SAE
Oil Filter Test Procedure

2009 Edition

SAE HS-806

SAE International™
Warrendale, Pa.

For permission and licensing requests contact:

SAE Permissions
400 Commonwealth Drive
Warrendale, PA 15096-0001-USA
Email: permissions@sae.org
Tel: 724-772-4028
Fax: 724-772-4891

For multiple print copies contact:

SAE Customer Service:
Tel: 877-606-7323 (inside USA and Canada)
Tel: 724-776-4970 (outside USA)
Fax: 724-776-1615
Email: CustomerService@sae.org

ISBN 978-0-7680-2155-4

Printed in USA

Table of Contents

Section 1

Scope

This lubrication oil filter test code is to provide a means for evaluating the performance characteristics of full-flow oil filters on bench equipment. This code combined with data collected from "in service" applications may be used for establishing standards or performance goals for filters tested in this manner.

Section 2

Foreword

Because the lube oil filter becomes an integral part of the engine lubrication system, it is subjected to variations in operating conditions that are difficult to duplicate. However, with the equipment and procedures set forth in this test code, comparisons with effective filters for "in service" applications can be made with a high degree of confidence.

To achieve the highest degree of reliability from the test results, the procedures and equipment must conform to those outlined in the test code. Throughout this test code, no limitations have been placed on filter performance requirements or tolerances, as these are considered the responsibility of the user and manufacturer.

The test code is composed of distinct sections to provide the test methods necessary to evaluate various functional capabilities and mechanical properties of the filter. Each section is complete with the recommended materials, apparatus, methods, and procedures for testing and evaluation.

In addition to the test procedure, Appendices with sections covering contaminants, oil sample analysis, filter media envelope volume, and source information are included. Throughout the individual test methods, references are made to specific equipment that is recommended. However, equivalents may be substituted where noted.

Oil filter tests have been performed for many years on a variety of equipment using various procedures. As a result, the information accumulated does not necessarily correlate with information from other manufacturers or users. With this existing condition, most manufacturers and users developed their own standards based on procedures that each used. Obviously, no universally recognized characteristics for defining the filterability of the filter could be established. Considering this situation, the Filter Test Methods Committee has attempted to establish criteria for evaluating the filterability characteristics of an oil filter. These criteria involve several individual and separately determined characteristics that should be given equal consideration.

Section 6, Filter Capacity and Contaminant Removal Characteristics of Full-Flow Filters, and Section 7, Single Pass Particle Retention Capability Test, have been prepared to be used in determining the filterability characteristics of the filter. However, it is necessary to standardize all phases of the test to obtain repeatable and meaningful test results. Consequently, these test methods prescribe the test oil, contaminants, analysis procedure, and test stands required.

The oil prescribed in the filterability test method is SAE J1260, Standard Oil Filter Test Oil (RFO-3). The oil contains additives used in motor oil formulations intended to meet engine oil performance and engine service classification SG/CF4 as outlined in SAE J183 Engine Oil Performance and Engine Service Classification (other than energy conserving).

The test contaminants recommended, SOFTC-2A and ISO 12103-1 A2 Fine Test Dust, are used for evaluating various aspects of filterability. Both fall into the broad range of contaminants being generated under the infinite variables of field operation. SOFTC-2A is a sludge-type contaminant mainly used to evaluate the plugging characteristics of a filter. Although SOFTC-2A can be used to evaluate filter efficiency, the broad variability in test results is likely to yield misleading conclusions. Continuing investigations are underway to identify and define further actual contaminants encountered in the lube systems. As this study progresses, changes in the test contaminants will be made to remain more consistent with the field conditions.

For the Filterability Test, oil is circulated through the filter at a constant flow rate while contaminant is added at a predetermined rate. The test equipment, oil, and contaminants, along with other critical parameters, are specified in this method to minimize variations between tests and laboratories. Filterability may be used to evaluate various filter designs, for quality control, and for possible correlation with engine wear. This procedure describes a test as it is to be run on an automated SAE stand, but other equipment can be used as long as the equipment has met the validation criteria described in this standard.

With the necessity of standardization of equipment, two classes of test stands have been developed. Class A stands are for flow rates up to 30 L/min, and Class B stands are for flow rates of 26 to 57 L/min. Where greater flow rates are required, stands built to the same design criteria sized for the increased flow should be used. These larger stands could substitute manual control for any of the automated features of Class A and Class B stands. The automated features have been included to permit overnight unattended operation and are as follows: flow rate control, continuous pressure and temperature recording, automatic sampling, and test stand protection from high pressure, high temperature, low sump level, or loss of control power.

In addition to the necessity of standardization of the equipment and materials used for these tests, a number of test conditions must be established. For the most part, these conditions will be dictated by the application for which the filter is intended and consist of flow rate, contaminant, contaminant add rate, oil temperature, and volume of oil. Consideration should also be given to the test purpose, such as differentiating between filter designs, quality control, and attempted correlation of bench tests and field performance. It is recognized that no bench test can duplicate the conditions existing in service, and compensations must be made to accommodate this mode of testing.

Section 3

Normative Reference

The following publications form a part of this standard to the extent specified herein. Unless otherwise specified, the latest issue of the publications shall apply.

3.1 SAE Publications

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

3.1.1 SAE J363, Spin-on Filter Base Mounting (Lubricating Oil).

3.1.2 SAE J1260, Standard Oil Filter Test Fluid.

3.1.3 SAE J1124, Glossary of Terms Related to Fluid Filters and Filter Testing.

3.1.4 SAE J183, Engine Oil Performance and Engine Service Classification (other than energy conserving).

3.2 ISO Publications

Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

3.2.1 ISO 1000, International Standard (SI) units and recommendations for the use of their multiples and certain other units.

3.2.2 ISO 1219-1, Fluid power systems and components—Graphic symbols and circuit diagrams—Part 1: Graphic symbols.

3.2.3 ISO 2942, Hydraulic fluid power—Filter elements—Verification of fabrication integrity and determination of the first bubble point.

3.2.4 ISO 12103-1, Road vehicles—Test dust for filter evaluation—Part 1.

3.2.5 ISO 4548-7, Methods of test for full-flow lubrication oil filters for internal combustion engines—Part 7: Vibration Fatigue Test.

3.2.6 ISO 4548-9, Methods of test for full-flow lubricating oil filters for internal combustion engines—Part 9: Inlet and Outlet Anti-drain Valve Tests.

3.3 NFPA Publications

Available from NFPA, 3333 N. Mayfair Rd. Suite 211, Milwaukee, WI 53222-3219.

3.3.1 NFPA/T2.10.17, Standard for Verification Level, Statistical Table.

3.4 Federal Specifications

Available on internet @ no charge on various sites.

3.4.1 F-F-351, Filter and Filter Elements, Fluid Pressure: Lubricating Oil, Bypass and Full Flow.

Section 4

Accuracy of Measuring Instruments and Test Conditions

The measuring instruments shall be capable of measuring to the levels of accuracy given in Table 1. The last column in the table gives the limits within which the test conditions shall be maintained.

TABLE 1—INSTRUMENT ACCURACY AND TEST CONDITION VARIATION

Test Condition	Units	Measurement Accuracy	Allowed Test Condition Variation
Flow	L/min	±2%	±5%
Pressure	kPa	±5%	–
Temperature	°C	±2°C	±3°C
Volume	L	±5%	±10%
Time	hr, min, sec	±1%	–

NOTE: These are in effect unless superseded by requirements listed in the individual sections of this handbook.

Section 5

Resistance to Flow

5.1 Scope

The Resistance to Flow test determines the pressure loss, which may result when the fluid is passed through the filter element under predetermined conditions of flow and fluid viscosity. This procedure may be used to establish flow capacities.

5.2 Test Material

5.2.1 Test Oil—SAE J1260, Standard Oil Filter Test Oil (RFO-3) or as specified.

5.3 Test Equipment

5.3.1 A flow stand consisting of a pump, flowmeter, thermometer, and manometer or differential pressure instrument, as shown in Fig. 1, or the SAE standardized oil filter test stand.

5.3.2 Filter housing or mounting plate with pressure taps located to give pressure loss across the element. See Figs. 2 and 3 for housing and mounting plate.

5.3.3 In the event that a special housing design is necessary, special emphasis to locate inlet and outlet pressure taps properly must be considered.

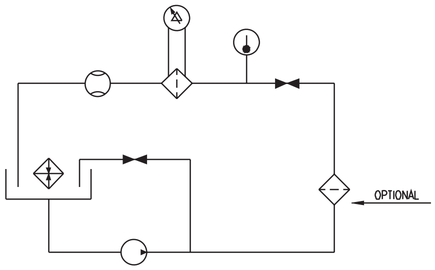


Fig. 1—Flow Stand

NOTE: The use of a pitot tube is recommended when flows exceed 11.3 L/min. If the pitot tube is positioned in an area of high turbulence, such as at the outlet of the mounting stud, variability in results may be experienced. The tube end should be placed in an area of low turbulence, for example, in the lower half of the filter center tube. This location will be dependent upon the filter construction and test base design. Therefore, the exact position of the pitot tube cannot be specified relative to the test fixture.

5.4 Test Preparation

5.4.1 Install the filter assembly on the stand and add the test oil.

5.4.2 Recirculate the oil in the flow stand until the required temperature is reached.

5.4.3 Circulate oil through the stand with a cleanup filter to clean the system. (A cleanup filter may be installed in series with the test filter. Flow to the cleanup filter should be shut off during the test.)

5.5 Test Procedure

5.5.1 Circulate oil through the filter housing at a low flow rate. When the temperature stabilizes, take pressure differential readings at 20% increments of the rated flow, including a reading at 20% over the rated flow.

5.5.2 If the filter housing does not have pressure taps located to provide element loss only, an empty housing differential pressure must be determined. The difference between pressure loss for the empty housing and the housing with element indicates loss across the element only.

5.6 Presentation of Data

5.6.1 Tabulate the pressure differential at each required flow rate and temperature.

5.6.2 Plot a flow rate versus pressure loss curve, using pressure loss for the ordinate and flow rate for the abscissa.

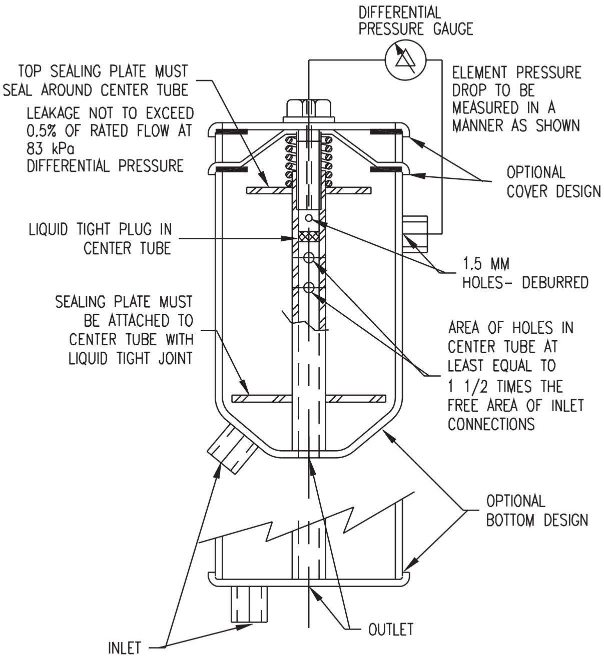
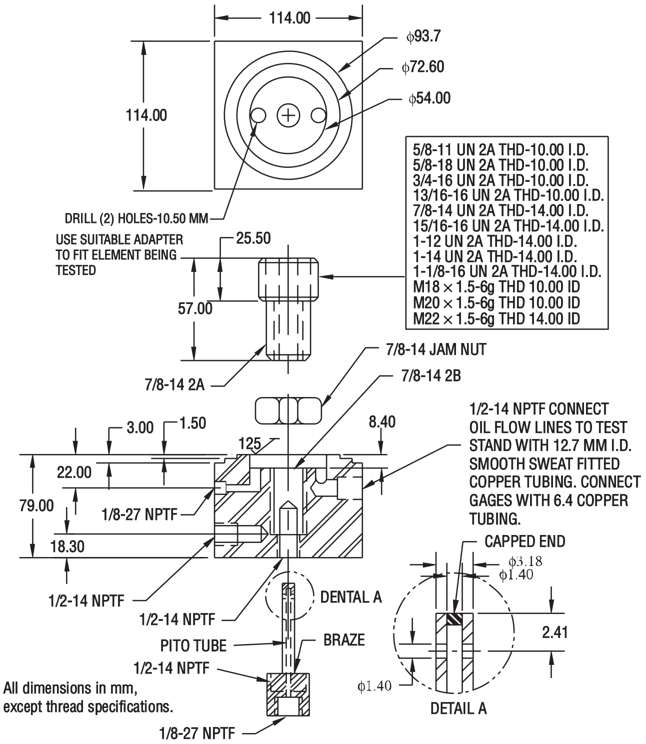


Fig. 2—Test Filter Housing for Full-Flow Elements



All dimensions in mm,
except thread specifications.

Fig. 3—Universal Test Fixture for Spin-on Filters

Section 6

Filter Capacity and Contaminant Removal Characteristics of Full-Flow Filters

6.1 Scope

To include an SAE standardized filterability test for determining the contaminant capacity and contaminant removal characteristics of a full-flow oil filter.

6.2 Purpose

To provide a precise test procedure for determining contaminant capacity and contaminant removal characteristics of a full-flow oil filter.

6.3 Test Equipment

6.3.1 A filter test circuit—SAE standardized oil filter test stand as described in Fig. 4, or an equivalent designed stand.

6.3.2 An appropriate filter housing or standard filter mounting base for spin-on filters described in Figs. 2 and 3, found in Section 5, or SAE J363.

6.3.3 Analytical apparatus for oil sample analysis per Appendix B.

6.3.4 A blender consisting of the following: a 1-L stainless steel container that has a drawn one-piece shell and a two-speed motor that has a nominal no-load speed of 18,500 and 21,000 rpm or equivalent (see Appendix C).

6.3.5 A timer capable of measuring minutes.

6.3.6 Contaminant addition device described in Fig. 4a that meets the requirements of Section 6.5.

6.4 Test Materials

6.4.1 Test Fluid—SAE J1260, Standard Oil Filter Test Oil (RFO-3).

6.4.2 Test Contaminants.

6.4.2.1 SOFTC 2A (see Appendix A).

6.4.2.2 ISO 12103-1 A2 Fine Test Dust (see Appendix A).

6.4.2.3 *n*-Pentane or petroleum ether, or equivalent solvent.

6.4.2.4 No. 1 Fuel Oil, Stoddard Solvent, or equivalent solvent.

6.5 Test Equipment Validation

6.5.1 Equipment validation should be performed concurrently with measurement systems calibration frequency, or when equipment modifications are required.

6.5.2 Validation of the contaminant delivery device.

6.5.2.1 Validate at the maximum and minimum contaminant concentration that will be used.

6.5.2.2 Determine the concentration of contaminant necessary to achieve the desired mass of solids to be delivered to the filter as follows:

$$C = \frac{B}{A}$$

where

$C =$ Concentration of contaminant slurry in the contaminant delivery device (g/L)
$B =$ Desired contaminant delivery rate (g/hr)
$A =$ Calibrated delivery rate of the contaminant delivery device (L/hr)

6.5.2.3 If a quadrant or other device is used that does not have adequate agitation to maintain the contaminant in suspension, prepare the contaminant slurry as described in Paragraph 6.6.3.

6.5.2.4 Fill the contaminant addition device and allow it to stand for 1.5 hours, with agitator running, to release any air introduced in blending and to allow the temperature to stabilize.

6.5.2.5 Allow the delivery to dispense into a receptacle for 30 minutes or until the rate is stabilized. (The slurry caught in this container is to be discarded when the rate is stabilized.)

6.5.2.6 When the contaminant delivery system has stabilized, replace the receptacle with a clean unit and start a timer. This will be the first volumetric sample.

6.5.2.7 Allow the slurry to dispense into the receptacle for 115 minutes. At this time, replace the receptacle with a new unit for 5 minutes.

6.5.2.8 Continue sampling as in Paragraph 6.5.2.7 for a total of 22 hours.

6.5.2.9 Determine the volume of all samples as follows:

$$V_s = (m_s - m_d)/\rho_o + (m_d/\rho_d)$$

where

$V_s =$ Volume of slurry (mL)
$m_s =$ Mass of slurry (g)
$m_d =$ Mass of dust (g) as determined by the 5-minute sample
$\rho_o =$ Density of oil (g/mL) at validation temperature
$\rho_d =$ Density of dust (g/mL)

NOTE: Mass measurement and volumetric calculation using density properties may provide improved volume accuracy.

6.5.2.10 The deviation of the solids concentration from each 5-minute sample should be within 5% of the desired solids add rate.

6.5.2.11 Repeat Steps 6.5.2.1 up to Step 6.5.2.10 two additional times.

6.5.2.12 The maximum volume deviation from the average of the three determinations should be no greater than 4% for any determination.

NOTE: Because there is a possibility that with peristaltic pumps, tubing fatigue can change the delivery rate over a period of time, with this method the contaminant should be dispensed for twice the maximum expected test duration and the validation procedure repeated. The validation requirements remain the same.

NOTE: The delivery rate should be 88 ± 4 mL/hr or multiples thereof. For variable-speed delivery positive displacement pumps, constant-speed motors with speed controlled through mechanical transmission may be more consistent in delivery. For variable-stroke piston pumps, a maximum rate of 100 strokes/min is recommended. The configuration of the reservoir and the type of agitator is left as optional. The only requirements are that the system can be validated and that the circulating pump and the agitator do not reduce the primary particle size of the contaminant. The agitation rate in the contaminant reservoir is to be sufficient to maintain a uniform suspension of solids, but not so vigorous as to pull air into the slurry. The minimum reservoir size is to be sufficient to contain 3.2 L of contaminant slurry under agitation. Larger reservoirs can be used with any test class.

Select a delivery pump sized to deliver contaminant at a rate equal to that specified in Table 2. Because tubing fatigue and set can affect the delivery rate of peristaltic pumps, it is recommended that delivery rates be determined before and after the test when this type of pump is used to ensure so that the desired addition rate is maintained. For any delivery pump suspected of being subject to drift in output use, this same re-check should be made (see Table 2 as separate document).

6.5.3 Validation of Test Circuit (SAE Class A and Class B).

6.5.3.1 Validate the test system is constructed in accordance with Fig. 4.

6.5.3.2 Select the specified test conditions from Table 2 for the minimum Filter Size Rating Class at which the test system will operate.

6.5.3.3 Adjust the test system fluid volume, specified in Table 2 in accordance with Filter Size Rating Class selected under Paragraph 6.5.3.2.

6.5.3.4 Conduct the test according to Paragraph 6.6 for a period of 8 hours.

6.5.3.5 Determine the solids concentration per Appendix B.

6.5.3.6 Compare the contaminant concentration in the collected samples with the theoretical value. At termination (8 hours), the actual concentration of all samples should be within 10% of the theoretical value.

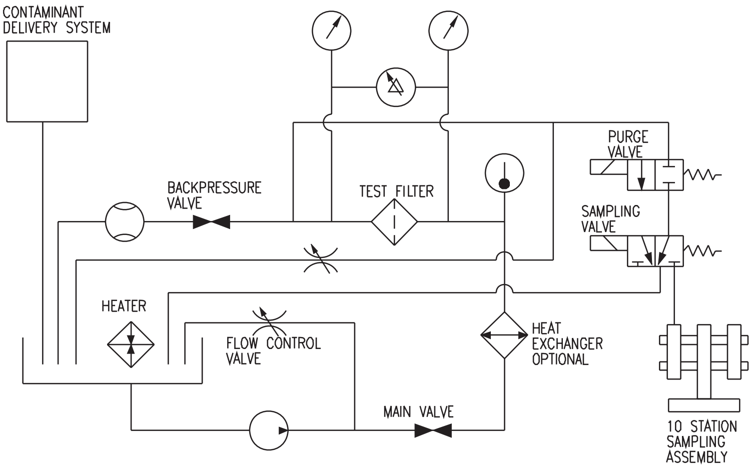


Fig. 4—SAE Standardized Oil Filter Test Stand, Class A and Class B

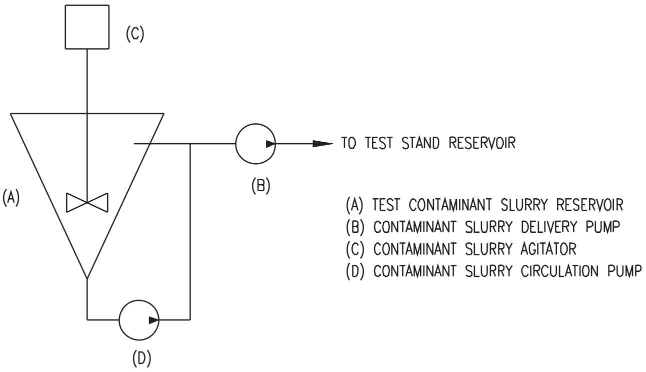


Fig. 4a—Schematic of Variable Delivery Pump Contaminant Delivery System

TABLE 2—SPECIFIED TEST CONDITIONS FOR LUBRICATING OIL FILTER ELEMENT CAPACITY TESTS SAE HS-806

							Contaminant		
Filter Rated Flow[a]	Filter Size Rating Classes[b,i]	Media Envelope Volume[i]	Test Flow Rate[c]	Test Flow Rate[c]	Starting Test Oil Volume[d]	Test Oil Turnover per Minute at Starting Volume	A-2 Dust Addition Rate Solids[e]	Organic Addition Rate Solids[f]	Contaminant Oil Slurry Addition Rate[g]
Liters per Hour	Class	cc.	Liters per Hour	Liters per Minute	Liters	Frequency	Grams per Hour	Grams per Hour	Milliliters per Hour
180–480	A	328	480	8	3.64	2.2	1.2	2.4	88
481–600	B	410	600	10	4.54	2.2	1.5	3.0	88
601–720	C	492	720	12	5.45	2.2	1.8	3.6	88
721–900	D	655	900	15	6.82	2.2	2.25	4.5	88
901–1140	E	819	1140	19	8.64	2.2	2.85	5.7	88
1141–1440	F	983	1440	24	10.91	2.2	3.6	7.2	88
1441–1800	H	1229	1800	30	13.64	2.2	4.5	9.0	88
The final gravimetric levels for tests run at 2.2 turnover frequency may not be comparable to tests run at 4 turnover frequency.									
1801–2280	J	1639	2280	38	17.27	2.2	5.7	11.4	88
2281–2820	K	2048	2820	47	21.36	2.2	7.05	14.1	88
2821–3600	L	2458	3600	60	27.3	2.2	9.0	18.0	88
3601–4500	M	3277	4500	75	18.75	4.0	11.25	22.5	176
4501–5700	N	4097	5700	95	23.75	4.0	14.25	28.5	176
5701–7200	P	4916	7200	120	30.00	4.0	18.0	36.0	176
7201–9000	Q	6555	9000	150	37.50	4.0	22.5	45.0	264
9001–11400	R	8194	11400	190	47.50	4.0	28.5	57.0	264
11401–14400	S	9832	14400	240	60.00	4.0	36.0	72.0	352
14401–1800	T	13110	18000	300	75.00	4.0	45.0	90.0	440
18001–22200	U	16387	22200	370	92.50	4.0	55.5	110.0	528
Flow in excess of 22001	x		Test conditions to be agreed upon between user and supplier.						

Table 2—Specified Test Conditions—Entry into Table 2 is made by either knowing the Filter Size Rating Class or the recommended test flow rate of the filter to be tested. In general, it has been found that a contaminant addition rate as specified in Table 2 will yield test duration in the range of 15–30 hours. This test duration is sufficient to yield accurate results in a reasonable length of time. Although an optional provision has been made in Table 2 to allow accelerated test conditions to be used, filters used for the same application should be tested under identical conditions.

It is recommended that the test termination differential pressure for most automotive applications or a differential pressure be agreed upon by the user and supplier. If practical, the valve should be blocked prior to the start of the filterability test. If the test is conducted with an unblocked valve and an uncharacteristic flattening of differential pressure rise is experienced during the test, the result of the test should be considered suspect until the characteristics of the differential valve have been determined. The SAE Class A automated test stand is usable for Filter Classes A–H, with the Class B test stand usable for Filter Classes H–L. The overlap of Class H filters necessitates that the Flow Control Circuit Flow Rate be 4 L for the Class A test stand and 8 L for the Class B test stand.

---

[a] Suppliers' specification, rated under the conditions of this test.
[b] Class letter designation assigned for convenient reference. See paragraph 6.10 for scaled-down tests.
[c] Unless otherwise agreed upon between user and supplier, test by class size rated flow. Maintain test flow rate within ± 2%.
[d] Adjust starting test oil volume to within ± 5%.
[e] 0.15 g solids/h/L/min flow rate (2.5 mg/L base upstream gravimetric level). Maintain base upstream gravimetric level within 0.25 mg/L (see Note).
[f] 0.30 g solids/h/L/min flow rate (5.0 mg/L base upstream gravimetric level). Maintain base upstream gravimetric level within 0.50 mg/L (see Note).
[g] Contaminant addition system described in Figs. 4 and 4a (see Note).
[i] For large filters not completely conforming to Table 2, see paragraph 6.8.2 nonconformance related to (d).
[j] Calculate media envelope volume according to Appendix D.

NOTE: Conditions under e, f, and g may be accelerated up to 50 times when agreed upon by the user and supplier. Multiple contaminant addition systems may be required. Retain contaminant concentration in delivery system as defined by e, f, and g.

Base Upstream Gravimetric Level is defined as the mass of contaminant admitted to the test system per minute per liter per minute test flow rate.

NOTE: Standardized test conditions have been established by filter manufacturers for comparing and reporting filter performance regardless of class rating. The following test conditions are commonly used as default for light-duty automotive oil filters: test oil temperature 82°C, test flow rate (a) 11.3 L/min, test oil volume (d) 6 L, contaminant ISO 12102-1 A2 Fine Dust, addition rate (e) 1.5 g/h.

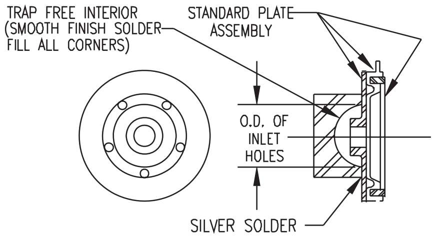


Fig. 5—Blank Filter

6.6 Test Preparation

6.6.1 Filter Assembly.

6.6.2 Subject the unused test element to a fabrication integrity test in accordance with the test method referenced in Section 3, Paragraph 3.2.3, when required.

NOTE: When it is impractical to disassemble the filter to conduct the fabrication test, as is the case with spin-on filters, it may be conducted on the disassembled filter after the contaminant removal test.

6.6.2.1 Disqualify the element from further testing if it fails to exhibit the designated minimum test pressure agreed upon by the filter user and supplier.

6.6.2.2 Allow any volatile fluid to evaporate from the test filter element before installing in the test filter housing.

6.6.2.3 Install the test filter housing in the filter test system in an attitude as close as possible to the service attitude. Where the service attitude is unknown, a horizontal attitude is recommended.

6.6.3 Filter Test System (SAE Class A or Class B test stands).

6.6.3.1 Select the test conditions for the Filter Size Rating Class from Table 2 under which the test will be operated.

6.6.3.2 Fill the test system with the specified amount of SAE J1260 (RFO-3) oil from Table 2 as specified for the Filter Size Rating Class selected.

6.6.3.3 Set the test stand temperature controller to maintain 82°C at the filter inlet. Other test temperatures may be used when agreed upon by the user and supplier.

6.6.3.4 Withdraw a sample from the sampling port. This sample should have a concentration of less than 0.020 g/L of insoluble petroleum ether. If the concentration exceeds this value, the oil should be circulated through a cleanup filter until the allowable value is met.

NOTE: The initial concentration listed in Paragraph 6.6.3.4 has been found adequate for typical automotive filters. For “high efficiency” filters, lower initial cleanliness levels may be required.

6.6.3.5 Set the sampling system to withdraw a sample volume between 0.025 and 0.050 L of fluid for each sample to be taken. A minimum of five samples should be withdrawn at equal intervals in addition to a zero-hour sample. The zero-hour sample will be used to determine a tare or baseline for the oil.

6.6.4 Contaminant Slurry Preparation.

6.6.4.1 ISO 12103-1 A2 Fine Test Dust.

NOTE: The test dust jar shall be rolled for a minimum of 5 minutes and then a sufficient quantity shall be dried in an open container (less than 25 mm depth) at 110°C for a minimum of 2 hours. Allow the dried dust to return to room temperature in a desiccator before weighing.

6.6.4.1.1 Measure the appropriate amount of test oil for the contaminant delivery system to be used.

6.6.4.1.2 Calculate the weight of contaminant to give the solids addition rate specified in Table 2 for the Filter Size Rating Class selected under Paragraph 6.6.3.1.

NOTE: Some contaminant delivery systems incorporate a system circulation pump. These pumps may be adequate to mix and keep the contaminant in suspension without pre-mixing the contaminant into slurry. Steps 6.6.4.1.3 through 6.6.4.1.9 can be omitted only if the contaminant delivery system has demonstrated the ability to mix and maintain the contaminant slurry for both the maximum and minimum contaminant concentrations.

6.6.4.1.3 Weigh one third of the amount of test dust required for the contaminant addition system of the test stand being used.

6.6.4.1.4 Place approximately one third of the oil required into the blender.

6.6.4.1.5 Add the pre-weighed test dust to the blender.

6.6.4.1.6 Start the blender and operate at high speed for 90 ± 5 seconds.

6.6.4.1.7 Add the blended slurry to the contaminant addition system and start the contaminant addition agitator system. Do not attempt to flush or wash out the blender container during the slurry transfer.

6.6.4.1.8 Repeat the steps in Paragraphs 6.6.4.1.3 through 6.6.4.1.7.

6.6.4.1.9 Allow the contaminant addition system to stand for 1.5 hours with agitation to release any air introduced and to allow the temperature to stabilize.

6.6.4.2 SOFTC-2A (Organic Contaminant for Determination of Capacity Only). See Appendix A, Paragraph 3.2, for contaminant handling.

6.6.4.2.1 Determine the solids content of an approximately 0.010 L sample per Appendix B.

6.6.4.2.2 Refer to Table 2 to determine the contaminant (solids) dispensing rate required for the testing of the Filter Size Rating Class selected under Paragraph 6.6.3.1.

6.6.4.2.3 Calculate the required solids concentration of the mixture to give a contaminant solids addition rate of 0.3 g solids/hr per L/m flow rate.

6.6.4.2.4 Weigh the appropriate amounts of contaminant concentrate and test oil into the blender cup to give the required volume of the proper concentration. The amount may be separated into portions to accommodate the blender and the contaminant delivery system reservoir.

6.6.4.2.5 Turn the blender to high speed and blend the mixture for 90 ± 5 seconds.

6.6.4.2.6 Add the blended mixture to the contaminant addition system and allow to stand for 1.5 hours with agitation to release any air introduced and to allow the temperature to stabilize.

6.7 Test Procedure

6.7.1 Start the contaminant delivery system dispensing into a receptacle, and allow approximately 5% of the total volume to be dispensed or until the delivery rate has stabilized. Discard the mixture dispensed during this interval.

6.7.2 Start the flow of oil through the test filter and allow the oil temperature at the filter inlet to stabilize at the set point.

6.7.3 Place a sufficient amount of clean sample containers into the sampling system.

6.7.4 Only after all test conditions are met, direct the contaminant delivery into the test stand reservoir.

6.7.5 Continue the test until the differential pressure across the filter exceeds 75% of the bypass component opening pressure or a pressure otherwise agreed upon by the user and supplier.

6.7.6 Analyze the samples obtained per Appendix B.

6.7.7 Recharging the Contaminant Addition Device During Test—The outlined test procedure is designed for a stand operation of 22 hours. With this test cycle time, the contaminant addition system may be prepared for the subsequent cycle in 2 hours, thus permitting one complete cycle per day. If it is apparent that the test will terminate beyond 24 hours, it will be necessary to recharge the addition device. The use of a single charge beyond 24 hours is not recommended. The procedure for interrupting the test to recharge the addition device is as follows:

6.7.7.1 Stop the contaminant addition after 22 hours.

6.7.7.2 Stop the flow of oil to the test filter. Ensure that the test stand reservoir is agitated to prevent contaminant from falling out of suspension during the shut-down period.

NOTE: On some Class B test stands, it may be necessary to reduce the motor setting and return to this setting when restarting the test.

6.7.7.3 Switch the pressure/temperature recorder to "OFF."

6.7.7.4 Switch the test timer to "OFF."

6.7.7.5 Discard the remaining slurry from the contaminant addition device.

6.7.7.6 Wash the contaminant addition device with solvent and allow to dry.

6.7.7.7 Prepare the contaminant slurry as at the test start and described in Paragraph 6.6.4.

6.7.7.8 To restart the test at 24 hours, follow the same procedure as at the start of the test, eliminating those steps made necessary by the cleanup procedure.

6.8 Suggested Test Conditions

6.8.1 See Table 2 for test conditions for filters sized for conventional applications on mobile equipment. For large filters not completely conforming to Table 2, see Paragraphs 6.8.2 through 6.8.2.3

6.8.1.1 The termination pressure drop should be 75% of the bypass component opening pressure unless otherwise specified.

6.8.2 Test Conditions for Large Volume Filters Not Conforming to Table 2—Nonconformance is related to the inability of oil specified in Footnote (d) to fill filter and test system.

6.8.2.1 Designate the filter size rating class as AA, BB, CC, and so on.

6.8.2.2 Select a specified flow rate between 8 and 370 L/min.

6.8.2.3 Calculate the test fluid volume equal to the volume of oil the filter holds with the element installed plus a volume numerically equal to one fourth of the test flow rate per minute.

Example: A Class LL filter with a 40-L filter capacity would require:

$$40\ \text{L volume} + (60\,\text{L} \div 4) = 55\ \text{L of test fluid}$$

6.8.2.4 Select Contaminant Addition Rate grams per hour from Table 2. This rate may be accelerated up to 50 times when agreed upon by the user and supplier. See constraints as stated in the Note under Table 2, which states that acceleration requires increased slurry volume without increasing contaminant concentration.

6.9 Calculation and Reporting of Test Results

6.9.1 At the conclusion of a test, a great deal of data is available that can be transformed into several types of information. Those that have been found most useful are measures of the duration of the test (life), the amount of contaminant actually removed by the filter (capacity), the oil cleanliness (usually expressed in terms of the maximum concentration of contaminant in the sump), and the percentage of contaminant added that is removed by the filter (efficiency). All of these can be expressed in terms of their respective values both at the termination of the tests and at some intermediate stage; Tables 3 and 4 show a typical data format. The calculating mode shall account for any change in volume due to the contaminant addition or removal of samples. The life of the filter is defined as the duration of the test under the specified test conditions: in the example, the life is 22.2 hours. The filter capacity can be obtained from Table 4 and, in this example, is 37.8 g at the test termination. A graph of the amount of contaminant removed by the filter as a function of the hours of the test will

TABLE 3—EXAMPLE OF TYPICAL TEST INFORMATION TABLE 2

Test Time (hr)	Sample Volume (L)	Contaminant Weight (g)	Contaminant Concentration (g/L)	Blank Correction (g/L)	Net Contaminant Concentration (g/L)
0	0.050	0.0035	0.070	0.070	0
4	0.048	0.0098	0.204	0.070	0.134
8	0.050	0.0130	0.260	0.070	0.190
12	0.048	0.0155	0.323	0.070	0.253
16	0.048	0.0189	0.394	0.070	0.324
20	0.050	0.0200	0.400	0.070	0.330
22.2	0.050	0.0180	0.360	0.070	0.290

Test Contaminant: ISO 12103-1 A2 Fine
Test Oil: RFO-3
Filter Rating Class: C
Test Conditions:
    Temperature: 83°C
    Sump Volume: 5.45 L
    Contaminant Add Rate: 1.8 g/hr (solids)
    Flow Rate: Through Filter: 12 L/min; Through Bypass: 4 L/min
    Termination, Total Differential: 55 kPa
    Average Contaminant Delivery Rate: 0.0892 L/hr (see Paragraph 6.5.2)

TABLE 4—CALCULATED INFORMATION

Test Time (hr)	Net Contaminant Concentration (g/L)	System Volume (L)	Contaminant in System (g)	Contaminant Added (g)	Contaminant Removed by Filter (g)	Filter Efficiency (%)
(a)	(b)	(c)	(d)	(e)	(f)	(g)
0	0	5.40	0	0	0	–
4	0.134	5.76	0.773	7.2	6.43	89.27
8	0.190	6.11	1.16	14.4	13.24	91.93
12	0.253	6.47	1.64	21.6	19.96	92.42
16	0.324	6.83	2.21	28.8	26.59	92.32
20	0.330	7.18	2.37	36.0	33.63	93.41
22.2	0.029	7.38	2.14	39.96	37.82	94.64

(a) = Hours
(b) = See Table 3
(c) = See Table 2
(d) = b × c
(e) = a × (contaminant add rate, see Table 3)
(f) = e - d
(g) = (f/e) × 100

directly yield the capacity at any intermediate stage of the test.

NOTE: Mass measurement and volumetric calculation using density properties may provide improved volume accuracy.

The maximum sump concentration is obtained from Table 3 and is 0.330 g/L for this example. Efficiencies are calculated in Table 4. It should be noted that each of these figures is a cumulative efficiency and represents the overall efficiency from the start of the test up to the hour for which the efficiency is calculated. Differential efficiencies can also be calculated and may exceed 100%. In the example, the differential efficiency for the interval 20 to 22.2 hours is:

$$100 * \frac{(37.82 - 33.63)}{39.96} = 104.9\%$$

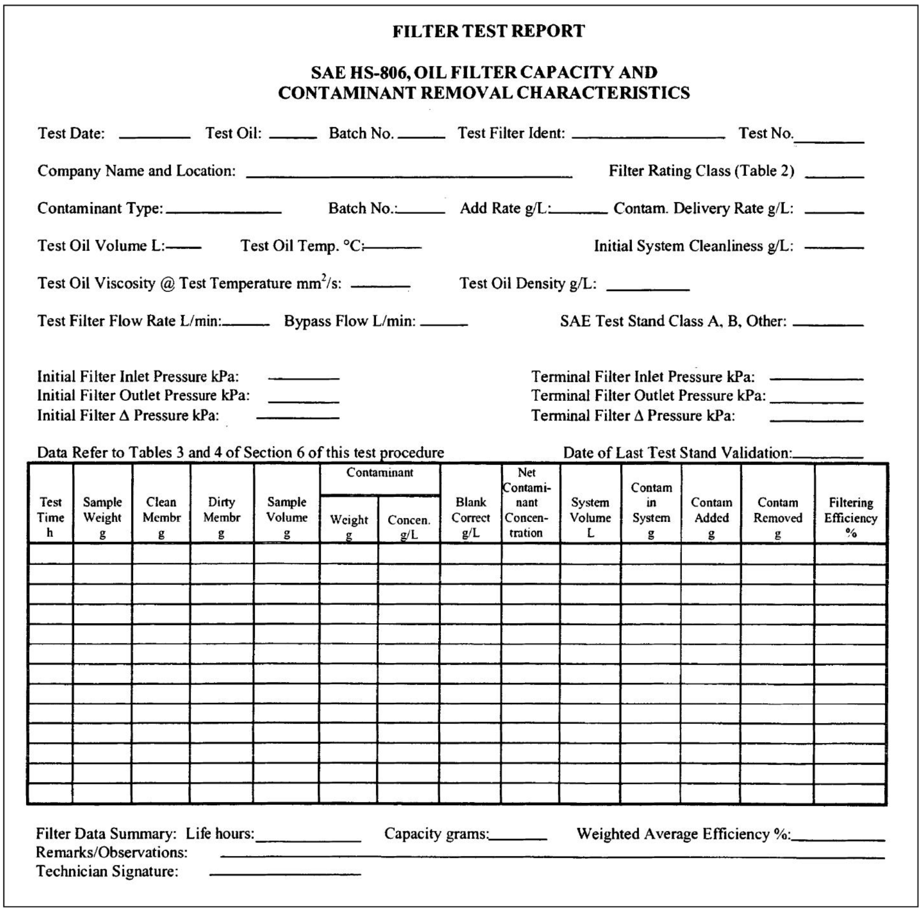
The use of the final efficiency as a single number to characterize the contaminant removal characteristics of a filter is not recommended because a filter characteristically exhibits large changes in efficiency in the terminal stages of the test. Consequently, a slight error in setting the cutoff pressure for the test can have a disproportionate effect on the calculated final efficiency. For this reason, the averaging of efficiency values throughout the course of the test is sometimes employed. It should be recognized that the averaging of cumulative efficiency figures yields a number that has little physical significance, but is nevertheless quite useful.

Simple arithmetic averaging also presents some difficulties in that a test that terminated shortly after a regular sampling interval would yield an average that is biased high compared to one that terminated just prior to the regular sampling interval. Again, this arises from the characteristic sharp rise in the efficiency at termination. An effective means of minimizing this problem (which yields a rather useful result) is to employ weighted average efficiency. This gives equal weight to all efficiency data taken at the regular sample intervals and a lesser weight to the final efficiency according to the period of time between the termination sample and the last regular sample. For the example, the calculation would proceed as follows:

$$\begin{array}{lcr}
(4\text{ hr})(89.27\%) & = & 357.1 \\
(4\text{ hr})(91.93\%) & = & 367.7 \\
(4\text{ hr})(92.42\%) & = & 369.7 \\
(4\text{ hr})(92.32\%) & = & 369.3 \\
(4\text{ hr})(93.41\%) & = & 373.6 \\
\underline{(2.2\text{ hr})(94.64\%)} & = & \underline{208.2} \\
22.2 & & 2045.6
\end{array}$$

Weighted Average Efficiency = (2045.6)/(22.2) = 92.14%

Direct comparisons between weighted average efficiency of different elements are possible only if the two tests have similar regular sampling intervals.



FILTER TEST REPORT

SAE HS-806, OIL FILTER CAPACITY AND CONTAMINANT REMOVAL CHARACTERISTICS

Test Date: ________ Test Oil: ______ Batch No. ______ Test Filter Ident: ________________ Test No.________

Company Name and Location: ____________________________________ Filter Rating Class (Table 2) ______

Contaminant Type: ______________ Batch No.: ______ Add Rate g/L: ______ Contam. Delivery Rate g/L: ______

Test Oil Volume L: _____ Test Oil Temp. °C: ________ Initial System Cleanliness g/L: _______

Test Oil Viscosity @ Test Temperature mm^2/s: _______ Test Oil Density g/L: __________

Test Filter Flow Rate L/min: ______ Bypass Flow L/min: ______ SAE Test Stand Class A, B, Other: ________

Initial Filter Inlet Pressure kPa: ________
Initial Filter Outlet Pressure kPa: ________
Initial Filter Δ Pressure kPa: __________

Terminal Filter Inlet Pressure kPa: ___________
Terminal Filter Outlet Pressure kPa: ___________
Terminal Filter Δ Pressure kPa: ___________

Data Refer to Tables 3 and 4 of Section 6 of this test procedure

Date of Last Test Stand Validation: ________

Test Time h	Sample Weight g	Clean Membr g	Dirty Membr g	Sample Volume g	Contaminant		Blank Correct g/L	Net Contaminant Concentration	System Volume L	Contam in System g	Contam Added g	Contam Removed g	Filtering Efficiency %
					Weight g	Concen. g/L							

Filter Data Summary: Life hours: ____________ Capacity grams: _______ Weighted Average Efficiency %: ___________
Remarks/Observations: ____
Technician Signature: ________________

Figure 6

It should be pointed out that the data format shown in Tables 3 and 4 is based on test data in which the volumes of the samples are recorded. Of course, it is entirely feasible and proper to weigh each of the contaminated oil samples and to express all concentrations on a gravimetric basis. A convenient unit of concentration is milligrams of contaminant per kilogram of sample. In this case, the system volume (liters) is converted to system mass (grams) by multiplying by the density of SAE oil (typical density: 877 to 888 g/L at 22.8°C).

NOTE: To insure accuracy, the density of the test oil should be determined by measurement or by supplier certification.

6.9.2 Reporting of Test Results—Complete report sheet (Fig. 6).

6.10 Variations of Test Conditions

6.10.1 Scaled-Down Tests of Filter Elements—By agreement between the supplier and the user, it is permissible to carry out scaled-down tests. Filter elements used for such scaled-down tests are to be of the same basic design (including direction of flow), material, workmanship, and structural integrity. All size reduction will be in the length of the element only. Test conditions for the scaled-down element are to be scaled down in proportion to the full-scale filter test conditions.

NOTE: A minimum of four samples must be taken.

6.10.2 Test conditions may be changed when agreed upon by the filter user and supplier. Such changes are to be documented and detailed.

6.11 Reliability of Test Results

Confidence in a single test result depends on many things, including such obvious items as the nature of the element under test, sampling, and laboratory technique. For this reason, any statement concerning the reliability of a single test performed on a random sample at any location is, at best, approximate. The information contained in Table 4 must be viewed in this manner; however, it can give a starting point for estimating whether or not replicate testing is necessary and the relative degree of confidence that can be placed in differing types of information. The information in Table 5 was developed from several round-robin filterability tests conducted by various labs in the filter industry. The variability results are expressed in terms of the anticipated standard deviation (as a percentage of the test value) for a single test performed in a single laboratory. It should be noted that the standard deviations for single test results obtained by testing in different laboratories are about double those indicated in Table 5.

TABLE 5—STANDARD DEVIATION OF SINGLE TESTS PERFORMED IN THE SAME LABORATORY

Test	Contaminant	Standard Deviation as a Percentage of the Mean Test Value (100 S/X), %
Life (L)	Fine Test Dust	6
	*SOFTC-2A	5
Capacity (g)	Fine Test Dust	7
	*SOFTC-2A	8
Maximum concentration of sump contaminant (g/L)	Fine Test Dust	8
	*SOFTC-2A	6
Weighted average efficiency (%)	Fine Test Dust	4
	*SOFTC-2A	15

*Due to the high standard deviation with SOFTC-2A on weighted average efficiency evaluation, it is recommended that use of SOFTC-2A be limited to life test only.

Section 7

Single-Pass Particle Retention Capability Test

7.1 Scope

This method describes the particle retention testing of lubrication oil filters, which are used to protect internal combustion engines. The method of testing has been developed for rating filter elements or filter assemblies in terms of percent filtering efficiency on a contaminant single-pass basis for a specific particle size or particle size range of contaminant.

NOTE: Single-pass retention results should be used in conjunction with performance results from a filterability test method that generates an increasing differential pressure across the filter media. This is necessary to address contaminant re-entrainment issues with filters used on multi-pass systems.

7.2 Test Materials

7.2.1 Test Fluid—SAE 30 non-additive oil mixed with No. 1 heater oil to provide an 18.4 cSt viscosity at test temperature. Mineral oils with the same viscosity at test temperature may be used.

7.2.2 Test Contaminants—Three types of contaminants, or narrow particle range extractions thereof, are considered applicable for particle retention capability evaluations.

7.2.2.1 Broad Particle Range Contaminant—Dry glass beads in industrial fractions within the 29 to 470 μm range.

7.2.2.2 Narrow Particle Range Contaminant—Dry glass beads in 10 μm fractions.

7.2.2.3 Natural Contaminant—ISO 12103-1 A4 Coarse Test Dust in the 0 to 200 μm range or fractions thereof.

7.2.3 Solvents.

7.2.3.1 Analytical.

7.2.3.1.1 *n*-Pentane.

7.2.3.1.2 Petroleum ether.

7.2.3.1.3 Equivalent solvent (solvent that contributes no weight gain measurable to 0.0001 g to the analytical membrane).

7.2.3.2 System cleanup.

7.2.3.2.1 Mineral spirits.

7.2.3.2.2 Heater oil (No. 1 or equivalent).

7.3 Test Apparatus

7.3.1 Test Stand—The schematic diagram presented in Fig. 7 represents a minimum of equipment.

7.3.1.1 Motor-driven pump capable of delivering 23 L/min minimum at up to 690 kPa.

7.3.1.2 Sump (7.6 L capacity, minimum) with heater capable of maintaining 82°C.

7.3.1.3 Flowmeter—0 to 38 L/min calibrated for test fluid, or as specified.

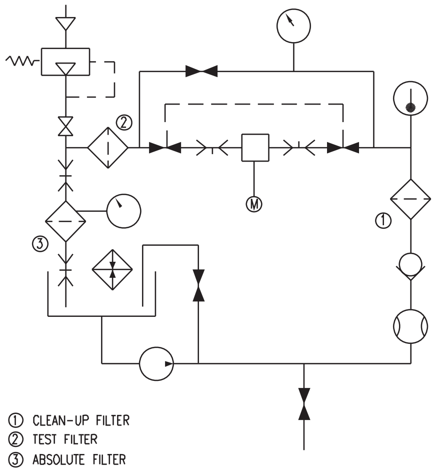


Fig. 7—Single Pass Test Stand

7.3.1.4 Use a blender power unit and modified micromixer per fig. 8 if test dust is used. Use a swirl chamber per Fig. 9 when beads are used as the contaminant.

NOTE: The micromixer bearing seal may require modification to prevent leakage under pressure.

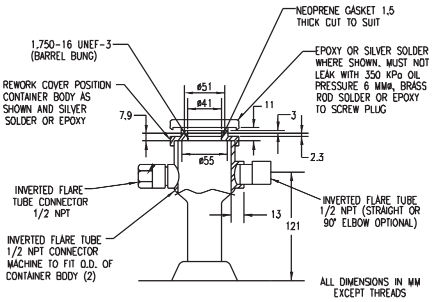


Fig. 8—Modified Micromixer

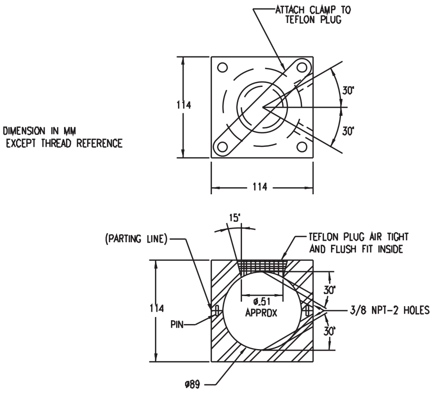


Fig. 9—Single Pass Swirl Chamber

7.3.1.5 Test filter mounting fixture per Figs. 2 or 3, or as required.

7.3.1.6 Two pressure gauges, 0 to 690 kPa.

7.3.1.7 Absolute filter holder: 142 mm diameter or 293 mm diameter, as required.

NOTE: All fittings between the mixing chamber and the absolute filter require internal step relief to ensure smooth flow and reduction of contaminant entrapment in this part of the test system. This portion of the test circuit should be as short as possible and must not exceed 610 mm.

7.3.1.8 Tubing or hose with suitable connection for test circuit. All hydraulic lines and fittings to be 10-mm tubing or larger.

7.3.1.9 Mixer bypass system. Three ball valves, with 90° turn actuation.

7.3.1.10 Flow control bypass valve, globe type or equivalent.

7.3.1.11 Check valve.

7.3.1.12 Cleanup filter less than 20 μm actual rating, with not more than 2 L of oil holding capacity.

7.3.1.13 Temperature gauge, 0 to 120 C.

7.3.1.14 Valve interlock (mechanical linkage between valves on either side of the mixer to ensure simultaneous actuation of these valves).

7.3.1.15 Air pressure regulator and shutoff valve capable of controlling air pressure to less than 35 kPa. Valve to be globe or needle type.

7.3.2 Absolute Filter—Select to suit contaminant and size and type of filter being tested. Normally, the wire cloth filters are used with glass bead contaminants and membrane-type filters with natural contaminants. The analysis method to be used (Paragraph 7.6.10) will also affect this choice. Typical flow versus differential pressures are shown for absolute filters in Figs. 10 and 11.

7.3.2.1 Wire cloth, 41 μm nominal (44 μm actual).

7.3.2.2 Wire cloth, 10 μm nominal (17 μm actual).

7.3.2.3 Wire cloth, 5 μm nominal (8 μm actual).

7.3.2.4 Membrane type (8, 5, 3, etc., μm).

NOTE: Flows in excess of 11 L/min will require the 293-mm diameter membrane filters. Elastomer gaskets are required on screens to ensure no edge leaks.

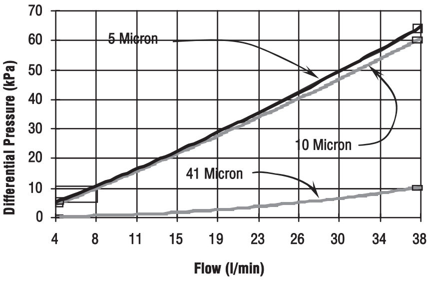


Fig. 10—Flow Versus Differential Pressure Across 293 mm Test Fixture with Indicated Screen Installed Using SAE 30 Oil at 82°C

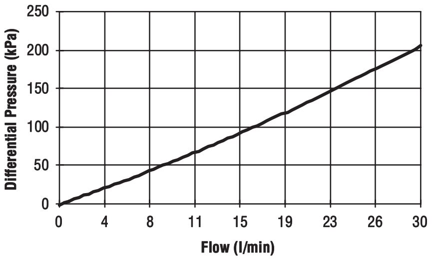


Fig. 11—Flow Versus Differential Pressure Across 293 mm Test Fixture with 8 µm Membrane Installed Using SAE 30 Oil at 82°C

7.4 Test Preparation

7.4.1 Assemble a single-pass efficiency test system as per Fig. 7. Either mixer is satisfactory unless test dust is used as a contaminant. The blender is required for adequate mixing of the test dust. The test filter must be mounted horizontally.

7.4.2 Flush the system thoroughly several times with No. 1 fuel oil or equivalent to remove the majority of foreign particles within the system. Use an empty test filter container during cleanup.

7.4.3 Drain the fuel oil from all system components and flush the system free of fuel oil using the test oil.

7.4.4 Install the absolute filter and fill the sump with a minimum of 7.5 L of test oil.

7.4.5 Install a clean element in the dry cleanup filter housing.

7.4.6 Clean the blank system, including the mixer, to a maximum level of 0.005 g (on absolute filter) for a 15-minute flow period, using specified test oil, and empty the test filter container during the cleanup check.

7.5 System Validation Procedure

7.5.1 Run the validation check exactly like the test procedure (Section 7.6), except substituting a blank filter adapter (Fig. 5) for the test filter.

7.5.2 The quantity of contaminant recovered on the absolute filter should not deviate by more than 1.5% of the amount added in a single test or by more than 1.0% of the average amount added in three such tests. If these levels are not met, the source of error should be determined and eliminated before proceeding to ensure adequate and repeatable results during normal filter tests.

7.6 Test Procedure

7.6.1 Install the test filter in the system.

7.6.2 Install a clean absolute filter.

7.6.3 Flow the test fluid of specified test viscosity at the selected flow rate (see Table 2 in Section 6) through the test filter for 30 minutes to collect media migration and stabilize the temperature and flow rate. At the end of this period, clean the screen or replace the membrane in the absolute filter holder, and determine the test system cleanliness with the test filter installed. This must not exceed 0.005 g (on absolute filter) for a 15-minute flow period. This value will be used as a tare for the test.

7.6.4 Open the mixer bypass valve, and close the inlet and outlet valves to the mixer chamber.

7.6.5 Introduce 0.3000 ± 0.0050 g of contaminant (in the desired size range) into the mixer chamber and close the cover.

7.6.6 Mix the contaminant for 1 minute at low speed, if a blender is used.

7.6.7 Start the flow through the mixer to test the filter, and continue to flow for a total test period of 15 minutes. (The micromixer must operate at a low speed level throughout the entire test.)

7.6.8 Shut off the test system (and micromixer drive motor, if used).

7.6.9 Introduce filtered air at moderate pressure at the absolute filter holder inlet to remove excess test fluid.

7.6.10 Prepare the absolute filter for weight analysis of the contaminant by one of the following methods.

7.6.10.1 Screen-type absolute filters. Screen filters larger than 142-mm diameter cannot be directly weighed on an analytical balance. Therefore, when using these filters the contaminant must be flushed from the surface using pre-filtered analytical solvent onto a smaller, pre-weighed membrane. Analysis can then be accomplished by the method described in Appendix B.

7.6.10.2 Membrane filters of 142-mm diameter or less may be pre-weighed before use, and then weighed after use after thorough rinsing with a pre-filtered analytical solvent (see Appendix B for detailed instructions). This solvent can then be analyzed per Appendix B.

7.6.10.3 Any membrane absolute filter can be analyzed by the following ashing method if non-additive oil is used. Wash the membrane nearly free of oil with pre-filtered analytical solvent wash from the outside toward the center to retain contaminant. Allow the solvent and moisture to evaporate, and then fold the membrane and place in furnace-fired, pre-weighed, porcelain crucible. Saturate the folded membrane with denatured alcohol and ignite. When burning stops, place the uncovered crucible in a 776°C muffle furnace for 30 minutes. After cooling, reweigh and report the weight gain as the contaminant passed by the filter.

7.6.11 Determine the weight of the contaminant left in the mixer by flushing with pre-filtered analytical solvent through a small, pre-weighed, analytical membrane filter.

7.7 Evaluation of Results

7.7.1 Test filter single pass efficiency (%)

$$= \frac{(W_1 - W_2 - W_4)}{(W_1 + W_3 + W_4)} * 100$$

where

$W_1 =$ Weight of test contaminant presented to the filter (Paragraph 7.6.5)
$W_2 =$ Weight of test contaminant collected on absolute filter (Paragraph 7.6.10) (that is, total weight on the absolute filter minus W_3)
$W_3 =$ Tare value from test system cleanliness (Paragraph 7.6.3)
$W_4 =$ Weight of test contaminant left in mixer (Paragraph 7.6.11)

7.7.2 Successive tests on identical elements should provide for good repeatability. Past experience indicates that the standard deviation should be less than 5% of the mean value of such repeat tests. That is,

$$\frac{100\,(S_x)}{\overline{X}} \leq 5\%$$

where

$S_X =$ Standard deviation of efficiency of tests
$\overline{X} =$ Mean efficiency of tests

Section 8

Media Migration Test

8.1 Scope

The purpose of this test is to determine if the filter introduces contaminant into the lubricating oil stream. This contaminant is generally referred to as media migration. The source of the contaminant is not necessarily the filter media. Any component of the filter, or manufacturing techniques of fabricating the filter, can also be a source of passed contaminant. The test method consists basically of flowing clean oil through several filters and collecting the contaminant from the effluent on a wire cloth screen from which weight determinations and visual observations can be made. The method is applicable to filters of the partial flow, shunt, and full-flow types.

8.2 Test Materials

8.2.1 Test Oil—SAE J1260, Standard Oil Filter Test Oil (RFO-3) or oil of equivalent viscosity at test temperature.

8.2.2 Four test filters.

8.2.3 Solvent, analytical grade.

8.2.3.1 *n*-Pentane.

8.2.3.2 Petroleum ether.

8.2.3.3 Equivalent solvent (solvent that contributes no weight gain measurable to 0.0001 g to the analytical membrane).

8.3 Test Apparatus

8.3.1 Test Stand—Same as in Section 7, Paragraph 7.3.1, except without the mixer unit.

8.3.2 Media Migration Filter Screen.

8.3.2.1 Wire cloth screen, 41 μm nominal.

8.3.3 Analytical equipment (see Appendix B).

8.4 Test Preparation

8.4.1 Install the wire cloth screen in the holder and fill the sump with a minimum of 7.5 L of test oil.

8.4.2 Circulate test oil through the system (without a test filter) at the rated flow (Table 2, Section 6) and 82°C for 15 minutes and determine system cleanliness by the method described in Paragraph 8.5.4. Repeat as often as necessary to achieve a cleanliness level of 0.001 g maximum.

8.5 Test Procedure

8.5.1 After satisfying Paragraph 8.4.2, install a test filter.

8.5.2 Install a clean wire cloth screen in the holder.

8.5.3 Flow test fluid through the test filter at the rated flow (or inlet pressure) and temperature for 30 minutes. Repeat this cycle of 30 minutes circulation on a total of four test filters without a change or addition to the oil sump. Discard any oil spillage that occurs during filter changes. Do not replenish the sump with any makeup oil.

8.5.4 Carefully remove the wire cloth screen from the holder and wash the collected media from the screen into a clean beaker with pre-filtered *n*-pentane, petroleum ether, or equivalent solvent. No less than 0.3 L of solvent should be used for a thorough washing. Filter the washing through a tared 0.8-μm, 47-mm diameter analytical membrane filter disc following the recommended gravimetric technique. Determine the total weight of contaminant contained in the washing to the nearest 0.0001 g.

8.5.5 Analyze the contaminant to determine its nature.

8.6 Presentation of Data and Evaluation of Results

8.6.1 The total weight of media migration (contaminants from the washing) shall be divided by four to obtain media migration per filter.

8.6.2 Report the nature of media migration from the test filters.

Section 9

Collapse Test for Lube Oil Elements

9.1 Scope

The collapse, or element strength, test is designed to ensure that a filter element will withstand the anticipated maximum differential pressure to avoid bypassing due to breakage or collapse while filtering. The test method will determine element strength by means of pumping contaminated oil through the element until collapse occurs or the maximum anticipated differential pressure is reached without element failure.

9.2 Test Materials

9.2.1 Test Oil—SAE J1260, Standard Oil Filter Test Oil (RFO-3) or oil of similar viscosity.

9.2.2 Contaminant—ISO 12103-1 A2 Fine or other suitable choking-type contaminant.

9.3 Test Apparatus

9.3.1 A suitable filter housing with pressure taps to sense filter element differential pressure.

9.3.2 A pump and motor capable of maintaining flow of the test fluid at a pressure in excess of the required pressure differential.

9.3.3 A reservoir of sufficient size.

9.3.4 Necessary piping, fittings, and valves to flow oil and control flow through the filter, per Fig. 12.

9.3.5 A differential pressure measuring device, with a peak pressure indicator, capable of registering at least 120% of the maximum expected collapse pressure.

9.3.6 A device for heating and controlling the temperature of the test oil if an elevated temperature is desired.

9.4 Test Preparation

9.4.1 The filter element to be tested may be one previously subjected to a filterability test. The element should be examined for any apparent damage before being subjected to the collapse test. (This is not applicable for spin-on filters.)

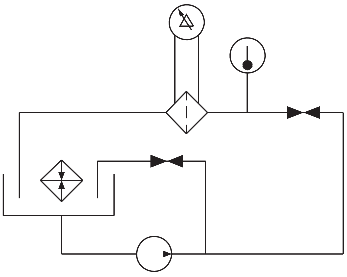


Fig. 12—Collapse Test Stand

9.4.2 Block or eliminate the relief valve, if present.

9.4.3 The test element may be subjected to a fabrication integrity test (ISO 2942; bubble point) before the collapse test begins and after the element has been tested.

9.5 Test Procedure

9.5.1 Place the element in the test housing on the test stand.

9.5.2 With the main valve closed and the bypass valve open, start the pump and circulate the oil until it has reached the proper temperature desired.

9.5.3 Open the main valve and close the bypass valve as necessary to achieve sufficient flow through the test element. At this time, all air must be bled from the test filter housing.

9.5.4 After the air has been bled out, start adding the contaminant to the oil in the reservoir; it may be added manually or automatically.

9.5.5 When a differential pressure of approximately 172 kPa across the test element is reached, stop the contaminant addition and allow the pressure to increase. If the pressure drop ceases to increase, add more contaminant until the pressure drop starts to increase again. If flow stops, close the bypass valve until flow restarts.

9.5.6 Differential pressure should be increased until the element collapses as evidenced by a sudden drop in differential pressure, or until the anticipated maximum differential pressure is reached.

NOTE: It may be beneficial to visually observe the outlet flow from the filter under test. This in conjunction with the drop in differential pressure will aid in determining the point of element collapse. It is also possible that an internal bypass may prevent the filter from increasing beyond a certain pressure.

9.5.7 After either of the conditions of Paragraph 9.5.6 is reached, shut down the test stand, remove the filter element from the housing, and examine the element.

9.6 Presentation of Data and Evaluation of Results

9.6.1 The report shall include the following information.

9.6.1.1 Pretreatment of the filter element—that is, life test, pre-flow, or new element.

9.6.1.2 Maximum differential pressure attained.

9.6.1.3 Reason for terminating test.

9.6.1.4 Condition of filter element after test.

Section 10

Inlet and Outlet Anti-Drain Valve Test

NOTE: Refer to International Standard ISO 4548–9 to perform this procedure.

Section 11

Ability to Meet Environmental Conditions

11.1 Scope

The following test methods are applicable to oil filters used in internal combustion engine lubrication oil systems. The methods evaluate the following environmental factors:

- Effect of water in the oil on filter capacity
- Effect of high oil temperature on integrity or collapse strength of filter element
- Oil additive removal tendencies of the filter element (for ash-type oil additives only)
- Effect of low temperatures on sealing characteristics of spin-on oil filter sealing gaskets.

11.2 Test Method for Effect of Water in the Oil on Filter Capacity

11.2.1 Test Materials

11.2.1.1 Distilled or de-ionized water.

11.2.1.2 SOFTC-2A, ISO 12103-1 A2 Fine Test Dust or qualifying contaminant.

11.2.1.3 SAE 30 non-additive oil.

11.2.2 Test Apparatus—SAE standardized oil filter test stand, Class A or Class B, for applicable flow rate with external cooling added to maintain 50°C oil temperature to filter.

11.2.3 Test Preparation—Refer to Section 6 on Filterability.

11.2.3.1 Prepare the test stand per Paragraph 6.6, Section 6, using non-additive oil and the appropriate class stand for the rated filter flow, except use 50°C filter inlet temperature.

11.2.4 Test Procedure

11.2.4.1 Conduct the test per Paragraph 6.7, Section 6, using non-additive oil and the qualifying contaminant or SOFTC-2A, with the following modifications to the procedure.

11.2.4.2 Test temperature to be 50°C at the filter inlet.

11.2.4.3 Add distilled or de-ionized water hourly to the sump at a rate equal to 0.1% of the initial oil sump fill volume. For example, for an initial oil filter fill volume of 6 L, the hourly add rate is 0.006 L of water. Water can be added through continuous injection or batch add. Time zero would be considered at the first batch add of water or the start of the water injection system. Report the method of water addition in the test report.

11.2.4.4 Terminate the test when the pressure differential across the filter exceeds the condemning pressure or a prescribed time limit has elapsed, whichever occurs first.

11.2.4.5 Sump samples need not be taken. Portions of Paragraph 6.7, Section 6, referring to sampling are not applicable to this test.

11.2.5 Evaluation of Results

11.2.5.1 Test life, in hours, with addition of water must meet the specified relation to test life without addition of water. Test life is defined as test hours required to reach the condemning pressure drop.

11.3 Test Method with High Oil Temperature for Element Integrity

11.3.1 Test Oil

11.3.1.1 SAE J1260, Standard Oil Filter Test Oil (RFO-3) or as specified.

11.3.2 Test Apparatus

11.3.2.1 SAE standardized oil filter test stand, Class A or Class B, for applicable flow rate, or an equivalent test stand.

11.3.3 Test Procedure

11.3.3.1 Adjust the stand to produce filter rated flow, except use 135°C or maximum intended service temperature and extend the circulation time per element to 24 hours, unless a longer time is specified.

11.3.3.2 At the end of the circulation time, subject the filter elements to the collapse test per Section 9. If the filter assembly contains an anti-drain valve, subject the assembly to test per Section 10 before proceeding with the collapse test.

11.3.4 Presentation of Data and Evaluation of Results—Tabulate the collapse pressure for each element per Paragraph 9.6, Section 9. Indicate the prescribed acceptable limits required to pass the test.

11.4 Test Method for Determination of Oil Additive Removal by Filter

11.4.1 Test Materials

11.4.1.1 SAE J1260, Standard Oil Filter Test Oil (RFO-3) or as specified.

11.4.1.2 Test filter cartridge and housing, if applicable.

11.4.1.3 Spin-on test filter assembly and empty spin-on filter shell, if applicable.

11.4.2 Test Apparatus

11.4.2.1 SAE standardized oil filter test stand, Class A or Class B, or similar test stand capable of maintaining conditions described herein.

11.4.3 Test Preparation

11.4.3.1 Clean the test stand thoroughly by circulating with Stoddard Solvent or equivalent fluid. Drain the stand and purge the system with specified test oil. Test oil contaminant level should not exceed 0.020% by weight.

11.4.3.2 On the test stand, install an empty filter housing or spin-on shell without element. The hardware should be identical with that to be used in Paragraph 11.4.4.1, with the exception of element omission.

11.4.3.3 Place 8 L of specified test oil in a Class A stand or 19 L of test oil in a Class B stand, whichever is applicable.

11.4.3.4 For a Class A stand: Set the oil pump delivery rate at 34 L/min. Adjust the bypass and heater controls such that 23 L/min goes through the filter at 82°C. For a Class B stand: Set the oil pump delivery rate at 68 L/min. Adjust the bypass and heater controls such that 45 L/min goes through the filter at 82°C. If the filter rated flow is lower than specified here, use the filter rated flow.

11.4.3.5 Circulate test oil for 16 hours at conditions of Paragraph 11.4.3.4. Remove oil sample and determine oil additive content. Suggested methods are noted in Paragraph 11.4.6.

11.4.3.6 Drain the test oil from the stand, but do not flush the test stand.

11.4.3.7 Repeat procedures of Paragraphs 11.4.3.3 through 11.4.3.6 with fresh test oil. The average of these two runs shall be considered the test blank.

11.4.3.8 Take a sample of the specified test oil from the drum and determine the oil additive content by use of the same method used in Paragraph 11.4.3.5. This is to be recorded as the additive content of the test oil as received.

11.4.4 Test Procedure

11.4.4.1 On the test stand, install a test filter cartridge into housing or spin-on assembly containing the test element, and proceed as per Paragraphs 11.4.3.3 and 11.4.3.4.

11.4.4.2 Circulate the test oil through the filter for 24 hours, withdrawing a 0.10-L sample at the filter outlet every 8 hours.

11.4.4.3 Analyze each 0.10-L sample removed for oil additive content by use of the same method used in Paragraphs 11.4.3.5 and 11.4.3.8.

11.4.5 Presentation of Data and Evaluation of Results

11.4.5.1 Tabulate the oil additive content data showing values for oil as received (per Paragraph 11.4.3.8), the test blank (per Paragraph 11.4.3.7), and 8-hour samples run through a filter (per Paragraph 11.4.4.3). The data sheet and report must state which analysis method was used.

11.4.5.2 The oil additive content of each 8-hour sample should be corrected to account for the test blank. Correction should be carried out as detailed in the following.

Corrected 8-hr sample =
8-hr sample + (as received additive content − test blank)

11.4.5.3 The difference between oil additive content as received and corrected content after circulation through a filter must be within agreed qualifying limits.

11.4.5.4 For reference purposes, primary additives (and their typical concentrations) contained in J1260 (RFO-3) test oil are calcium (220 to 270 ppm wt) and zinc (200 to 250 ppm wt).

11.4.6 Analysis Methods for Oil Additive Contaminant—The following methods are recommended for determining oil additive content as discussed herein. The method chosen should be used throughout the test.

11.4.6.1 Atomic Absorption Spectrophotometry.

11.4.6.2 Flame Emission Spectrophotometry.

11.4.6.3 X-Ray Spectrophotometry.

11.4.6.4 Argon Plasma Spectrophotometry.

11.4.6.5 Atomic Emission Spectrometer.

NOTE: To achieve reasonably accurate results, it is important to observe the following:

a) The viscosity of the instrument calibrating fluid must match the viscosity of the test fluid sample.
b) For atomic absorption analysis: The higher temperature nitrous oxide flame must be used. Consult the instrument operating manual for details.

11.5 Low-Temperature Sealing Characteristics of Spin-On Oil Filter Sealing Gaskets

11.5.1 Scope—The purpose of this test is to evaluate the low-temperature sealing characteristics of lube oil filter gaskets. The test method consists of fitting the test gaskets into the appropriate filter assemblies and installing these filters onto a test base. This combination is first exposed to a period of hot oil circulation, followed by a period of exposure to a sub-zero temperature; they are pressurized until gasket leakage occurs or until the specified pressure is reached. This pressure is recorded as the test result and defines the low-temperature sealing characteristic of the test gasket.

11.5.2 Test Materials

11.5.2.1 Test Oil—SAE J1260, Standard Oil Filter Test Oil (RFO-3) or oil of equivalent viscosity at test temperature.

11.5.2.2 Mineral Spirits (Petroleum Aliphatic Solvent).

11.5.3 Test Apparatus

11.5.3.1 Test Stand—A test stand capable of maintaining a flow of 9.5 L/min and test oil temperature at 135°C with a head pressure of 420 kPa. The test stand is to have a provision to bypass the test filters to allow for initial system warm-up. To prevent oil oxidation, it is recommended that the test system be a closed system capable of being pressurized with 70 to 140 kPa of nitrogen.

11.5.3.2 Environmental Chamber—Capable of maintaining a temperature of −40°C.

11.5.3.3 Test Manifold—The assembly should be built of the appropriate mounting bases to test the required number of test units. There should be a provision for draining the test assembly without disturbing the test filters. The mounting bases should be constructed to the requirements of SAE J363. Adherence to the requirements for sealing surface finish is especially important for reproducible test results.

11.5.3.4 Hydraulic Pressure Pump— Pressure source (with pressure gauge) capable of applying a minimum of 2100 kPa.

11.5.3.5 Reservoir—Capacity of 4 L minimum.

11.5.3.6 Interconnecting hoses and fittings as needed.

CAUTION: The test stand should be equipped with the appropriate safety systems to prevent operator injury from hot or pressurized oil.

11.5.4 Test Procedure

11.5.4.1 Install test gaskets into the retainers of the appropriate filter assemblies.

11.5.4.2 Lubricate the sealing surface of the gaskets with a thin film of test oil. Install the test filters onto the test bases and tighten each to the required torque or number of turns.

11.5.4.3 Install the test manifold with test filters onto the test stand. Run the stand on bypass until a temperature of 135°C is reached. Close the bypass and adjust the controls for a flow of 9.5 L/min at a pressure of 420 kPa.

11.5.4.4 Circulate for 40 hours, checking for leaks in the gasket seal periodically.

11.5.4.5 At 40 hours, shut off the stand and allow to cool. Remove the manifold and drain, but do not disturb the test filters.

11.5.4.6 Place the test manifold and the reservoir in the environmental chamber with the hydraulic pump outside of the chamber. Route the hose connections so the pump will draw cold fluid from the reservoir in the chamber and apply pressure to the test manifold in the chamber. Check that all air has been bled from the system.

11.5.4.7 Connect the hydraulic pump to the test manifold and fill pump, manifold, and test filters with a 50/50 mixture of test oil and mineral spirits. Continue until all air has been bled from the system.

11.5.4.8 Close the environmental chamber and reduce the temperature to −40°C. Allow the test assembly to stabilize at this temperature (usually 2 to 4 hours).

11.5.4.9 With all air and oil bleeds shut off, gradually apply pressure at a controlled ramp up of no greater than 690 kPa/min. (If approximate leak pressure for the test filter is known, the initial pressure increment may be 50% of the expected leak pressure.) Pressurize the assembly until leakage occurs or until the required pressure is reached (whichever occurs first). Record leakage pressure or required pressure attained as the test result. When testing multiple filters, tighten or isolate from pressure any leaky filters and continue pressurizing until all filters have failed or reached the required pressure.

Section 12

Installation and Removal

12.1 Installation Seal Retention

12.1.1 Scope—This test method relates to the maintenance of sealing ability of spin-on filters during use and subject to vibration. Results indicate the ability of the filter to remain sealed at the sealing surface of its head after being subjected to environmental conditions.

12.1.2 Test Materials, Test Apparatus, Test Preparation, Test Procedure

Refer to the International Standard ISO 4548-7 to perform this test procedure with the following exceptions.

12.1.2.1 To the test oil, add a fluorescent dye that can be detected by using ultraviolet light.

12.1.2.2 Test shall be terminated after 100 hours or when leakage is observed, whichever occurs first.

12.1.2.3 Leakage can be observed by the use of an ultraviolet light when the oil is treated with a fluorescent dye.

12.1.3 Presentation of Data

12.1.3.1 Report hours to leakage failure or test termination, noting location and type of failure if it occurs.

12.1.3.2 Completely report all test conditions.

12.2 Installation Sealing Torque

12.2.1 Scope—This test method relates to the static sealing characteristics of spin-on oil filters. Results indicate the ability of the filter to be sealed at the sealing surface of its head when installed by application of torque.

12.2.2 Test Material—Test Fluid: Oil of ISO viscosity grade 68 at 37.8°C.

12.2.3 Test Apparatus—Fig. 19.

12.2.3.1 Hydraulic pressure source, 0 to 3500 kPa.

12.2.3.2 Pressure measuring device, 0 to 2100 kPa.

12.2.3.3 SAE universal test fixture for spin-on filter (Fig. 3).

12.2.3.4 Flexible 3500-kPa hydraulic hose.

12.2.3.5 Translucent shield observation enclosure around product being evaluated.

12.2.3.6 Torque wrench with a torque range of 0 to 60 N-m readable to 0.5 N-m.

12.2.4 Test Preparation

12.2.4.1 Connect the hydraulic hose from the pump to the filter test head.

12.2.4.2 Check the gasket to ensure that it is bottomed out in the retainer groove.

12.2.4.3 Measure the filter flange to determine the relationship of the gasket groove and threaded portion.

12.2.5 Test Procedure

12.2.5.1 Apply a thin film of oil to the gasket surface and fill the test filter with oil.

12.2.5.2 Screw the filter on the test fixture until the gasket makes contact.

12.2.5.3 Tighten the filter to the test fixture with the application of 2.8 N-m of torque, or torque recommended by the filter manufacturer.

12.2.5.4 Position the translucent shield between the operator and filter fixture assembly.

12.2.5.5 With all air and oil bleeds shut off, gradually apply pressure at a controlled ramp up of no greater than 690 kPa/min. (If approximate leak pressure for the test filter is known, the initial pressure increment may be 50% of the expected leak pressure.) Record the leakage pressure.

12.2.5.6 Determine the leakage pressure at increasing torque intervals of 2.8 N-m, or torque recommended by the filter manufacturer, until required turns after first gasket contact have been achieved or recommended torque has been applied.

12.2.5.7 Remove the filter from the fixture and measure to determine if any permanent deformation of the filter flange has taken place.

12.2.6 Presentation of Data

12.2.6.1 Graph the torque as the abscissa and the pressure, leakage as the ordinate.

12.2.6.2 Report permanent deformation of the filter flange at leak pressure.

12.2.6.3 Note the torque required to attain the seal pressure desired.

12.3 Removal Torque Test Method

12.3.1 Scope—This test method relates to the torque required to remove spin-on filters after exposure to specified installation torque pressure and simulated engine temperatures.

12.3.2 Test Material—Test Fluid: Oil of ISO viscosity grade 68 at 37.8°C.

12.3.3 Test Apparatus

12.3.3.1 Constant temperature oven capable of maintaining 100°C.

12.3.3.2 Thermometer (immersion type) with a temperature range of 0 to 125°C.

12.3.3.3 Torque wrench with a torque range of 0 to 60 N-m readable to 0.5 N-m.

12.3.3.4 Torque wrench adapter; suggested design is shown in Fig. 15.

12.3.3.5 Filter Test Base—Use manufacturer's specified base.

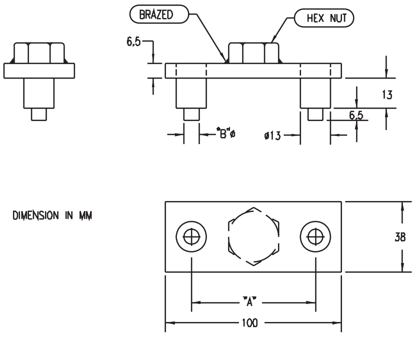
12.3.3.6 Product to be evaluated. Gasket and spin-on filter flange assembly (unit end plate assembly, nut plate assembly, and so on).

12.3.4 Test Preparation

12.3.4.1 Preheat oven to 100°C.

12.3.4.2 Secure the filter base in a vise. Be sure threads are clean and properly sized.

12.3.4.3 Check the gasket to ensure that it is fully seated in the retainer groove.



"A" AND "B" TO BE DETERMINED BY FLANGE DESIGN

Fig. 15—Torque Wrench Adapter

12.3.5 Test Procedure

12.3.5.1 Apply a light film of oil to the gasket surface.

12.3.5.2 Assemble the filter flange assembly to the filter test head until the gasket makes contact.

12.3.5.3 Using a torque wrench adapter, apply the specified torque (or rotation).

12.3.5.4 Place the total assembly in an oven for 24 hours minimum.

12.3.5.5 Remove the assembly and allow to cool to room temperature (20 to 25°C).

12.3.5.6 Using a torque wrench with uniformly applied force, remove the filter flange assembly and record the maximum torque required.

12.3.5.7 Comparison should be based on a minimum of three tests conducted.

12.3.6 Presentation of Data—Tabulate the following information.

12.3.6.1 Installation torque used.

12.3.6.2 Filter head used.

12.3.6.3 Removal torque required.

12.3.6.4 Revolutions required to achieve installation torque (fractions of turn).

12.3.6.5 Whether or not the gasket remained in the retainer groove.

12.3.7 Definition of Terms

12.3.7.1 Removal Torque—The maximum torque required to remove the filter flange assembly from the filter test head.

12.3.7.2 Installation Torque—Manufacturer's specified torque to achieve a good seal.

12.3.7.3 Filter Flange Assembly—Threaded inlet and outlet support plate and gasket retainer combination.

12.3.7.4 Filter Test Base—Manufacturer's recommended base to be used for this test. Sealing surface should have microfinish specified.

Section 13

Mechanical Tests

13.1 Scope

These test methods describe laboratory testing of filters to prove their mechanical integrity. Filters are tested to determine vibration fatigue life, pressure impulse fatigue life, and hydrostatic burst pressure strength of the housing material and construction. These tests simulate conditions of engine vibration, engine lubrication system cyclic pressure pulsation, and maximum pressure surge. The test condition values should correspond with those actually measured on the intended engine applicable when such information is available. The test methods and equipment have been developed primarily for use on filters of the spin-on type, but can be adapted for evaluation of replaceable element type filters no greater than Class 3 size as defined in Federal Specification F-F-351. Any mounting plates, brackets, bases, external lines, or other components peculiar to the actual engine filter mounting arrangement should be duplicated as closely as possible.

NOTE: The described methods and equipment may be modified to accommodate other sizes and types of filters for specific applications.

CAUTION: Take special precautions while conducting any of the pressure tests, in the design of test apparatus, and in training the operators to maximize operator safety.

13.2 Pressure Impulse Fatigue Test

13.2.1 Scope—This test simulates conditions of lubrication system cyclic pressures encountered by the filter during engine operation.

13.2.2 Test Materials—Test Oil: SAE J1260, Standard Oil Filter Test Oil (RFO-3) or a fluid of suitable viscosity to achieve the waveform profile or as specified.

13.2.3 Test Apparatus—See Fig. 16.

13.2.3.1 Rotary Gear Pump or equivalent.

13.2.3.2 Motor—0.75 kW, 1725 rpm.

13.2.3.3 Sump—8-L capacity with heater capable of maintaining 100°C.

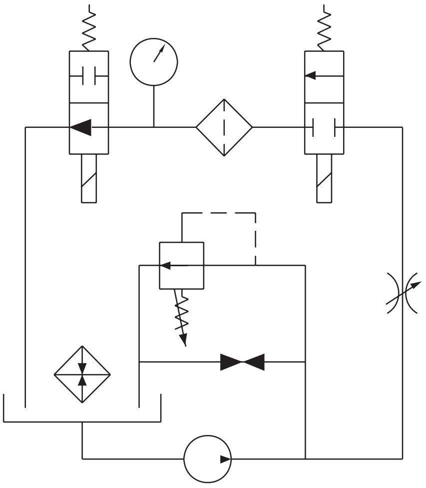


Fig. 16—Pressure Impulse Stand

13.2.3.4 Timer.

13.2.3.5 Solenoid.

13.2.3.6 Electric Counter.

13.2.3.7 Pressure shutoff switch or equivalent, wired to shut down test stand in the event of overpressure.

13.2.3.8 Direct acting pressure relief valve adjustable from 0 to 1400 kPa.

13.2.3.9 Tubing, valves, and gauges.

13.2.3.10 Float-type low fluid level shutoff switch.

13.2.3.11 Test filter mounting fixture (Fig. 3) or base required.

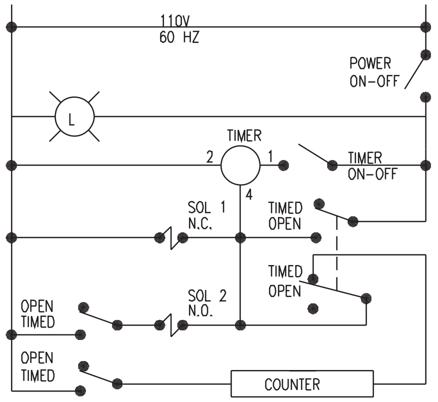


Fig. 17—Impulse Timer Wiring Diagram

13.2.3.12 Test apparatus connected in accordance with Fig. 16 and wiring diagram (Fig. 17).

13.2.3.13 Oscilloscope and transducer. The accuracy of the oscilloscope and transducer must be within 0.25 of 1% of instrument range.

13.2.3.14 Translucent shield.

13.2.4 Test Preparation

13.2.4.1 Fill the sump with test fluid and circulate through the bypass circuit, allowing the temperature to stabilize to 50°C or suitable temperature to achieve the viscosity necessary to meet the specified waveform profile.

13.2.4.2 Install the test filter.

13.2.4.3 Place the translucent observation shield/enclosure around the filter being evaluated.

13.2.4.4 Circulate test fluid through the filter to purge all air from the system.

13.2.4.5 Set the timer to provide the required cycle frequency, and set the system relief valve to the test pressure required.

NOTE: The timer and relief valve adjustments must be made to produce the test waveform as required. See Fig. 18 for a test waveform of the pressure impulse showing the pressure time cycle. The shaded area shows the percent variation of pressure and time permissible from the required waveform. Note that the slopes of the pressure time curve should be 100% of pressure rise in 15% of the cycle time and 100% of pressure decay in 10% of the cycle time. The waveform is very critical to the fatigue life of the test filter and must be closely duplicated. It is mandatory that an oscilloscope and pressure transducer be used to monitor the waveform.

13.2.4.6 Unless otherwise stated, a pressure impulse of 0 to 690 kPa is to be applied at a frequency of 0.5 to 1.0 Hz.

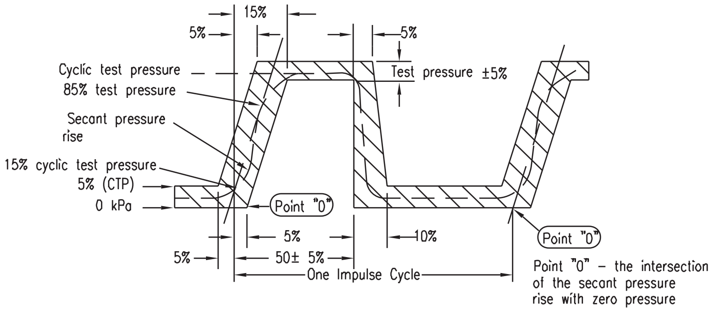


Fig. 18—Impulse Pressure Cycle Waveform

13.2.5 Test Procedure

13.2.5.1 With a counter set at zero, activate the timer to apply the impulse cycle to the test filter.

13.2.5.2 After the filter fails, stop the test and record the number of cycles.

13.2.5.3 Definition of Filter Failure. Failure of the filter is determined at leakage volume of greater than 10 mL, unless otherwise specified.

13.2.5.3.1 Consider any crack produced by metal fatigue due to pressure cycling, as verified by magnetic particle or fluorescent penetrate techniques after testing, a failure.

13.2.5.3.2 Consider leakage at seals or sealing surfaces a failure.

13.2.5.4 It is recommended to test a minimum of six filters.

13.2.6 Presentation of Data

13.2.6.1 Report the number of cycles completed before failure. Also, note the location and type of failure.

13.2.6.2 Completely report all test conditions. Refer to statistical tables in standard NFPA/T3.10.17 for verification level.

13.3 Vibration Fatigue Test

Refer to the International Standard ISO 4548-7 to perform this test procedure.

13.4 Hydrostatic Burst Pressure Test

13.4.1 Scope—This test determines the ability of the filter to withstand the maximum engine surge pressure.

13.4.2 Test Materials—Test Fluid: Non-additive paraffinic petroleum mineral oil of ISO viscosity grade 68 at 37.8°C or a suitable fluid meeting the same viscosity requirements.

13.4.3 Test Apparatus—Similar to Fig. 19. Other types of pumps may be substituted.

13.4.3.1 High-pressure hydraulic pump.

13.4.3.2 High-pressure tubing or hose and necessary connections, and valves (6900 kPa minimum rating).

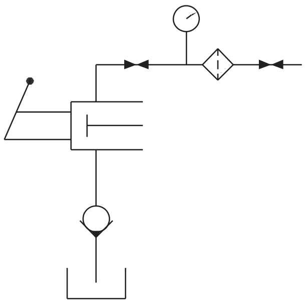


Fig. 19—Hydrostatic Burst Stand

13.4.3.3 Pressure measurement device with a peak pressure indicator to range required (maximum graduation to 100 kPa).

13.4.3.4 Test filter mounting fixture or base.

13.4.3.5 Translucent observation shield/enclosure around product being evaluated.

13.4.4 Test Preparation

13.4.4.1 Fill the test filter with oil and then connect to the test system. Follow the manufacturer's installation instructions for spin-on filter tightening torque or rotation.

13.4.4.2 Apply a small amount of pressure to fill the complete system with fluid and vent off all air.

13.4.4.3 Position the shield between the operator and test filter.

13.4.5 Test Procedure

13.4.5.1 With all air and oil bleeds shut off, gradually apply pressure at a controlled ramp up no greater than 690 kPa/minute. If approximate burst pressure for the test filter is known, the initial pressure increment may be 50% of the expected burst pressure.

13.4.5.2 Continue increasing pressure until the filter fails and allows leakage of fluid.

13.4.5.3 Definition of Filter Failure

13.4.5.3.1 Consider any structural fracture a failure.

13.4.5.3.2 Consider any crack produced by internal static pressure, as verified by magnetic particle or fluorescent penetrate techniques after testing, a failure.

13.4.5.3.3 Consider leakage at seals or sealing surfaces a failure.

13.4.5.4 After failure, relieve the system pressure, remove the filter, drain, and inspect for damage.

13.4.5.5 It is recommended to test a minimum of six filters.

13.4.6 Presentation of Data

13.4.6.1 Report failure pressure and comment on the type of failure.

13.4.6.2 Completely report all test conditions, including tightening torque or number of rotations.

13.4.6.3 Refer to statistical tables in standard NFPA/T3.10.17 for verification level.

Section 14

Relief Valve Performance

14.1 Scope

This method is used to determine the performance of a relief valve with respect to its leakage rate, opening and reseat pressures, and resistance to flow.

14.2 Test Material

14.2.1 Test Oil—SAE J1260, Standard Oil Filter Test Oil (RFO-3) or as specified.

14.3 Test Apparatus

14.3.1 A flow stand similar to that shown in Fig. 1, consisting of a pump, flowmeter, thermometer, and pressure gauges.

14.3.2 Relief valve test fixture in place of the filter housing or element in Fig. 1. Test fixture to be designed to allow unrestricted flow to and from the valve and to prevent flow around the valve.

14.3.3 Pressure measurement device of a range suitable for valve opening pressure, with 1 kPa divisions.

14.3.4 Heat source for oil if necessary to obtain the oil viscosity desired.

14.4 Test Preparation

14.4.1 Remove the relief valve assembly from the filter and mount in the test fixture.

14.4.2 Fill the sump with test oil and recirculate through the bypass circuit until the test temperature is attained. A value of 82°C may be used when no other test temperature is specified. Other temperatures may be used when agreed upon by the user and supplier.

14.5 Test Procedure

14.5.1 Open the flow control valve located before the test fixture and adjust the bypass valve to cause oil to flow through the relief valve.

14.5.2 Continue flow through the relief valve until the test oil and fixture have reached an equilibrium temperature.

14.5.3 Open the bypass valve and allow the relief valve to reseat for 1 to 2 minutes.

14.5.4 Repeat opening and reseating of the relief valve five times to assure proper seating of the valve.

14.5.5 Starting at 1 kPa pressure, increase the pressure on the relief valve at a uniform rate of approximately 35 kPa/min until 0.38 L/min or the maximum permissible leakage rate is reached. Record the pressure as the opening pressure.

14.5.6 Continue increasing the pressure on the valve. Record the pressure required for flow rates up to the rated flow of the valve. The increments for recording should be 2 L/min.

14.5.7 After attaining rated flow through the relief valve, decrease the flow slowly and record the pressure observed at the maximum permissible leakage rate. This is the reseat pressure.

14.6 Presentation of Data

14.6.1 Plot a flow rate versus pressure curve, using flow rate for the abscissa and pressure for the ordinate. Indicate on the curve the rated flow for the valve.

14.6.2 Report the cracking pressure and reseat pressure at specified leakage rate.

14.6.3 Record observations of the valve as the flow or pressure was changed. Particular attention should be given to chatter, oscillation, noise, or other erratic operation.

14.7 Definition of Terms

14.7.1 Leakage Rate—The flow rate through the closed valve expressed as volume per unit of time.

14.7.2 Opening Pressure—The pressure required to open the valve to permit flow at a specified maximum permissible leakage rate.

14.7.3 Reseat Pressure—The pressure at which the valve closes and restricts the flow to a level below a specified maximum permissible leakage rate.

Appendix A

Contaminants

1. Glass Beads

See Appendix C for addresses of suppliers:

1.1 Powder Technology Inc.

1.2 Potters Industries

1.3 Thermo Scientific

2. Test Dust

Test dust is available in four standard grades: ISO 12103-1 A1, A2, A3, and A4. These contaminants have also been referred to as "Arizona Test Dust." Arizona test dust conforming to the ISO 12103 A1, A2, A3, and A4 standard is manufactured by Powder Technology Inc. Differences in test results may occur between different batches of test dust. Therefore, it is recommended that comparison testing of filters be performed using a single batch of dust per test program whenever possible.

Arizona test dust is a naturally occurring contaminant consisting primarily of silicon dioxide with smaller amounts of other crystalline and organic matter. It is collected from a select area of Arizona desert, milled, and classified to specified particle size. Technical specifications of Arizona test dust are available in ISO 12103-1.

Care should be taken in handling test dust because stratification or agglomeration of particles may occur during shipping or handling. It is therefore recommended that test dust be re-suspended or blended prior to use.

3. Contaminant SOFTC-2A—Standardized Oil Filter Test Contaminant

3.1 SOFTC-2A is a mixture of ferric oxide, carbon black, and pulverized vinsol (PV) resin of graded sizes blended in mineral oil, in proportions by weight of 22% solids and 78% oil. The specified composition of solids is as follows.

3.1.1 Sixteen parts by weight carbon black powder, average particle size 0.70 μm.

3.1.2 Two parts by weight of ferric oxide, of which a minimum of 95% by volume is in the range of 0 to 5 μm.

3.1.3 Four parts by weight of PV resin, particle size advertised to be as follows:

- 100% to pass through a 30-mesh screen
- 90% minimum to pass through an 80-mesh screen
- 80% minimum to pass through a 200-mesh screen
- Formulation procedure is described in Federal Specification F-F-351d.

Ready-mixed SOFTC-2A is manufactured and sold by Powder Technology Inc. (see Appendix C for address and telephone number).

Because SOFTC-2A is a blend of controlled substances, it can be reproduced with minimal variation. Therefore, tests conducted with this contaminant over an extended period of time (other things being equal) will be more reproducible than with a natural sludge-type contaminant.

3.2 Contaminant Handling— When purchased in 3.8-L cans, the standard contaminant concentrate should be dated and the container inverted and stored so that the opening access is on the bottom. Prior to contaminant usage, warm the contents of the can to approximately 82°C, shake thoroughly, and transfer the contents from the can, being sure all contaminant is removed.

Place 7.6 L of standard contaminant in the agitator and recirculate through a centrifugal impeller-type pump at 3450 rpm, 68 L/min at 700 mm head. Regulate flow of contaminant through the pump at 3.8 L/min. Depending on ambient conditions, oil temperature normally falls within the range of 51 to 71°C during circulation in the agitator. Continuous operation of the agitator may be maintained throughout the filter test, but the contaminant must be agitated by circulation through the centrifugaltype pump for at least 1 hour immediately prior to each addition to the blender or injector. Add additional SOFTC-2A to reestablish the original contaminant level when approximately 3.8 L of contaminant has been removed from the agitator (see Fig. 20).

Re-establishment of the original level is necessary to prevent "working" of the contaminant by a high turnover rate in the pumping cycles. Remove a sample of the contaminant from the agitator original charge after 1 hour of operation; the samples thus removed are analyzed to determine the percentage of solids content using the petroleum ether and *n*-pentane insolubles analysis procedure. Homogeneity of contaminant being added to the blender or injector must be assured. The importance of having a truly representative material for addition to the testing system cannot be overemphasized.

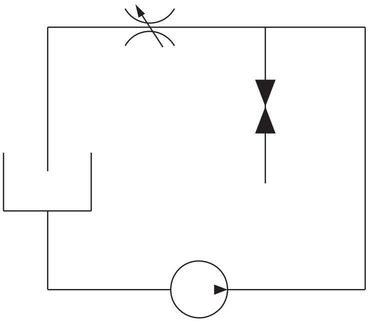


Fig. 20—SOFTC-2A Contaminant Agitator

Appendix B

Method for Oil Sample Analysis

1. Scope

The method covers the gravimetric procedure for the determination of *n*-pentane, petroleum ether, or other suitable solvent insolubles found in a representative sample of oil drawn from the laboratory test stand in the manner specified by the filter test procedure.

2. Summary of Method

2.1 The method uses a microporous filter membrane technique for the separation of solids from the test fluid. This procedure can be effectively used for most sample analyses; however, where extreme accuracy is required or where the level of contaminant is very low, additional steps are recommended. These steps are described at the end of this procedure.

3. Analysis Method (Membrane Filtration)

3.1 Test Apparatus and Materials

3.1.1 Membrane filters, white, plain, 47-mm diameter, 0.8-μm pore size (1).

3.1.2 Filter holder, 47 mm, consisting of a borosilicate glass or stainless steel funnel and funnel base, plus clamp (2).

3.1.3 Analytical balance, accurate to 0.0001 g.

3.1.4 Petri dishes, 60-mm ID.

3.1.5 Non-circulatory air oven capable of maintaining a temperature of 90°C.

3.1.6 Forceps, flat-bladed (3).

3.1.7 Washing bottles and storage bottles.

3.1.8 Vacuum system, aspirator or pump, capable of producing 51 kPa vacuum. If pump is used, a cold trap should be installed.

3.1.9 Petroleum ether (filtered) at 30 to 60°C boiling point range or an equivalent analytical grade solvent that is compatible with the membrane material and contributes no weight gain measurable to 0.0001 g.

3.1.10 *n*-Pentane (filtered).

3.2 Test Preparation

3.2.1 Solvents—Solvents used for flushing and dilution of the sample must be pre-filtered through a 0.8-μm membrane and stored in a container that has been thoroughly washed, dried, and flushed three times with filtered solvent.

3.2.2 Filter Membranes (0.8-μm pore size)—Identify each membrane with a sample number by marking the rim (sealing edge) with a ballpoint pen.

3.2.3 Equipment—The filter funnel, petri dishes, and all other glassware used must be washed with detergent, rinsed thoroughly, oven dried, and flushed with filtered solvent before use.

3.3 Test Procedure

3.3.1 With clean forceps, place the filter membrane in an open petri dish and oven dry for a minimum of 30 minutes at 90°C.

3.3.2 Stand the petri dish with the cover slightly ajar in the balance room, or area near the balance. The membrane must be protected from airborne contamination.

3.3.3 Allow 30 minutes (minimum) for the membrane to equilibrate with the ambient temperature and humidity before weighing.

3.3.4 Weigh the membrane to the nearest 0.0001 g.

3.3.5 Place the membrane centrally on the funnel base, center funnel position, and clamp the assembly securely. Place a large watch glass on top of the funnel to protect the membrane until used.

NOTE: Static electricity is frequently generated during the filtration process. Because the solvents are highly flammable, it is recommended that the equipment and operator be safely grounded. In addition, the vacuum pump must be located in a well-ventilated area or the pump exhaust vented to a safe area.

3.3.6 If the liquid sample is stored in a container and the weight of the sample must be known, the outside surface of the container should be rinsed thoroughly with pre-filtered solvent, and then the cap reused. Allow the container to reach room temperature again (about 5 minutes), then record the weight of the container and sample (no cap) to the nearest 0.0001 g.

3.3.7 Pour 0.150 L of solvent into the filter funnel and add the sample, rinsing only the sample bottle inner surface. Put the clean sample bottle aside for reweighing. Apply 51 kPa vacuum to the flask and maintain a liquid head in the funnel until filtration is completed. During this operation, rinse the inner surface of the funnel using the wash bottle. Repeat this wash down several times, using at least 0.150 L of solvent. About 0.400 L of solvent should be used in the entire analysis.

3.3.8 With the vacuum still applied, carefully remove the clamp and funnel. Wash the sealing rim of the membrane with solvent by directing a gentle stream from the wash bottle. Direct the stream toward the center of the membrane, taking care not to wash off any of the contaminant. Also wash the sealing rim of the filter funnel onto the membrane.

3.3.9 Disconnect the vacuum and carefully remove the filter membrane and place into a covered petri dish. Use clean forceps for handling.

3.3.10 Dry the membrane and re-weigh as described in Paragraphs 3.3.1 and 3.3.4.

3.3.11 Re-weigh the empty sample container and record the weight. Be sure that the outside of the container is free from oil before re-weighing.

3.4 Evaluation of Results

The difference between the membrane weights determined in Paragraphs 3.3.4 and 3.3.10 is the weight of the contaminant solids collected. The weight of the oil analyzed is equal to the difference between the weight determined in Paragraphs 3.3.6 and 3.3.11, expressed in % w/w (percent insolubles):

$$\%PE = \frac{W_c}{W_a} * 100$$

where

$W_c =$ Weight of contaminant solids collected
$W_a =$ Weight of oil sample analyzed

3.5 Additional Suggestions of Technique

3.5.1 During periods of high humidity, the cooling effect of the solvent evaporation will cause moisture condensation on the disc. This may retard the complete solvent washing and solid deposit; an intermediate air-drying step followed by an additional wash with solvent may be necessary.

3.5.2 The analyst may insert a porous absorbent pad between the filter membrane and the base to ensure a clean surface for the membrane and to minimize "freezing" of the filter to the base.

3.5.3 Visual examination of the membrane under ultraviolet light for absorbed oil residue will quickly determine if the rinsing operation was thorough. Traces of residual oil will show a fluorescent effect, whereas a clean membrane will not.

3.6 Additional Operations for Improved Accuracy of Analysis

3.6.1 Conditioning Filter Membrane

3.6.1.1 All filter membranes must be conditioned by a warm-water soak to remove extraneous manufacturing material and to assure accurate and constant tare weight. Place the filter membrane in a clean beaker containing pre-filtered distilled water at a temperature of 32 to 38°C. Cover the beaker and soak the filter membrane for 1 hour.

3.6.1.2 Carefully remove the filter membrane with clean forceps. Allow all surface water to run off the membrane.

3.6.1.3 Place the filter membrane in an open petri dish. Place the petri dish, with cover slightly ajar, in the oven and dry for a minimum of 60 minutes at 90°C.

3.6.1.4 Remove the petri dish, with membrane, from the oven and place in a desiccator, or constant temperature and humidity area, with the cover slightly ajar. Allow 30 minutes (minimum) for the membrane to equilibrate with environmental conditions before weighing.

3.6.2 Control Filter Membrane

3.6.2.1 A control filter membrane should be carried for all analysis work. Subject this membrane to all preparation, handling, and weighing techniques of Paragraphs 3.6.1.1 through 3.6.1.4.

3.6.2.2 Insert the control filter membrane directly beneath a test membrane in the filter holder in at least one instance during a single group test run. Subject it to all handling and weighing techniques specified in Paragraphs 3.3.9 and 3.3.10.

3.6.2.3 Apply the weight change of the control filter as a correction factor to test results, subtracting this factor when the control filter shows a weight increase or adding the factor when the control shows a weight decrease.

Appendix C

Source Information

Test Material Suppliers for SAE HS-806

Supplier	**Material**
Rock Valley Oil and Chemical 1911 Windsor Road Rockford, IL 61111 Phone: (815) 654-2400	Test Oil SAE J1260 (RFO-3)
Powder Technology Inc. 14331 Ewing Avenue South Burnsville, MN 55337 Phone: (952) 894-8737	ISO 12103-A2 Fine Test Dust ISO 12103-A4 Course Test Dust Soft-C-2A Synthetic Micronic Beads
Potters Industries P.O. Box 840 Valley Forge, PA 19482-0840 Phone: (616) 651-4700	Micronic Beads
Thermo Scientific 46360 Fremont Blvd. Feemont, CA 94583-6406 Phone: (510) 979-5000	Micronic Beads
Pall Corp. Laboratory Products Phone: (800) 521-1520	Analytical Membrane
Millipore Corp. 80 Ashby Road Bedford, MA 01730 Phone: (800) 225-1380 / (617) 275-9200	Analytical Membrane
Sartorius-Membranfilter GmbH 34 Gottingen, Germany	Analytical Membrane
Fisher Scientific Co. Ltd. 711 Forbes Avenue Pittsburgh, PA 15219 Phone: (800) 766-7000	General Lab Ware
VWR Scientific, Inc. P.O. Box 999 South Plainfield, ND 07080 Phone: (800) 932-5000	General Lab Ware

1. Membrane filters, plain white, 47-mm diameter, 0.8–m pore size—Millipore AAWP 047 00, Sartorius SM-11306, or other equivalent.
2. Filter holder, 47-mm diameter—Millipore XX10 047 00 or XX10 047 30, Sartorius 16306, or other equivalent.
3. Stainless steel forceps—Millipore XX62 000 06 or equivalent.
4. Desiccator—Fisher Scientific 08-594B or other equivalent.

Test Equipment Suppliers for SAE HS-806

Bonavista Technologies, Inc.
6004 South 118th East Ave
Tulsa, OK 74146-6820
Phone: (918) 250-3435
Fax: (918) 250-3437
(Filter test equipment)

FES, Inc.
5111 N. Perkins Road
Stillwater, OK 74075
Phone: (405) 743-4337
(Filter test equipment)

IBR, Inc.
11599 Morrissey Road
Grass Lakes, MI 49240
Phone: (517) 522-5781
Fax: (517) 522-3695
(Filter test equipment)

Microspec, Inc.
3591 Enterprise Drive
Rock Hill, SC 29730
Phone: (803) 366-3015
Fax: (803) 329-4504
(Vibration equipment)

Thermatron Industries
291 Kollen Park Drive
Holland, MI 49423
Phone: (616)393-4580
Fax: (616) 392-5643
(Vibration an thermal conditioning)

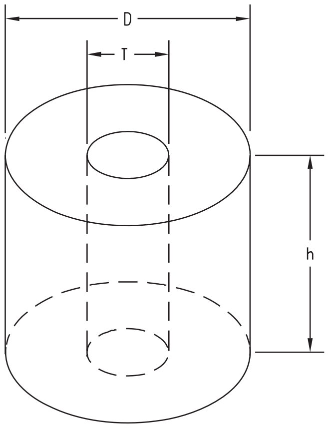
Unholtz-Dickie Corporation
3000 Whitney Avenue
Hamden, CT 06518
Phone: (203) 265-3929
(Vibration equipment)

Waring Products Division
Dynamics Corporation of America
Rt. 44
New Hartford, CT 0605
Phone: (203) 379-0731

NOTE: This list of suppliers reflects those used by members of the SAE Filter Test Methods Committee. Other materials or manufacturers may be available. It is not the intention of the Filter Test Methods Committee to promote or endorse vendors listed herein.

Appendix D

Media Envelope Volume



$$\text{VOLUME} = \frac{\pi h\,(D^2 - T^2)}{4}$$