the complete flow range of 4 l/min to 600 l/min.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 4548. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 4548 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

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 3968:1981, *Hydraulic fluid power — Filters — Evaluation of pressure drop versus flow characteristics.*

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

ISO 4405:1991, *Hydraulic fluid power — Fluid contamination — Determination of particulate contamination by the gravimetric method.*

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

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

ISO 11841-2:—[1)], *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 for liquids — Methods 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 part of ISO 4548, the terms and definitions given in ISO 11841-1and ISO 11841-2, together with the following, apply.

3.1
multi-pass test
test which requires the recirculation of unfiltered 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

3.5
***X* % micron[2)] (µm) rating**
particle size, in micrometres, corresponding to an overall efficiency of a given percentage *X*

4 Symbols

The graphical symbols used in this part of ISO 4548 are in accordance with ISO 1219-1.

5 Equipment

5.1 Test rig

The test rig shall comprise a filter test circuit and a contaminant injection circuit, as described in 5.1.1 and 5.1.2. See Figure 1.

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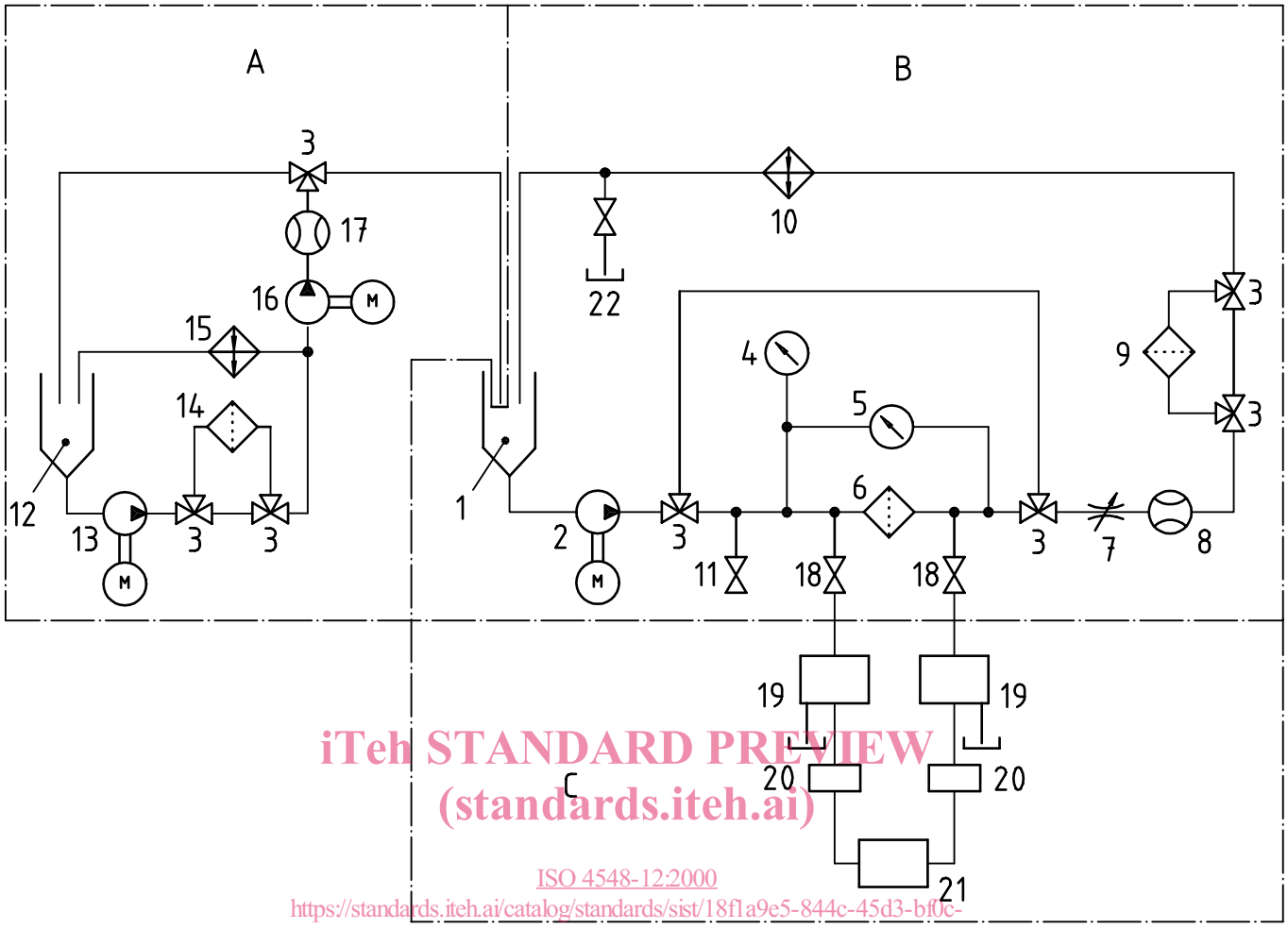
1) To be published.

2) 1 micron ≡ 1 micrometre.



Key

1 Reservoir incorporating a thermostatically controlled heater
2 Pump
3 Three-way valve
4 Pressure gauge
5 Differential pressure gauge
6 Test filter
7 Throttle valve (for pressure regulation)
8 Flow meter
9 Clean-up filter
10 Heat exchanger
11 Sampling valve
12 Reservoir incorporating a thermostatically controlled heater
13 Pump
14 Clean-up filter
15 Heat exchanger
16 Injection pump
17 Flow meter
18 Sampling valve
19 Dilution system
20 Particle sensor
21 Particle counter
22 Volume control valve

A Contaminant injection circuit
B Filter test circuit
C Dilution and counting system

Figure 1 — Diagrammatic arrangement of test rig

5.1.1 Filter test circuit

The filter test circuit shall include the following components.

a) 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.

b) Oil pump (2) which does not alter the contaminant particle size distribution and which does not exhibit excessive flow pulses.

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

d) System clean-up filter (9) capable of providing an initial system contamination level of less than 15 particles greater than 10 µm/ml.

e) 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).

f) Pressure tappings in accordance with ISO 3968.

g) Piping sized to ensure that turbulent mixing conditions exist throughout the filter test circuit.

5.1.2 Contaminant injection circuit

The contaminant injection circuit shall include the following components:

a) 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.

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

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

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

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

d) Piping sized to ensure that turbulent mixing conditions exist throughout the contaminant injection circuit.

5.2 On-line dilution and particle counting system

The on-line dilution and particle counting system shall include the following components:

a) On-line sample delivery pipework sized to maintain a fluid velocity which will prevent silting.

b) Dilution system (19) comprising a reservoir, pump, clean-up filters, flowmeters and flow regulation valves.

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

5.3 Timer, capable of measuring minutes and seconds.

6 Materials

6.1 Test contaminant

6.1.1 Contaminant grade

The contaminant shall be in accordance with the specification given for ISO 12103-A3 medium grade test dust in ISO 12103-1:1997.

6.1.2 Contaminant preparation

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

6.2 Test fluid, having a petroleum base and conforming to the specifications given in annex A.

7 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	Units	Measurement accuracy	Allowed test condition variation
Flow	l/min	± 2 %	± 5 %
Pressure	Pa	± 5 %	–
Temperature	°C	± 1 °C	± 2 °C
Volume	l	± 5 %	± 10 %
Base upstream gravimetric level	mg/l	–	± 1 mg/l
Conductivity	pS/m	± 10 %	
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 mm^2/sec ± 1 mm^2/sec.

8 Test rig validation

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

8.1 Validation of filter test circuit

8.1.1 Validate the filter test circuit at the minimum flow rate at which the circuit will be operated. Install a straight section of pipe in place of a test filter during the validation procedure.

8.1.2 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 6 l. For flows higher than 60 l/min, adjust the total circuit volume to be numerically equal to one-quarter of the value of the minimum flow volume per minute through the filter.

8.1.3 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.

8.1.4 Circulate the fluid in the test system for 1 h whilst obtaining downstream cumulative counts at 10 µm and 20 µm without on-line dilution at 10 min sample intervals.

8.1.5 Calculate and record the on-line count (C_o) in particles/ml, 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.

8.1.6 Accept the validation test only if:

— each particle count obtained at 10 µm and 20 µm does not deviate by more than 10 % from the average particle counts for these sizes;

— the average for all particle counts per millilitre at channel > 10 µm is not less than 750 nor more than 1 000;

— the particle counts per millilitre at channel > 20 µm are not less than 70 nor more than 120.

8.2 Validation of contaminant injection circuit

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

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

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

8.2.3 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.

NOTE These samples should be taken at the intended test injection flow rate.

8.2.4 Accept the validation test 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 level selected in 8.2.1.

8.3 Validation of on-line dilution and particle counting system

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