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Road vehicles — Fuel filters for automotive compression ignition engines — Part 1 : Test methods

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FOREWORD

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

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It has been approved by the member bodies of the following countries :

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Road vehicles — Fuel filters for automotive compression ignition engines — Part 1 : Test methods

1 SCOPE

This International Standard specifies the types of test for fuel filters according to their application.

Filter classification is specified in ISO 4020/2.

2 FIELD OF APPLICATION

This International Standard applies to fuel filters provided for motor vehicles with diesel engines and for test installations for injection equipment.

The test described may also be used for diesel engine fuel filters for use with fuel which by specification is free from residuals.

This International Standard is intended for filters having a rated flow of up to 200 l/h.

By agreement, the tests, with some modifications, may be used for filters with higher rates of flow.

3 REFERENCES

ISO 760, *Determination of water by the Karl Fischer method.*

ISO 4020/2, *Road vehicles — Fuel filters for automotive compression ignition engines — Part 2 : Filter classification.*

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4 TERMS AND DEFINITIONS

No.	Term	Symbol	Unit	Definition
1	Fine filter	–	–	Filter used for final protection of the fuel injection equipment
2	Prefilter	–	–	Filter defined by its position in the fuel system, i.e. a filter before the final filter
3	Strainer	–	–	Separator with fixed apertures
4	Sedimentor	–	–	Separator in which contaminant is removed by density difference
5	Particle retention	–	%	A measure of the ability of a filter to remove a specified test dust offered under specified conditions of test. It is expressed quantitatively by relating the test dust retained by the filter to that offered
6	Test liquid	–	–	The liquid to be used may be different for the various tests
7	Life	T V	min l	Expression in terms of time and volume of contaminated test liquid to choke a filter element to a pressure difference of 0,7 bar when the test liquid is passed through the filter at a specified flow rate
8	Pressure difference	Δp	mbar	A measure of the difference in pressure taken at the inlet and outlet of a filter when test liquid is flowing through the filter at a specified flow rate
9	Rated flow	Q	l/min l/h	Normal operating flow at which liquid is passed through a filter. It can be that specified by the manufacturer or as agreed between manufacturer and user
10	Contaminant, organic	–	–	Suspension of finely divided carbon black in test liquid, formulated to provide similar filter choking characteristics to those of normal diesel fuel
11	Contaminant, inorganic	–	–	Fused aluminium oxide dust of closely controlled particle size. It is the incombustible constituent which is added to the organic contaminant for the purpose of revealing the particle retention property of a filter
12	Collapse/burst pressure of filter element	Δp	bar	The pressure difference at which a choked filter element suffers structural failure
13	Burst pressure of complete filter	p	bar	The internal pressure at which the filter housing suffers structural failure
14	Bubble test	V_B	ml/min	Indicates quality standard of filter element by measurement of volume of air escaping through filter medium or joints in unit time, when immersed in liquid at specified depth and internal pressure
15	Test of cleanliness	W	mg	This test enables the degree of cleanliness of new filters to be determined. It reveals the amount of impurities flushed from the clean side of the filter under specified test conditions
16	Test flow rate	Q	l/min l/h	The rate at which test liquid flows through the filter during a specific test. It may be different from the rated flow
17	Undissolved water	–	–	Water dispersed in test liquid, i.e. diesel fuel containing water which can be separated by physical means, for example by centrifuging

NOTE – Pressure are indicated in bars; to obtain them in kPa, multiply them by 10^2 (1 bar = 10^5 Pa).

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5 TEST MATERIALS

5.1 Test liquid

The test liquid used for all tests except the water separation test (6.5) and collapse/burst test of the filter element (6.6) shall be a straight mineral oil[2] with properties as shown in annex D.

Except for tests 6.1 and 6.2, this liquid shall be used at such a temperature that its kinematic viscosity lies between 4 and 6 mm^2/s (4 and 6 cSt). Alternatively, it shall be blended with refined spindle oil or premium grade kerosene to give a viscosity between these limits at the test temperature. All test liquids shall be free from additives apart from colouring dyes. Provision shall be made to ensure that the test liquid is free from undissolved water. The liquid for each test shall be drawn from its storage container at a point above the zone of sedimentation.

Before use, all liquids shall be passed through a highly efficient filter medium, the latter being adequately supported and suitably clamped at the edges; see the following items from A.4 of annex A (2nd, 3rd and 4th items under "other equipment"), for example :

- vacuum pump : 0,85 bar below atmospheric pressure;
- filtration apparatus : filter paper disc holder;
- filter paper disc or membrane : diameter 140 mm, mean pore size between 0,4 and 1,1 μm.

The pressure differential across the filter paper shall not exceed 0,85 bar.

5.2 Test contaminants for tests for particle retention and life

5.2.1 *Organic contaminant concentrate for choking fuel filters*[1)2)]

The concentrate shall consist of a dispersion in a ratio of 1 g of carbon black to a mixture of 90 ml of test liquid and 10 ml of detergent additive.

For the method of preparation, see annex E.

5.2.2 *Inorganic contaminant*

The contaminant shall be fused aluminium oxide dust[2]. The particle size distribution shall conform to the diagram in E.8 of annex E.

5.3 Test installation, general

There shall be no sudden changes in tube or hose bore throughout the test rigs.

6 TESTS

6.1 Test of cleanliness of new filters

This test shall be carried out first to ascertain whether the clean side of the filter to be tested is free from dirt and of other loose particles which may result from production, storage and transport.

6.1.1 *Test installation*

See A.1 of annex A.

The test liquid temperature shall be 23 ± 10 °C.

6.1.2 *Other equipment*

See A.1 of annex A.

6.1.3 *Procedure*

a) Clean and dry the test sieve for 30 min in a drying cabinet at approximately 20 °C above the final boiling point of the petroleum ether employed according to 6.1.3d) and allow to cool for 30 min to ambient temperature.

b) Weigh the test sieve to the nearest 0,1 mg on a laboratory balance and insert the test sieve in a horizontal position in the measuring device (7).

c) Pump the test liquid through the circuit for 1 h at twice the rated flow of the filter under test.

d) Spray approximately 10 ml of petroleum ether through the cleaning hole on to the inner walls of the measuring device in order to wash down particles from the wall and to gather them on the sieve.

e) Remove the test sieve with tweezers, place it on filter paper and allow to dry.

f) Then place the test sieve in a clean, dry Petri dish, cover it with a lid, dry and allow to cool as before the first weighing.

g) Weigh the test sieve to the nearest 0,1 mg. The mass of dirt released by the filter is equal to the difference between the results of the two weighings of the sieve.

6.1.4 *Test report*

6.1.4.1 The test report shall indicate at least the following :

a) the filter make and model;

b) a description of the filter tested and internal diameter of connections;

c) the rated flow, in litres per hour;

d) the type or blend of test liquid.

1) This concentrate is difficult to prepare and when prepared requires to be tested for suitability as described in annex E.

2) Suitable products are available commercially. Details may be obtained from the Secretariat of Technical Committee ISO/TC 22 or from the ISO Central Secretariat.

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6.1.4.2 Indicate the mass, in milligrams, of dirt released.

6.2 Bubble test

This test may show whether the filter element is "tight", i.e. whether it does not contain pores larger than the unused filter medium. If this test is made, it should be carried out prior to the other tests specified, but it may be carried out after the cleanliness test.

6.2.1 *Test installation*

See A.2 of annex A.

The test liquid temperature shall be 23 ± 5 °C.

6.2.2 *Other equipment*

See A.2 of annex A.

6.2.3 *Procedure*

a) Before mounting the filter element to be tested (9) on the rotating axle, immerse it in the test liquid sufficiently long to completely wet the filter medium, and drain off the surplus test liquid.

b) Mount the filter element on the rotating axle (10) and immerse it in the tank (8).

c) Open the stopcock (3) and adjust the constant-pressure device (5) to indicate a pressure of 13 + 1 mbar on the liquid manometer (6).

d) Turn the filter element at approximately 10 min^{-1} on the rotating axle. The volume of air escaping in 1 min shall be measured.

6.2.4 *Test report*

6.2.4.1 The test report shall indicate at least the following :

a) the filter make and model;

b) a description of the filter; whether it is new or used; in the latter case, the approximate period of service;

c) the type or blend of test liquid;

d) its viscosity at the test temperature, in millimetres squared per second (centistokes);

e) the test temperature, in degrees Celsius.

6.2.4.2 Indicate the volume, in millilitres, of escaped air.

6.3 Test for pressure difference of new filters

The purpose of this test is to measure the pressure differential across the filter at the filter manufacturer's rated flow. This test shall be carried out prior to the tests for particle retention and life and for water separation efficiency, but may be carried out after the cleanliness and bubble tests.

NOTE — This method is equally applicable for the measurement of the pressure drop in a filter which has been in use for a determined period, or at a flow rate different from the nominal rate.

6.3.1 *Test installation*

See A.3 of annex A.

The test liquid temperature shall be 23 ± 5 °C.

6.3.2 *Other equipment*

See A.3 of annex A.

6.3.3 *Procedure*

a) Connect the filter to be tested into the test rig, start up the system and prime and vent the filter to ensure removal of air from the filter and pressure gauges, inverting the filter if necessary.

b) Close the control valve (10) and adjust the pressure by means of the by-pass valve (12) to that used in practice. Adjust the zero of the differential pressure gauge (14).

c) Open the control valve (10) to re-establish the pressure reading on the upstream pressure gauge (8) to that used in practice, and partially close the by-pass valve (12).

Thus adjust the flow rate, indicated by the flow-meter (6), to the desired value.

d) Record the value shown on the differential pressure gauge (14).

6.3.4 *Test report*

6.3.4.1 The test report shall indicate at least the following :

a) the filter make and model;

b) a description of the filter; whether it is new or used; in the latter case, the approximate period of service;

c) the rated flow and the test flow rate, in litres per hour;

d) the type of blend of test liquid;

e) its viscosity at the test temperature, in millimetres squared per second (centistokes);

f) the test temperature, in degrees Celsius;

g) the internal diameter, *d*, actually used for the pipes (9) itemized in A.3 of annex A.

6.3.4.2 Indicate the differential pressure in millibars.

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6.4 Test for particle retention and life

The purpose of this test is to measure the percentage retention of specific particles by a filter under determined test conditions.

It is useful to conduct the test with filters which have already been tested by the cleanliness test, the bubble test and the pressure difference test.

6.4.1 *Test installation*

See A.4 of annex A.

The test liquid temperature shall be 23 ± 5 °C.

6.4.2 *Other equipment*

See A.4 of annex A.

6.4.3 *Procedure*

6.4.3.1 Description

The filter test shall be carried out as a continuous process during which the contamination concentration of the test liquid being fed to the filter is constant. The effectiveness of the filter under test (8) is determined by measuring the amount of inorganic test dust remaining in the effluent samples initially and during the process of choking.

Clean test liquid is pumped from the tank (1a) by means of the pump (6) through the filter under test (8) into the collection tank (12). This enables the filter to be primed and vented. The organic and inorganic contaminants are added to the test liquid and maintained in suspension by the stirrer (2). The pump (6) transfers this suspension to the filter under test, from which the filtered liquid flows via the flow-measuring device (10 and 11) into the collection tank (12).

Samples of the effluent are taken 2 min after the addition of the contaminants and at 4 min intervals thereafter for determination of inorganic concentration. The continuity of the process is ensured by having a second tank (1b) prepared and ready for use in the event that the whole 50 l of contamined test liquid contained in tank (1a) has been used up.

The test for particle retention and life ends when a pressure differential of 0,7 bar is attained.

6.4.3.2 Preparation of contaminants

6.4.3.2.1 Organic choking contaminant (see 5.2.1 and annex E)

a) The contaminant shall be supplied in a 5 l container which is 75 % full. It shall be agitated by hand shaking for approximately 5 min. To do this, the container shall be turned upside down and back again a number of times.

b) Immediately following this, the container shall be placed on its side on a laboratory shaker and agitated at a frequency of approximately 250 cycles per minute* at approximately 25 mm amplitude for 2 h.

c) The container shall then be taken from the shaker and the cap removed. A laboratory stirrer shall be lowered into the container to a position as near the bottom as possible and stirring shall be maintained for 3 h at a rotational frequency of approximately 1 000 min^{-1}.

d) Immediately after stirring, a sample shall be removed and the solid content determined (see annex F) to ensure that it is within 1 ± 0,1 % mass/volume. Throughout the duration of a test series, the contents of the container shall be kept stirred as directed in 6.4.3.2.1c).

6.4.3.2.2 Inorganic contaminant for efficiency determination (see 5.2.2 and E.8 of annex E)

a) To obtain the test dust samples from the bulk supply, the appropriate standard sampling method shall be used.

b) Immediately before use, each small quantity of inorganic contaminant shall be dried at a temperature between 110 and 150 °C for not less than 1 h.

c) The inorganic contaminant shall be allowed to cool in a desiccator and shall be stored in it.

6.4.3.3 Preparation of test rig

a) Prepare the test liquid as described in 5.1.

b) Flush the test rig by pouring 5 l of clean test liquid into the test tanks (1a and 1b) and recirculating for 15 min. This is achieved by attaching a separate flexible hose to the flexible transparent hose (7) and suspending the other end in the tanks 1a or 1b respectively.

c) After this flushing operation, pump out and discard the test liquid.

d) Clean the test rig with an arrangement in accordance with diagram A or diagram B of A.4 in annex A.

e) After approximately 30 min and before discarding the test liquid, take a sample at the orifice (11) and determine the level of contamination using the method specified in 6.4.3.5.

f) If the level of contamination exceeds 0,004 g/l (i.e. 1 % of the inorganic test contaminant concentration), the cleaning shall be repeated until this or a lower level is reached.

g) Prime the system by partially filling tank (1a) with clean test liquid, and starting the pump (6) to transfer test liquid through the filter under test (8) into the collecting tank (12). During this process, vent air from the filter by opening bleed orifices normally located on the filter head.

* 4,2 Hz (approximately).

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h) When priming is complete, close the bleed orifices, and continue pumping test liquid through the filter until the tank (12) is almost full but before the level of the test liquid reaches the outlet opening of the tank (1a).

i) Prepare a mixture of the organic choking contaminant concentrate and test liquid in a volume ratio of 1 to 99 in tanks 1a and 1b, making a total of 50 l in each tank. (The concentrate shall have been thoroughly mixed as indicated in 6.4.3.2.1.)

j) Weigh out the inorganic test dust to give a concentration in the test liquid in the tanks 1a and 1b of 0,4 g/l. Add the inorganic contaminant to 500 ml of the tank contents and stir at approximately 1 000 min^{-1} for 15 min.

The suspension containing the inorganic contaminant shall then be added to the bulk of the test liquid containing the organic contaminant in the main tanks 1a and 1b.

k) The prepared test liquid, with organic and inorganic contaminants now added, shall be stirred with the stirrer (2) for at least 30 min before commencing the test.

6.4.3.4 CONDUCTING THE TEST

a) Open the stopcock (4) at the bottom of the main tank (1a).

b) Start the pump (6) and allow the test liquid to flow through the filter under test (8) and adjust the flow to the required rate by controlling the speed of the pump (6).

c) Record the pressure difference indicated by the differential pressure gauge (9).

d) After 1 min, take a 300 ml sample of the test liquid from the sampling pipe (14).

e) After 2 min, 4 min and at intervals of 4 min thereafter, take 300 ml samples of effluent at the orifice (11) and record the pressure difference. The speed of the stirrer should be reduced to prevent aeration.

f) When a pressure difference of 0,7 bar is reached, take a final sample from the orifice (11) and a final sample from the sampling pipe (14).

g) Shut off the pump (6) and close the stopcock (4) at the bottom of the main tank (1a).

h) Should the test liquid from tank 1a become exhausted during the test, open the stopcock (4) on the main tank 1b, close the stopcock (4) on the main tank 1a, and continue the test.

Care shall be taken that the test liquid level does not drop so low as to allow air to be entrained.

i) Care shall be taken that there is no interruption or variation of flow in the course of the test.

j) Care shall be taken that the filter is not subjected to vibration or shock during the test.

6.4.3.5 DETERMINATION OF THE MASS OF INCOMBUSTIBLE (INORGANIC) PARTICLES IN THE TEST LIQUID SAMPLES

6.4.3.5.1 Each sample shall be passed through the filtration apparatus specified in A.4 of annex A, (2nd, 3rd and 4th items under "other equipment") or an equivalent apparatus. After filtration, wash the filter medium and the collected solids and the walls of the filter holder with a suitable solvent, such as petroleum ether of analytical quality, to remove all traces of the test liquid (150 to 200 ml is usually sufficient).

6.4.3.5.2 Ignite the filter medium and weigh the residue as specified in 6.4.3.5.3, making a correction for the ash content of the filter medium and any change in mass of the inorganic contaminant due to the incineration.

6.4.3.5.3 Ashing and weighing procedure

a) Wash a crucible (see A.4 of annex A) in water to which a little detergent has been added.

b) Dry the crucible and, using tongs, place it in the muffle furnace controlled at 800 ± 50 °C for 1 h. The crucible shall be handled with tongs from this stage.

c) Remove the crucible and place it in a desiccator until cool (i.e. for at least 1 h). Weigh to the nearest 0,1 mg.

d) Remove the filter medium from the filter holder with care, keeping it horizontal so that no insolubles are lost.

e) If a membrane is used, roll it into a cylindrical form, holding the lower end of the filter medium above the crucible, and carefully squeeze with thumb and forefinger of both hands to form a "flat tube".

NOTE — The membrane may be moistened to avoid cracking. Moistening may be achieved by carefully holding the membrane in contact with the flat surface of a clean sponge dampened with distilled water.

f) Fold the filter medium in half until small enough to go into the crucible.

g) Place the crucible and its contents on the hot-plate to incinerate the larger portion of combustible material. Care shall be taken to avoid open flaming of the contents.

h) When all the filter material has been incinerated on the hot-plate, place the crucible in the muffle furnace controlled at 800 ± 50 °C.

i) After 2 h, remove the crucible and place it in a desiccator to cool for at least 1 h before weighing to the nearest 0,1 mg.

j) Subtract the initial mass of the crucible from the final mass to obtain the mass of the residue, i.e. of the incombustible (inorganic) material.

k) The results shall be corrected by the subtraction of the mass of ash obtained from an unused filter medium.

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6.4.3.5.4 Calculation of particle retention

The mass of inorganic material in each effluent sample shall be related to the average mass of inorganic material in the initial and final applied influx samples.

The percentage particle retention is given by the formula :

$$\frac{m_1 - m_2}{m_1} \times 100$$

where

m_1 is the average mass, in grams, of inorganic material in the applied influx;

m_2 is the mass, in grams, of inorganic material in the effluent.

This formula applies to each test, i.e. with and without water saturation of the element.

6.4.4 *Test to determine the effect of water* (optional)

Immerse an unused filter element in the test liquid for 10 min, remove and drain for 10 min. Then immerse it in water for 30 min, after which remove it and allow it to drain for 10 min before installation in the test rig. Then carry out the test for particle retention and life in accordance with the procedure specified in 6.4.3.

6.4.5 *Test report*

6.4.5.1 The test report shall indicate at least the following :

a) the filter make and model;

b) a description of the filter; whether it is new or used; in the latter case, the approximate period of service;

c) the rated flow and the test flow rate, in litres, per hour;

d) the type or blend of test liquid;

e) its viscosity at the test temperature, in millimetres squared per second (centistokes);

f) the test temperature, in degrees Celsius;

g) the organic contaminant (see 5.2.1) :

- supplier;
- batch No.;
- volume, V_6, in millilitres, of test liquid to choke reference paper 633/6;
- volume, V_9, in millilitres, of test liquid to choke reference paper 633/9;
- choking ratio $\frac{V_6}{V_9}$;

h) inorganic contaminant (see 5.2.2) :

- supplier;
- grade;
- batch No.;
- 50 % mean particle size, in micrometres.

6.4.5.2 The test results shall be presented as follows :

6.4.5.2.1 Particle retention

Stage	Retention %	Δp bar
Initial (2 min)		
4 min		
8 min		
12 min and at 4 min intervals until 0,7 bar pressure difference is reached		

6.4.5.2.2 Filter life

a) In terms of time :

- measured time (t_1) to choke test filter to 0,7 bar : . . . min;
- corrected time : $t_2 = t_1 \frac{V_0}{V_9}$

where

V_0 is the standard volume (20 ml) to choke reference paper 633/9;

V_9 is the volume, in millilitres, to choke reference paper 633/9 with the batch of contaminant used in the test.

b) In terms of choking volume :

- measured volume (V_1) to choke test filter to 0,7 bar : . . . l;
- corrected volume : $V_2 = V_1 \frac{V_0}{V_9}$ l.

6.4.5.2.3 Diagram

The diagram showing particle retention and differential pressure versus choking time (see annex B).

6.5 Test for water separation efficiency

With this test it is possible to determine the quantity of water separated by the filter from a water-oil dispersion. This test should only be applied to filters which are claimed to separate water. The test may be conducted with new or used filters.

NOTE — The main pump (8), as specified in annex C, limits the use of the test to filters with rated flows up to 50 l/h. Filters with higher rated flows require the use of two or more pumps operating in parallel.

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