ERRATA
HS J806 JUN83
Oil Filter Test Procedure

On page 10, in the right-hand column, section 13.3.6 Note: should include the address change of:

Penn Anderson Equipment Co.
P.O. Box 305
Oakmont, PA 15139

On page 18, in the right-hand column, under Note:, the last two lines should read:

from Penn Anderson Equipment Co., P.O. Box 305, Oakmont, PA 15139.

On page 39, in the right-hand column of Appendix A, the second paragraph should read:

Ready-mixed SOFTC 2A contaminant is available in 1 gal (3.8 L) and larger lots at the Sherwin-Williams Company, 2325 Hollins Ferry Road, Baltimore, Maryland 21230. Reference should be made to Product No. TM-450.

On page 47, in the left-hand column, in the second entry, the address should read:

Penn Anderson Equipment Co.
P.O. Box 305
Oakmont, PA 15139

Also on page 47, in the right-hand column, this entry should be added:

SOFTC-2A Contaminant
Sherwin-Williams Company
2325 Hollins Ferry Road
Baltimore, Maryland 21230
Reference Product No. T-M450

Oil Filter Test Procedure
HS J806 JUN83

Report of the Engine Committee, approved September 1958,
last revised June 1983

SAE Recommended Practice

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The ϕ symbol is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. If the symbol is next to the report title, it indicates a complete revision of the report.

INTRODUCTION

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

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

The total test code is comprised of distinct chapters to provide the test methods necessary to evaluate various functional capabilities and mechanical properties of the filter. Each chapter is complete with the recommended materials, apparatus, methods, and procedures for testing and evaluation. They are as follows:

1. Resistance to Flow
2. Filterability
3. Single Pass Efficiency
4. Media Migration
5. Collapse
6. Anti-Drainback
7. Environmental
8. Installation and Removal
9. Mechanical
10. Relief Valve

In addition to the test procedures, an Appendix with sections covering contaminants, oil sample analysis, and miscellaneous equipment is included.

Throughout the individual test methods, references are made to specific equipment which is recommended. However, equivalents may be substituted wherever noted.

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CHAPTER 1

RESISTANCE TO FLOW

1. **Scope**--The Resistance to Flow test determines the pressure loss which will 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.

2. **Test Material**

ϕ 2.1 **Test Oil**--SAE J1260, Standard Oil Filter Test Oil (RM 99) or as specified.

3. **Test Apparatus**

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

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.

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

4. **Test Preparation**

4.1 Install filter assembly on stand and add test oil.

4.2 Recirculate oil through bypass system until required temperature is reached.

4.3 Circulate oil through stand with a cleanup filter to clean system. One hour recirculation is recommended. (It is suggested that cleanup filter be installed in series with the test filter and used during the test.)

5. **Test Procedure**

5.1 Circulate oil through housing at part flow. When temperature stabilizes, take pressure differential readings at 20% increments of rated flow, including a reading at 20% over rated flow.

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 housing with element indicates loss across element only.

6. **Presentation of Data**

6.1 Tabulate pressure differential at each required flow and temperature.

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

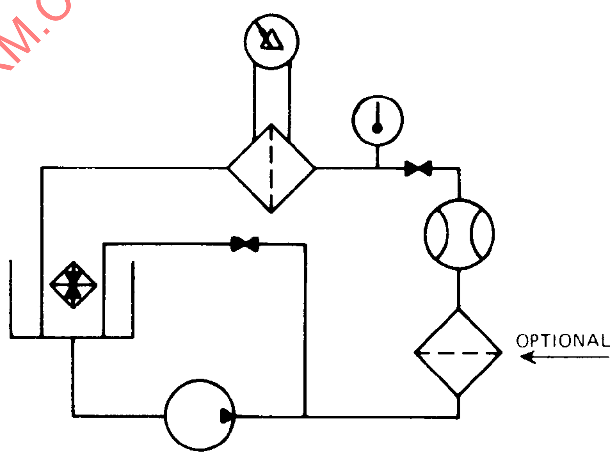

Fig. 1 - Flow Stand

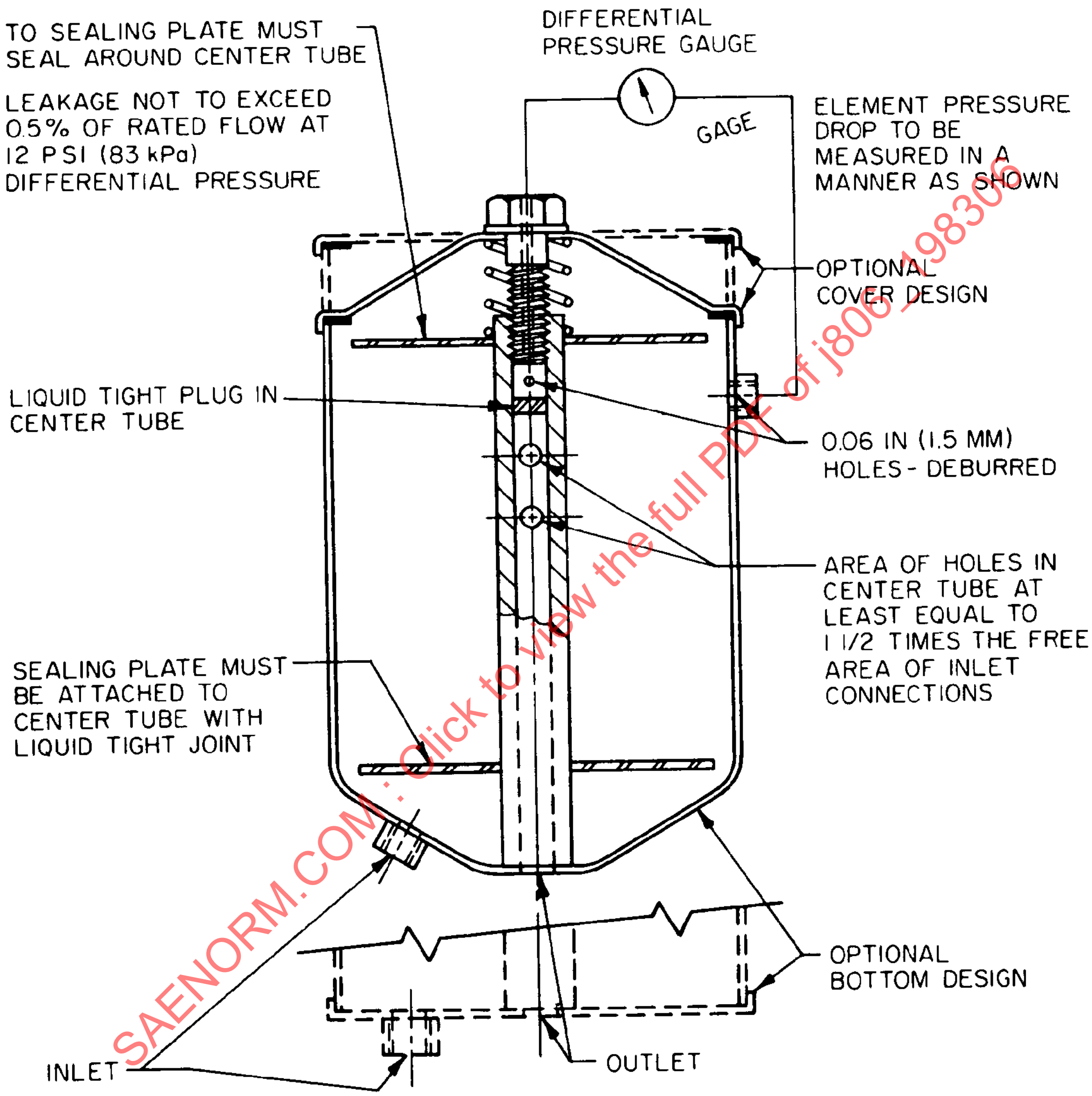

Fig. 2 - Test Filter Housing for Full-Flow Elements

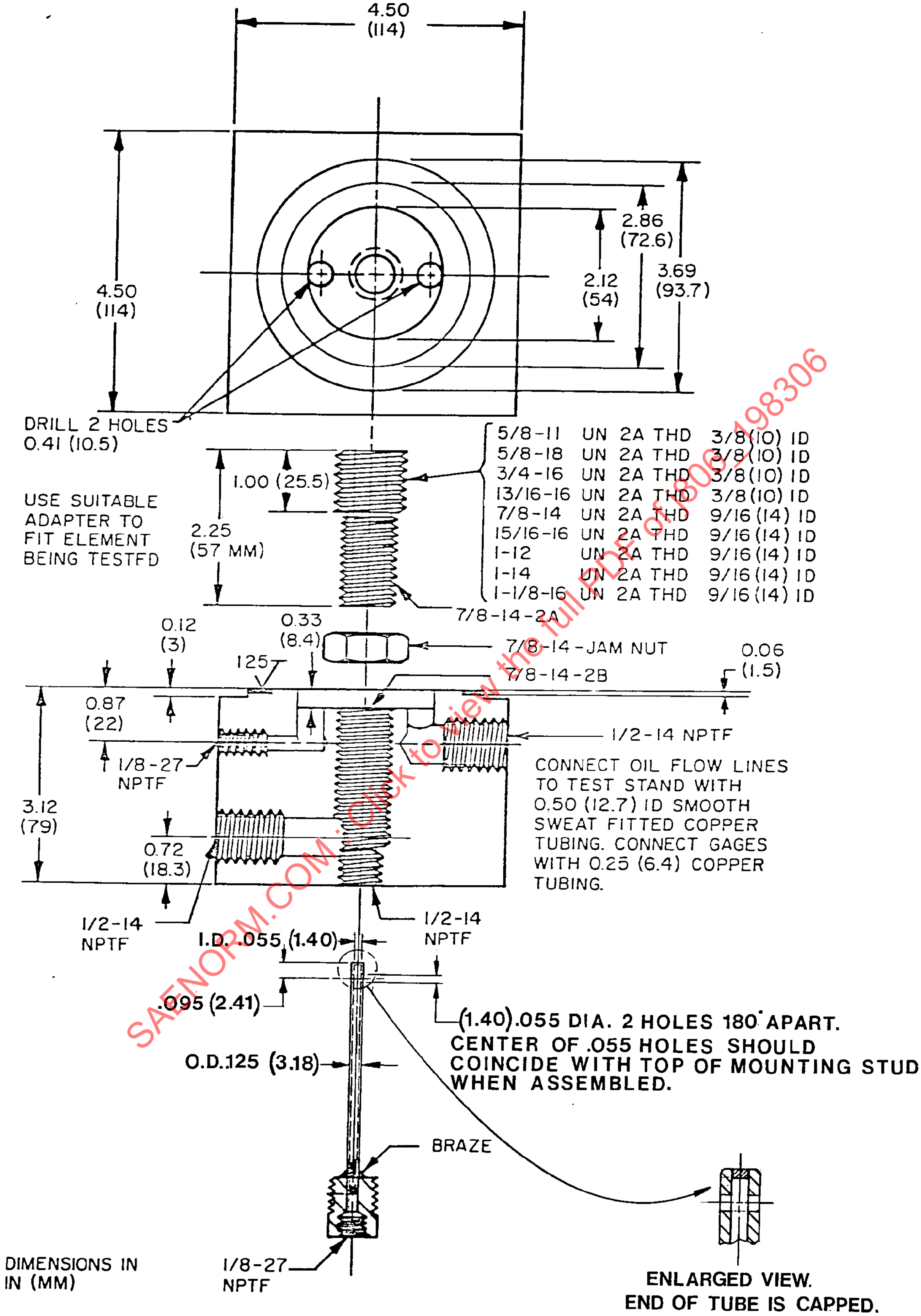

Fig. 3 - Universal Test Fixtures for Spin-On Elements

CHAPTER 2

FILTER CAPACITY AND CONTAMINANT REMOVAL CHARACTERISTICS OF FULL-FLOW FILTERS

1. **General Information**--Oil filter tests have been performed for many years on a variety of equipment utilizing various procedures. As a result, the information accumulated did not necessarily correlate with information from other manufacturers or users. With this condition existing, most of the 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 the above, the Filter Test Method Subcommittee has attempted to establish criteria for evaluating the filterability characteristics of an oil filter. These criteria involve several individual and separately determined characteristics which should be given equal consideration and are as follows: contaminant holding capacity, particle size retention, and ability to maintain oil cleanliness.

To clarify further, it is necessary to define these characteristics:

Contaminant Holding Capacity--The amount of contaminant removed and held by a filter from the oil during a constantly recirculating flow of contaminated oil while attaining a predetermined pressure drop across the filter. This pressure drop is associated with the setting of a filter bypass valve.

Particle Size Retention--The measure of the degree of retention of particles of various sizes by the filter. Retention measurement can be made by particle counting or gravimetric efficiency when a known size range of particles is introduced to the filter on a single pass basis.

Oil Cleanliness--The measure of the level of contaminant present in the oil at various intervals of time. The cleanliness can be expressed as a weight of contaminant per unit of oil or as a ratio of contaminant removed to contaminant presented.

This Chapter and Chapter 3 on Single Pass Efficiency have been prepared to be used in determining these characteristics. 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 (RM 99). This oil is an additive type, blended in quantities large enough to provide the filter testing industry a supply for 1-1/2 to 2 years. Control of the oil is maintained by physical and chemical properties, infrared spectrum, and filterability tests. These filterability tests are conducted using reference filters to establish if the filterability of the oil is equivalent between blends or if adjustments to results are required to correlate with previous tests. ϕ

The test contaminants recommended, SOFTC-2A and AC 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 and AC Test Dust is an abrasive type, each closely controlled with respect to composition and particle size. 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 keep more in line 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 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 with the procedural changes necessary to accommodate the mechanics of the stand.

With the necessity of standardization of equipment, two test stands have been developed. Class A stand is for flow rates to 8 gpm (30 L/min) and Class B is for flow rates of 7--15 gpm (26--57 L/min). Where higher 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 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, there are a number of test conditions which have to be established. These conditions, for the most part, 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/or attempted correlations 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. These compensations take the form of constant conditions and accelerated contaminant add rates as contrasted with variable conditions and low add rate for contaminants under normal operative conditions. Consequently, constant flow and add rates for contaminants as shown in Table 1 and Section 7 of this Chapter are recommended, along with 180°F (82°C) oil temperature, for most testing. If the "in service" application differs to the extent that these conditions will not develop meaningful data, the tests should be changed accordingly.

The test methods for evaluation of lube filters are complex and the interpretation of the results can be difficult and misleading. Results can be drastically altered by seemingly insignificant changes in any of the four major components of testing procedure, materials, analysis, and equipment. This test method and specified equipment will provide a reliable bench test which has been designed with special emphasis on control of equipment and other variables. Therefore, the following test procedure, along with the Single Pass Efficiency Test, are recommended to establish filter filterability.

φ This procedure has been performed by a number of laboratories with calibrating filters and a statistical analysis of the results performed. Use of these calibrating filters, along with the analysis of results, provides a means of calibrating the equipment and detecting changes in materials. New batches of materials are qualified by performing tests with calibrating filters to insure that results do not change from batch to batch.

φ While the procedure does not measure instantaneous (single pass) efficiency, this can be determined on new filters as described in Chapter 3. This, along with cumulative effi-

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φ **Table 1--Specified Test Conditions**--Entry into Table 1 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 1 will yield a test duration in the range of 15--30 h. This test duration is sufficient to yield accurate results in a reasonable length of time. Although an optional provision has been made in Table 1 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 should be either 75% of the filter bypass valve theoretical opening differential pressure, 8 psi (55 kPa) differential pressure for most automotive applications, or a differential pressure agreed upon by the user and supplier. If practicable, the valve should be blocked closed prior to the start of the filterability test. If a test is conducted with an unblocked valve and an uncharacteristic flattening of the differential pressure rise curve is experienced during the test, the results of the tests 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 at 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.

ϕ TABLE 1--SPECIFIED TEST CONDITIONS FOR LUBRICATING OIL FILTER ELEMENT CAPACITY TESTS SAE J806 JUN83

Filter Rated Flow[a]	Filter Size Rating Classes[b,i]	Test Flow Rate[c]	Test Flow Rate[c]	Starting Test Oil Volume[d]	Test Oil Turnover per Minute at Starting Volume	Contaminant: ACFTD Addition Rate Solids[e]	Contaminant: Organic Addition Rate Solids[f]	Contaminant Oil Slurry Addition Rate[g]	Flow Control Circuit Flow Rate[h]	Test Flow Rate[c]
Litres per Hour	Class	Litres per Hour	Litres per Minute	Litres	Frequency	Grams per Hour	Grams per Hour	Millilitres per Hour	Litres per Minute	U.S. Gallons per Minute
180--480	A	480	8	3.64	2.2	1.2	2.4	88	4	2.1
481--600	B	600	10	4.54	2.2	1.5	3.0	88	4	2.6
601--720	C	720	12	5.45	2.2	1.8	3.6	88	4	3.2
721--900	D	900	15	6.82	2.2	2.25	4.5	88	4	4.0
901--1140	E	1140	19	8.64	2.2	2.85	5.7	88	4	5.0
1141--1440	F	1440	24	10.91	2.2	3.6	7.2	88	4	6.3
1441--1800	H	1800	30	13.64	2.2	4.5	9.0	88	4 or 8	7.9
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	2280	38	17.27	2.2	5.7	11.4	88	8	10.0
2281--2820	K	2820	47	21.36	2.2	7.05	14.1	88	8	12.4
2821--3000	L	3600	60	27.3	2.2	9.0	18.0	88	8	15.9
3601--4500	M	4500	75	18.75	4	11.25	22.5	176	12	19.8
4501--5700	N	5700	95	23.75	4	14.25	28.5	176	12	25.1
5701--7200	P	7200	120	30.00	4	18.0	36.0	176	12	31.7
7201--9000	Q	9000	150	37.50	4	22.5	45.0	264	12	39.6
9001--11 400	R	11 400	190	47.50	4	28.5	57.0	264	12	50.2
11 401--14 400	S	14 400	240	60.00	4	36.0	72.0	352	12	63.4
14 401--18 000	T	18 000	300	75.00	4	45.0	90.0	440	12	79.3
18 001--22 200	U	22 200	370	92.50	4	55.5	111.0	528	12	97.7
Flow in Excess of 22 001	X	Test conditions to be agreed upon between user and supplier.								

[a]Suppliers' specifications, rated under the conditions of this test.
[b]Class letter designation assigned for convenient reference. See paragraph 18.1 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% of true value.
[d]Adjust starting test oil volume to within ± 2% of true value and maintain throughout test.
[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]Quadrant and pump type contaminant addition system described in Figs. 4 and 4a (see Note).
[h]These flows have been used on automated test stands with flow controllers. Use the minimum volume required to control flow on all other test stand designs.
[i]For large filters not completely conforming to Table 1, see paragraph 16.2, nonconformance related to (d).

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

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

ciency information, gives an indication of the particle separation characteristics of the filters being tested.

The Filter Test Method Subcommittee considers this method as satisfactory but not final and will amend it as further development investigations dictate.

ϕ **2. Scope**--To include an SAE standardized filterability test for determining the contaminant holding capacity and contaminant removal characteristics of full-flow oil filters.

ϕ **3. Purpose**--To provide a precise test procedure for determining contaminant capacity and contaminant removal characteristics of a full-flow oil filter.

ϕ **4. References**

4.1 SAE HS J806 JUN83, Oil Filter Test Procedure, Appendix A, Contaminants.

4.2 SAE HS J806 JUN83, Oil Filter Test Procedure, Appendix B, Methods for Oil Sample Analysis.

4.3 SAE HS J806 JUN83, Oil Filter Test Procedure, Chapter 3, Single Pass Particle Retention Capability Test.

4.4 ISO 1000-1973, International Standard SI Units and Recommendations for the Use of Their Multiples and Certain Other Units.

4.5 ISO/R 1219, Graphical Symbols for Hydraulic and Pneumatic Equipment and Accessories for Fluid Power Transmission.

4.6 SAE HS J806 JUN83, Appendix D, Source Information.

4.7 SAE HS J806 JUN83, Appendix E, Spin-On Oil Filter Base Mounting.

4.8 ISO 2942-1974, Hydraulic Fluid Power--Filter Elements--Determination of Fabrication Integrity.

ϕ **5. Definitions and Symbols**

5.1 For meanings of symbols not defined within this document, see Ref. 4.5.

ϕ **6. Units**

6.1 The International System of Units (SI) is used in accordance with Ref. 4.4.

ϕ **7. Letter Symbols**

7.1 Letter symbols are used in accordance with Ref. 4.4.

ϕ **8. Graphic Symbols**

8.1 Graphic symbols are used in accordance with Ref. 4.5.

ϕ **9. General Procedure Outline**

9.1 Set up and maintain apparatus as described in Sections 11 and 13.

9.2 Run tests as described in Section 15.

9.3 Present data per paragraph 17.2.

9.4 Select scaled down tests per paragraph 18.1.

10. Measurement Accuracy ϕ

10.1 Measure flow and pressure within 2% of the true value.

10.2 Measure temperature within 1°C of the true value.

11. Test Equipment ϕ

11.1 A filter test circuit--SAE Standardized Oil Filter Test Stand as described in Fig. 4 or equivalent designed stand.

11.2 An appropriate filter housing or standard filter mounting base for spin-on filters described in Figs. 2 and 3, Chapter 1, and Ref. 4.7, SAE HS J806 JUN83.

11.3 Analytical apparatus for oil sample analysis per Ref. 4.2.

11.4 Use the following or proven equivalent: Waring Blender Model #7011S. Its 1 L stainless steel container (#SS610) has a drawn one piece shell and its two speed motor has nominal no load speeds of 21 000 rpm and 18 500 rpm.

11.5 Timer capable of measuring minutes.

11.6 Contaminant addition device described in Fig. 4a.

12. Test Materials ϕ

12.1 Test Fluid--SAE J1260, Standard Oil Filter Test Oil (RM 99).

12.2 **Test Contaminants**

12.2.1 SOFTC 2A (See Ref. 4.1).

12.2.2 AC Fine Test Dust (See Ref. 4.1).

12.3 n-Pentane or petroleum ether.

12.4 No. 1 Fuel Oil or Stoddard Solvent.

13. Test Equipment Validation ϕ

13.1 This is required only when the equipment is first placed in service or is modified. Since there is more than one type of contaminant addition system being successfully used, the method of contaminant addition is optional as long as the equipment can be validated.

NOTE: For tests having a duration of less than 8 h, the SAE Class A and B 3.2 litre standard quadrant should not be used since sizeable variations in dispensing rate occur in the initial stages of the dispensing cycle. If a smaller quadrant contaminant addition device is used, it should be sized so that at least one-third of the total volume is dispensed during the test.

13.1.1 **Validation of the Quadrant Contamination Addition Device**

13.1.1.1 Validate at the maximum contaminant concentration which will be used.

$$C = \frac{\text{Desired g/h solids add rate (From Table 1)}}{A}$$

C = Concentration of contaminant in quadrant, grams of solids/litre

A = Calibrated delivery rate quadrant, L/h

13.1.1.2 Prepare the contaminant slurry as described in paragraph 14.3.

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

13.1.1.4 Tilt the quadrant forward to begin flow of contaminant mixture. Start quadrant rotation and allow it to rotate for 30 min to allow the dispensing rate to stabilize. Collect the mixture dispensed during this interval for the determination of solids concentration.

13.1.1.5 Allow the mixture to dispense for 22 h into a suitable receptacle and measure the total volume dispensed in a graduated container accurate within 1% of the volume measured.

13.1.1.6 Determine the solids concentration of a 0.010 L sample of the mixture dispensed in paragraph 13.1.1.4 per Ref. 4.2.

13.1.1.7 Determine the solids concentration of a 0.010 L sample of the mixture remaining in the quadrant per Ref. 4.2.

13.1.1.8 Repeat steps 13.1.1.1 up to and including 13.1.1.7 two additional times.

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

13.1.1.10 The maximum concentration deviation from the average of the nine determinations made should be no greater than 3% for any determination.

13.1.2 Validation of Variable Delivery Rate Pumps for Contaminant Addition Constructed in Accordance with Fig. 4a

13.1.2.1 Validate at the maximum contaminant concentration which will be used. Refer to Table 1.

13.1.2.2 Prepare the contaminant slurry as described in paragraph 14.3.

13.1.2.3 Charge the contaminant addition reservoir and allow it to stand for 1.5 h with agitator running to release any air introduced in blending and to allow the temperature to stabilize.

13.1.2.4.1 For variable stroke piston pumps, adjust the pump stroke to give the displacement which will result in the desired delivery rate.

13.1.2.4.2 For variable speed peristaltic pumps, adjust the pump speed to give the desired delivery rate with the tubing used.

13.1.2.5 Start the pump and allow it to run for 2 h.

13.1.2.6 Collect the mixture dispensed during this period and measure the total volume dispensed in a graduated container accurate within 1% of the volume measured.

13.1.2.7 If the total volume of the mixture dispensed deviates more than 4% from the theoretical value, correct by adjusting the pump stroke or speed and repeat steps 13.1.2.1 up to and including 13.1.2.6 until this level of accuracy is reached.

13.1.2.8 Determine the solids concentration of a 0.010 L sample of the mixture dispensed per Ref. 4.2.

13.1.2.9 If the solids concentration deviates more than 2% from the theoretical value, correct by changing the degree of agitation or the agitator location and repeat steps 13.1.2.1 up to and including 13.1.2.6 (omit volume measurement) and 13.1.2.8.

13.1.2.10 After reaching the required level of accuracy, adjust the solids concentration, if necessary, so that the specified rate of solids dispensed will be maintained at the volumetric delivery rate determined and repeat steps 13.1.2 up to and including 13.1.2.6 and 13.1.2.8 three times.

13.1.2.11 The maximum deviation from the theoretical value for total solids dispensed should be no greater than 3% for any determination.

NOTE: Since 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 (paragraph 13.1.2.11).

NOTE: Delivery rate to be 88 $\pm$ 4 mL/h 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. ϕ

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.

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. 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 1. Since 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 insure that the desired addition rate is maintained. For any delivery pump suspected of being subject to drift in output during use, this same recheck should be made.

13.2 Orifice and Flow Controller Calibration (SAE Class A and Class B Test Stands)

13.2.1 Remove the filter mounting base and install between the inlet and outlet ports of the test stand an integrating flowmeter, flow totalizer, or other calibrated flowmeter.

13.2.2 Make sure that the orifice to be calibrated is securely in place and that the orifice and all lines are clear.

13.2.3 Fill the sump with 6 L SAE oil (Class A stand) or 5 gal (19 L) SAE oil (Class B stand).

13.2.4 Turn the flow controller to manual position. Close bypass valve and fully open main valve.

13.2.5 Turn on main switch and turn shunt switch to "start" position. Set pump drive for minimum delivery.

13.2.6 Set thermostat to maintain a temperature of 150°F (65°C) at the inlet to the flowmeter. Circulate oil until the temperature has stabilized (about 30 min).

13.2.7 Make sure the valve on the line which sends the pressure signal to the controller is open.

13.2.8 Reset the pump to deliver just over 5 psi (35 kPa) on flow controller.

13.2.9 Open the bypass valve slowly until the flow controller reads exactly 5 psi (34.5 kPa). Measure and record the flow rate to the nearest 0.05 gpm (0.19 L/min).

13.2.10 Continue opening the bypass valve until the flow controller reads exactly 4.5 psi (31.0 kPa). Measure and record the flow rate at this setting.

13.2.11 Continue in 0.5 psi (3.5 kPa) increments until the entire range of the flow controller has been covered. It may be necessary to close the main valve partly for the lowest pressure readings on the flow controller.

13.2.12 Repeat the calibration at 180°F (82°C) and at 210°F (100°C).

13.2.13 Plot flow as a function of the flow controller pressure for each of the three temperatures. These are the calibration curves for the orifice and flow controller.

13.2.14 The calibration procedure should be repeated every 3 months or at any change in orifice, test fluid, or after any repairs to controller or pump have been effected.

13.3 Validation of Test Circuit (SAE Class A and Class B)

13.3.1 Validate the test system constructed in accordance with Fig. 4.

NOTE: Install a trap-free connector in place of the test filter. (See Fig. 5.)

13.3.2 Select the specified test conditions from Table 1, for the minimum Filter Size Rating Class, at which the test system will be operated.

13.3.3 Adjust the total test system fluid volume specified in Table 1 in accordance with Filter Size Rating Class selected under paragraph 13.3.2.

13.3.4 Conduct a test according to Section 15 for a period of 8 h.

13.3.5 Determine the solids concentration per Ref. 4.2.

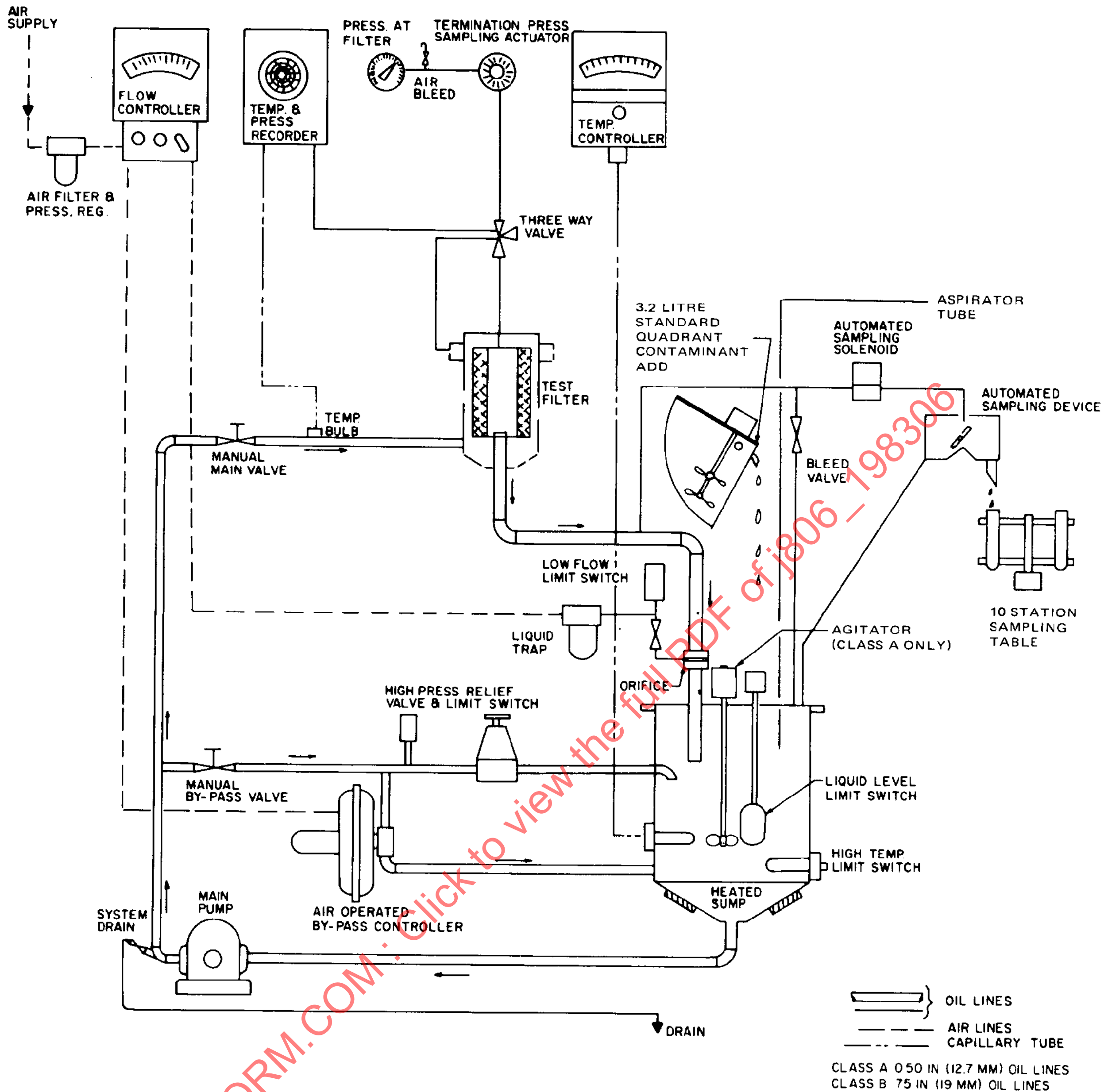
13.3.6 Compare the contaminant concentration in the samples collected with the theoretical value. At termination (8 h) the actual concentration of all samples should be within 10% of the theoretical value.

NOTE: For the Class A stand, additional assurance that materials as well as equipment will produce reproducible results can be developed by performing this test using calibrating filters. These filters which carry a Class C size rating are identified COF-1-80. Subsequent batches of calibration filters will be identifiable by the year of production as coded by the last two numbers. They are available from:

Penn Anderson Equipment Co.
1832 Graham Blvd.
Pittsburgh, PA 15235

Complete instructions for their use accompany each set of filters.

Sourcing for calibration filters may be reassigned by the SAE Filter Test Methods Subcommittee. The Subcommittee may introduce additional sizes of calibration filters as dictated by industry requirements. Inquiries in regard to calibration filters may be directed to the Chairman: SAE Filter Test Methods Subcommittee.



φ Fig. 4 - SAE Standardized Oil Filter Test Stand, Classes A and B

φ 14. Test Preparation

14.1 Filter Assembly

14.1.1 Subject the unused test element to a fabrication integrity test in accordance with Ref. 4.8 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.

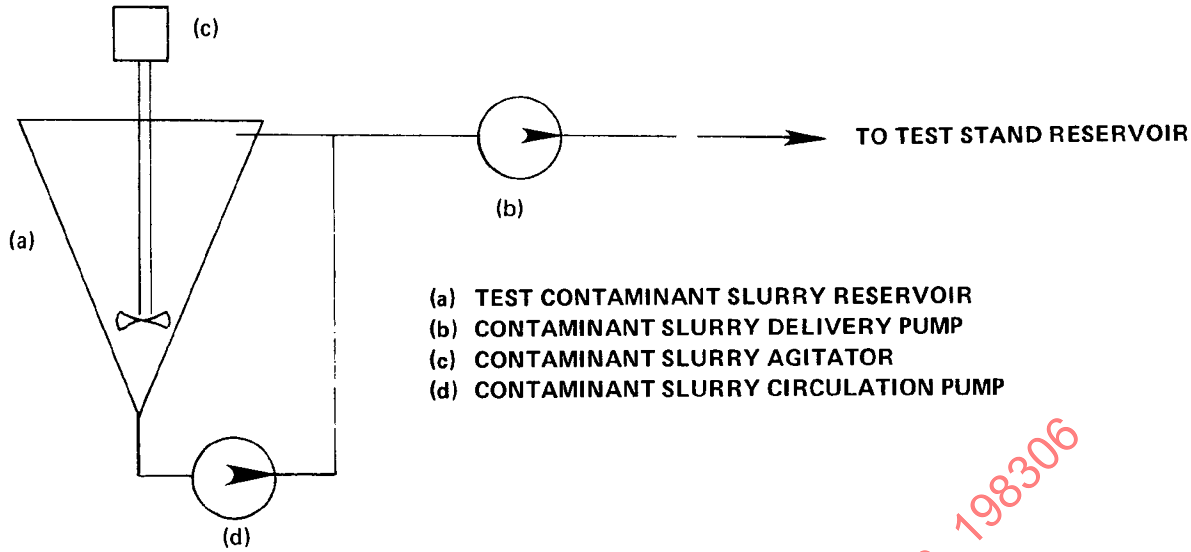
14.1.2 Disqualify the element from further testing if it fails to exhibit the designated minimum test pressure, agreed upon by the filter user and supplier.

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

14.1.4 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.

14.2 Filter Test System (SAE Class A or Class B Test Stands)

14.2.1 Place No. 1 fuel oil or Stoddard solvent in the main sump of the test stand and circulate through the complete test system, including the sampling port.



ϕFig. 4a - Schematic of Variable Delivery Pump Contaminant Delivery System

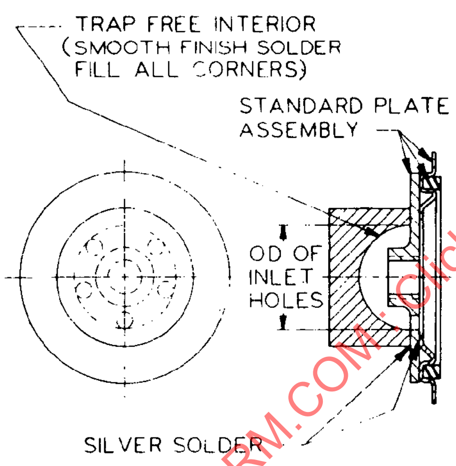


Fig. 5 - Blank Filter

14.2.2 Drain system and repeat step 14.2.1. When draining the stand, it will be necessary to lock out the low oil level switch located on the sump. Repeat until the solvent is visually free of contamination.

14.2.3 Drain the system and repeat step 14.2.1 using SAE oil instead of solvent.

14.2.4 Wash quadrant in No. 1 fuel oil or Stoddard solvent and dry.

14.2.5 Select the test conditions for the Filter Size Rating Class from Table 1 under which the test system will be operated. Drain the system and refill with SAE oil.

14.2.6 Adjust the total test system fluid volume from Table 1 as specified for the Filter Size Rating Class selected under paragraph 14.2.1. Check that the low oil level switch is operational.

14.2.7 Switch on the sump agitator (Class A). Fully open the bypass valve and close main valve.

14.2.8 Install a preweighed cleanup filter and preweighed drip pan under the filter.

14.2.9 Ensure that the flexible lines from inlet and outlet pressure taps on the filter base or housing are connected to the three-way valve at the pressure recording port, so that either pressure may be recorded.

14.2.10 Open the main valve. Set the temperature controller at 180°F (82°C). Turn on the main switch, set the shunt switch to start position, and start the pump motor. If necessary, adjust temperature to maintain 180 ± 5°F (82 ± 2°C) at the filter inlet. This is the temperature that will be recorded. Other test temperatures may be used when agreed upon by the user and supplier.

14.2.11 Close the bypass valve and fully open the main valve. Set the pump to deliver the flow rate specified under Test Flow Rate for the Filter Size Rating Class paragraph 14.2.5 plus sufficient flow to operate the flow control circuit as specified in Table 1. Open bypass valve.

14.2.12 Set the red pointer on the flow controller to the pressure which will route the required oil flow through the test filter and switch controller to "automatic" following the instructions in the test stand manual. The shunt switch should now be moved to "run" position.

14.2.13 Bleed all gages. After the temperature has stabilized, circulate oil through the system for 5 min.

14.2.14 Set the timer cams to deliver 0.018--0.022 L for SOFTC-2A and AC Dust Tests. The sample should not be withdrawn sooner than 30% of the way into the purge and sampling cycle and should be as late in the cycle as practical.

14.2.15 Withdraw a sample from the sampling port. This sample should have not more than 0.075 g/L of petroleum ether insolubles. If the insolubles exceed this value, the oil should be circulated through the cleanup filter until this maximum value is obtained.

14.2.16 Move the shunt switch back to "start" and turn flow controller switch to "manual". Close the main valve and remove and reweigh the cleanup filter and drip pan plus the amount removed in the sample. Add to the sump an amount of oil equivalent to the increase in weight of the cleanup filter and drip pan plus the amount removed in the sample.

14.2.17 Install the test filter and fully open the main valve. Set the flow controller to automatic following instructions in test stand manual. Move the shunt switch to "run."

14.3 Contaminant Slurry Preparation

14.3.1 ACFTD

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

14.3.1.2 Calculate the weight of contaminant to give the solids addition rate specified in Table 1 for the Filter Size Rating Class selected under paragraph 14.2.5 and divide into two approximately equal portions.

14.3.1.3 Place approximately one quarter of the oil in the blender described in paragraph 11.4, turn to low speed and add one of the portions of dust. After addition of the dust, blend at high speed for 5 min.

14.3.1.4 With the contaminant addition system in place on the stand, add the blended mixture.

14.3.1.5 Start the contaminant addition vessel agitator.

14.3.1.6 Repeat steps 14.3.1.3 and 14.3.1.4 with the second portion of oil and dust.

14.3.1.7 Add to the blender approximately one half of the remaining oil and allow to mix at low speed for 1 min.

14.3.1.8 Add this mixture to the contaminant addition reservoir.

14.3.1.9 Add to the blender the remainder of the oil. Allow to mix for 1 min, then add the mixture to the contaminant addition reservoir.

14.3.1.10 Allow the contaminant addition system to stand for 1 1/2 h with agitation to release any air introduced and to allow the temperature to stabilize.

14.3.1.11 Start dispensing and allow 5% of the total volume to be dispensed to stabilize the dispensing rate. Discard the mixture dispensed during this interval.

14.3.2 SOFTC-2A (Organic Contaminant)

14.3.2.1 Shake the 3.8 L paint can in which the contaminant is stored for 15 min on an oscillating paint shaker.

14.3.2.2 Determine the solids content of a 0.010 L sample per Ref. 4.2.

14.3.2.3 Refer to Table 1 to determine the contaminant (solids) dispensing rate required for the testing of the Filter Size Rating Class selected under paragraph 14.2.5.

14.3.2.4 Calculate the required solids concentration of the mixture to give a contaminant solids addition rate of 0.3 g solids/h/L/min flow rate.

14.3.2.5 Weigh into a 3.8 L paint can the appropriate amounts of contaminant concentrate and test oil to give the required volume of the proper concentration based on the average delivery rate determined for the contaminant addition system.

14.3.2.6 Repeat steps 14.3.2.1 and 14.3.2.2 and add mixture to the contaminant addition reservoir.

14.3.2.7 Perform steps 14.3.1.10 and 14.3.1.11.

15. Test Procedure ϕ

15.1 Prepare stand according to paragraph 14.2.

15.2 When the contaminant addition system has stabilized, set the sample time selector to the required sample intervals by pulling out the cam lugs on the master clock. A minimum of five samples should be withdrawn at equal time intervals. Take a zero hour sample. This will be used as a blank correction. Set the sample timer selector and recording chart at proper time of day. Fill the pens in the recorder with ink.

15.3 Switch the three-way valve to record the filter outlet pressure on the chart for reference, then switch the valve back to record the inlet pressure.

15.4 Set the high pressure cutoff switch to the desired termination pressure. Termination pressure is the outlet pressure recorded in paragraph 15.2 plus the desired differential.

15.5 Place clean sample containers in the rotating holder. Place the holder on the spindle under the sampling port. Adjust the position of the holder so that the sampling nozzle is halfway between two containers. (When the sample is to be drawn, the holder will rotate automatically so that the container will be directly under the nozzle.) Tighten the wing nut on top of spindle down against the holder.

15.6 Put the timer switch (front panel) and recording chart switch (on back of recorder) in "on" position.

15.7 Begin contaminant addition at time zero.

15.8 Adjust the test stand reservoir aspirator tube to coincide with the starting oil level and actuate the aspirating device to restore the oil level to the starting level at a minimum rate of once every 15 min throughout the test. Discard the oil collected.

NOTE: Although not part of the standard test practice, the oil may be collected in a clean container if there is interest in correcting the mass of the contaminant removed by the filter for the mass discarded in the oil drainoff. If this is to be determined, sample the material aspirated and analyze for contaminant mass. Compute the total amount of contaminant in the oil withdrawn from the reservoir and subtract the figure from the mass of contaminant added from all calculations of contaminant removed by the filter. Enter the corrections on data sheet, Fig. 6 as Grams Capacity Corrected for Oil Aspirated.

15.9 Recharging the Contaminant Addition Device During Test--The outlined test procedure is designed for stand operation of 22 h. With this test cycle time, the contaminant addition system may be prepared for the subsequent cycle in 2 h, thus permitting one complete cycle per 24 h day. If it is apparent that the test will terminate within a quadrant cycle time of 30 h, it is not necessary to recharge the quadrant. However, the use of a single quadrant charge beyond 30 h is not recommended. The procedure for interrupting the test to recharge the quadrant is as follows:

15.9.1 Place the quadrant switch in "off" position after the twenty-second hour.

15.9.2 Place the shunt switch in "start" position.

15.9.3 Return the flow controller to "manual" position.

15.9.4 Close the main valve.

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

15.9.5 Switch recorder "off".

15.9.6 Set timer switch to "off".

15.9.7 Remove the quadrant and discard the remaining slurry.

15.9.8 Wash the quadrant with solvent and dry.

15.9.9 Prepare the contaminant slurry as at the test start and described in paragraph 14.3.

15.9.10 To restart the test at the twenty-fourth hour, follow the same procedure as at start of the test, eliminating those steps made necessary by the cleanup procedure.

15.10 Sample Analysis--Analyze the samples obtained per Ref. 4.2.

16. Suggested Test Conditions ϕ

16.1 See Table 1 for test conditions for filters sized for conventional applications on mobile equipment. For large filters not completely conforming to Table 1, see paragraphs 16.2 through 16.2.3.

16.1.1 Termination pressure drop to be 75% of the bypass component opening pressure unless otherwise specified.

16.2 Test Conditions for Large Volume Filters Not Conforming to Table 1--Nonconformance is related to the inability of oil specified in footnote (d) to fill filter and test system.

16.2.1 Designate filter size rating class as AA, BB, CC, etc.

16.2.2 Select a specified flow rate 8--370 L/min.

16.2.3 Calculate <u>test fluid volume</u> equal to volume of oil the filter holds with element installed plus a volume numerically equal to one-fourth of the test flow rate per minute.

Example: An LL filter with a 40 L filter capacity would require:

$$40\text{ L volume} + \frac{60\text{ L}}{4} = 55\text{ L of test fluid}$$

16.2.4 Select <u>Contaminant Addition Rate</u> grams per hour from Table 1, but may be accelerated up to 50X when agreed upon by the user and supplier. See constraints as stated in Note under Table 1 which state that acceleration requires increased slurry volume without increasing contaminant concentration.

FILTER TEST REPORT
SAE J806 JUN83, OIL FILTER TEST PROCEDURE, CHAPTER 2

Test No.: __________

Test Date: __________ Test Oil Ident.: __________ Test Filter Ident.: __________

Company Name and Location: __________ Filter Rating Class (Table 1): __________

Contaminant: Type: __________ Batch No.: __________ Add Rate g/h: __________

Test Oil: Volume L: __________ Temperature: °C, °F: __________ Initial System Cleanliness g/L: __________

Test Flow Rate: Filter Lpm: __________ Filter Bypass Lpm: __________ Quadrant Delivery Rate L/h: __________

Filter gpm: __________ Filter Bypass gpm: __________ SAE Test Stand A, B, Other: __________

A (Initial) Filter Inlet Pressure: __________ (psi) (kPa) C (Terminal) Filter Inlet Pressure: __________ (psi) (kPa)

B (Initial) Filter Outlet Pressure: __________ (psi) (kPa) D (Terminal) Filter Outlet Pressure: __________ (psi) (kPa)

(Initial) Filter Δ Press. (A-B): __________ (psi) (kPa) (Terminal) Filter Δ Press. (C-D): __________ (psi) (kPa)

Data: (Refer to Tables 2 and 3 of Chapter 2 of SAE J806 JUN83, Oil Filter Test Procedure)

Test Time h	Sample Volume L	Contaminant		Blank Correction g/L	Contaminant Net Conc. g/L	System Volume L	Contaminant			Filtering Efficiency %
		Weight g	Conc. g/L				System g	Added g	Removed g	

Data Summary: Hours Life __________, Grams Capacity __________, Weighted Average Efficiency __________,

(Optional) Grams Capacity Corrected for Oil Aspirated __________.

Remarks: __________

__________ Technician: __________

ϕ Fig. 6

ϕ 17. Calculation and Reporting of Test Results

17.1 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 which 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 2 and 3 show a typical data format.

The calculating mode does not account for the mass of contaminant removed by sampling or removed for the purpose of keeping the system volume constant. The correction for sampling volume is considered to be negligible. The accumulated test oil removed for the purpose of keeping the system level is analyzed. The result is used to calculate the filter capacity.

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 h.

The filter capacity can be obtained from Table 3 and, in this example, is 38.7 g at the test termination. A graph of the amount of contaminant removed by the filter as a function of the number of hours of test will yield directly the capacity at any intermediate stage of test.

The maximum sump concentration is obtained from Table 2 and is 0.324 g/L for this example.

Efficiencies are calculated in Table 3. 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--22.2 h is:

100(38.73--34.06)/40.0--36.0 = 115.8%

The use of the final efficiency as a single number to characterize the contaminant removal characteristics of a filter is not recommended because this value is subject to sizable errors. These errors arise because all the information is derived from the analysis of a single sample and 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 a weighted average efficiency. This gives equal weight to all

ϕ TABLE 2--EXAMPLE OF TYPICAL TEST INFORMATION FROM TABLE 1

Test Contaminant: AC Fine Dust
Filter Rating Class: C

Test Conditions:

Temperature 180°F (82°C)
Sump volume 5.45 L
Contaminant add rate 1.8 g solids/h
Flow rate
Through filter 3.20 gpm (12 L/min)
Through bypass 1.06 gpm (4 L/min)
Termination, total differential 8.0 psi (55 kPa)
Grand average delivery rate 0.0892 L/h (see paragraphs 13.1.1 and 13.1.2)

Test Time, h	Sample Volume, L	Contaminant Weight, g	Contaminant Concentration, g/L	Blank Correction, g/L	Net Contaminant Concentration, g/L
0	0.020	0.0020	0.102	0.102	0
4	0.018	0.0039	0.216	0.102	0.114
8	0.021	0.0064	0.303	0.102	0.201
12	0.019	0.0073	0.384	0.102	0.282
16	0.020	0.0084	0.419	0.102	0.317
20	0.022	0.0094	0.426	0.102	0.324
22.2	0.018	0.0057	0.314	0.102	0.212

ϕ TABLE 3--CALCULATED INFORMATION

Test Time, h	Net Contaminant Concentration, g/L[a]	System Volume, L[b]	In System[c]	Added[d]	Contaminant, g Removed by Filter[e]	Efficiency, %[f]
0	0	6.000	--	--	--	--
4	0.114	6.000	0.68	7.2	6.52	90.5
8	0.201	6.000	1.20	14.4	13.20	91.7
12	0.282	6.000	1.69	21.6	19.91	92.1
16	0.317	6.000	1.90	28.8	26.90	93.4
20	0.324	6.000	1.94	36.0	34.06	94.6
22.2	0.212	6.000	1.27	40.0	38.73	96.8

[a]See Table 2.
[b]See Table 1.
[c]Prduct of items a and b.
[d]Product of test time and contaminant add rate (see Test Conditions, Table 2).
[e]Item d--item c.
[f]100X item e ÷ item d.

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:

(4) (90.5) = 362.0
(4) (91.7) = 366.8
(4) (92.1) = 368.4
(4) (93.4) = 373.6
(4) (94.6) = 378.4
(2.2) (96.8) = 213.0
2062.2

Weighted Average Efficiency = (2062.2)/(22.2) = 92.9%

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

It should be pointed out that the data format shown in Tables 2 and 3 is based on test data in which the volumes of the samples are recorded. It is, of course, 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 (litres) is converted to system mass (grams) by multiplying by the density of SAE oil (895 g/L at room temperature).

17.2 **Reporting of Test Results**--Complete report sheet (Fig. 6).

18. Variations of Test Conditions ϕ

18.1 **Scaled-Down Tests of Filter Elements**--It is permissible, by agreement between the supplier and the user, to carry out scaled-down tests on filter elements exceeding 4550 L/h (Rating Class M). The elements used for such scaled-down tests are to be of the same basic design (including direction of flow), materials, workmanship, and structural integrity. All size reductions 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.

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

ϕ 19. **Reliability of Test Results**--Confidence in a single test result depends upon a great 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 4 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 4.

NOTE: To check on performance of Class A test stands, calibration filters designated COF-1-80 and instructions for their use are available from Penn Anderson Equipment Co., 1832 Graham Blvd., Pittsburgh, PA 15235.

ϕ TABLE 4--STANDARD DEVIATION OF SINGLE TESTS PERFORMED IN SAME LABORATORY

Test	Contaminant	Standard Deviation as a Percentage of the Mean Test Value (100 S/X), %
Life, L	AC Fine	6
	SOFTC-2A	5
Capacity, g	AC Fine	7
	SOFTC-2A	8
Maximum Concentration of Sump Contaminant, g/L	AC Fine	8
	SOFTC-2A	6
Weighted Average Efficiency, %	AC Fine	4
	SOFTC-2A	15

CHAPTER 3

SINGLE PASS PARTICLE RETENTION CAPABILITY TEST

1. Scope--This method describes the particle retention testing of lubrication oil filters which are used to protect internal combustion engines. The method of test 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.

2. Test Materials

ϕ **2.1 Test Fluid**--SAE 30 nonadditive oil (Texaco URSA P-100 or equivalent) mixed with No. 1 heater oil to provide a 92 SSU viscosity at test temperature, or as otherwise specified.

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

2.2.1 Broad Particle Range Contaminant--Dry glass beads in industrial fractions within the 29--470 μm range.

2.2.2 Narrow Particle Range Contaminant--Dry glass beads in 10 μm fractions.

2.2.3 Natural Contaminant--AC Test Dust (coarse) in the 0--200 μm range or fractions thereof.

2.3 Solvents

2.3.1 Analytical

2.3.1.1 n-Pentane.

2.3.1.2 Petroleum ether.

2.3.2 System Cleanup

2.3.2.1 Mineral spirits.

2.3.2.2 Heater oil (No. 1 or equivalent).

3. Test Apparatus

3.1 Test Stand--The schematic diagram presented in Fig. 7 represents a minimum of equipment.

3.1.1 Motor driven pump capable of delivering 6 gpm (23 L/min) minimum at up to 100 psi (690 kPa).

3.1.2 Sump (2 gal (7.6 L) capacity, minimum) with heater capable of maintaining 180°F (82°C) or other specified temperature, ±5°F (±2°C).

3.1.3 Flowmeter, 0--10 gpm (38 L/min) calibrated for test fluid, or as specified.

3.1.4 Swirl chamber per Fig. 9 when beads are used as a contaminant, or a Waring blender power unit and modified micromixer per Fig. 8 if test dust is used.

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

3.1.6 Two pressure gages, 0--100 psi (0--690 kPa).

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

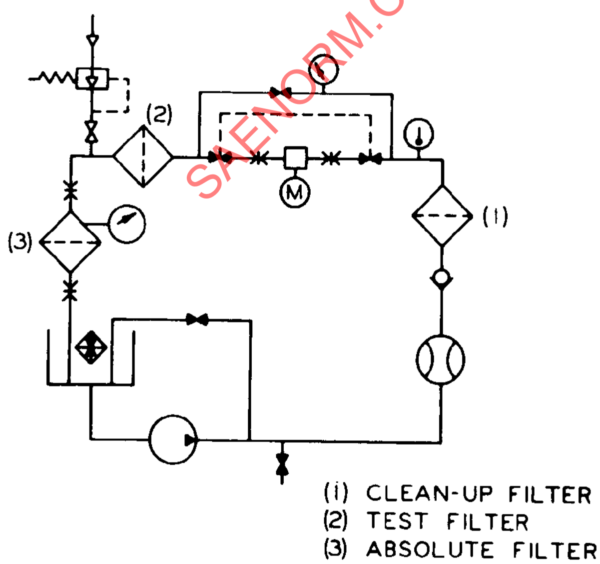


Fig. 7 - Single Pass Test Stand

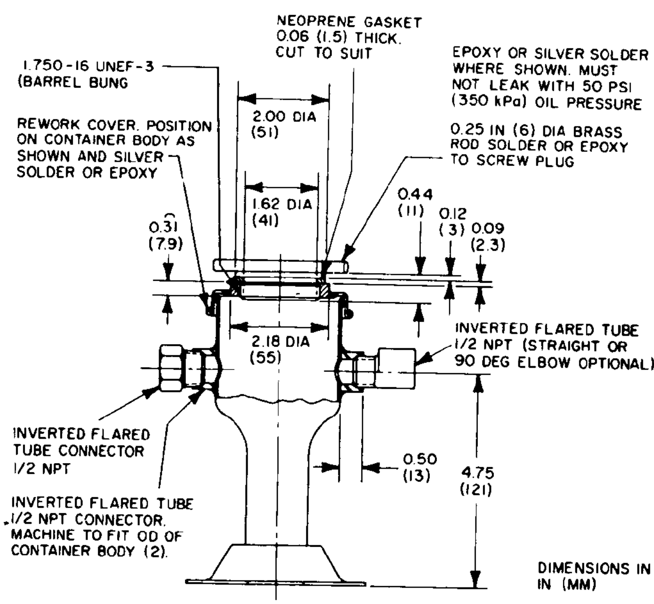


Fig. 8 - Modified Micromixer

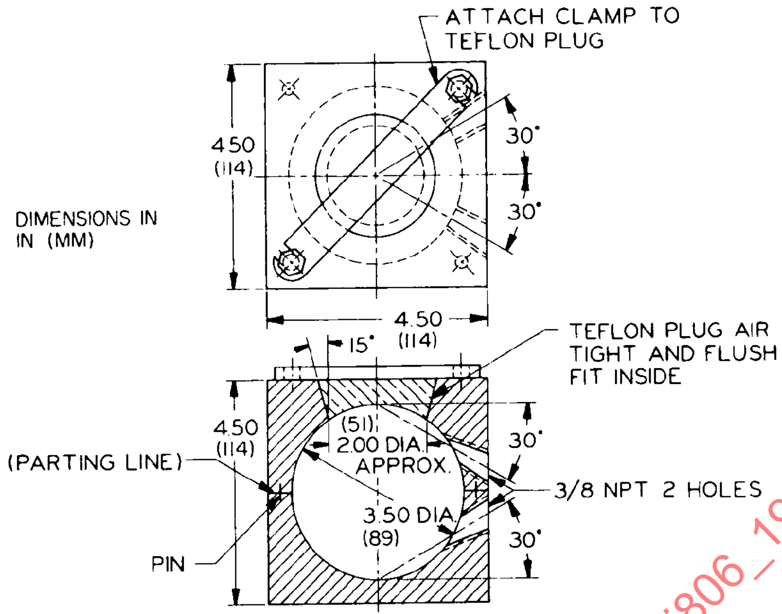


Fig. 9 - Single Pass Swirl Chamber

NOTE: All fittings between the mixing chamber and the absolute filter require internal step relief to insure 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 24 in (610 mm).

3.1.8 Tubing and/or hose with suitable connection for test circuit. All hydraulic lines and fittings to be 0.50 in (12.7 mm) tubing or larger.

3.1.9 Mixer bypass system. Three ball valves, with 90 deg turn actuation.

3.1.10 Flow control bypass valve. Globe or equivalent.

3.1.11 Check valve.

3.1.12 Cleanup filter. Less than 20 μm actual rating, with not more than 2 qt (2 L) of oil holding capacity.

3.1.13 Temperature gage, 0--250 ± 5°F (0--120 ± 2°C) accuracy calibration.

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

3.1.15 Air pressure regulator and shutoff valve capable of controlling air pressure to less than 5 psi (35 kPa). Valve to be globe or needle type.

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 6.10) will also affect this choice. Typical flow versus differential pressures are shown for absolute filters in Figs. 10 and 11.

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

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

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

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

NOTE:

1. Flows in excess of 3 gpm (11.4 L/min) will require the 293 mm diameter membrane filters.

2. Elastomer gaskets are required on screens to ensure no edge leaks.

4. Test Preparation

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

4.2 Flush 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.

4.3 Drain fuel oil from all system components and flush system free of fuel oil using

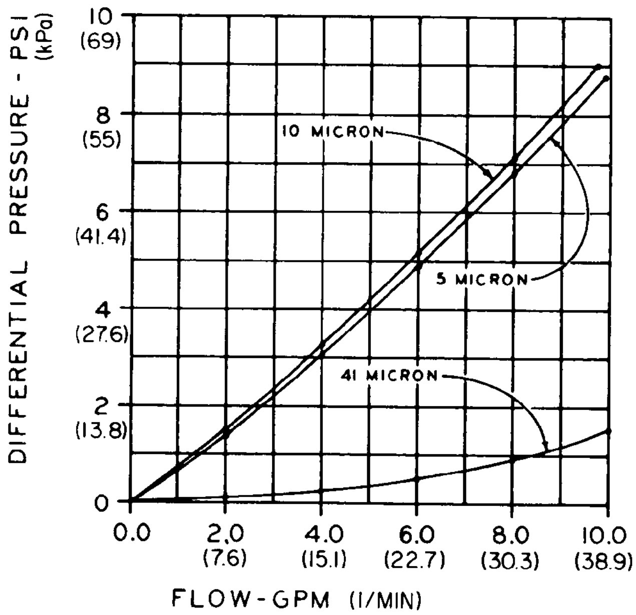


Fig. 10 - Flow Versus Differential Pressure across 293 mm Test Fixture with Indicated Screens Installed Using SAE 30 Oil at 180°F (82°C)

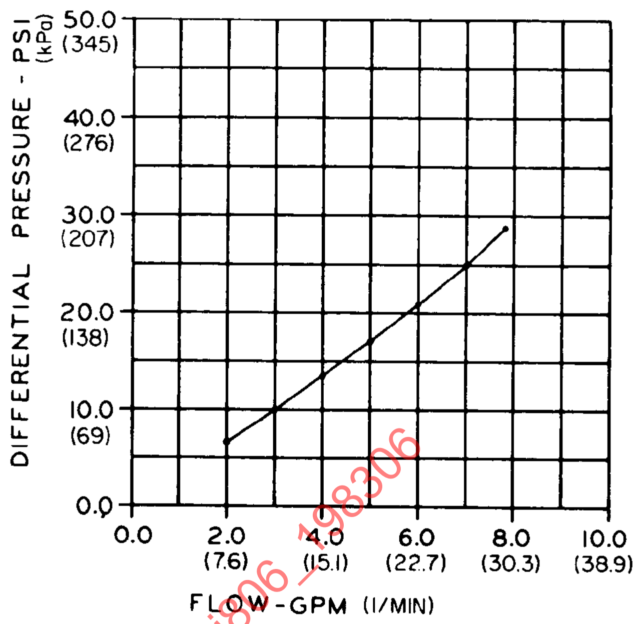


Fig. 11 - Flow Versus Differential Pressure across 293 mm Test Fixture with 8 μm Membrane Installed Using SAE 30 Oil at 180°F (82°C)

the test oil.

4.4 Install the absolute filter and fill the sump with 2 gal (7.6 L) minimum of test oil.

4.5 Install clean element in the dry cleanup filter housing.

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

5. Calibration Procedure

5.1 Run the calibration check exactly like the test procedure (Section 6), except substitute a blank filter adaptor (Fig. 5) for the test filter.

5.2 The quantity of contaminant recovered on the absolute filter should not deviate more than 1.5% of the amount added in a single test, or 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.

6. Test Procedure

6.1 Install the test filter in the system.

6.2 Install a clean absolute filter.

6.3 Flow the test fluid of specified test viscosity at the selected flow rate (see Table 1 in Chapter 2) through the test filter for 30 min 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, and determine the test system cleanliness with the test filter installed. This must not exceed 0.005 g (on absolute filter) for a 15 min flow period. This value will be used as a tare for the test.

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

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

6.6 Mix the contaminant for 1 min at low speed, if a blender is used.

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

6.8 Shut off test system (and microblender drive motor, if used).

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

6.10 Prepare the absolute filter for weight analysis of the contaminant by one of the following methods:

6.10.1 Screen type absolute filters. Membrane 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 prefiltered analytical solvent, onto a smaller, preweighed membrane. Analysis can then be accomplished per Appendix B, Method A.

6.10.2 Membrane filter of 142 mm diameter or less may be preweighed before use, and then reweighed after use, after thorough rinsing with a prefiltered analytical solvent. See Appendix B for detailed instructions. This solvent can then be analyzed per Appendix B, Method A.

6.10.3 Any membrane absolute filter can be analyzed by the following ashing method, if nonadditive oil is used. Wash the membrane nearly free of oil with prefiltered 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 a furnace fired, preweighed, porcelain crucible. Saturate the folded membrane with denatured alcohol, and ignite. When burning stops, place the uncovered crucible in a 1430 ± 30°F (776 ± 16°C) muffle furnace for 30 min. After cooling, reweigh and report the weight gain as the contaminant passed by the filter.

6.11 Determine the weight of contaminant left in the mixer by flushing with prefiltered analytical solvent through a small, preweighed, analytical membrane filter.

7. Evaluation of Results

7.1 Test filter single pass efficiency (%)

$$= \frac{W_1 - W_2 - W_4}{W_1 + W_3 - W_4} \times 100$$

where:

W_1 = weight of test contaminant presented to filter (paragraph 6.5)

W_2 = weight of test contaminant collected on absolute filter (paragraph 6.10) (that is, total weight on absolute filter - W_3)

W_3 = tare value from test system cleanliness (paragraph 6.3)

W_4 = weight of test contaminant left in mixer (paragraph 6.11)

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:

$$\frac{100\,(S_x)}{\bar{x}} \leq 5\%$$

where:

S_x = standard deviation of efficiency of tests

$\bar{x}$ = mean efficiency of tests

CHAPTER 4

MEDIA MIGRATION TEST

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.

2. Test Materials

ϕ **2.1 Test Oil**--SAE J1260, Standard Oil Filter Test Oil (RM 99) or oil of equivalent viscosity at test temperature.

2.2 Four test filters.

2.3 Solvent, analytical grade.

2.3.1 n-Pentane.

2.3.2 Petroleum ether.

3. Test Apparatus

3.1 Test Stand--Same as in Chapter 3, paragraph 3.1, except without mixer unit.

3.2 Media Migration Filter Screen

3.2.1 Wire cloth screen--41 μm nominal.

3.3 Analytical Equipment--See Appendix B.

4. Test Preparation

4.1 Install wire cloth screen in holder and fill sump with 10 L of test oil.

4.2 Circulate test oil through the system (without test filter) at rated flow (Table 1, Chapter 2) and 180°F (82°C) for 15 min and determine system cleanliness by method described in paragraph 5.4. Repeat as often as necessary to achieve a cleanliness level of 0.001 g maximum.

5. Test Procedure

5.1 After satisfying paragraph 4.2, install a test filter.

5.2 Install a clean wire cloth screen in holder.

5.3 Flow test fluid through the test filter at rated flow (or inlet pressure) and temperature for 30 min. Repeat this cycle of 30 min 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 make-up oil.

5.4 Carefully remove wire cloth screen from holder and wash collected media from the screen into a clean beaker with prefiltered n-Pentane or petroleum ether. 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.

5.5 Analyze contaminant to determine its nature.

6. Presentation of Data and Evaluation of Results

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

6.2 Report nature of media migration from test filters.

CHAPTER 5

COLLAPSE TEST FOR LUBE OIL ELEMENTS

1. **Scope**--The collapse, or element strength, test is designed to assure 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.

2. **Test Materials**

ϕ 2.1 **Test Oil**--SAE J1260, Standard Oil Filter Test Oil (RM 99) or a similar viscosity oil.

2.2 **Contaminant**--AC Test Dust (fine) or other suitable choking type contaminant.

3. **Test Apparatus**

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

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

3.3 A reservoir of sufficient size.

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

3.5 A differential pressure gage, with a maximum indicating pointer, capable of registering at least 150 psig (1040 kPa).

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

4. **Test Preparation**

4.1 The filter element to be tested may be one previously subjected to a filterability test according to Chapter 2 or a new element. Element should be examined for any apparent damage before being subjected to the collapse test.

4.2 Block or eliminate relief valve, if present.

5. **Test Procedure**

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

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 as desired.

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 the air must be bled from the test filter housing.

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.

5.5 When a differential pressure of approximately 25 psi (172 kPa) across the test element is reached, stop the contaminant addition and let the pressure increase. If pressure drop ceases to increase, add more contaminant until pressure drop starts to increase again. If flow stops, close the bypass valve until flow restarts.

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.

5.7 After either of the conditions of paragraph 5.6 is reached, shut the test stand down, remove the filter element from the housing, and examine the element.

6. **Presentation of Data and Evaluation of Results**

6.1 The report shall include the following information:

6.1.1 Pretreatment of filter element, that is, life test, preflow, or new element.

6.1.2 Maximum differential pressure attained.

6.1.3 Reason for terminating test.

6.1.4 Condition of filter element after test.

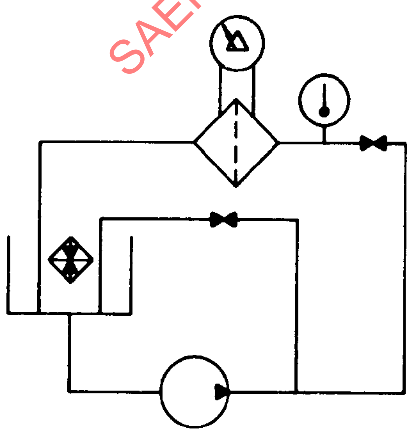


Fig. 12 - Collapse Test Stand

CHAPTER 6

ANTI-DRAINBACK VALVE TEST

1. Scope--The purpose of this test is to evaluate the performance of the anti-drainback valves in new and used spin-on type filters with respect to leakage under a static pressure head.

The anti-drainback feature is important in certain spin-on filter applications where the filter can drain during engine shutdown. If the filter drains, there is a time delay in getting pressure to critical engine parts.

The test consists of installing a filter on a special base and applying a static head of oil through a pipe fastened to the filter base outlet. The leakage past the valve is collected and measured over a period of time.

2. Test Materials

ϕ **2.1 Test Fluid**--Mentor No. 28 (Exxon) or equivalent (38--45 SSU).

3. Test Apparatus

3.1 Test stand as shown in Fig. 13.

3.1.1 Main reservoir with approximately 2 L capacity.

3.1.2 Low capacity centrifugal pump; for example, 0.5 gpm (1.9 L/min) type.

3.1.3 Necessary piping, valves, and fittings.

3.1.4 Graduate for leakage measurement.

3.1.5 Graduated column for static pressure head 24 in (610 mm) above the filter mounting base.

3.1.6 Special filter mounting base as shown in Fig. 14.

4. Test Preparation

4.1 Assemble special filter mounting base by screwing proper stud into the base until the O-ring is firmly seated.

4.2 Install filter on mounting base according to the recommended procedure and torque.

4.3 Fill main reservoir with the required amount of test fluid.

5. Test Procedure

5.1 Test to be run at 70 ± 5°F (21 ± 3°C).

5.2 Purge the filter by opening the necessary valves and pumping fluid through the filter until the fluid is free of air bubbles. If a used filter is being tested and the fluid becomes excessively contaminated, discard the contaminated fluid and replace with clean fluid. The anti-drainback valve must be actuated a minimum of five times during the purging cycle by stopping and restarting the flow through the filter.

5.3 After purging the filter, close the valve in the sump return line and slowly open the valve to the graduated column, allowing it to be filled to slightly above the 24 in (610 mm) mark. After the column is filled, close the filter inlet valve and shut off the pump.

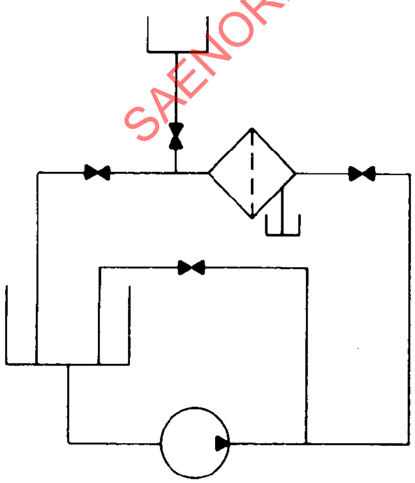


Fig. 13 - Anti-Drainback Valve Test Stand

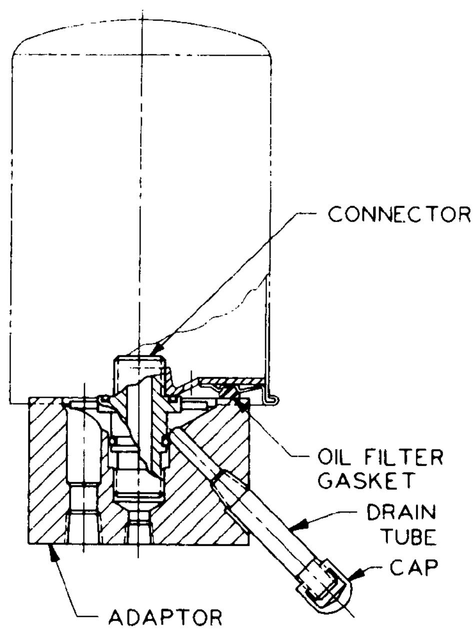


Fig. 14 - Anti-Drainback Valve Fixture

5.4 Remove the cap on the leakage drain tube and allow the trapped fluid to drain for 2 min. Then adjust the pressure head to maintain a 24 in (610 mm) level throughout test.

5.5 At the end of the 2 min period, place a graduate under the drain tube and record the leakage rate. The pressure head column should be filled from the top to maintain the 24 in (610 mm) level.

5.6 Record the leakage rate in milliliters at 10 min intervals for the first hour and hourly thereafter.

6. Presentation of Data

6.1 Present data as total leakage over a given period. Limits to be established by user.

CHAPTER 7

ABILITY TO MEET ENVIRONMENTAL CONDITIONS

1. Scope--The following test methods are applicable to oil filters of the bypass, shunt, or full flow types used in internal combustion engine lubrication oil systems. The methods evaluate the following environmental factors:

1.1 Effect of water in the oil on filter capacity.

1.2 Effect of high oil temperature on integrity and/or collapse strength of filter element.

1.3 Oil additive removal tendencies of the filter element (for ash type oil additives only).

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

2.1 Test Materials

2.1.1 Distilled water.

2.1.2 SOFTC-2A or qualifying contaminant.

ϕ **2.1.3** SAE 30 nonadditive oil (Texaco URSA P-100 or equivalent).

2.2. Apparatus--SAE standardized oil filter test stand, Class A or B, for applicable flow rate, with external cooling added to maintain 125°F (50°C) oil temperature to filter.

2.3 Preparation--Refer to Chapter 2 on Filterability.

2.3.1 Prepare the test stand per Section 14, Chapter 2, using nonadditive oil and the appropriate class stand for the rated filter flow, except use 125 ± 5°F (50 ± 3°C) filter inlet temperature.

2.4 Test Procedure

2.4.1 Conduct the test per Section 15, Chapter 2, using nonadditive oil and the qualifying contaminant or SOFTC-2A, with the following modifications to the procedure:

2.4.2 Test temperature to be 125 ± 5°F (50 ± 3°C) at the filter inlet.

2.4.3 Add distilled 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.

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.

2.4.5 Sump samples need not be taken. Portions of Section 15, Chapter 2, referring to sampling, are not applicable to this test.

2.5 Evaluation of Results

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.

3. Test Method with High Oil Temperature for Element Integrity

3.1 Test Oil--SAE J1260, Standard Oil Filter Test Oil (RM 99) or as specified. ϕ

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

3.3 Test Procedure

3.3.1 Adjust the stand to produce element rated flow except use 275°F (135°C) or maximum intended service temperature and extend the circulation time per element to 24 h unless a longer time is specified.

3.3.2 At end of circulation time, subject the filter elements to the collapse test per Chapter 5. If the filter assembly contains an anti-drainback valve, subject the assembly to test per Chapter 6 before proceeding with the collapse test.

3.4 Presentation of Data and Evaluation of Results--Tabulate the collapse pressure for each element per Section 6, Chapter 5. Indicate the prescribed acceptable limits required to pass the test.

4. Test Method for Determination of Oil Additive Removal by Filter ϕ

4.1 Materials ϕ

4.1.1 SAE J1260, Standard Oil Filter Test Oil (RM 99) or as specified. ϕ

4.1.2 Test filter cartridge and housing, if applicable. ϕ

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

4.2 Apparatus--SAE standardized oil filter test stand, Class A or B, or similar test stand capable of maintaining conditions described herein. ϕ

4.3 Preparation ϕ

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

4.3.2 Install on the test stand an empty filter housing or spin-on shell without element. Hardware should be identical with that to be used in paragraph 4.4.1, with the exception of element omission. ϕ

4.3.3 Place 8 L (2 gal) of specified test ϕ oil in Class A stand or 19 L (5 gal) of test oil in Class B stand, whichever is applicable.

ϕ 4.3.4 For Class A stand: Set oil pump delivery rate at 34 L/min (9 gpm). Adjust bypass and heater controls such that 22.7 L/min (6 gpm) goes through filter at 82°C (180°F).

For Class B stand: Set oil pump delivery rate at 68.5 L/min (18 gpm). Adjust bypass and heater controls such that 45.5 L/min (12 gpm) goes through filter at 82°C (180°F).

If filter rated flow is lower than specified here, use filter rated flow.

ϕ 4.3.5 Circulate test oil for 16 h at conditions of paragraph 4.3.4. Remove oil sample and determine oil additive content. Suggested methods are noted in paragraph 4.6.

ϕ 4.3.6 Drain test oil from stand, but do not flush test stand.

ϕ 4.3.7 Repeat steps 4.3.3--4.3.6 with fresh test oil. The average of these two runs shall be considered the test blank.

ϕ 4.3.8 Take a sample of specified test oil from the drum and determine oil additive content by use of the same method utilized in paragraph 4.3.5. This is to be recorded as the additive content of the test oil as received.

ϕ **4.4 Test Procedure**

ϕ 4.4.1 Onto test stand install test filter cartridge into housing or spin-on assembly containing test element, and proceed as per paragraphs 4.3.3 and 4.3.4.

ϕ 4.4.2 Circulate test oil through filter for 24 h, withdrawing a 0.10 L sample at the filter outlet every 8 h.

ϕ 4.4.3 Analyze each 0.10 L sample removed for oil additive content by use of the same method utilized in paragraphs 4.3.5 and 4.3.8.

ϕ **4.5 Presentation of Data and Evaluation of Results**

ϕ 4.5.1 Tabulate the oil additive content data showing values for oil as received (per paragraph 4.3.8), the test blank (per paragraph 4.3.7), and 8 h samples run through filter (per paragraph 4.4.3). The data sheet and report must state which analysis method was used.

ϕ 4.5.2 The oil additive content of each 8 h sample should be corrected to account for the test blank. Correction should be carried out as follows:

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

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

4.5.4 For reference purposes, primary additives (and their typical concentrations) contained in J1260 (RM 99) test oil are calcium (2200--2600 ppm wt); zinc (1100--1300 ppm wt); and phosphorous (900--1100 ppm wt). ϕ

4.6 Analysis Methods for Oil Additive Content--The following methods are recommended for determining oil additive content as discussed herein. The method chosen should be utilized throughout the test. ϕ

Atomic Absorption Spectrophotometry--Equipment manufactured by Perkin-Elmer, Norwalk, CT.

Flame Emission Spectrophotometry--Equipment manufactured by Perkin-Elmer, Norwalk, CT.

X-Ray Spectrophotometry--Equipment manufactured by Siemena Corp., Rosemont IL.

Argon Plasma Spectrophotometry--Equipment manufactured by Spectrametrics, Inc., Andover, MA.

Atomic Emission Spectrometer--Baird Corp., Bedford, MA.

Complexiometric Titration per ASTM D811, Part No. 17.

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

1. The viscosity of the instrument calibrating fluid must match the viscosity of the test fluid sample.

2. For atomic absorption analysis:

(a) The higher temperature nitrous oxide flame must be used.

(b) Phosphorous analysis should be done by complexing the phosphorus with a more readily analyzable element such as molybdenum in aqueous solution. Consult instrument operating manual for details.

3. Phosphorus analysis is often more easily accomplished using X-ray or visible spectrophotometry as an analysis method.

CHAPTER 8

INSTALLATION AND REMOVAL

1. Installation Seal Retention

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.

1.2 Test Materials--See Chapter 9, paragraph 2.2.

1.3 Test Apparatus--See Chapter 9, paragraph 2.3. (Vibration test machine not required.)

1.4 Test Preparation--See Chapter 9, paragraph 2.4.

1.5 Test Procedure

1.5.1 Install filter on mounting base with prescribed torque.

1.5.2 Pressurize filter at 70 psi (483 kPa) and start test at time zero.

1.5.3 Test to be terminated at 100 h or when leakage is observed, whichever occurs first.

1.5.4 Leakage can be observed by use of an ultraviolet light. The test oil used is fluorescent and readily detected even in small amounts.

1.6 Presentation of Data

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

1.6.2 Completely report all test conditions.

2. Installation Sealing Torque

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.

ϕ **2.2 Test Material**--Test Fluid: Oil of ISO viscosity grade 68 at 37.8°C.

2.3 Test Apparatus--Fig. 20.

2.3.1 Hydraulic hand pump 0--500 psi (0--3450 kPa).

2.3.2 Pressure gage--0--300 psi (0--2070 kPa).

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

2.3.4 Flexible 500 psi (3450 kPa) hydraulic hose.

2.3.5 Plexiglas shield observation enclosure around product being evaluated.

2.4 Test Preparation

2.4.1 Connect hydraulic hose from pump to filter test head.

2.4.2 Check gasket to insure that it is bottomed out in retainer groove.

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

2.5 Test Procedure

2.5.1 Apply thin film of oil to gasket surface and fill test filter with oil.

2.5.2 Screw filter on test fixture until gasket makes contact.

2.5.3 Tighten the filter to the test fixture with the application of 25 in-lb (2.82 N·m) of torque.

2.5.4 Position plastic shield between operator and filter-fixture assembly.

2.5.5 Using the hydraulic hand pump, pressurize the assembly until the first sign of leakage appears. Record leakage pressure.

2.5.6 Determine leakage pressure at increasing torque intervals of 25 in-lb (2.82 N·m) until required turns after first gasket contact have been achieved or recommended torque has been applied.

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

2.6 Presentation of Data

2.6.1 Graph the following: Abscissa - torque; ordinate - pressure, leakage.

2.6.2 Report permanent deformation of filter flange at leak pressure.

2.6.3 Note torque required to attain seal pressure desired.

3. Removal Torque Test Method

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

3.2 Test Material--Test fluid: Oil of ISO viscosity grade 68 at 37.8°C. ϕ

3.3 Test Apparatus

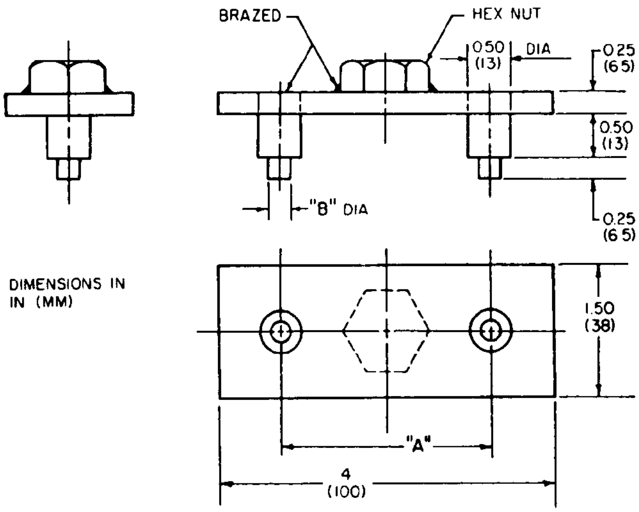
3.3.1 Constant temperature oven, capable of maintaining 212 ± 2°F (100 ± 0.6°C).

3.3.2 Thermometer (immersion type) with a temperature range of 0--250°F (0--120°C).

3.3.3 Torque wrench with a torque range of 0--500 in-lb (0--56.5 N·m) readable to 5 in-lb (0.56 N·m).

3.3.4 Torque wrench adaptor. Suggested design is shown in Fig. 15.

3.3.5 Filter Test Base--Use manufacturer's



A AND B TO BE DETERMINED BY FLANGE DESIGN

Fig. 15 - Torque Wrench Adapter

specified base.

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

3.4 Test Preparation

3.4.1 Preheat oven to 212°F (100°C).

3.4.2 Secure filter base in vise--be sure threads are clean and properly sized.

3.4.3 Check gasket to insure that it is fully seated in retainer groove.

3.5 Test Procedure

3.5.1 Apply light film of oil to gasket surface.

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

3.5.3 Using torque wrench adapter, apply specified torque (or rotation).

3.5.4 Place total assembly in oven for 24 h minimum.

3.5.5 Remove assembly and allow to cool to 72°F (22°C) (room temperature).

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

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

3.6 Presentation of Data--Tabulate following information:

3.6.1 Installation torque used.

3.6.2 Filter head used.

3.6.3 Removal torque required.

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

3.6.5 Whether or not gasket remained in retainer groove.

3.7 Definition of Terms

3.7.1 **Removal Torque**--The maximum torque required to remove filter flange assembly from filter test head.

3.7.2 **Installation Torque**--Manufacturer's specified torque to achieve a good seal.

3.7.3 **Filter Flange Assembly**--Threaded inlet and outlet support plate and gasket retainer combination.

3.7.4 **Filter Test Base**--Manufacturer's recommended base to be used for this test. Sealing surface should have finish specified (micro-inch).

CHAPTER 9

MECHANICAL TESTS

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-c. 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/or equipment may be modified to accommodate other sizes and types of filters for specific applications.

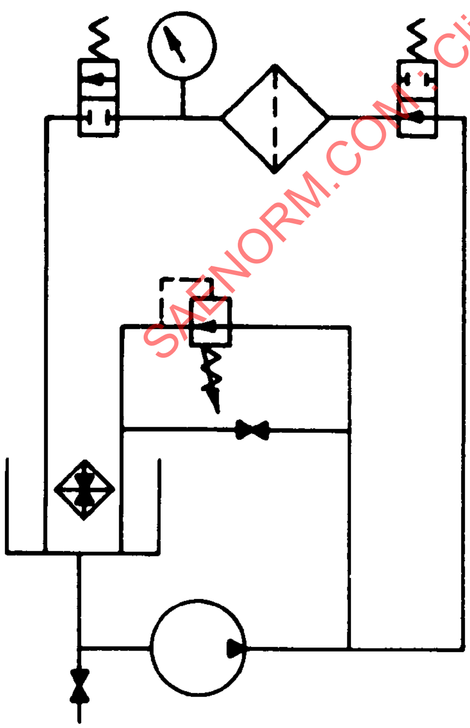


Fig. 16 - Pressure Impulse Stand

1. Pressure Impulse Fatigue Test

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

1.2 Test Materials--Test Oil: SAE J1260, Standard Oil Filter Test Oil (RM 99) or as specified. ϕ

1.3 Test Apparatus--See Fig. 16.

1.3.1 Brown and Sharpe No. 1S Rotary Gear Pump or equivalent.

1.3.2 1 hp, 1725 rpm motor.

1.3.3 2 gal (7.6 L) capacity sump with heater capable of maintaining 212°F (100°C).

1.3.4 Eagle Signal Corp. Flexopulse Timer (model 4A71, type CA100A60202) or equivalent.

1.3.5 General Controls Type K-10B solenoid (Catalog No. K10CA137T and K-10AA137T) or equivalent.

1.3.6 Durant Corp., Electric Counter, Model No. 6-Y-1 MF or equivalent.

1.3.7 Ashcroft Dura-switch Model No. 4077 pressure shut-off switch or equivalent, wired to shut test stand down in event of over-pressure.

1.3.8 Direct acting pressure relief valve adjustable to 0--200 psi (0--1380 kPa).

1.3.9 Tubing, valves, and gages.

1.3.10 Float type low fluid level shut-off switch.

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

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

1.3.13 Tektronix type 564 oscilloscope with memory feature or equivalent.

1.3.14 Shield.

1.4 Test Preparation

1.4.1 Fill sump with test fluid and circulate through the bypass circuit allowing the temperature to stabilize to 160 ± 5°F (70 ± 3°C).

1.4.2 Install test filter and circulate test fluid through it to purge all air from the filter.

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

1.4.3.1 The timer and relief valve adjustments must be made to produce the test wave form as required. See Fig. 18 for a test wave form of the pressure impulse showing the pressure-time cycle. The shaded area shows the percent variation of pressure and time permissible from the required wave form. Note that the slopes of the pressure time curve should be 100% pressure rise in 5% of the cycle time and 100% of pressure decay in 10% of the cycle time.

1.4.3.2 The wave form is very critical to the fatigue life of the test filter and must be closely duplicated. It is recommended that an oscilloscope be used to monitor the wave form.

1.4.3.3 Unless otherwise stated, a pressure impulse of 0--100 psi (0--690 kPa) is to be applied at a frequency of 30 cycles/min.

1.5 Test Procedure

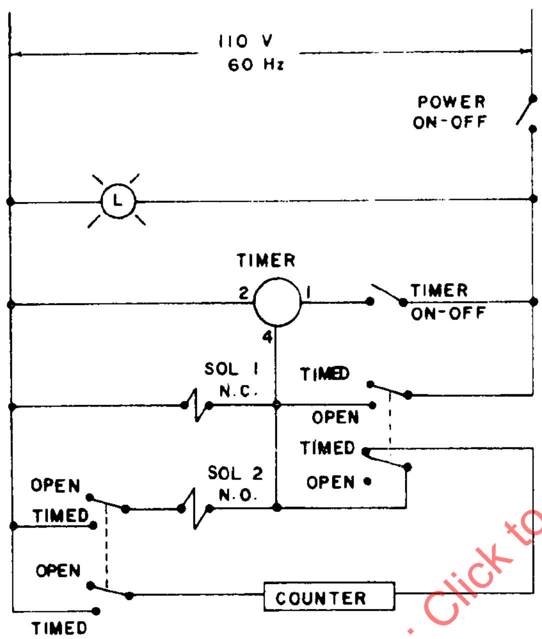


Fig. 17 - Timer Wiring Diagram

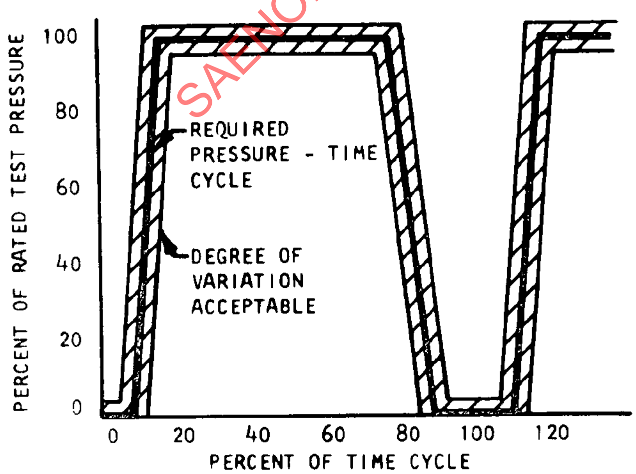


Fig. 18 - Impulse Stand Pressure Cycle

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

1.5.2 After filter fails, as evidenced by fluid leakage, stop test and record number of cycles.

1.6 Presentation of Data

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

1.6.2 Completely report all test conditions.

2. Vibration Fatigue Test

2.1 Scope--This test determines the ability of the filter to withstand vibratory forces that result during engine operation.

2.2 Test Materials--Test Fluid: Nonadditive paraffinic petroleum mineral oil of ISO viscosity grade 68 at 37.8°C. ϕ

2.3 Test Apparatus--See Fig. 19.

2.3.1 Horizontal vibration test machine with automatic variable frequency control--All American Vibration Fatigue Testing Machine Model ARVF-24-100 or equivalent.

2.3.2 Mounting fixtures, lines, fittings, valves, pressure source, and gages as required.

2.3.3 Ultraviolet light source.

2.3.4 Shield.

2.4 Test Preparation

2.4.1 Fill filter with oil and mount in accordance with instructions on vibration machine table.

2.4.1.1 Test filter including base and/or brackets must be rigidly mounted so that table motion is transmitted directly to the test unit undiminished.

2.4.1.2 Filter must be mounted so that the direction of motion simulates, as closely as possible, the vibrational movement experienced on the engine.

2.4.2 Set vibration machine controls to

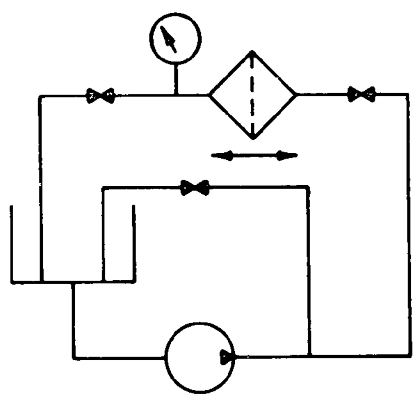


Fig. 19 - Vibration Fatigue Stand

obtain a vibration amplitude of 0.030 in (0.76 mm) with a frequency which varies automatically from 10 to 50 cycles/s once every minute.

2.4.3 Connect pressure line to filter and adjust to obtain 70 psi (483 kPa) pressure.

2.4.4 If it is desired that the filter be tested at resonant frequency, the automatic cycling controls can be shut off and the equipment made to operate continuously at resonant frequency and required amplitude.

2.5 Test Procedure

2.5.1 Pressurize filter and start test at time zero.

2.5.2 Activate ultraviolet light source to indicate oil leakage during test.

2.5.3 Vibration motion may be observed with a stroboscopic light and the acceleration coupled to a vibration meter.

2.5.4 Continue test until failure occurs. A filter assembly is considered to have failed if there is a loss in pressure, indication of leakage, or a break in the filter or mounting accessories which would make it unacceptable for further use.

2.6 Presentation of Data

2.6.1 Report hours run to failure and note location and type of failure.

2.6.2 Completely report all test conditions.

3. Hydrostatic Burst Pressure Test

3.1 Scope--This test determines the ability of the filter to withstand the maximum engine surge pressure.

ϕ **3.2 Test Materials**--Test Fluid: Nonadditive paraffinic petroleum mineral oil of ISO viscosity grade 68 at 37.8°C.

3.3 Test Apparatus--Fig. 20.

3.3.1 Hand operated high pressure hydraulic pump (Enerpac No. P80 or equivalent).

3.3.2 High pressure tubing or hose and necessary connections, and valves (1000 psi (6900 kPa) minimum rating).

3.3.3 Pressure gages with pointer indicator to range required (maximum graduation--10 psi (69 kPa)).

3.3.4 Test filter mounting fixture or base.

3.3.5 Plexiglas shield observation enclosure around product being evaluated.

3.4 Test Preparation

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

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

3.4.3 Position shield between operator and test filter.

3.5 Test Procedure

3.5.1 With all air and oil bleeds shut off, gradually apply pressure in increments no greater than 10 psi (69 kPa). Hold applied pressure for about 1 min at each increment.

(If approximate burst pressure for the test filter is known, the initial pressure increment may be 75% of the expected burst pressure.)

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

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

3.6 Presentation of Data

3.6.1 Report failure pressure and comment on type of failure.

3.6.2 Completely report all test conditions.

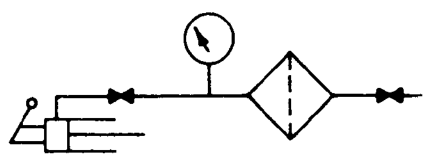


Fig. 20 - Hydrostatic Burst