INTERNATIONAL STANDARD

ISO 4548-4

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

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

Méthodes d'essai des filtres à huile de lubrification à passage intégral pour moteurs à combustion interne —

Partie 4: Efficacité initiale, capacité de rétention et efficacité cumulée (méthode gravimétrique)

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Annexes

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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.

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.

International Standard ISO 4548-4 was prepared by Technical Committee ISO/TC 70, *International combustion* engines, subcommittee SC 7, *Tests for lubricating oil filters*.

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

— *Part 1: Differential pressure/flow characteristics*

— *Part 2: Elements by-pass component 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: Particle retention ability and contaminant holding capacity using particle counting*

Annexes A, B, C, D and E form an integral part of this part of ISO 4548. Annex F 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 4:
Initial particle retention efficiency, life and cumulative efficiency (gravimetric method)

Section 1: General

1.1 Scope

This part of ISO 4548 specifies tests for determining the performance of full-flow lubricating oil filters for internal combustion engines as follows.

Section 2: Initial particle retention efficiency. This gives the test procedures and parameters for the determination of the initial particle retention efficiency of lubricating oil filter elements under defined test conditions. By reporting the results in accordance with subclause 2.6, the probable retention efficiency for any particle size may be derived. The retention efficiency is determined by the gravimetric method.

Section 3: Life and cumulative efficiency. This gives the test procedures and parameters for the determination of element life and cumulative efficiency of lubricating oil filters. The cumulative efficiency is determined by the gravimetric method.

NOTE — By agreement between filter manufacturer and purchaser, tests on large filters can be conducted on the basis of tests carried out on filters scaled-down in length. The relationship of the filter flow and test dust addition rate to the effective length of the filter medium should be the same in the scaled-down tests as in the full size filter. For the purposes of this part of ISO 4548, a filter having a test flow rate exceeding 100 l/min is considered large.

1.2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 4548. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 4548 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO 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 4548-1:—[1)], *Methods of test for full-flow lubricating oil filters for internal combustion engines — Part 1: Differential pressure/flow characteristics.*

ISO 11841-1:— [2)], *Road vehicles and internal combustion engines — Filter vocabulary — Part 1: Definitions of filters and filter components.*

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1) To be published. (Revision of ISO 4548-1:1982)

2) To be published.

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

ISO 12103-1:— 2), *Road vehicles — Test dust for filter evaluation — Part 1: Arizona test dust*.

ISO 12103-2:— 2), *Road vehicles — Test dust for filter evaluation — Part 2: Aluminium oxide test dust*.

1.3 Definitions

For the purposes of this part of ISO 4548, the definitions given in ISO 11841-1 and ISO 11841-2 apply.

1.4 Graphical symbols

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

2) To be published.

Section 2: Initial particle retention efficiency

2.1 Operational characteristics to be assessed

The main function of the oil filter in engine lubricating oil systems is to prevent the damaging abrasive particles from reaching the bearings and other internal rubbing surfaces. It is generally accepted that particles between 5 µm and 40 µm cause the greatest amount of wear and it is therefore important to engine users and manufacturers that any proposed filter is adequate in removing particles within this defined range of sizes on an instantaneous, single-pass basis. This requirement is particularly relevant to filters fitted to new engines which may contain significant quantities of metallic and other abrasive contaminants accumulated during engine production processes.

This test procedure assesses the ability of an oil filter to retain abrasive contaminant, within a defined range of particle sizes, using a gravimetric method of analysis.

2.2 Test rig

2.2.1 The test rig, shown diagrammatically in figures 1 and 2, shall include the components indicated together with the necessary tubing connections and supports.

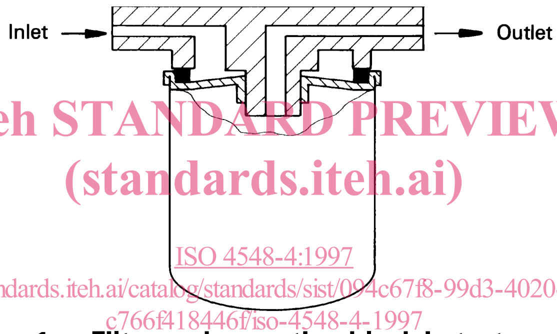


Figure 1 — Filter and mounting block in test position

2.2.2 The sump shall be capable of holding a quantity of oil as given in annex A and shall be equipped with a thermostatically controlled heater capable of maintaining the test temperature. The heater shall be arranged so that local overheating of the oil is avoided. The by-pass return to the sump and the main filter outlet pipe shall terminate below the surface of the oil in the sump when the oil is in circulation. The temperature shall be adjusted so that the stipulated test oil viscosity is maintained within a limit of ± 3 mm^2/s [3)].

2.2.3 The pump shall be the pulse-free type.

2.2.4 The two valves **3** and **8** (see figure 2) shall be used for the purpose of pressure and flow control. Needle valves or diaphragm valves are recommended.

2.2.5 The flow-meter **4** shall be suitable for use with oil of 24 mm^2/s kinematic viscosity and shall register the flow in the pipeline leading to the test filter with an accuracy of ± 2 %.

2.2.6 The pressure tapping **14** shall be made at five internal pipe diameters upstream of the filter inlet port. The filter inlet and outlet pipes shall be straight and free from obstruction for eight internal pipe diameters upstream and 13 internal pipe diameters downstream of the filter inlet and outlet ports.

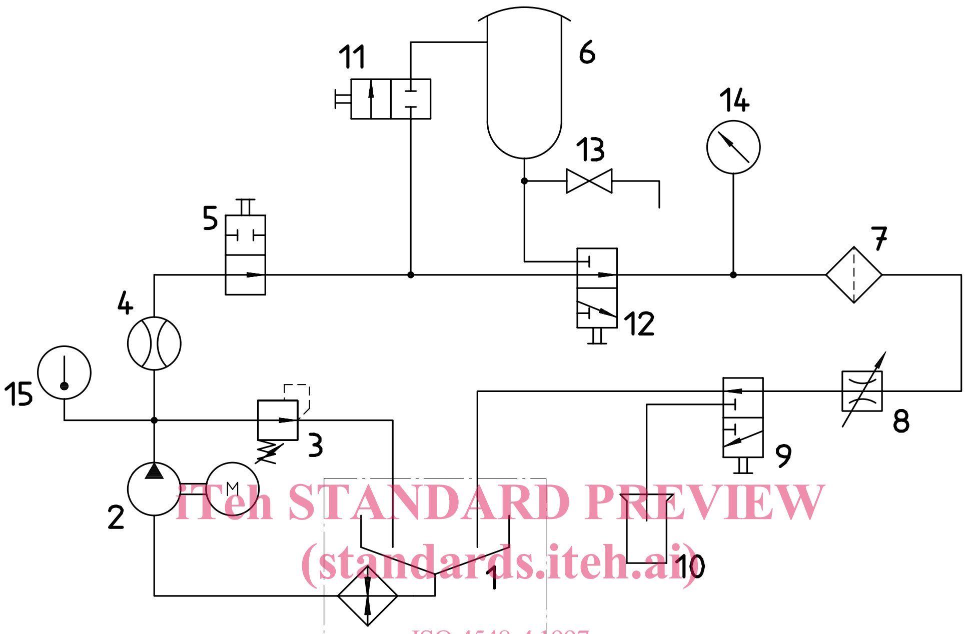
2.2.7 The filter shall be mounted vertically in the test rig (see figure 1) in accordance with the requirements of ISO 4548-1 to ensure consistency of tests to enable meaningful comparisons to be made.

3) 1 mm^2/s = 1 cSt

2.3 Test liquids

2.3.1 The test liquid for these tests shall be a straight mineral oil of ISO VG 100 (SAE 30) grade or ISO VG 150 (SAE 40) grade (see [2] and [3]).

2.3.2 The oil shall be used at a kinematic viscosity of 24 mm^2/s ± 3 mm^2/s, at approximately 74 °C with ISO VG 100 (SAE 30) or at approximately 83 °C with ISO VG 150 (SAE 40).



Key

1 Insulated sump with thermostatically controlled heater, conical bottom and smooth internal surfaces

2 Motor-driven pump

3 Pressure-regulating valve

4 Flow meter

5 ON-OFF valve

6 Slurry addition reservoir with a capacity equivalent to half the volume of the test filter ± 25 % with bleed screw in removable cover (see figure 3)

7 Test filter

8 Flow-regulating valve

9 Three-way valve

10 Filtrate receptacle with a capacity of four times the volume of the test filter

11 ON-OFF valve

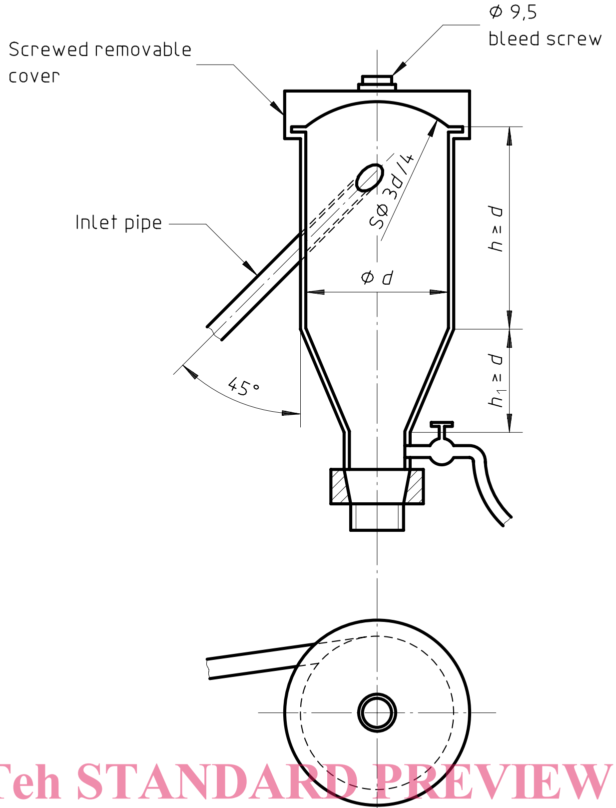
12 Three-way valve

13 Drain cock

14 Inlet pressure gauge

15 Indicating temperature controller

Dimensions in millimetres



NOTE — See **6** in figure 2 for the volume.

Figure 3 — Details of slurry addition vessel

2.4 Test contaminant

2.4.1 Contaminant grades

The grades of aluminium oxide dust[4] given in table 1 shall be used.

The particle size distribution of the grades of test dust in table 1 is given in ISO 12103-2.

Table 1 — Test dust grades

Grade	50 % mean particle size µm
ISO 12103-M3	13,6 ± 0,9
ISO 12103-M4	30,1 ± 2,3
ISO 12103-M5	54 ± 3

4) Suitable fused aluminium oxide test dusts can be obtained from the Motor Industry Research Association, Lindley, Nuneaton, Warwickshire, UK. This information is given for the convenience of users of this part of ISO 4548 and does not constitute an endorsement by ISO of the product named. Equivalent products may be used if they can be shown to lead to the same results.

2.4.2 Contaminant preparation

2.4.2.1 The dusts are normally supplied in a selection of different size jars. The dust, in storage, will tend to precipitate and quantities removed from the top of the jars will not be representative of the original particle distribution as defined in 2.4.1. To ensure that the dust used meets these requirements, the whole quantity from each jar shall be thoroughly mixed before individual increments are removed for weighing.

2.4.2.2 A sufficient quantity of the particular grade of test dust to be used shall be dried in an oven at a temperature of 105 °C ± 5 °C for at least 1 h. The dried dust shall then be stored for use in a desiccator.

2.4.2.3 When required for use in the test rig a quantity of the particular grade of dust as given in annex A shall be weighed into a clean beaker and to it shall be added a volume of test liquid equivalent to that of the slurry addition reservoir (see figure 2, **6**).

2.4.2.4 The contents of the beaker shall then be thoroughly mixed by means of a high speed stirrer (see annex E).

2.4.2.5 Mixing shall proceed for at least 1 h immediately prior to placing in the slurry addition reservoir and commencing the test.

2.5 Test procedure

2.5.1 General

This test procedure specifies the method of determining the retention efficiency of a filter element where a test dust of a particular mean particle size, suspended in a small quantity of oil, is injected into the main flow of oil being passhrough the test filter under controlled conditions of temperature, pressure and flow rate. The period of injection will vary according to the size of the test filter and the test flow rate but for practical purposes the evaluation may be regarded as a measure of the instantaneous or single-pass retention efficiency of the test filter at the mean particle size of the test dust being used.

NOTE — The retention efficiency is a function of time, so the instantaneous or single-pass retention efficiency during the life of the filter element may differ from the initial value.

2.5.2 Test rig preparation

Before commencing particle retention efficiency tests, it is essential that the test rig be cleaned such that the results obtained are not influenced by residual contaminant in the test rig circuit. The total contaminant content of the test fluid shall not exceed 60 mg/l.

2.5.2.1 In order to achieve this degree of cleanliness, the following procedure is suggested.

Fit a new clean-up filter in place of the test filter and drain all fluids from the test rig.

Pour a sufficient quantity of suitable flushing fluid into the test rig sump such that the pump does not cavitate when running.

Circulate the flushing fluid through the complete test rig system, including the slurry addition by intermittent change-over of the appropriate valves, for at least 30 min at a flow rate which allows the clean-up filter to function at maximum efficiency in removing residual contaminant.

WARNING — Do not switch on the heater when using highly volatile or inflammable liquids.

Drain the test rig and refill with a sufficient quantity of the specified test oil so that the pump does not cavitate when running.

With the heater switched on, circulate the oil until the temperature stabilizes at the required figure and run the test rig for at least 20 min.

Drain the test rig and remove the clean-up filter.

2.5.2.2 The cleanliness of the rig shall be determined by the following procedure.

a) Fit a new clean-up filter and fill the test rig with the required quantity of oil as given in annex A. Record the relative density of the oil used.

b) With the heater switched on, circulate the oil until the temperature stabilizes at the required figure and run the test rig for at least 20 min.

c) Take a 50 ml sump oil sample and analyse for percentage contaminant content as described in B.6. The result of this analysis and calculation shall be referred to as the rig blank, and these rig blank tests shall be carried out prior to each retention test on any test filter. Where the total contaminant content of the test liquid exceeds 60 mg/l the rig cleaning operation shall be repeated until the rig blank contamination level is below the maximum mass allowed. The final rig blank test result shall be used for correction of particle retention values in 2.6.

d) Remove the clean-up filter and replace its oil content with an equal quantity of clean test oil added to the sump.

2.5.3 Particle retention test

2.5.3.1 Prepare the test rig as described in 2.5.2 and necessary dust increments as in 2.4.1 and 2.4.2.

2.5.3.2 The filter for test shall be installed vertically in the test rig as shown in figure 2 and the element by-pass component shall remain operative. Care shall be taken to ensure that the test filter housing and any additional pipe-work are clean before installation.

NOTE — The filter for test may be tested for fabrication integrity in accordance with ISO 2942 [2] prior to installation unless it is impractical to disassemble the filter assembly.

2.5.3.3 The test oil shall be circulated through the test rig system via the by-pass pipe only. Valve **5** is closed. No liquid shall pass through the test filter at this stage. The heater is switched on and the thermostat adjusted to a test temperature which provides the specified oil viscosity shown in annex A. Allow temperature to stabilize. The viscosity of the test oil shall be maintained within the defined limits for the duration of the test.

2.5.3.4 When the temperature has stabilized, the test oil shall be allowed to flow through the test filter while by-passing the slurry addition reservoir.

2.5.3.5 The flow through the test filter shall be adjusted to the required figure with the inlet pressure at a minimum of 40 kPa [5)].

2.5.3.6 Slurry, containing one of the test dusts, shall be added to the slurry addition reservoir. The test dusts are specified in 2.4.1 and the quantity of test dust and preparation of the slurry shall be in accordance with 2.4.2.

2.5.3.7 By the simultaneous operation of valves **11**, **12** and **9**, flow shall be directed through the slurry addition reservoir and the effluent collected in the pre-cleaned receptacle **10**. The volume of effluent collected shall be approximately four times the volume of the test filter.

2.5.3.8 Reset valves **9** and **12** and close valve **11**, allowing the test liquid to flow directly through the filter into the sump. The test liquid flow shall then be stopped by closing valve **5** and opening valve **3**.

2.5.3.9 Collect the dust not offered to the test filter as follows: place the beaker used for mixing the slurry beneath the drain cock **13** of the reservoir **6** and drain the reservoir by opening the cock and the top cover bleed screw.

5) 100 kPa = 1 bar

2.5.3.10 Rinse all internal surfaces of the reservoir with 100 ml of petroleum spirit, collecting the rinsings in the beaker referred to in 2.5.3.9.

2.5.3.11 The test dust content of the filter effluent shall be determined in accordance with annex B and the amount of test dust in drainings and rinsings from 2.5.3.9 and 2.5.3.10 shall be determined in the same manner, except that all the rinsings shall be used and finally washed through the membrane with 100 ml of petroleum spirit.

2.5.3.12 The filter bowl and test element shall be removed and the element discarded. In the case of sealed unit type filters, the filter shall be discarded.

2.5.3.13 The retention efficiency of the test filter relative to the particular grade of test dust used shall be calculated as defined in clause 2.6.

2.5.3.14 The test rig shall be prepared as in 2.5.2 before repeating the test as in 2.5.3.1 to 2.5.3.13 using the remaining grades of test dust. A clean element shall be used for each separate test.

2.5.4 Test rig validation

A test to check the efficiency of the slurry addition apparatus shall be made when the test rig is first assembled, when any major alteration is made to the rig, and at intervals based on approximately 250 rig running hours. This efficiency shall be determined by carrying out the test procedure in accordance with 2.5.3.1 to 2.5.3.13 except that a piece of smooth connecting pipe shall be inserted in the place of the test filter and the slurry containing test dust of grade ISO 12103-M5 (see table 1) shall be used.[6] The content of the effluent shall be determined as described in annex B and the mass of the test dust recovered in the test shall be not less than 95 % of the mass of dust added to the slurry addition reservoir.

If the recovery is less than the stipulated figure, or more than 100 %, the cause shall be investigated and rectified.

2.6 Test results and calculations

The results obtained from analysis of oil samples in accordance with annex B shall be used to calculate the percentage of dust retained by the filter and shall be expressed as a percentage for each grade of dust used.

The retention efficiency, E_r, as a percentage retained is given by the equation:

$$E_r = 100\left(1 - \frac{m_1}{m_2}\right)$$

where

m_1 is the mass of test dust transmitted after correction, in grams:

$$m_1 = m - m_0$$

in which

m is the uncorrected total mass of contaminant transmitted (see B.4.9 to B.4.17),

m_0 is the mass of contaminant in the effluent from the rig blank sample analysis [see B.6 and 2.5.2.2 c)];

6) For spin-on filters with a screwed adaptor block, a screw-on cap of minimum volume connecting the inlet with outlet may be used.