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

*Véhicules routiers — Filtres à combustible pour moteurs à combustion interne à allumage par compression — Partie 1 :
Méthodes d'essai*

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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.*

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).

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 oil²⁾ 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 mm²/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 μ m.

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 filters¹⁾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 dust²⁾. 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.

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.

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 contaminated 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 $1 \pm 0,1$ % 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).

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 $1\ 000\ \text{min}^{-1}$ 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 $800 \pm 50\ ^\circ\text{C}$ 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 $800 \pm 50\ ^\circ\text{C}$.

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.

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.

6.5.1 Test installation

See A.5 of annex A, and annex C.

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

For this test, ordinary diesel fuel oil free from anti-smoke additives and undissolved water shall be used.

6.5.1.1 TEST FOR SUITABILITY OF DIESEL FUEL

Add 20 ml of distilled water to 80 ml of the diesel fuel in a 100 ml measuring cylinder. Stopper the cylinder and shake it for 2 min. With the cylinder at rest, observe the fuel-water separation.

For the fuel to be suitable, the separation must be almost complete after 2 min and complete after 5 min.

(Diesel fuel that has been used repeatedly for water separation tests may have become dirty so that it will fail the above test and will have to be discarded.)

6.5.2 Other equipment

See A.5 of annex A.

6.5.3 Procedure

6.5.3.1 PREPARATION AND CALIBRATION

- a) All equipment shall be clean and free from water. Fit a new element in the absorbent filter (24), if necessary.
- b) Fill the main tank (1) with test liquid free from undissolved water. Open valve (11) and check that the stopcock (13) is shut. Start the main pump (8) and adjust valve (11) so that the flow through the pump is 50 l/h^1 .
- c) If a recirculation system is used, allow the collection tank (20) to fill partly and refill the main tank (1). Start the transfer pump (21), flush the coalescer (23) and absorbent filter (24), and adjust valve (25) to balance the main flow.
- d) Fill the water tank (3) with distilled or de-ionized water. Open valve (6) and adjust it to give a flow of 1 l/h^1 . The percentage water content in the test liquid will then be approximately 2% and the water will be dispersed by the action of the main pump (8). It is essential to keep the level in the water tank (3) reasonably constant, otherwise frequent adjustment of valve (6) will be necessary. For this purpose, it is recommended that a constant level device (4) be fitted.
- e) Stop the water feed by shutting valve (6).

NOTE — The over-flow valve should be made non-operative during these operations.

6.5.3.2 TEST TO DETERMINE THE SEPARATION OF UNDISSOLVED WATER

- a) Fit the filter to be tested (15) into the circuit. Open valve (17) (and valve (19)) and the stopcock (13). Flush the filter under test (15) to remove air locks. Then set the flow to the rated value of the filter under test or to any other required value by adjusting valves (17) and (19) and at the same time adjusting the by-pass valve (11) so that the flow through the main pump (8) is $50 \pm 5 \text{ l/h}^{1)2)}$. Note and maintain constant the level in the head tube (18).
- b) Open valve (6) and adjust to give a flow of $1 \pm 0,02 \text{ l/h}^1$. The filter under test will now receive test liquid having a water concentration of approximately 2%. Note the pressure difference in the manometer (16).
- c) Continue the flow for a period of 60 min, taking 100 ml samples at the outlet (19) after 5 min, and then at 5 min intervals. As the test proceeds, water will collect in the bowl of the filter under test. This water shall be drained off whenever the bowl is 50% full. Water shall not be drained off when a sample is being taken. If the bowl is not transparent, measure its volume and calculate the draining time interval, assuming 100% water separation. After the final sample has been taken, again note the pressure difference on the manometer (16).
- d) Analyse the samples of effluent taken according to 6.5.3.2c) for undissolved water content in accordance with the method specified in annex C, clause C.2, or by the Karl Fischer method (ISO 760).

6.5.4 Test report

6.5.4.1 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 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.

6.5.4.2 The test results shall be presented as follows :

- a) in graphical form as shown in annex C;
- b) average undissolved water content in milligrams per litre (state method of analysis used, either annex C or Karl Fischer method, ISO 760);

1) If two or more pumps are used, this value shall be multiplied by their number.

2) The reason for maintaining this flow through the main pump (8), regardless of the rated flow of the filter under test (15), is to maintain a standard condition with regard to water droplet size.

- c) initial differential pressure across filter tested, in bars or millibars;
- d) final differential pressure across filter tested, in bars or millibars.

6.6 Collapse/burst test of the filter element

The purpose of this test is to determine the resistance of the filter element to rupture under applied differential pressure.

It is useful to conduct the test with filters which have already been tested by the bubble test.

6.6.1 Test installation

See A.6 of annex A.

The test liquid temperature shall be 23 ± 15 °C.
- 10

For this test, an engine oil in the SAE 20 to 40 range shall be used.

6.6.2 Other equipment

See A.6 of annex A.

6.6.3 Procedure

Use as contaminant pulverized Vinsol resin¹⁾ (P.V. resin); the particle size distribution shall be :

- 100 % to pass 20 mesh (850 µm)
 - 85 % to pass 80 mesh (180 µm)
 - 50 % to pass 200 mesh (75 µm)
- (ASTM E11 sieve sizes)

Prepare a concentrate containing 100 g of contaminant per litre of test liquid. Pour into the tank 5 l of test liquid. Then start the pump and adjust the flow to the rated flow of the filter under test. Then start the stirrer. Every 5 min, add 25 ml of the concentrate to the tank.

Plot a graph of pressure difference against time. Failure of the filter element is indicated by a permanent fall in pressure difference, or by a marked drop in the rate of pressure rise. Continue the test until failure, or until a pressure difference of 3 bar is reached, whichever occurs first.

6.6.4 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 collapse/burst test in accordance with the procedure specified in 6.6.3.

6.6.5 Test report

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, in litres per hour;
- d) the collapse/burst pressure, in bars, or
- e) the time, in minutes, to reach a pressure difference of 3 bar.

6.7 Burst test of complete filters

The purpose of this test is to determine the mechanical resistance of the complete filter to internal pressure.

6.7.1 Test installation

Laboratory hydraulic hand pump, with suitable connections or adaptors to attach to the filter under test.

Pressure gauge, with a measuring range of 0 to 15 bar.

Test liquid, the properties of which are shown in annex D, suitably coloured for visual observation of leakage.

The test liquid temperature shall be $+ 23 \pm 5$ °C.

6.7.2 Test procedure

- a) Install the detachable filter housing on an appropriate head, applying the recommended average tightening torque. Connect to the pump by means of a suitable adaptor. Install spin-on filters on an appropriate adaptor, applying the recommended tightening torque for the filter under test.
- b) Connect the pump outlet pipe to the inlet of the filter or adaptor and ensure that the outlet from the filter is open.
- c) Position the filter so that the outlet is at the highest point relative to the remainder of the filter.
- d) Introduce test liquid into the filter by operating the hydraulic pump until liquid is seen to emerge from the outlet connector of the filter. This indicates that all the air has been excluded from the system.
- e) Close the filter outlet using a suitable plug and clean off all surplus liquid.
- f) Raise the internal pressure to 1 bar, and maintain for 30 s, checking the filter for leaks and other adverse effects during the raising and maintenance periods of pressure.

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

- g) Reduce the pressure to zero by opening the venting cock on the pump, wait 30 s and check for permanent distortion, or other visual defects. Attempt to rotate the housing by hand to ensure that pressure has not caused loosening. Relative movement of one half to the other of the housing assembly should be checked.
- h) Close the venting cock and repeat the above procedure, increasing the pressure in steps of 1 bar.
- i) Continue until ultimate failure (i.e. bursting or leaking) occurs or until a pressure of 10 bar is reached.

6.7.3 Test report

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 in litres per hour;
- d) the failure pressure in bars, or no failure at 10 bars;
- e) the mode of failure and its location;
- f) the torque applied in accordance with 6.7.2 a).

6.8 Pulsating pressure fatigue test

The purpose of this test is to determine the mechanical resistance of the complete filter to pulsating pressure such as would occur under stop/starting conditions.

6.8.1 Test installation

See clause A.7 of annex A.

Pulse rig as shown in the figure, capable of producing the pressure wave form indicated in 6.8.4, with suitable adaptors to attach the test filter to the rig. An alternative rig is permissible provided that the pressure wave form is as indicated in 6.8.4.

Suitable torque wrench and adaptors.

Test liquid, the properties of which are shown in annex D. It shall be suitably coloured for visual observation of leakage. The test liquid temperature shall be 23 ± 5 °C. Other temperatures may be used as agreed between the filter manufacturer and the engine manufacturer.

6.8.2 Test procedure

- a) Install the filter on an appropriate adaptor, applying the recommended tightening torque for the filter to be tested.
- b) Connect the test adaptor into the pipework system of the pulse test rig.
- c) Start the pump, ensuring that the valve (4) is fully open before commencing the test, by operating the solenoid valve control switch and the main switch.

d) Allow the rig to run under the above conditions until all air has been excluded from the system, shut the solenoid valves, adjust valve (4) until the required peak test pressure is attained, switch on the solenoid valves to obtain a pressure wave form as indicated in clause 6.8.4. Any further adjustments during the test should be made as necessary during the periods when the solenoid valves are closed in order to avoid the filter being overloaded.

e) Set the counter to zero.

f) When using the test rig illustrated, open the inlet and return valves of the water cooling system and adjust the water flow to regulate the reservoir oil temperature (preferred maximum : 30 °C). Ensure that the thermostat situated in the rig oil reservoir is set at 30 °C as this is fitted as a safety device to switch off the rig should the temperature rise to this level.

g) Allow the test to continue, making visual checks for signs of failure at frequent intervals, until failure occurs or until the required number of pulses has been applied.

h) To stop the test, fully open valve (4), and switch off the pump and solenoid valve control switch.

i) Check and record the tightening torque (i.e. turn in the tightening direction).

j) Remove the filter, allow to drain, and visually examine the filter to determine the failure point and type of failure.

6.8.3 Test report

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 in litres per hour;
- d) the test pressure in bars;
- e) the mode of failure and its location;
- f) the torque applied initially and at the end of the test [see 6.8.2 a) and i)];
- g) the number of cycles to failure or the number of cycles completed.

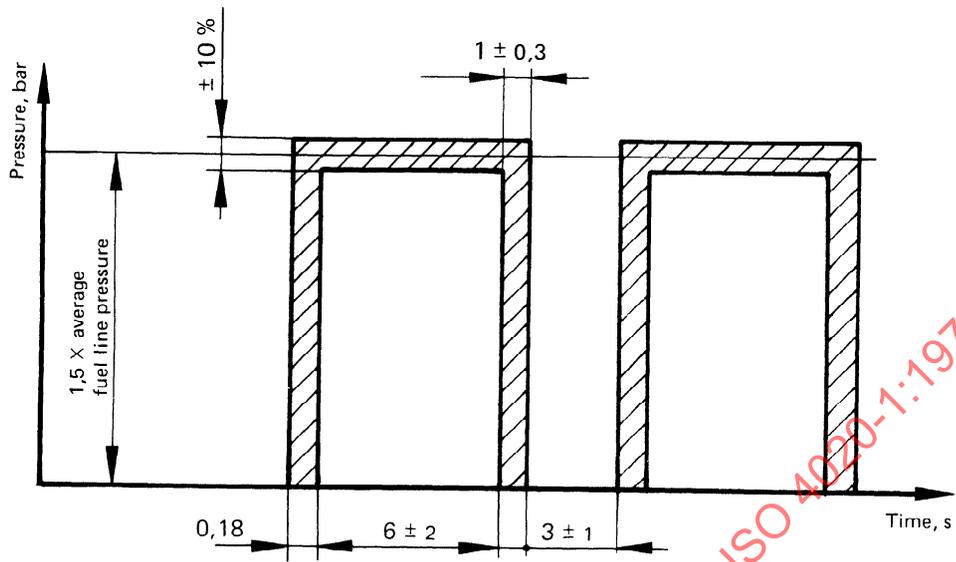
NOTE — The number of cycles to be completed shall be as agreed between the engine manufacturer and the filter manufacturer.

6.8.4 Pulsating pressure wave form requirement (See figure on next page.)

6.9 Vibration resistance fatigue test

The purpose of such a test is to determine the mechanical resistance to vibration under normal service conditions.

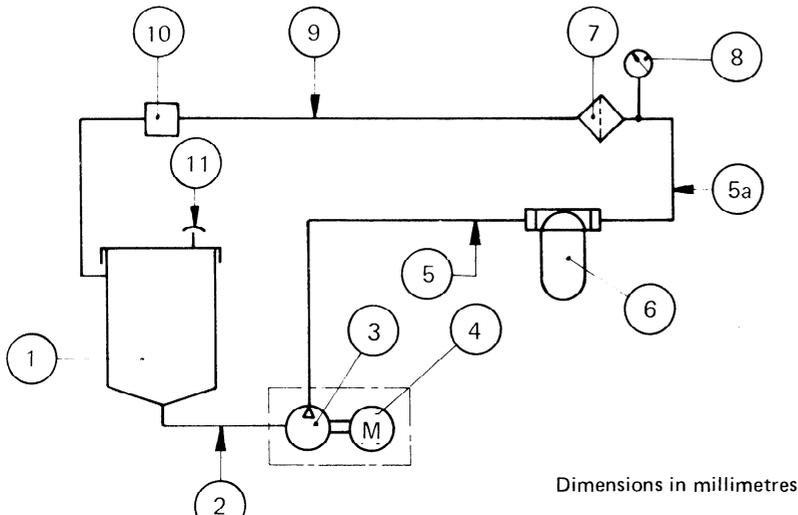
Depending on the application and location of the filter on the vehicle, the vibration fatigue test parameters shall be as agreed between engine manufacturer and filter manufacturer.



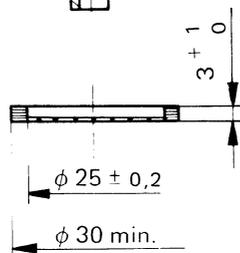
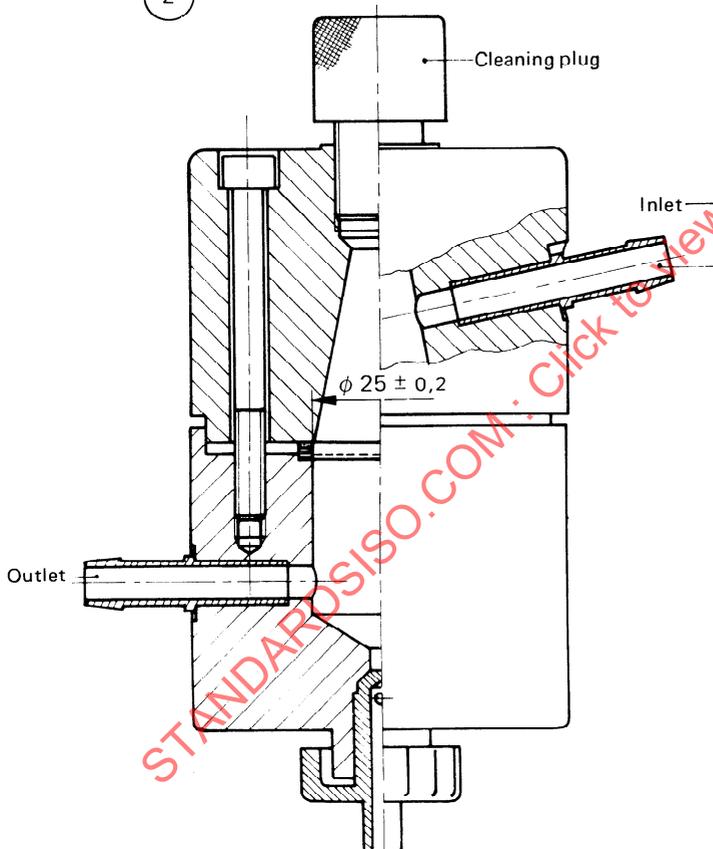
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ANNEX A
TEST INSTALLATIONS

A.1 TEST FOR CLEANLINESS OF NEW FILTERS (see 6.1)



Dimensions in millimetres



Test sieve of polyamide, fabric basket or twill weave, size of aperture width $28 \mu\text{m}$, wire diameter $25 \pm 1 \mu\text{m}$, open area of sieve 28 %

This drawing is only an example. However, dimensions specified and specifications given for the test sieve shall be complied with.

Measuring device (item 7)

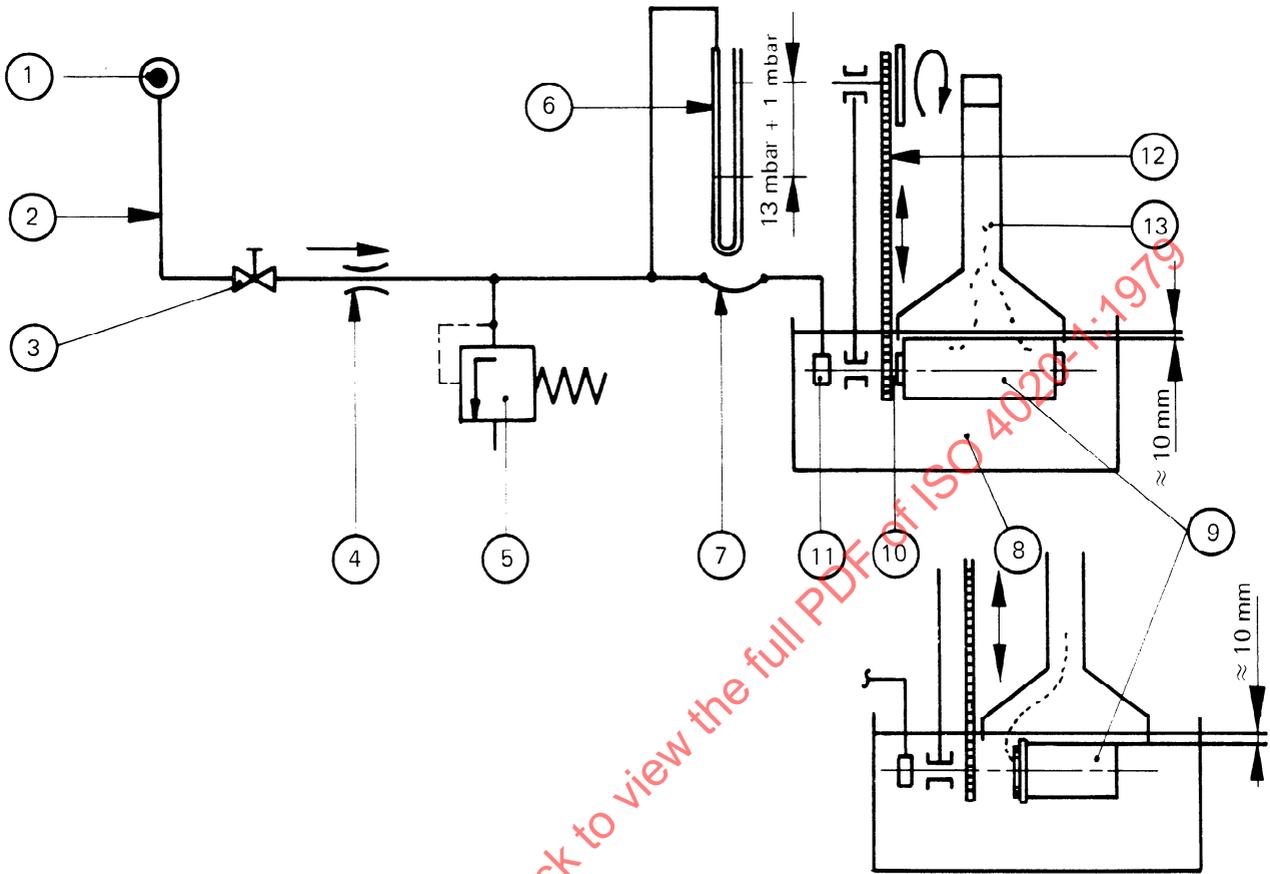
TEST RIG COMPONENTS

- 1 Tank with test liquid, minimum capacity 10 l, overlapping cover
- 2 Suction pipe
- 3 Feed pump
Only pumps of plunger or diaphragm type shall be used. The flow rate of the pump shall be approximately twice the rated flow of the filter under test at a pressure difference of 0,2 bar
- 4 Electric motor
- 5 Pressure pipe
- 5a Flexible hose
- 6 Filter to be tested
- 7 Measuring device (see drawing at bottom left)
- 8 Pressure gauge, measuring range 0 to 1,5 bar (above atmospheric pressure)
- 9 Return pipe
- 10 Flowmeter adapted to nominal test flow
- 11 Air-vent

OTHER EQUIPMENT

- Drying cabinet
- Laboratory balance, accuracy $\pm 0,1 \text{ mg}$
- 2 Petri dishes, with lids
- Tweezers
- Soft hair brush
- Wash bottle, 100 ml, filled with petroleum ether
- Filter paper

A.2 BUBBLE TEST (see 6.2)



TEST RIG COMPONENTS

- 1 Connection to compressed air line; air must be dry
- 2 Connection pipe, of metal, nominal internal diameter 4 to 6 mm
- 3 Stopcock
- 4 Needle valve (fixed throttle)
- 5 Constant-pressure device, adjustable
- 6 Manometer, adapted to the measuring range

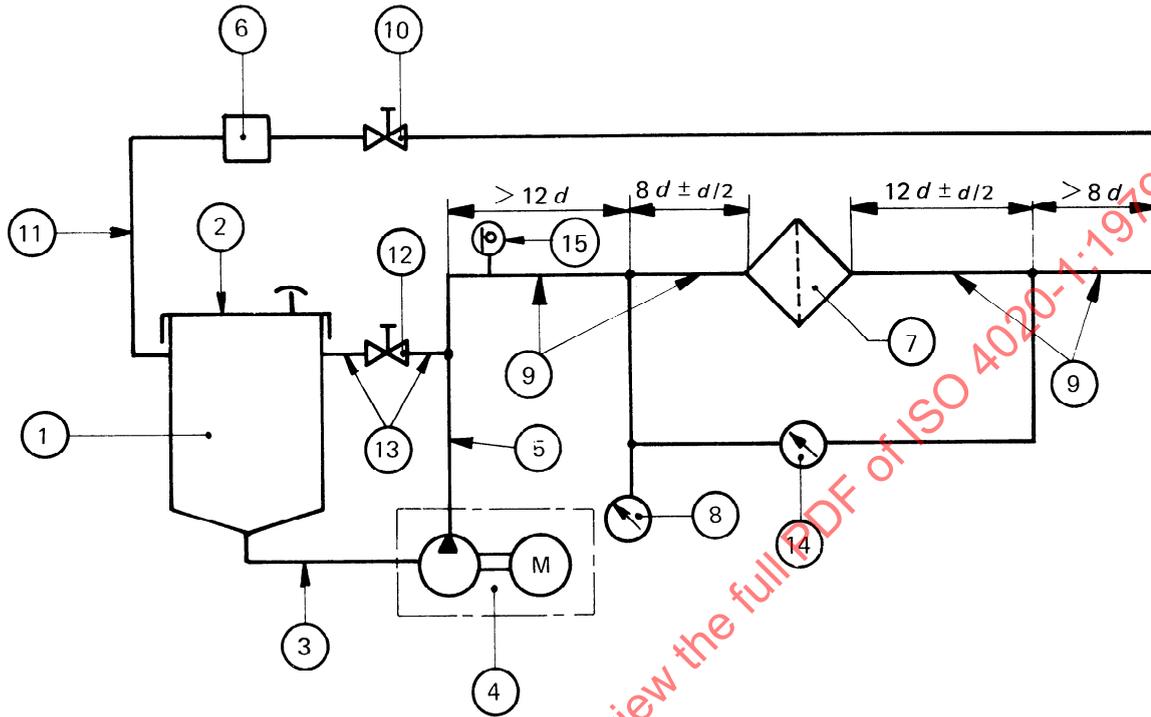
- 7 Flexible hose, nominal internal diameter 4 to 6 mm
- 8 Tank, minimum capacity 20 l
- 9 Filter element to be tested
- 10 Rotating axle
- 11 Rotary fitting
- 12 Device for rotation of filter element
- 13 Bubble trap, capacity approximately 1 l, with graduated scale, accuracy of reading 1 cm³

OTHER EQUIPMENT

Stop-watch

A.3 TEST FOR PRESSURE DIFFERENCE OF NEW FILTERS (see 6.3)

d = internal diameter of pipes



TEST RIG COMPONENTS

- 1 Tank with test liquid, minimum capacity 10 l
- 2 Cover of the tank, with air-vent
- 3 Suction pipe
- 4 Variable speed motor-pump set, capable of non-pulsating delivery of the nominal flow at the pressure used normally in practice.
- 5 Pressure pipe
- 6 Suitable flow-meter
- 7 Filter to be tested

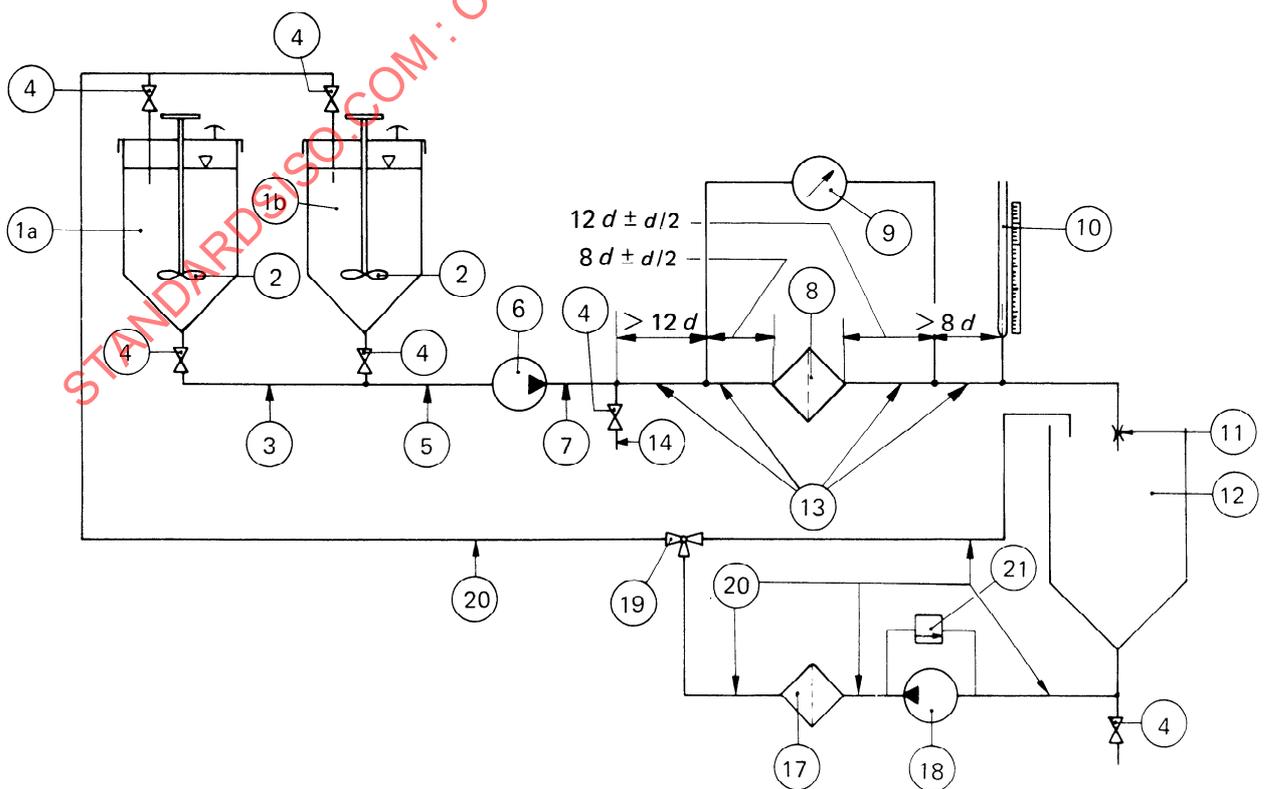
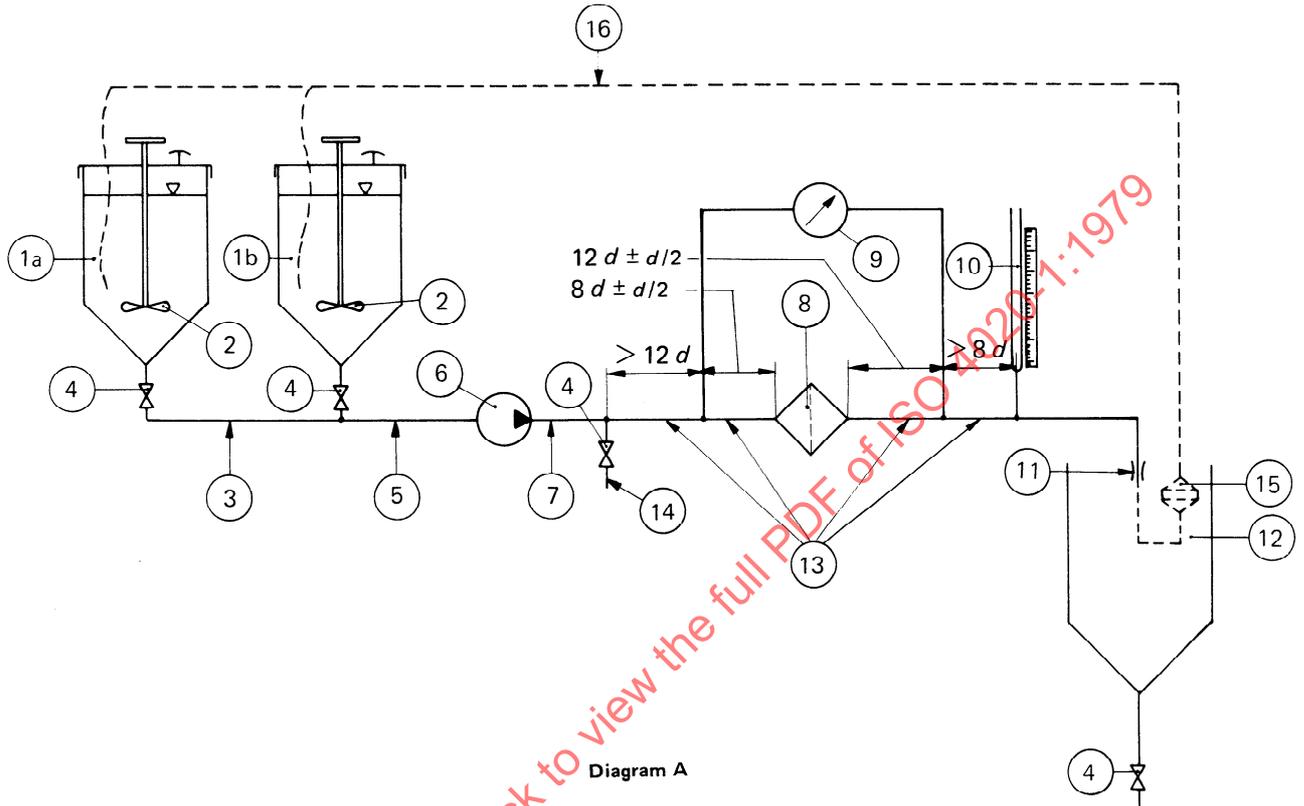
- 8 Pressure gauge, measuring range 0 to 1,5 bar (above atmospheric pressure)
- 9 Filter connecting pipes, internal diameter, d , identical to filter inlet and outlet bores and straight for the lengths specified in the diagram above
- 10 Control valve
- 11 Return pipe
- 12 By-pass valve
- 13 By-pass pipes
- 14 Differential manometer adapted to the measuring range
- 15 Thermometer

OTHER EQUIPMENT

Stop-watch

A.4 TEST FOR PARTICLE RETENTION AND LIFE (see 6.4)

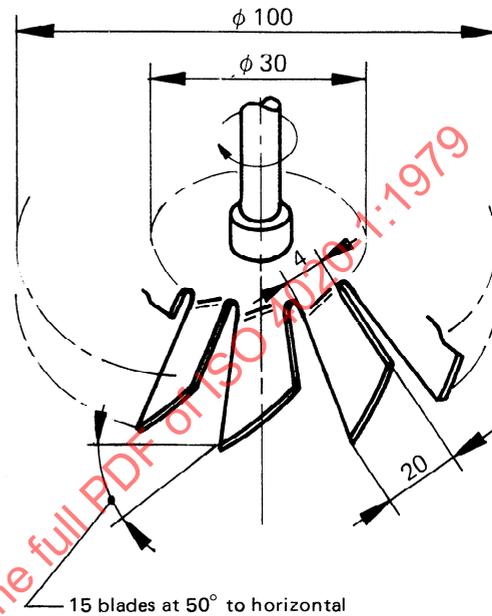
d = internal diameter of pipes



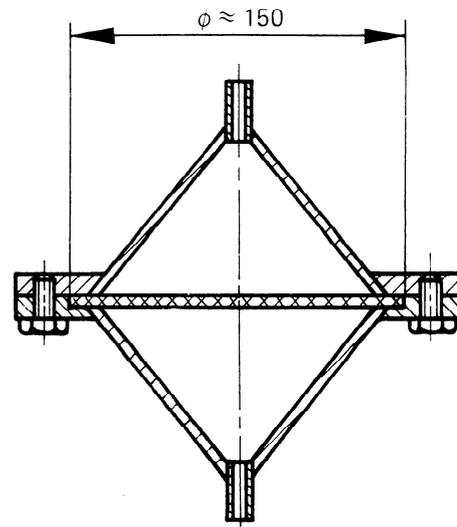
TEST RIG COMPONENTS

- 1a **Main tank with test liquid**
Round tank with smooth inside, minimum capacity 50 l diameter approximately 380 mm, conical bottom with 90° included angle, central outlet, overlapping cover
 - 1b **Reserve main tank with test liquid**
Tank as in 1a
 - 2 **Stirrer**, approximately 200 min⁻¹, positioned as close to the bottom as possible; for details, see drawing at top right. (Stirrers with at least equal efficiency may be used.)
 - 3 **Pipe**, minimum internal diameter 12 mm
 - 4 **Stopcock**, on/off, straight-through bore type
 - 5 **Hose**, minimum internal diameter 12 mm
 - 6 **Pump assembly**, peristaltic, with 2 rollers and a nominal hose bore diameter of 8 mm; with a continuously variable speed control. The material of the tube should be neoprene
 - 7 **Pipe**, minimum internal diameter 12 mm
 - 8 **Filter under test**
 - 9 **Differential pressure gauge**, measuring range 0 to 0,7 bar
 - 10 **Head tube** : glass tube with arbitrary scale to check flow rate in conjunction with orifice (11)
 - 11 **Orifice**, to provide pressure for head tube (10)
 - 12 **Collection tank**, minimum capacity 50 l (same as item 1a but without cover)
 - 13 **Filter connecting pipes**, internal diameter, *d*, identical to filter inlet and outlet bores and straight for the lengths specified in diagrams A and B
 - 14 **Sampling pipe**, of metal, nominal internal diameter 6 mm
- For cleaning operation of the test rig, according to diagram A**
- 15 **Membrane clean-up filter**, as in drawing at bottom right, for example
 - 16 **Separate hose**, minimum internal diameter 12 mm
- For cleaning operation of the test rig and the test liquid, according to diagram B**
- 17 **Clean-up filter**, high efficiency
 - 18 **Pump**, having a flow rate suitable for item 17
 - 19 **Three-way stopcock**
 - 20 **Pipe or hose**, minimum internal diameter 12 mm
 - 21 **Relief valve**

Dimensions in millimetres



Detail of stirrer (item 2)



Membrane clean-up filter (item 15)

For "other equipment", see following page

OTHER EQUIPMENT

Laboratory balance, accuracy $\pm 0,1$ mg

Vacuum pump, 0,85 bar below atmospheric pressure

Filtration apparatus: filter paper disc holder (see drawing at right)

Filter paper disc or membrane, mean pore size between 0,4 and 1,1 μm ; ϕ 140 mm (see drawing at right)

Drying oven, capable of being controlled at 130 ± 20 °C

Desiccator

Muffle furnace, capable of being controlled at 800 ± 50 °C

Hot-plate, for preliminary combustion of filter disc, capable of being controlled at approximately 500 °C

Crucibles, of porcelain or quartz. diameter approximately 40 mm, depth 36 mm

Stop-watch

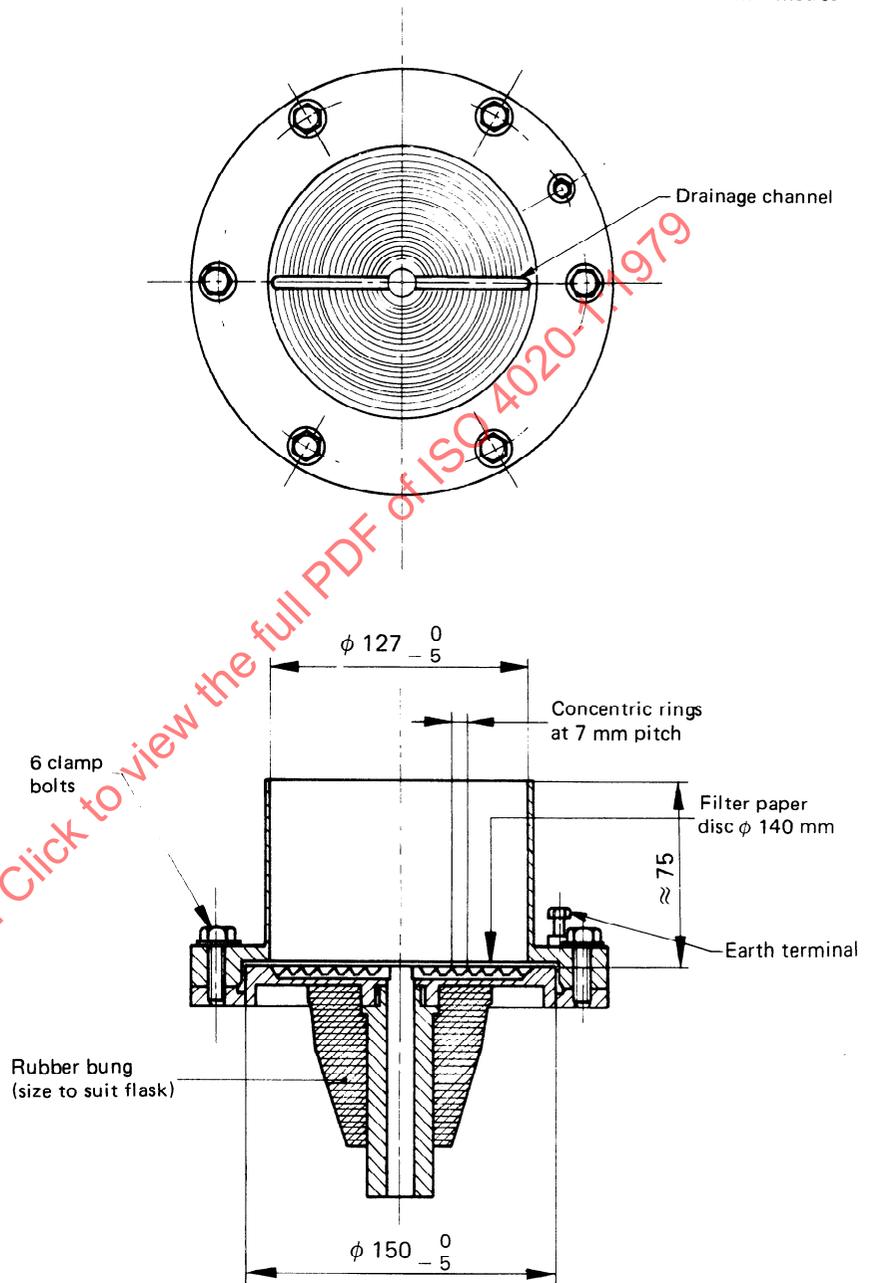
Petri dishes with lid: glass dishes 65 mm diameter for storage of used filter papers

Beakers, glass, 400 ml capacity

Measuring cylinder, glass, capacity 2 l

Tongs, for holding crucibles

Dimensions in millimetres

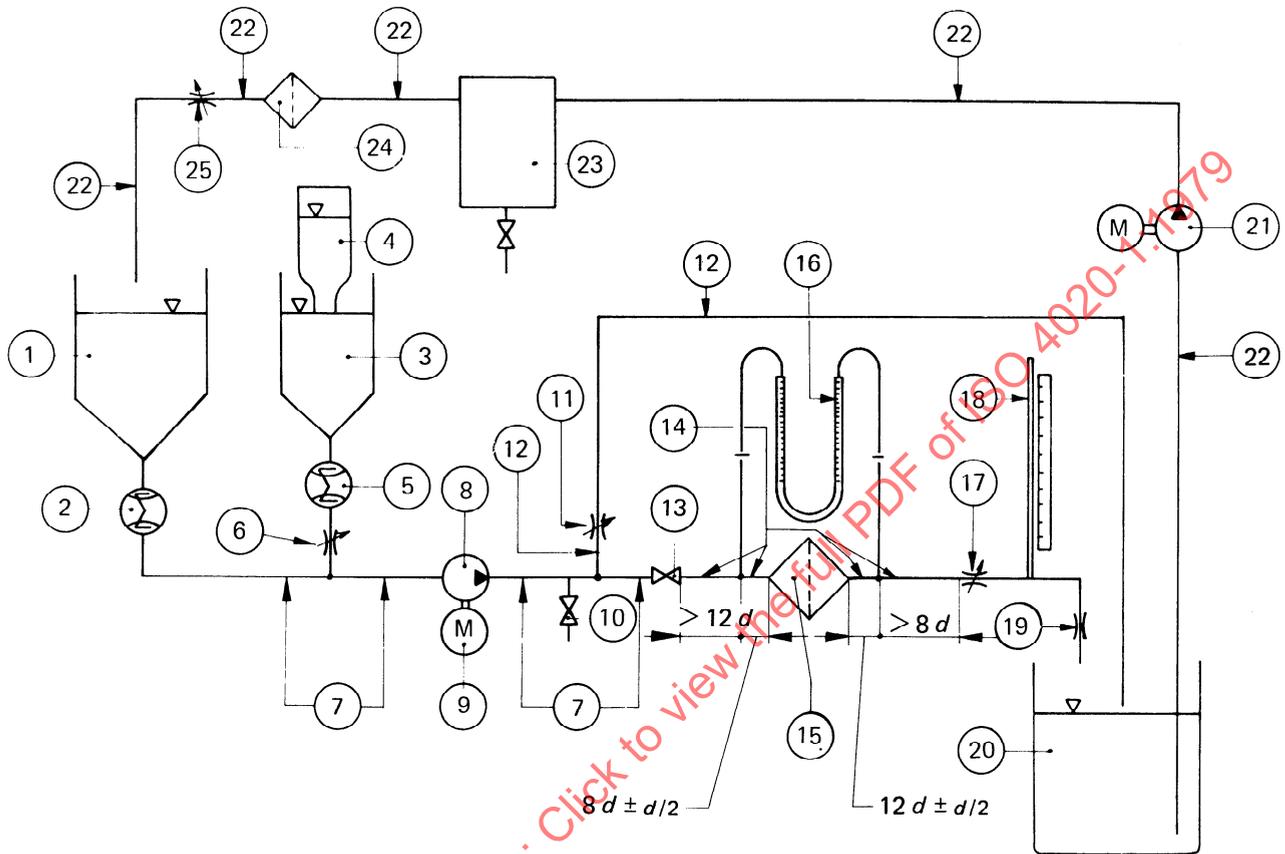


Filtration apparatus

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A.5 TEST FOR WATER SEPARATION EFFICIENCY (see 6.5)

d = internal diameter of pipes



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TEST RIG COMPONENTS

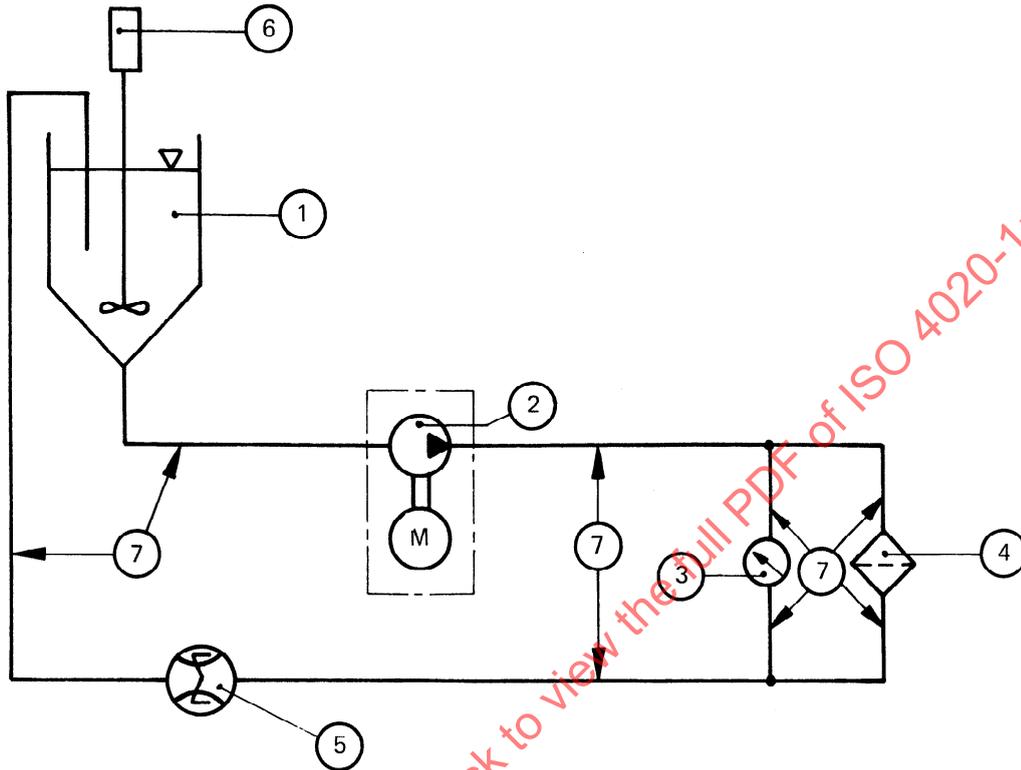
- 1* **Main tank with test liquid**, minimum capacity 50 l
- 2 **Flow-meter**, measuring range 0 to 200 l/h
- 3 **Water tank with distilled water**, minimum capacity 1 l
- 4 **Constant-level device**, minimum capacity 4 l (optional)
- 5 **Flow-meter**, measuring range 0 to 4 l/h
- 6 **Valve**, adjustable
- 7 **Main pipe**, minimum internal diameter 12 mm
- 8 **Main pump**, diaphragm type, capable of generation of consistent water droplet size distribution (for further details, see C.1 of annex C)
- 9 **Electric motor**
- 10 **Stopcock for sampling**, mounted at a distance of approximately $8d$ from the outlet of the pump (8), on/off straight-through bore type with a 65 mm length of 1,2 mm bore pipe at the outlet
- 11 **Valve**, adjustable
- 12 **By-pass pipes**, minimum internal diameter 12 mm
- 13 **Stopcock**, on/off straight-through bore type
- 14 **Filter connecting pipes**, internal diameter, d , identical to filter inlet and outlet bores and straight for the lengths specified in the diagram
- 15 **Filter to be tested**
- 16 **Differential pressure measuring device**; measuring range 0 to 0,4 bar
- 17 **Valve**, adjustable
- 18 **Head tube with scale**, measuring range 0 to 300 mm
- 19 **Orifice or adjustable valve**
- 20* **Collection tank**, minimum capacity 10 l
- 21* **Transfer pump**, minimum flow rate 200 l/h (optional)
- 22* **Transfer pipes**, minimum internal diameter 12 mm (optional)
- 23* **Coalescer**, capable of reducing free water content to less than 300 mg/l (optional)
- 24* **Absorbent filter**, minimum flow rate 200 l/h capable of removing any undissolved water after coalescer (optional)
- 25* **Valve**, adjustable (optional)

OTHER EQUIPMENT

- Sample bottle**, capacity 100 ml
- Ultrasonic bath**, frequency 30 to 50 kHz
- Laboratory centrifuge**, capable of producing a relative centrifugal force of approximately 1 500
- Centrifuge tubes**, capable of reading down to 0,04 % of tube volume
- Methylene blue powder**
- Surfactant**, water-miscible, surface tension-reducing agent
- Acetone**
- Microlitre syringe**

* If the optional items are omitted, the tanks as indicated in items 1 and 20 shall have a minimum capacity of 200 l.

A.6 COLLAPSE/BURST TEST OF THE FILTER ELEMENT (see 6.6)



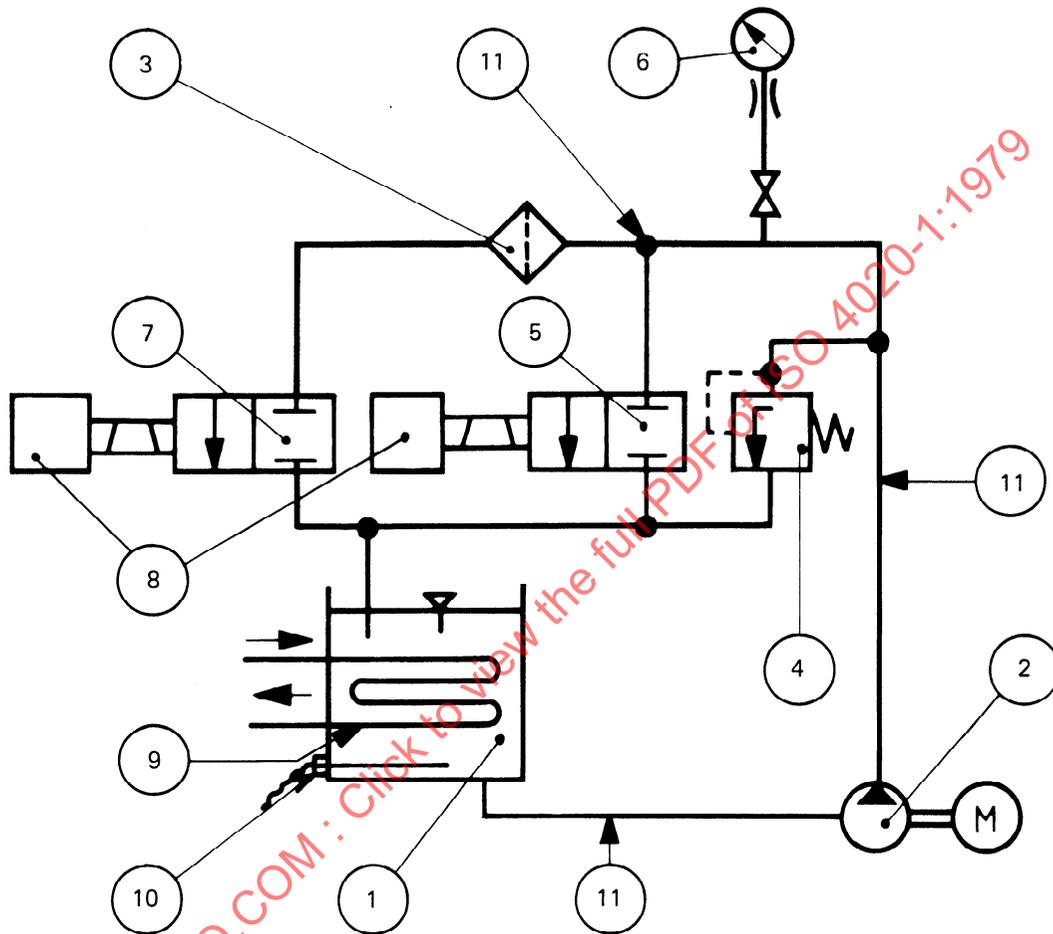
TEST RIG COMPONENTS

- ① Tank with test liquid, minimum capacity 5 l
- ② Pump assembly, gear type driven by electrical motor with continuously variable speed control, capable of supplying a flow of 200 l/h under a pressure of up to 3 bar above atmospheric pressure
- ③ Differential pressure gauge, measuring range 0 to 3 bar
- ④ Filter to be tested
- ⑤ Flow-meter, measuring range 0 to 200 l/h
- ⑥ Stirrer
- ⑦ Pipes, minimum internal diameter 12 mm

OTHER EQUIPMENT

- Glass jar, capacity 1 l
- Laboratory stirrer

A.7 PULSATING PRESSURE FATIGUE TEST (see 6.8)

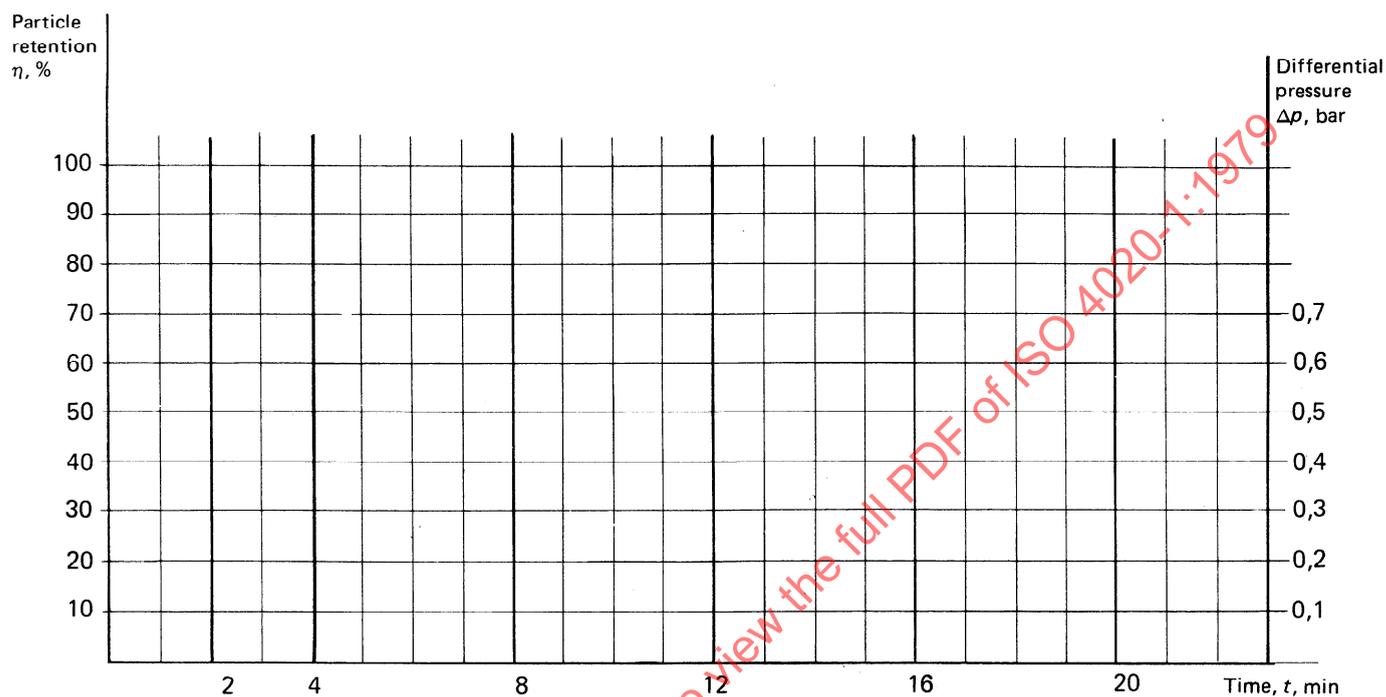


TEST RIG COMPONENTS

- | | |
|--------------------------------|---|
| ① Oil reservoir | ⑥ Pressure gauge |
| ② Pump assembly | ⑦ Solenoid valve |
| ③ Filter to be tested | ⑧ Solenoid sequence timer and counter to operate valves ⑤ and ⑦ |
| ④ Inlet pressure control valve | ⑨ Cooling coils (heat exchanger) |
| ⑤ Solenoid valve | ⑩ Thermostat |
| | ⑪ Metal pipes of 12 mm internal diameter |

ANNEX B

DIAGRAM SHOWING PARTICLE RETENTION AND DIFFERENTIAL PRESSURE VERSUS CHOKING TIME



ANNEX C

SUPPLEMENTARY DETAILS FOR WATER SEPARATION TEST

C.1 DIAPHRAGM PUMP

Static pressure (no flow) : 0,345 to 0,551 bar above atmospheric pressure

Displacement per stroke : 8,5 cm³ max.

Movement up : 2,72 mm max.

Movement down : 2,84 mm max.

Fuel flow through 3 mm orifice at 1 500 min⁻¹ cam speed : 90 l/h min.

Valve orifice diameter (two) : 10 mm

Diaphragm effective diameter : 60 mm

Cam rotational frequency during test : 1 425 ± 25 min⁻¹

C.2 METHOD OF DETERMINING UNDISSOLVED WATER CONTENT

C.2.1 Each sample of test liquid shall be ultrasonically dispersed at 30 to 50 kHz for 5 min and then shaken by hand a few times.

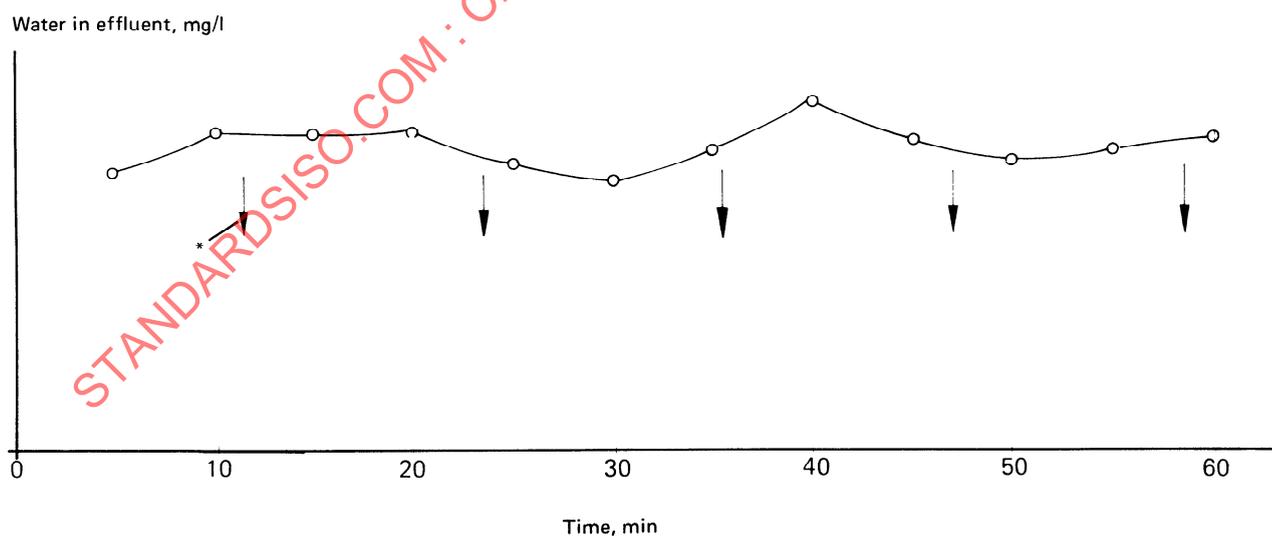
C.2.2 Fill a clean centrifuge tube from the sample.

C.2.3 Add a trace of methylene blue powder sufficient to adequately colour the water.

C.2.4 Using a microlitre syringe, dispense approximately 1 µl of water-miscible surfactant into the tube and ultrasonically disperse for 5 min. (This will remove water adhering to the sides of the centrifuge tube.)

C.2.5 Centrifuge the tube for 10 min at approximately 1 500 relative centrifugal force.

C.2.6 Remove the tube from the centrifuge and read off the volume of water indicated by the blue portion on the capillary scale. Subtract 1 µl to compensate for the surfactant. (To clean the tube, tip out the majority of the contents and refill with acetone. Agitate the capillary contents with a fine wire. Centrifuge in the inverted position for 5 min.)

C.3 CURVE SHOWING UNDISSOLVED WATER IN EFFLUENT

* Draining of separated water.

ANNEX D

TEST LIQUID FOR FUEL FILTER TEST

Kinematic viscosity	4 to 6 mm ² /s at an ambient temperature between 10 and 40 °C (ISO 3104)	
Density at 15 °C	0,816 to 0,850 g/ml (ISO 3675)	
Flash point	99 to 127 °C (ISO 2719)	
Pour point	-10 °C max. (ISO 3016)	
Colour	+ 18 (ASTM-D156)	
Additives	none	
Sulphur content	0,1 % (weight per weight) max. (ASTM-D1551 or ASTM-D2784)	
Surface tension	(23 ± 1) 10 ⁻³ N/m (ASTM-D971)	
Distillation :		
Initial boiling point	252 °C	} (ISO 3405)
50 % reclaimed boiling point	275 °C	
Final boiling point	320 °C	

The test liquid shall not contain components in such a concentration that irritation of a normal skin could be caused.

TYPICAL VISCOSITY/TEMPERATURE CURVE FOR TEST LIQUID

