

Fuel filters, strainers and sedimentors for compression-ignition engines —

Part 1: Methods of test

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Filtration Society	Individual experts

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Foreword

This revision of BS 4552-1 has been prepared under the direction of the Mechanical Engineering Standards Committee.

Section 2, on the determination of the pressure drop/flow characteristics, and section 3, on the determination of initial particle retention, supersedes BS 4552-1:1970, with only minor modifications necessitated by the experience that has been gained since its publication.

Section 4, on the determination of particle retention stability and life, contains the material referred to as the proposed Part 2 in the foreword of BS 4552-1:1970.

Section 5, on the determination of the separation of undissolved water, contains the material referred to as the proposed Part 3 in the foreword of Part 1:1970.

Sections 6 to 12 contain material which is additional to the material mentioned in the foreword of Part 1:1970.

The application of the tests described in this standard to various types of filter is given in Appendix D.

If agreed between the purchaser and the manufacturer of the unit, the methods of test specified in this British Standard may be applied to units used with fuels other than those specified, the characteristics being measured with fuel relevant to the particular service.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 44, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

1 Scope

1.1 This British Standard specifies methods of testing certain performance characteristics of fuel filters, strainers and sedimentors for compression-ignition engines using diesel fuel (gas-oil) of classes A1 or A2 as specified in BS 2869, with flow rates in the range 5 litres/h to 500 litres/h.

1.2 The requirements of this standard are applicable to fuel filters with replaceable elements and elements integral with the canister.

2 References

The titles of the publications referred to in this standard are listed on the inside back cover.

3 Tests: general

3.1 For any test specified in this British Standard other than the test specified in section nine, the test flow rate shall be as agreed between the manufacturer and the purchaser.

NOTE In order to facilitate comparison with other tests, it is recommended that the test flow rate should be one of those specified in 3.2.

3.2 If no test flow rate is agreed between the manufacturer and the purchaser, the test flow rate for any test specified in this British Standard, other than the test specified in section 9, shall be one of the following:

5 litres/h, 10 litres/h, 25 litres/h,
50 litres/h, 75 litres/h,
100 litres/h, 125 litres/h, 150 litres/h,
175 litres/h,
200 litres/h, 250 litres/h, 300 litres/h,
400 litres/h or
500 litres/h.

3.3 For the test specified in section 9, the test flow rate shall be twice the value that would be selected for the unit under test in accordance with 3.1 or 3.2.

NOTE It is recommended that a minimum of four specimens of each type of unit are used in each test.

Section 2. Pressure drop/flow characteristics

4 Introduction

This section specifies the method of measuring the pressure drop across a filter, strainer or sedimentor at its rated flow, or at a rate of flow agreed between the purchaser and the manufacturer of the unit¹⁾.

5 Test rig

5.1 A gravity feed system fitted with a constant head device shall be used for this test.

5.2 The test rig shall include the components listed below, together with the necessary tubing, connectors and supports (see Figure 1 which shows the test rig diagrammatically; where items are identified by reference numbers, the following are used).

- 1) A header tank with sight glass.
- 2) A flow control valve.
- 3) The filter under test.
- 4) A pressure head tube to indicate the static pressure in the unit inlet pipe.
- 5) A pressure head tube to indicate the static pressure in the unit outlet pipe.
- 6) A collecting tank.
- 7) A device to measure the temperature of the test liquid in the header tank.
- 8) A device to measure the temperature of the test liquid as it enters the collecting tank.
- 9) A graduated cylinder for use in conjunction with a stopwatch or, alternatively, a calibrated flow meter.

5.3 The inlet and outlet pipes connected to the unit shall have the same bore as the unit ports. They shall each be horizontal and straight for a length equal to 20 times the bore diameter.

5.4 The pressure tapping on the inlet side of the unit shall be located at a distance from the unit connector equal to 8 times the bore diameter of the pipe, and that on the outlet side at a distance from the outlet of the filter equal to 12 times the bore diameter of the pipe. Care shall be taken to remove any burrs from the bore of the pipes near the tappings. In order to ensure that both inlet and outlet pipes remain full, the outlet pipe shall be so elevated that it terminates on a line above the highest part of the unit.

¹⁾ In this section, the filter, strainer or sedimentor under test is referred to as "the unit".

6 Test liquid

6.1 The test liquid shall be calibrating fluid²⁾ conforming to the characteristics specified in Figure 2.

6.2 The test liquid shall be free from undissolved water and free from additives other than any colouring dyes.

6.3 Before use, the test liquid shall be passed through a filter medium with a mean pore size between $0.4\ \mu\text{m}$ and $1.1\ \mu\text{m}$ ³⁾, clamped at the edges. A suitable filter holder is shown in Figure 3. The pressure drop across the filter medium shall not exceed $0.85\ \text{bar}$ ⁴⁾.

6.4 The test liquid shall be used at such a temperature that its kinematic viscosity lies between $4\ \text{mm}^2/\text{s}$ and $6\ \text{mm}^2/\text{s}$ ⁵⁾. Alternatively, it may be blended with refined spindle oil⁶⁾ or premium grade kerosine to give a kinematic viscosity between these limits at the test temperature.

6.5 Care shall be taken to ensure that the test liquid does not contain components in such a concentration that they will harm the skin.

7 Preparation of test rig

7.1 All equipment shall be clean.

7.2 The quantity of test liquid required for the test shall be stored in the vicinity of the test rig so that it attains the ambient temperature in the neighbourhood of the test rig.

7.3 Prime the test rig with the test liquid, taking care to bleed all air from the unit under test, and close valve (2).

7.4 Refill header tank (1) with test liquid.

8 Test procedure for determination of pressure drop/flow characteristics

8.1 Open and adjust the control valve (2) so that the flow is approximately equal to the nominal test flow rate (see clause 4) and observe the temperature of the test liquid in the header tank (1) and as it enters the collecting tank (6). The test shall not be valid if the temperatures at these two points differ by more than $3\ ^\circ\text{C}$ (corresponding to a viscosity difference of approximately $0.5\ \text{mm}^2/\text{s}$).

Use the mean of the two temperatures to assess the viscosity of the test liquid in the unit under test; the test shall not be valid if the viscosity does not lie between $4\ \text{mm}^2/\text{s}$ and $6\ \text{mm}^2/\text{s}$.

8.2 After stabilized flow and viscosity conditions have been achieved, maintain a steady flow for one further minute and then measure the rate of flow and the pressure drop.

8.3 If the rate of flow is measured by collection and timing, the measured volume (in litres) shall be not less than one-hundredth of the value of the test flow rate (in litres per hour).

8.4 Three readings shall be taken at different rates of flow not more than 20 % higher than the nominal test flow rate, and three readings at different rates of flow not more than 20 % lower than the nominal test flow rate.

9 Report of test results

9.1 The pressure drop at the nominal test flow rate shall be determined graphically.

9.2 The result of the test shall be presented as follows:

- a) testing establishment;
- b) date of test;
- c) unit make and model;
- d) a description of the unit tested;
- e) new or used unit;
- f) test flow rate in litres/h;
- g) direction of flow during test;
- h) type or blend of test liquid;
- i) viscosity at test temperature in mm^2/s ;
- j) test temperature in $^\circ\text{C}$;
- k) pressure drop in bars.

²⁾ A suitable oil is that designated "Fusus oil A" produced by the Shell International Petroleum Company Limited or that designated "Energol LM" produced by the British Petroleum Company Limited.

³⁾ Whatman no. 50 filter paper, Barcham Green no. 975 paper or any other medium giving a finer filtration, such as oxid cellulose acetate membranes, preferred diameter 140 mm.

⁴⁾ $1\ \text{bar} = 10^5\ \text{N/m}^2 = 100\ \text{kPa}$.

⁵⁾ $1\ \text{mm}^2/\text{s} = 1\ \text{cSt}$.

⁶⁾ A suitable oil is that designated "EM 40 spindle oil" produced by the British Petroleum Company Limited or that designated "Carnea 15" produced by the Shell International Petroleum Company Limited.

Section 3. Initial particle retention

10 Introduction

10.1 This section specifies the method of determining the percentage of a specified abrasive powder of known particle sizes that is retained by a filter, strainer or sedimentor under controlled conditions⁷⁾.

10.2 The tests shall be carried out on new filter elements (but see 14.1).

11 Test rig

11.1 The test rig shall include the components listed below, together with the necessary tubing, connectors and supports (see Figure 4 which shows the test rig diagrammatically; where items are identified by reference numbers, the following are used).

- 1) A main supply tank with a smooth internal finish and fitted with a sight glass (see 11.2).
- 2) A slurry supply tank with a polished internal finish and fitted with stirrer placed as close to the bottom of the tank as possible (see 11.3).
- 3) A stopcock (e.g. a pinch clip).
- 4) A transparent slurry feed tube (see 11.4).
- 5) A transparent main flow tube.
- 6) A thermometer (see 11.2).
- 7) A stopcock (e.g. a pinch clip).
- 8) A peristaltic pump incorporating either two or three rollers driven by a motor with variable speed control.
- 9) The filter, strainer or sedimentor under test.
- 10) A head tube in glass with a scale to which a mark can be applied to indicate the flow in conjunction with the restriction at (11).
- 11) A restriction to provide adequate back pressure (e.g. a tapered glass nozzle).
- 12) A collecting funnel.
- 13) A funnel cover.
- 14) A flexible pipe.
- 15) A stopcock (e.g. a pinch clip).
- 16) A filtrate receptacle.
- 17) A paddle stirrer.

11.2 The main supply tank (1) shall have a capacity sufficient to hold the total volume required to be passed through the unit under test (9) during the test. This volume (in litres) is equal to 0.4 times the value of the test flow rate in litres per hour. The thermometer (6) shall be inserted near the base of the tank.

11.3 The slurry supply tank (2) shall be cylindrical with a slightly tapered base and a central outlet. The diameter of this tank shall be between 0.3 and 0.5 times the diameter of the main supply tank (1)⁸⁾. The position of the slurry supply tank shall be such that, when both it and the main supply tank (1) are fully charged, the levels of the liquids are on the same plane.

11.4 The slurry feed tube (4) shall be of transparent small bore tubing inclined at not more than 45° to the vertical.

11.5 The pipes connecting the unit inlet to the rig shall have an internal bore equivalent to that of the unit or as agreed between manufacturer and user. An inverted U section terminating on a line above the highest point of the unit shall be included. The outlet of this pipe shall be fitted with a metering nozzle sufficient to create, at the rated flow, a head of at least 150 mm of test liquid in the head gauge (10) situated at the top of the inverted U section.

11.6 Provision shall be made for the reception of test liquid flowing from the metering nozzle (11) so that it may be directed into separate receptacles (16). (An arrangement of a small funnel, a flexible pipe and a pinch clip, as shown in Figure 4, enables this to be achieved quickly and without loss of test liquid.)

11.7 The following auxiliary equipment is also required:

- a) analytical balance with a capability of resolving to ± 0.1 mg;
- b) vacuum pump capable of producing 0.85 bar (85 kPa) vacuum;
- c) filtration apparatus suitable for suction operation with the filter discs referred to in d) (see Figure 5);

⁷⁾ In this section the filter, strainer or sedimentor under test is referred to as "the unit".

⁸⁾ The ratio of the cross-sectional areas of the main supply tank and the slurry supply tank is then approximately 6.25 : 1 and, since the liquids in the tanks are at the same height, the flow from the two tanks will also be in approximately this proportion. Since the volume of the slurry supply tank (in litres) is equal to 0.01 times the value of the test flow rate in litres per hour (see 16.1), the volume drawn from the main supply tank during a test run will be approximately 0.0625 times that value. Each test run will therefore take approximately $0.0725 \times 60 = 4.4$ min.

- d) ashless filter discs with a mean pore size between 0.4 μm and 1.1 μm ⁹⁾;
- e) drying oven set at 105 °C;
- f) desiccator;
- g) muffle furnace set at 800 °C;
- h) hot plate for the preliminary combustion of the filter disc, set at approximately 500 °C;
- i) crucibles, approximately 40 mm diameter and 36 mm in depth;
- j) stopwatch;
- k) glass beakers of suitable capacity;
- l) glass measuring cylinder of 2 litre capacity.

12 Test liquid

The test liquid shall be calibrating fluid as specified in clause 6. The provisions of that clause shall apply to the test specified in this section.

13 Test contaminant

The contaminant shall be fused aluminium oxide dust of the following grades¹⁰⁾.

- MIRA Grade 1 (see Figure 6)
- MIRA Grade 2 (see Figure 7)
- MIRA Grade 3 (see Figure 8)
- MIRA Grade 4 (see Figure 9)
- MIRA Grade 5 (see Figure 10)

The particle size distribution of the above test dusts shall fall within the limits illustrated by the curves in Figure 6, Figure 7, Figure 8, Figure 9 and Figure 10. Each dust shall be used separately for separate tests, using a new test filter or cleaned strainer or sedimentor for each test run.

This procedure will enable a complete particle retention curve, i.e. particle retention against 50 % MPS, to be drawn.

NOTE One grade of dust may be used, where an indication of performance is required, as may apply in the case of a quality check or where only one filter cartridge is available, e.g. grade 2 for fuel filters and grade 4 for strainers and sedimentors.

To obtain the test dust sample from bulk supply one of the methods of sampling given in BS 3406-1 shall be used. Method 1 described in BS 3406-1 is recommended. Immediately before use, each small quantity of test dust shall be dried by subjection to a temperature of between 110 °C and 150 °C for not less than 1 h.

14 Preparation

14.1 All equipment shall be clean. Fit the filter to be tested. If it is agreed between the user and the manufacturer that a unit should be tested after a given period of service, in order to minimize the effect of any residual transmission of contaminant already retained, the element shall be flushed with clean test liquid at the test flow rate for 30 min. This effluent shall be discarded.

14.2 Fill the main supply tank (1) (see Figure 4) with the test liquid, and flush the test unit to remove all air locks.

14.3 Switch on the pump (8) and, by means of a measuring cylinder and stopwatch, establish the datum on head tube (10) for the desired flow rate.

14.4 When the test liquid in the main tank (1) is exactly level with the slurry stopcock (3) close the stopcock and switch off the pump.

14.5 Refill the main tank (1) to a level equivalent to the charged level of slurry tank.

15 Test to determine insolubles in prepared test rig

15.1 Charge the slurry supply tank with the test liquid, equal in volume to 10 ml per litre per hour of the rating of the unit under test. Start the stirrer in slurry supply tank (2).

15.2 Without delay commence the test by switching on the pump, opening the slurry stopcock (3) simultaneously adjusting the pump speed, if necessary, to maintain the specified rate as indicated on the head tube (10). Collect the filtrate in the clean filtrate receptacle (16).

15.3 When the level of the liquid in the slurry supply tank has fallen to the base taper section of the tank (2) wash down the walls of the tank with an adequate amount of test liquid, using a wash bottle.

15.4 Complete this procedure before one-quarter of the total test volume of filtrate has passed through the unit under test.

15.5 Collect the filtrate in one or more receptacles (16) provided with suitable covers.

15.6 The flow through the test unit shall be maintained constant and continuous throughout the reception of the total test volume, after which, close cock (7) allowing the residue in the slurry and main transmission tubes to fall to the level of the unit under test. Switch off the pump.

⁹⁾ Whatman no. 50 filter paper, Barcham Green no. 975 paper or any other medium giving a finer filtration, such as oxid cellulose acetate membranes, preferred diameter 140 mm.

¹⁰⁾ It is recommended that, whenever possible, aluminium oxide dust should be purchased from the Motor Industry Research Association (MIRA), Watling Street, Nuneaton, Warwickshire.

15.7 The incombustible insolubles contained in the filtrate receptacle (s) shall be determined as detailed in **18.1**, **18.2** and **18.3**.

15.8 The total non-combustible insolubles shall be less than 1 % of the total test dust to be fed to the filter in the intended retention test.

16 Retention of particles

16.1 Prepare slurry as follows. For each 5 litres per hour rating of the unit take 0.050 ± 0.001 g of selected test powder and 50 ml of test liquid and mix intimately, e.g. by means of a mechanical shaker operating at a minimum of 250 Hz at an amplitude of 25 mm for 1 h. A drop of the suspension shall be examined microscopically to ensure that complete dispersion of the powder has been effected. Transfer the suspension to the slurry tank.

16.2 Without delay, commence the test by switching on the pump, opening the stopcock (7) and then opening the slurry stopcock (3) simultaneously adjusting pump speed, if necessary, to maintain the specified rate of flow as indicated on head tube (10). Collect the filtrate in a clean receptacle.

16.3 When the level of the slurry has fallen to the base of the taper section of the slurry supply tank (2) wash out the vessel in which the slurry was originally mixed with approximately 50 ml of test liquid and pour the washings into the slurry supply tank.

16.4 Subsequently, wash down the walls of the slurry supply tank with a quantity of test liquid using a wash bottle. During this procedure the level of liquid shall not fall below the slurry tank outlet.

16.5 Complete this procedure before one-quarter of the total test volume of filtrate has passed through the unit under test.

16.6 Collect the filtrate in one or more receptacles (16) provided with a suitable cover.

16.7 The flow through the unit shall be maintained constant and continuous throughout the reception of the total test volume, after which, close cock (7) allowing the residual liquid in the slurry and main flow tubes to fall to the level of the filter. Switch off the pump.

16.8 The incombustible insolubles, i.e. contaminant contained in the filtrate receptacle(s) and that remaining in the pipework and slurry supply tank, shall be determined as detailed in clause 18.

17 Reliability assurance of test results

In order to ensure reliability of test apparatus and procedure, a periodic test shall be made to determine the ability to recover contaminant offered. The procedure shall be as described in clause 16 with no test unit included in the system.

The total quantity of contaminant remaining in the slurry tank, pipework and that recovered from the filtrate receptacle(s) shall be not less than 97 % of that initially offered. The mass of solids recovered from the filtrate receptacle(s) shall be not less than 95 % of the total solids offered.

NOTE Where comparative tests between units are made it is recommended that the test powders used should be from the same batch.

18 Determination of incombustible contaminants in the test liquid

18.1 Each whole sample of filtrate for unit ratings up to and including 50 litres/h and at least a 5 litre representative sample of each volume of filtrate from large units (see **15.7**) shall be passed through a filter medium, as specified in **6.3**, ensuring that no leakage past the edges of the filter medium can occur. After filtration, wash the filter medium and collected solids with a suitable solvent, such as petroleum spirit of analytical quality, to remove all traces of test liquid: 200 ml to 250 ml is usually sufficient for a 140 mm diameter filter medium where 5 litres of filtrate have been used.

18.2 Ignite and weigh the filter medium as described in Appendix A.

18.3 Where only a proportion of the filtrate has been examined, the total mass of solids in the filtrate shall be calculated.

18.4 During filtrate analysis, remove and thoroughly wash out the receptacle in which the slurry was prepared, together with the slurry tank and all pipework from there to the unit inlet, to recover the residual contaminant. When determined, the mass of residual contaminant shall be deducted from that initially suspended in the test liquid, and the appropriate correction to the retention values applied. If this mass exceeds 5 % of the original mass of contaminant offered, the test shall be discounted and it shall be repeated.

19 Test to determine the effect of water contamination (filters only)

19.1 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 apparatus as specified in clause 11.

NOTE For filters with elements integral with the canister it is necessary to ensure that the element is thoroughly wetted.

19.2 The test for particle retention shall be made in accordance with the procedure described in clauses 14 to 18 inclusive.

20 Report of test results

The combined mass of solids in the filtrate shall be assessed. The mass of solids thus found shall be related to the corrected mass of solids offered and the results presented as the initial particle retention.

$$\text{Initial particle retention} = 100 \left(1 - \frac{m_1}{m} \right) \%$$

where

m is the corrected mass of test dust offered (in g)

m_1 is the combined mass of test dust in filtrate (in g).

The above applies to each test where applicable, i.e. with and without water saturation of the element, and the results of these tests shall be presented as follows:

- a) testing establishment;
- b) date of test;
- c) unit make and model;
- d) a description of the unit tested;
- e) new or used unit;
- f) test flow rate in litres/h;
- g) direction of flow during test;
- h) type or blend of test liquid;
- i) viscosity at test temperature in mm^2/s ;
- j) test temperature in $^{\circ}\text{C}$;
- k) abrasive contaminant:
 - grade;
 - batch number;
 - 50 % mean particle size (μm);
- l) initial particle retention %.

The 50 % mean particle size quoted shall be that recorded for the particular batch of test dust used.

Section 4. Particle retention stability and life

21 Introduction

21.1 This section specifies methods of comparing fuel filters by measuring their life and the variation in particle retention during their life, using a suspension of an abrasive powder of known particle size distribution and a fine carbon contaminant in a specified test liquid.

21.2 In order to obtain reliable information on the performance of a given type of filter, it is recommended that tests should be carried out on a minimum of four samples. The individual results shall be reported.

21.3 The tests shall be carried out on new filter elements.

21.4 The filter test is carried out as a continuous process during which a constant concentration of contaminant is fed to the filter in the test liquid. The performance of the filter under test is determined initially and during the process of choking by measuring the amount of abrasive test dust in samples taken from the effluent from the filter.

21.5 The test flow rate shall comply with the requirements of 3.2.

22 Test rig

22.1 The test rig shall include the following components, together with the necessary tubing, connectors and supports (see Figure 11 which shows the test rig diagrammatically; where items are identified by reference numbers, the following are used).

- 1) A main tank (see 22.2).
- 2) A reserve tank similar to the main tank.
- 3) Paddle stirrers operating in the main tank and in the reserve tank as close to the bottom of the tanks as possible (see 22.3).
- 4) ON/OFF valves controlling the output from the main tank and from the reserve tank.
- 5) A peristaltic pump driven by an electric motor with variable speed control and incorporating either two or three rollers.
- 6) The filter under test.
- 7) A mercury manometer reading up to 0.70 bar (70 kPa).
- 8) A head tube in glass to which a mark can be applied to indicate the flow in conjunction with the restriction at (9).
- 9) A restriction to provide adequate back pressure.
- 10) A filtrate receptacle.
- 11) A sampling point consisting of a 6 mm bore pipe with ON/OFF cock.
- 12) A clean-up filter holder (see 22.5).
- 13) Separate piping and flexible hoses, minimum bore 12 mm, for clean-up operation.

22.2 The main tank and the reserve tank shall each have a minimum capacity of 50 litres. This size is suitable for testing filters with a flow rate up to 90 litres/h. For higher flow rates, the capacity of each tank in litres should be not less than 55 % of the value of the hourly flow rate in litres per hour.

22.3 The paddle stirrers shall be as shown in Figure 12 and shall be operated at an approximate rotational frequency of 200 min^{-1} (200 r/min). If tanks larger than 50 litres capacity are used, a scaled stirrer shall be used, and the system validated.

22.4 The piping in the rig shall have a bore not less than 12 mm and shall be smooth, except that the inlet and outlet pipes connected to the unit under test shall have the same bore as those normally used with the unit in service and shall be straight for at least the lengths indicated in Figure 11.

22.5 The clean-up filter holder shall be suitable for use with 140 mm to 150 mm diameter ashless filter discs with a mean pore size between $0.4 \mu\text{m}$ and $1.1 \mu\text{m}$ ¹¹⁾ and shall support the filter paper adequately. A suitable design of filter holder is shown in Figure 3.

22.6 The following auxiliary equipment is also required:

- a) analytical balance with a capability of resolving to $\pm 0.1 \text{ mg}$;
- b) vacuum pump capable of producing 0.85 bar (85 kPa) vacuum;
- c) filtration apparatus suitable for suction operation with the filter disk referred to in **22.5** (see Figure 5);
- d) ashless filter discs with a mean pore size between $0.4 \mu\text{m}$ and $1.1 \mu\text{m}$ ¹²⁾;
- e) drying oven set at 105°C ;
- f) desiccator;
- g) muffle furnace set at 800°C ;
- h) hot plate for the preliminary combustion of the filter disc, set at approximately 500°C ;
- i) crucibles, approximately 40 mm diameter and 36 mm in depth;
- j) stopwatch;
- k) glass beakers of suitable capacity;
- l) glass measuring cylinder of 2 litre capacity.

22.7 The further equipment required for certain auxiliary procedures is described in Appendix B and Appendix C.

23 Test liquid

The test liquid shall be calibrating fluid as specified in clause 6. The provisions of that clause shall apply to the test as specified in this section.

24 Test contaminants

24.1 The carbon contaminant concentrate shall consist of a dispersion of 1 gram of carbon black in a blend of 90 millilitre test liquid and 10 millilitre detergent additive.

The carbon contaminant concentrate¹³⁾ is difficult to prepare and, when prepared, it shall be tested for suitability as described in Appendix B.

24.2 The abrasive contaminant shall be fused aluminium oxide dust as specified in clause 13. Unless otherwise agreed between the filter manufacturer and the purchaser, grade 2 dust, with a particle size distribution as shown in Figure 7, shall be used.

25 Preparation of test rig

25.1 Insert a straight connecting pipe in place of the test filter. Clean the test rig by pouring 10 litres of clean test liquid (see 6.3) into the main tank and circulate it through the clean-up filter and the rig for 30 min. Wash the walls of the tank continuously, using the flexible hose, during this operation. Discard the test liquid used in this operation. Repeat the complete operation using the test liquid from the reserve tank.

25.2 Repeat the operations specified in 25.1. At the end of this operation, take a 300 millilitre sample of liquid from each tank, collected through the sample cock (11). Discard the remainder of the test liquid.

25.3 Determine the level of contamination of each sample, using the method described in clause 28. If the level of contamination in the sample exceeds 0.004 g/l (i.e. 1 % of the test contaminant concentration), the cleaning operation described in 25.1 and 25.2 shall be repeated until this level is attained.

25.4 Remove the clean-up filter and connecting pipe and install the test filter in the rig.

¹¹⁾ Whatman no. 50 filter paper, Barcham Green no. 975 paper or any other medium giving a finer filtration, such as oxid cellulose acetate membranes, preferred diameter 140 mm.

¹²⁾ Whatman no. 50 filter paper, Barcham Green no. 975 paper or any other medium giving a finer filtration, such as oxid cellulose acetate membranes, preferred diameter 140 mm.

¹³⁾ Because of the difficulty of preparation it is recommended that, whenever possible, it should be purchased from the Motor Industry Research Association (MIRA), Watling Street, Nuneaton, Warwickshire.

25.5 Prime the system by partially filling the main tank and the reserve tank with clean test liquid; with the outlet valves from the tanks open, transfer the test liquid by pumping it through the test filter into the filtrate receptacle. During this process air shall be vented from the filter by opening the bleed orifices usually located on the filter head.

25.6 When priming is complete, close the bleed orifice and continue pumping test liquid through the filter until each tank is almost empty but close the outlet valve of each tank before the level of the test liquid reaches the outlet opening of the tank.

26 Preparation of test fluid contaminant mixture

26.1 Carbon contaminant. The carbon contaminant concentrate shall be supplied in a container of approximately 5 litres capacity which is approximately 75 % full. It shall be thoroughly agitated by shaking vigorously for 5 min.

Immediately following this preliminary shaking, place the container on its side on a laboratory shaker and agitate it longitudinally at a frequency of approximately 250 cycles per minute at approximately 25 mm amplitude for 2 h.

After shaking, the contents shall be transferred to a 5 litre beaker and stirred at a rotational frequency of 250 min^{-1} (250 r/min) until the tests are completed.

Immediately after this stirring, take a sample of the contaminant concentrate and check that its solid content is $1 \pm 0.1 \text{ % m/V}$ (mass to volume) (see Appendix C).

Prepare a mixture in the proportion of 1 : 99 by volume of the carbon contaminant concentrate to the test liquid. Fill the main and the reserve tanks, and stir with the paddle stirrer shown in Figure 12.

26.2 Abrasive contaminant for efficiency determination. An appropriate standard sampling method (see BS 3406-1) shall be used for the removal of the abrasive contaminant from its bulk supply.

Immediately before use, a small quantity of the abrasive contaminant shall be dried at a temperature between 110°C and 150°C for not less than 1 h. The abrasive contaminant shall be allowed to cool in a desiccator and shall be stored in the desiccator until required for use.

Weigh out the abrasive test dust to give a concentration in the test liquid in the tanks of 0.4 g/l (i.e. 20 g to 50 litres).

26.3 Mixing and final stirring. Add the required quantity of abrasive contaminant to 500 ml of the diluted carbon contaminant taken from the main tank; repeat for the reserve tank. Stir each mixture at 200 min^{-1} (200 r/min) using the stirrer for 30 min, and immediately check dispersion by examination using a microscope. The suspension containing the abrasive contaminant shall be added to the test liquid containing the carbon contaminant in the two tanks. Stir each tank continuously for a minimum of 30 min until the test is commenced. Stirring shall be continued throughout the duration of the test.

27 Test procedure for determination of particle retention stability and life

27.1 Open the control valve (4) (see Figure 11) at the base of the main tank.

27.2 Start the pump (5), allow the test liquid to flow through the filter under test (6) and adjust the flow to the test flow rate by controlling the speed of the pump. The measured time starts when the pump is started.

27.3 When the flow has reached the required rate, record the pressure drop across the filter indicated by the mercury manometer (7). The flow rate shall not vary or be interrupted throughout the test.

27.4 At the times after the start of the test shown in Table 1 (see 27.2 for the start of the test), take samples approximately of the size indicated in Table 1 from the inlet sampling point (11) and from the outlet (9) from the filter under test. Record the pressure drop shown by the manometer (7) when starting to take each outlet sample.

27.5 If the test liquid in the main tank (1) becomes exhausted during the test, change to the reserve tank (2) without interrupting the test. To do this, before the level of the test liquid in the main tank reaches the outlet opening, open valve (4) on the reserve tank and close valve (4) on the main tank. If necessary recharge each tank as it becomes empty (see 26.3) and continue the test using each tank in turn.

27.6 When a pressure drop of 0.7 bar (70 kPa) or a value agreed between the filter manufacturer and user is reached, record the time and take final samples from points (11) and (9). If the pressure drop, after an initial rise, has not substantially changed for 30 min, the test shall be discontinued and the results recorded.

27.7 Stop the pump (5) and close the valve (4) at the base of the main or the reserve tank, whichever is in use.

Table 1 — Sizes and timing of inlet and outlet samples in retention stability test

1	2	3	4	5
Test flow rate		Times of sampling after start		Size of each sample
Over	Up to and including	Inlet sample	Outlet sample	
litres/h	litres/h	min	min	ml
5	10	4 and at	6, 10, 14 ^a	100
10	25	4 end of	6, 10, 14 ^a	200
25	100	1 test	2, 4, 8, 12 ^a	300
100	500	1 (see 27.6)	2, 4, 8, 12 ^a	1 000

^a Continue at 4 min intervals.

28 Validation of test rig and sampling technique

28.1 In order to ensure reliability of test apparatus and procedure, a periodic test shall be made to determine the ability to recover contaminant offered. The procedure shall be as described in clauses 25 and 26 but the filter under test (25.4) shall be replaced by a piece of clear plastics tubing of 12 mm bore

28.2 Open the control valve (4) (see Figure 11) at the base of the main tank 1.

28.3 Start the main pump (5), allow the test fluid to flow through the system and adjust the flow to the required rate by controlling the speed of the pump. The measured time starts when the pump is started.

28.4 After 5 min, and at 5 min intervals thereafter, take an effluent sample from outlet (9), the sample volume to be as specified in Table 1.

28.5 After the taking of the effluent samples a sample shall be taken from the sampling point (11). The sample tap is first opened and a volume approximating to 10 % of the sample volume (as specified in Table 1) allowed to go to waste before the sample is taken.

28.6 The test is continued until approximately three-quarters of the tank volume has been used. The pump is then switched off and the control valve (4) closed.

28.7 Each sample taken shall be filtered as described in clause 29.

28.8 The concentration of abrasive contaminant in each sample shall be calculated.

28.9 The concentration of abrasive contaminant in each sample shall be within $\pm 5\%$ of 0.4 g/litre.

28.10 This test shall also be carried out on main tank 2.

29 Determination of abrasive contaminant in test liquid samples

29.1 Each sample of filtrate shall be passed through a filter medium [see 22.6 c) and d) and Figure 5]. Towards the end of the filtering of each sample, wash the filter medium, the solids collected on it and the walls of the filter holder with petroleum spirit of analytical quality, 40 °C to 60 °C boiling range: 150 ml to 200 ml is usually sufficient.

29.2 Ignite the filter medium and weigh the residue as specified in Appendix A.

30 Test procedure for determination of the effect of water contamination

30.1 Immerse an unused filter element in clean test liquid for 10 min, then remove it and allow it to drain for 10 min.

NOTE For filters with elements integral with the canister it is necessary to ensure that the element is thoroughly wetted.

30.2 Immerse the filter element in distilled water for 30 min and then remove it and allow it to drain for 10 min.

30.3 Install the filter element in the test rig.

30.4 A test for particle retention and life shall be carried out in accordance with the procedure described in clauses 25 to 29.

31 Report of test results

31.1 Particle retention. The mass of abrasive material in each effluent sample shall be related to the average mass of abrasive material in the initial and final influent samples, as follows:

$$\text{Particle retention (\%)} = 100 \left(1 - \frac{m_2}{m_1} \right)$$

where

m_1 is the average mass of abrasive material (in 100 ml) of the influent supplied to the filter

m_2 is the mass of abrasive material (in 100 ml) of the effluent sample.

31.2 Filter life

a) In terms of time:

measured time (t_1) to choke test filter
to 0.7 bar: minutes;

$$\text{corrected time: } t_2 = t_1 \frac{V_0}{V_9}$$

where

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

V_9 is the average volume (in ml) 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;

$$\text{corrected volume (litres): } V_2 = V_1 \frac{V_0}{V_9}$$

31.3 Presentation of results. The results of a test to determine the particle retention stability and life of a filter shall be presented as follows:

- testing establishment;
- date of test;
- unit make and model;
- a description of the unit tested;
- new or used unit;
- test flow rate in litres/h;
- direction of flow during test;
- type or blend of test liquid;
- viscosity at test temperature in mm^2/s ;
- test temperature in $^{\circ}\text{C}$;
- carbon contaminant concentrate
(see Appendix B):

supplier

batch no.

average volume (V_6) to choke reference
paper 633/6 ml

average volume (V_9) to choke reference
paper 633/9 ml

$$\text{choking ratio } \frac{V_6}{V_9};$$

l) abrasive contaminant:

supplier

grade

batch no.

mean particle size in μm (Stokes diameter);

m) particle retention stability:

Sampling time	Pressure drop across filter	% retention (see 30.1)
	bar (kPa)	

n) filter life:

Corrected time (in min) to choke
to 0.7 bar (70 kPa).

Corrected volume of carbon contaminant
Volume of concentrate (in ml) to choke
to 0.7 bar (70 kPa).

31.4 Graphical presentation. The results shall also be shown graphically. A typical graphical presentation is shown in Figure 13 and Figure 14.

Section 5. Test to determine the separation of undissolved water

32 Introduction

32.1 The test specified in this section determines the quantity of water separated by the filter from a water-in-diesel fuel (see 34.1) dispersion.

32.2 This test shall be applied only to filters that are claimed to be able to separate water from the fuel. The test may be conducted with new or used filter elements.

32.3 The main pump specified for the test in this section limits the test to filters with rated flows up to 50 litres/h. Filters with higher rated flows require the use of two or more pumps in parallel. Alternatively, and especially for the highest flow rates, the pump to be used with the filter in service may be used for the test specified in this section, but results are then only valid for comparison with other tests also made with that type of pump.

32.4 Diesel fuel that has been repeatedly used for water separation tests may have become degraded so that it is unsuitable for further use for these tests and should be discarded. The purpose of the preliminary test specified in 34.2 is to ensure that the liquid used for the test has characteristics similar to those of new diesel fuel in respect of water separation.