

**Full Flow Lubricating Oil Filters
Multipass Method for Evaluating Filtration Performance**

Foreword—The ideal filter for an engine lubricating oil system offers infinite restriction to the passage of particulate contaminants, exhibits zero resistance to the flow of fluid, and provides unlimited capacity for retained contaminant.

An actual filter cannot exhibit such phenomenal performance characteristics. Therefore, test procedures must be available to establish its degree of ideality (filter capacity and efficiency).

The performance characteristics of a filter are a function of the element (configuration and material) and the housing (general configuration and seal design).

In practice, a filter is subjected to a continuous flow of contaminant entrained in the oil until a specified terminal pressure drop (relief valve pressure) results.

Both the length of operating time (prior to reaching the terminal pressure drop) and the contaminant level at any point in the system are functions of the rate of contaminant addition (that is, the rates of contaminant ingress and generation) and the capability of the filter to remove contaminants.

Therefore, a realistic laboratory test which establishes filter capacity must provide the filter with a continuous supply of ingressed contaminant and allow the periodic monitoring of the performance characteristics of the filter.

The contaminant level of the fluid immediately downstream of a filter is directly related to the contaminant level of the upstream fluid. The contamination level of a fluid is given by the particle size distribution. This distribution can be accurately measured for particles greater than 10 μ m using currently available automatic particle counters. However, particle size distributions associated with an operating system always exhibit higher cumulative particle counts at 10 and 20 μ m than at larger sizes. Therefore, the separation characteristics of a filter can be most accurately determined statistically by using the particle counts at the lower μ m sizes.

Fluid samples must be extracted from the test system to evaluate the filter element's particle removal characteristics. To prevent this sampling from adversely affecting the test results, a lower limit is placed upon the rated flow of elements which may be tested with this procedure. Thus, the current maximum flow rate is based upon the gravimetric level of contaminant injection systems which have so far been qualified while the current maximum 10 μ m filtration ratio is based on the highest ratio for filters that have been tested in more than one laboratory. It has been determined that this procedure is currently only applicable for filter elements meeting the requirements given in Section 1.

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Since it is difficult to specify, achieve, and verify a cyclic flow requirement that is both realistic and consistent with the flow variations occurring in actual systems, the compromise of a steady-state condition has been used for this test to enhance the repeatability and reproducibility of results.

1. **Scope**—This standard establishes a multipass filtration performance test with continuous contaminant injection for lubricating oil filter elements.

It also includes a procedure for determining the contaminant capacity, particulate removal characteristics, and pressure loss.

It also includes a test currently applicable to lubricating oil filter elements which exhibit a 10 μm filtration ratio of less than 75 and a rated flow between 4 and 600 L/min.

This standard provides a test procedure which yields reproducible test data for evaluating the filtration performance of a lubricating oil filter element.

NOTE—Several test stand sizes are required to cover the entire test flow range (4-600 L/min). The method as written is geared toward the testing of heavy duty type filters. For high capacity, low flow filters or small filters for automotive applications, some concessions to the method in fluid volume, contaminant feed rates and injection system design may have to be considered. The base upstream gravimetric level of 10 mg/L should be adhered to unless agreed upon by the filter user and supplier. Base upstream levels up to 100 mg/L may be used to shorten test times. A test duration of 1-2 h is suggested.

2. References

- 2.1 **Applicable Publications**—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated the latest revision of SAE publications shall apply.

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

SAE ARP 785—Determination of Particulate Contaminant in Hydraulic Fluids by the Control Gravimetric Method.

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

ISO 1219—International Standard Graphic Symbols for Hydraulic and Pneumatic Equipment.

ISO 2942—Hydraulic Fluid Power—Filter Elements - Determination of Fabrication Integrity.

ISO 3722—Hydraulic Fluid Power—Fluid Sample Containers - Qualifying and Controlling Cleaning Methods.

ISO 3968—Hydraulic Fluid Power—Filter Elements—Evaluation of Pressure Drop versus Flow Characteristics.

ISO 4021—Hydraulic Fluid Power—Particulate Contaminant Analysis—Extraction of Fluid Samples from Lines of an Operating System.

ISO 4402—Hydraulic Fluid Power—Calibration of Liquid Automatic Particle Count Instruments—Method Using SAE Fine Test Dust.

ISO 4572-1981—Hydraulic Fluid Power—Filter Elements—Multipass Method for Evaluating Filter Performance.

3. Definitions

- 3.1 Multipass Test**—A test which requires the recirculation of unaltered fluid through the filter element (ref. ISO 4572-1981).
- 3.2 Base Upstream Gravimetric Level**—The solids injection rate per minute expressed as mg/L of test flow rate or the upstream contaminant concentration if no contaminant was recirculated.
- 3.3 Filtration Efficiency**—See Paragraph 16.1.
- 3.4 Filtration Ratio**—See Paragraph 16.2.

4. Graphical Symbols

- 4.1** Graphical symbols used are in accordance with ISO 1219.

5. General Procedure

- 5.1** Set up and maintain apparatus per Sections 6 and 7.
- 5.2** Run all tests per Sections 8, 9, and 10.
- 5.3** Analyze data from Sections 8, 9, and 10 per Sections 11, 12, 14, and 16.
- 5.4** Present data from Sections 10 and 12 per Sections 13 and 15.

6. Test Equipment

- 6.1** Use a suitable timer for measuring minutes and seconds.
- 6.2** Use an automatic particle counter calibrated per ISO 4402, or any ISO approved counting method. The accuracy of this filter test method is dependent upon the counting method used.
- 6.3** Use SAE 5-80 μm Test Dust (Figure 2) which has been predried for 1 h minimum at 110–150 °C in quantities no larger than 200 g and cooled to room temperature, then maintained until use in a desiccating chamber.
- 6.4** Use sample bottles containing less than 1.5 particles greater than 10 $\mu\text{m}/\text{mL}$ of bottle volume, as qualified per ISO 3722.

NOTE—This degree of cleanliness ensures a contamination contribution from the sample bottle of less than one-tenth of the minimum expected effluent level of any filter for which this test procedure is applicable.

- 6.5** Use petroleum base test fluid conforming to the following specifications:

6.5.1 PROPERTIES OF THE PETROLEUM BASE STOCK

pour point not lower than $-59.4\text{ }^{\circ}\text{C}$
flash point (min) $93.3\text{ }^{\circ}\text{C}$
acid or base number (max) 0.10
precipitation number 0

6.5.2 ADDITIVE MATERIALS

viscosity-temperature coefficient improver - not to exceed 10% (m/m).
 oxidation inhibitors - not to exceed 2% (m/m)
 tricresyl phosphate antiwear agent - in the amount of $0.5 \pm 0.1\%$ (m/m)

Limit the free phenol content of the TCP agent to a maximum of 0.05% (m/m).

6.5.3 PROPERTIES OF THE FINISHED OIL

viscosity (mm^2/s at 40 °C) (min)	10.0
viscosity (mm^2/s at -40 °C) (min)	500
pour point not lower than	-59.4 °C
flash point (min)	93.3 °C
precipitation number	0
acid or base number (max)	0.20

NOTE— $1 \text{ mm}^2/\text{s} = 1 \text{ cSt}$

6.5.4 COLOR OF FINISHED OIL—Use oil that is clear and transparent and which contains a red dye in a proportion not greater than one part of dye per 10 000 parts of oil (m/m) (used for identification only).

NOTE—The use of test fluid conforming to these specifications ensures greater reproducibility of results and is based upon current practices and other accepted filter standards. Fluid conforming to these specifications is available worldwide as aircraft hydraulic oil MIL-H-5606.

6.6 Use a filter performance test circuit comprising a "filter test system," and a "contaminant injection system." A typical layout is shown in Figure 1.

6.6.1 The filter test system consists of:

6.6.1.1 A reservoir constructed with a conical bottom having an included angle of not more than 90 deg and where the oil entering is diffused below the fluid surface.

NOTE—This reservoir design avoids a horizontal bottom and thus minimizes contaminant settling while the subsurface diffusion reduces the entrainment of air.

6.6.1.2 An oil pump which is essentially insensitive to contaminant at the operating pressure.

WARNING—Pumps exhibiting excessive flow pulses will cause erroneous results.

6.6.1.3 A system cleanup filter capable of providing an initial system contamination level of less than 15 particles greater than $10 \mu\text{m}/\text{mL}$.

6.6.1.4 Pressure gauges, temperature indicator and controller, and flow meter as shown (Figure 1).

6.6.1.5 Pressure taps in accordance with ISO 3968.

6.6.1.6 A means for turbulent sampling upstream and downstream of the test filter. Sample in accordance with ISO 4021.

6.6.1.7 Interconnecting lines which ensure that turbulent mixing conditions exist throughout the filter test system and that contaminant traps, silting areas, and combinations of cyclonic separation zones and quiescent chambers are avoided.

6.6.2 The contaminant injection system consists of:

6.6.2.1 A reservoir constructed with a conical bottom having an included angle of not more than 90 deg and where the oil entering is diffused below the fluid surface.

NOTE—This reservoir design avoids a horizontal bottom and thus minimizes contaminant settling while the subsurface diffusion reduces the entrainment of air.

6.6.2.2 A system cleanup filter capable of providing an initial system contamination level of less than 1000 particles greater than 10 μ m/mL and a gravimetric level less than 2% of the calculated level at which the test is being conducted.

6.6.2.3 An oil pump (centrifugal or of another type) which does not fracture the contaminant particles.

6.6.2.4 A sampling means for the extraction of a small portion of the injection flow from a point in the contaminant injection system where active circulation of the fluid exists. Sample in accordance with ISO 4021.

6.6.2.5 Interconnecting lines which ensure that turbulent mixing conditions exist throughout the filter test system and that contaminant traps, silting areas, and combinations of cyclonic separation zones and quiescent chambers are not present. In particular, turbulent mixing conditions must exist throughout the length of the line carrying the injection fluid.

6.7 Use membranes and associated laboratory equipment suitable for carrying out the double membrane gravimetric method (SAE ARP 785).

7. **Test Conditions Accuracy**—Set up and maintain equipment accuracy within the limits given in Table 1.

TABLE 1—TEST CONDITIONS ACCURACY

Test Condition	Units	Maintain Within True Value
Flow	L/min	$\pm 2\%$
Pressure	Pascal	$\pm 2\%$
Temperature	$^{\circ}\text{C}$	$40^{\circ} \pm 2^{\circ}\text{C}$
Volume	Liters	$\pm 2\%$

8. **Filter Performance Test Circuit Validation Procedures**

NOTE—These validation procedures reveal the effectiveness of the filter performance test circuit in maintaining contaminant entrainment and/or preventing contaminant size modification.

8.1 **Validation of Filter Test System**

8.1.1 Validate at the minimum flow rate at which the filter test system will be operated.

NOTE—Install a conduit in place of a test filter during validation.

8.1.2 Adjust the total system volume to be numerically equal to one-fourth of the value of the minimum flow volume per minute through the filter plus 4 liters.

NOTE—This is the volume to flow ratio required for the filter test procedure (see Paragraph 9.3.3).

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8.1.3 Contaminate the system fluid to the calculated gravimetric level of 5 mg/L using SAE 5-80 μ m Test Dust.

NOTE—This contamination level is below the saturation limitations of automatic particle counters.

8.1.4 Circulate the fluid in the test system for 1 h and extract fluid samples at 10 min intervals from the downstream sampling valve.

When on-line sampling and particle counting is to be used, obtain downstream cumulative counts at 10 and 20 μ m without on-line dilution at the 10 min sample intervals.

8.1.5 Analyze the six fluid bottle samples and record three cumulative particle counts per mL at 10 and 20 μ m for each sample.

Record the on-line count as the cumulative count for the sample period selected divided by the volume of fluid (mL) passed through the particle counter sensor during the sample period.

8.1.6 Accept the validation test only if:

8.1.6.1 The average for all particle counts obtained for a given size from each bottle sample does not deviate by more than 10% from the average particle counts for that size from all samples.

8.1.6.2 The average for all particle counts per mL at $> 10 \mu$ m is not less than 600 nor more than 900.

8.1.6.3 The particle counts per mL at $> 20 \mu$ m are not less than 100 nor more than 150.

8.2 Validation of Contaminant Injection System

8.2.1 Validate at the maximum gravimetric level and the maximum injection system circuit volume to be used (see Paragraphs 9.2.2 and 9.2.3).

8.2.2 Add the required quantity of contaminant in slurry form to the injection system fluid and circulate for sufficient time to completely disperse the contaminant.

NOTE—All systems may not disperse contaminant at the same rate.

8.2.3 Extract fluid samples at the point where the injection fluid is discharged into the filter test system at 30, 60, 90, and 120 min and analyze each sample gravimetrically. These samples should be taken at the intended test injection flow rate.

8.2.4 Accept the validation test only if the gravimetric level of each sample is within $\pm 5\%$ of the average of the four samples and within $\pm 5\%$ of the calculated gravimetric value.

9. Preliminary Preparation

9.1 Test Filter Assembly

9.1.1 Ensure that the test fluid cannot bypass the filter element to be evaluated.

9.1.2 Subject the test filter element to a fabrication integrity test in accordance with ISO 2942 using MIL-H-5606 fluid prior to the multipass test or following the multipass test if the element is not readily accessible as in the spin-on configuration.

9.1.3 Disqualify the element from further testing if it fails to meet the designated test pressure.

9.2 Contaminant Injection System

- 9.2.1 Using 10 mg/L as the base upstream gravimetric level, calculate the predicted test time (T') in minutes by the following equation:

$$T' = \frac{\text{(apparent capacity of filter element, mg)}}{(10\text{mg/L}) * (\text{test flow rate, L/min})} \quad (\text{Eq. 1})$$

NOTE—A second element may be tested for capacity analysis if the value of the apparent capacity of the test element is not supplied by the filter manufacturer.

- 9.2.2 Calculate the minimum volume required for the operation of the injection system (V, liters) which is compatible with the above predicted test time (T') and a value for the injection flow (0.5 L/min) using the following equation:

$$V = 1.2 * (T', \text{ min}) * (\text{injection flow, L/min}) \quad (\text{Eq. 2})$$

NOTE—The volume calculated above will ensure a sufficient quantity of contaminant fluid to load the element plus 20% for adequate circulation throughout the test. Larger injection volumes may be used.

NOTE—The 0.5 L/min value of the injection flow ensures that the downstream sample flow expelled from the filter test system will not significantly influence the test results even at the lower flow rate given in Section 1. Lower injection flow rates may be used provided that the base upstream gravimetric level of 10 mg/L is maintained and that the contaminant injection system can be validated at the intended flow rate. Injection flow rates below 0.25 L/min are not recommended due to silting characteristics and accuracy limitations.

- 9.2.3 Calculate the gravimetric level (Y', mg/L) of the injection system fluid using the following equation:

$$Y' = \frac{(10 \text{ mg/L}) * (\text{test flow, L/min})}{(\text{injection flow, L/min})} \quad (\text{Eq. 3})$$

- 9.2.4 Calculate the quantity of contaminant (w, grams) needed for the contaminant injection system using the following equation:

$$W = \frac{(Y', \text{ mg/L}) * (\text{injection system volume, l})}{1000} \quad (\text{Eq. 4})$$

- 9.2.5 Adjust the injection flow rate at stabilized temperature to within $\pm 5\%$ of the value selected in Paragraph 9.2.2 and maintain throughout the test.
- 9.2.6 Adjust the total volume of the contaminant injection system to the value determined in Paragraph 9.2.2.
- 9.2.7 Circulate the fluid in the contaminant injection system through its system clean-up filter until a contamination level of less than 1,000 particles greater than 10 μ m/mL and a gravimetric level of less than 2% of the value determined in Paragraph 9.2.3 are attained.
- 9.2.8 Bypass the system clean-up filter after the required initial contamination has been achieved.
- 9.2.9 Add in slurry form the quantity of contaminant (grams) as determined in Paragraph 9.2.4 to the injection system reservoir.

- 9.2.10 Add 0.25 mL of Shell ASA-3 antistatic agent, or equivalent, per 10 L of test oil to the charged injection system and circulate the fluid to thoroughly disperse the contaminant. Add the antistatic agent each time the system is charged.

NOTE—All systems may not disperse contaminant at the same rate.

9.3 Filter Test System

- 9.3.1 Install the filter housing (without the test element) in the filter test system.
- 9.3.2 Circulate the fluid in the filter test system at the rated flow and a stabilized test temperature of 40 ± 2 °C and record the pressure drop of the empty filter housing.
- 9.3.3 Adjust the total fluid volume of the filter test system (exclusive of the system clean-up filter circuit) such that it is numerically equal to one-fourth of the value of the test volume flow per minute through the filter plus 4 liters.

NOTE—Repeatable results require that the system volume be held constant. The specified 1:4 volume to flow ratio plus 4 L minimizes the physical size of the system reservoir as well as the quantity of test fluid required and maximizes the mixing conditions in the reservoir. The additional 4 liters provides sufficient fluid volume to conduct tests with flows as low as 4 L/min.

- 9.3.4 Circulate the fluid in the filter test system through the clean-up filter until a contamination level of less than 15 particles greater than 10 $\mu\text{m/mL}$ is attained.

NOTE—The time required to achieve the contamination level is directly proportional to the particle separation capability of the clean-up filter used.

- 9.3.5 When using the bottle sampling method, select and install suitable lengths of capillary tubing restriction upstream and downstream of the test filter such that the initial upstream sample flow is 0.3 ± 0.05 L/min and the downstream sample flow is within 5% of the injection flow. Maintain uninterrupted flow from the two sampling points during the entire test.

When using on-line sampling and particle counting, also provide the bottle sampling capability just described. The on-line sample delivery lines consist of small bore tubing loops originating at the bottle sampling point, extending to the on-line dilution and particle counting system, with a return to the test system reservoir. Flow in the upstream and downstream sample line loops is to be maintained at 0.3 - 0.5 L/min. Silting in the sample lines is to be avoided by sizing the tubing bore to maintain line velocity (Figure 1).

- 9.3.6 Return the bottle upstream sampling flow of the test filter directly to the reservoir when sampling is not in progress.
- 9.3.7 Collect the downstream bottle sampling flow outside of the filter test system to assist in maintaining a constant system volume which should be kept within 2% of the required system volume.

10. Filter Performance Test

- 10.1 Install the filter element in its housing and subject the assembly to the specified test conditions (test flow with test temperatures of 40 ± 2 °C) and recheck the fluid level. Add 0.25 mL of Shell ASA-3 antistatic agent or equivalent per 10 L of test oil to the reservoir at the start of each test.

- 10.2 Measure and record the clean assembly pressure drop. Calculate and record the clean element pressure drop (clean assembly pressure drop minus the housing pressure drop measured in Paragraph 9.3.2).

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- 10.3** Calculate the pressure drop corresponding to an increase of 80% and 100% of the net pressure drop (terminal pressure drop minus the clean element pressure drop).
- 10.4** Obtain a sample upstream of the test filter element (9.3.6) to determine the system initial contamination level.
- NOTE—Take all samples in such a manner as to minimize the aeration of the fluid sample.
- 10.5** Obtain a fluid sample from the contaminant injection system.
- 10.6** Measure and record the injection flow rate.
- 10.7** Initiate the filter test as follows:
- 10.7.1 Bypass the system clean-up filter.
- 10.7.2 Allow the injection flow to enter the filter test system reservoir.
- 10.7.3 Start the timer.
- 10.7.4 Start the downstream sample flow.
- 10.8** Record the test time (minutes) required for the pressure drop across the filter assembly to increase by 80% and 100% of the net pressure drop.
- 10.9** Extract upstream and downstream samples simultaneously when using bottle sampling at 10 min from test initiation and at 10-min intervals to terminal pressure drop. Extract an upstream sample for gravimetric analysis when the pressure drop across the filter assembly has increased by 80% of the net pressure drop.
- NOTE—The time of the upstream and downstream sample of each pair should not differ by more than 30 s when using sample bottles.
- 10.10** Divert into the on-line dilution and particle counting system fluid from the upstream and downstream sampling lines when using on-line sampling. Simultaneously, collect the flow from the downstream bottle sampling point outside the filter test system to assist in maintaining a constant system volume which should be kept within 2% of the required system volume.
- 10.11** Conclude the test by stopping the flow to the test filter.
- 10.12** Obtain a final fluid sample from the contaminant injection system.
- 10.13** Measure and record the final injection flow rate.
- 11. Data Accuracy**—Select and maintain instrumentation so that data accuracy is within the limits of Table 2, unless otherwise specified.

TABLE 2—DATA ACCURACY

Quantity	Unit	Accuracy Within True Value
Injection Flow Rate	L/min	±5%
Base Upstream	mg/L	±1 mg/L
Gravimetric Level		

12. Calculations

12.1 Analyze the 10-min interval and final bottle samples extracted from the filter test system by determining the number of particles greater than 10, 15, 20, 25, 30, and 40 μ m with an automatic particle counter calibrated per ISO 4402 or any ISO approved counting method.

NOTE—Care should be taken to dilute samples appropriately to avoid exceeding the saturation limit determined by the approved calibration procedure for the particular counting method used.

NOTE—When on-line sampling and particle counting is used, adjust the dilution at the start of the test to the anticipated maximum dilution required during the test to avoid particle counter saturation. Sample flow rates of approximately 25 mL per min into the dilution system are recommended. Obtain upstream and downstream cumulative particle counts at the six sizes indicated at 10-min sample intervals. Record the on-line count at the 10-min intervals as the cumulative count for the sample interval in minutes divided by the milliliters of fluid passed through the particle counter sensor in the same sample interval and multiplied by the dilution factor.

12.2 Accept the test only if the number of particles greater than 10 μ m/mL in the initial bottle sample from the filter test system is less than 15. For on-line sampling, start the test when the particle count per mL is less than eight after correcting for dilution.

12.3 Conduct a gravimetric analysis on the two samples extracted from the contaminant injection system and on the upstream sample extracted from the filter test system at the 80% sample point.

NOTE—The final sample for gravimetric analysis is taken at the 80% point because it often overlaps the 100% point.

12.3.1 Record the 80% gravimetric value as the final system gravimetric level.

12.3.2 Calculate the average (\bar{Y}) of the gravimetric levels for two samples from the contaminant injection system.

12.3.3 Accept the test only if the gravimetric level of each sample is within $\pm 10\%$ of this average.

12.4 Calculate and record the injection flow rate by averaging the measurements taken at the beginning and end of the test.

12.4.1 Accept the test only if this value is equal to the selected value $\pm 5\%$.

12.5 Calculate and record the actual base upstream gravimetric level by multiplying the average injection gravimetric level (\bar{Y} , mg/L) by the average injection flow rate (L/min) per Paragraph 12.3 and dividing by the test flow rate (L/min).

12.5.1 Accept the test only if this value is equal to 10 ± 1 mg/L or as covered under the scope and field of application.

12.6 Calculate the filtration ratio and filtering efficiency as shown in Section 16.

12.6.1 Record these calculated ratios as shown in Figures 3A and 3B.

12.6.2 Record these calculated efficiencies as shown in Figures 3A and 3B.

12.6.3 Plot the average filtration ratios from Figure 3A on Figure 4.

13. Data Presentation

13.1 Record the following minimum information for filter elements evaluated using this method:

13.1.1 Present all test data and calculation results as shown in Figure 3.

13.2 Using the actual test time (T) required to reach the terminal pressure drop, the average gravimetric level (Y) of the injection stream and the average injection flow rate, calculate the filter element test dust capacity (a) using the following equation:

$$a, \text{ grams} = \frac{(Y, \text{ mg/L}) * (\text{injection flow, L/min}) * (T, \text{ min})}{1000} \quad (\text{Eq. 5})$$

13.2.1 Record the test dust capacity as shown in Figure 3.

13.3 Report the values of the gravimetric levels obtained in Paragraph 12.3.

13.4 Have available a record of the following minimum test data in test reports referencing this method:

All physical values pertaining to the test
 All additional provisions or modifications pertaining to the test
 Record the particle counting method used

14. Criteria for Acceptance

14.1 Compare the average filtration ratio and filtration efficiency with the designated values.

14.2 Compare the filter element test dust capacity (a) with the designated value.

14.3 Check that there is no visual evidence of filter element damage as a result of performing this test.

15. Summary Of Designated Information—The following designated information is needed when applying this standard to a particular application or use:

Fabrication integrity test pressure per ISO 2942
 Filter element test flow rate
 Terminal pressure drop
 The acceptable average filtration ratio and average efficiency
 The minimum acceptable filter element capacity (a)

16. Calculations

16.1 Filtering efficiency percent =

$$\frac{\text{Upstream count } (\mu\text{m}) - \text{Downstream count } (\mu\text{m})}{\text{Upstream count } (\mu\text{m})} * 100$$

16.2 Filtration ratio =

$$\frac{\text{Upstream count } (\mu\text{m})}{\text{Downstream count } (\mu\text{m})}$$

NOTE—The μm symbol designates particle counts taken at one of the six specified particle sizes (Paragraph 12.1).

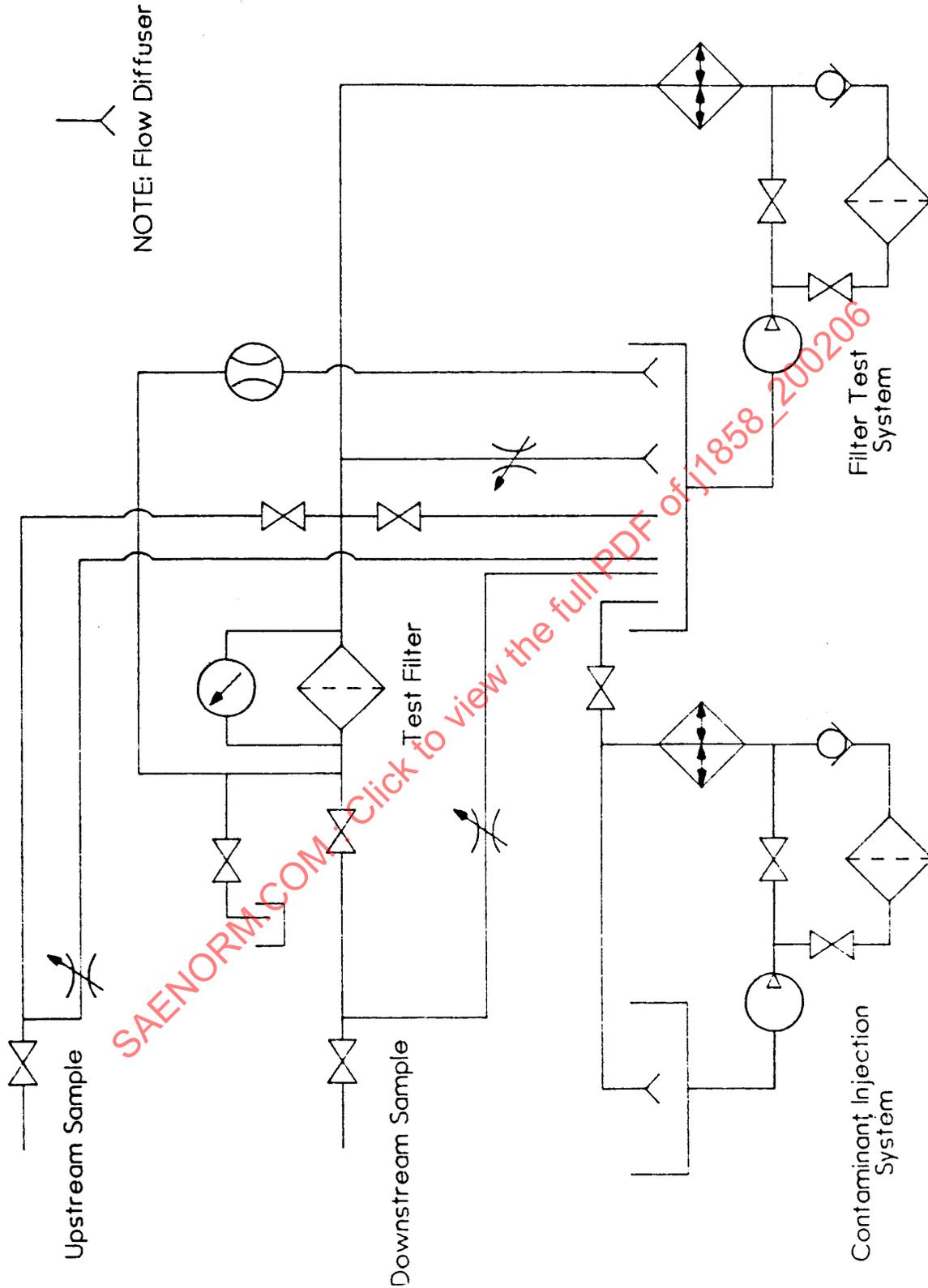


FIGURE 1—TYPICAL FILTER PERFORMANCE TEST CIRCUIT WITH PROVISION FOR ON-LINE SAMPLING

PRICE LIST - PP7B

SAE 5-80 MICROMETER TEST DUST

Container	Approx. Net. Wt. Per Jar	Cost Per Jar
1 Gallon Jar	8 pounds	\$45.92 (\$5.74/Lb.)

- * Price is in U.S. Dollars/Pound.
- * Each shipment will include Particle Size Distribution as analyzed with a Coulter Counter.
- * f.o.b. - shipping point.
- * Price is subject to change without notice.
- * All orders less than \$200 are subject to a \$15.00 handling charge.

SPECIFIED PARTICLE SIZE DISTRIBUTION

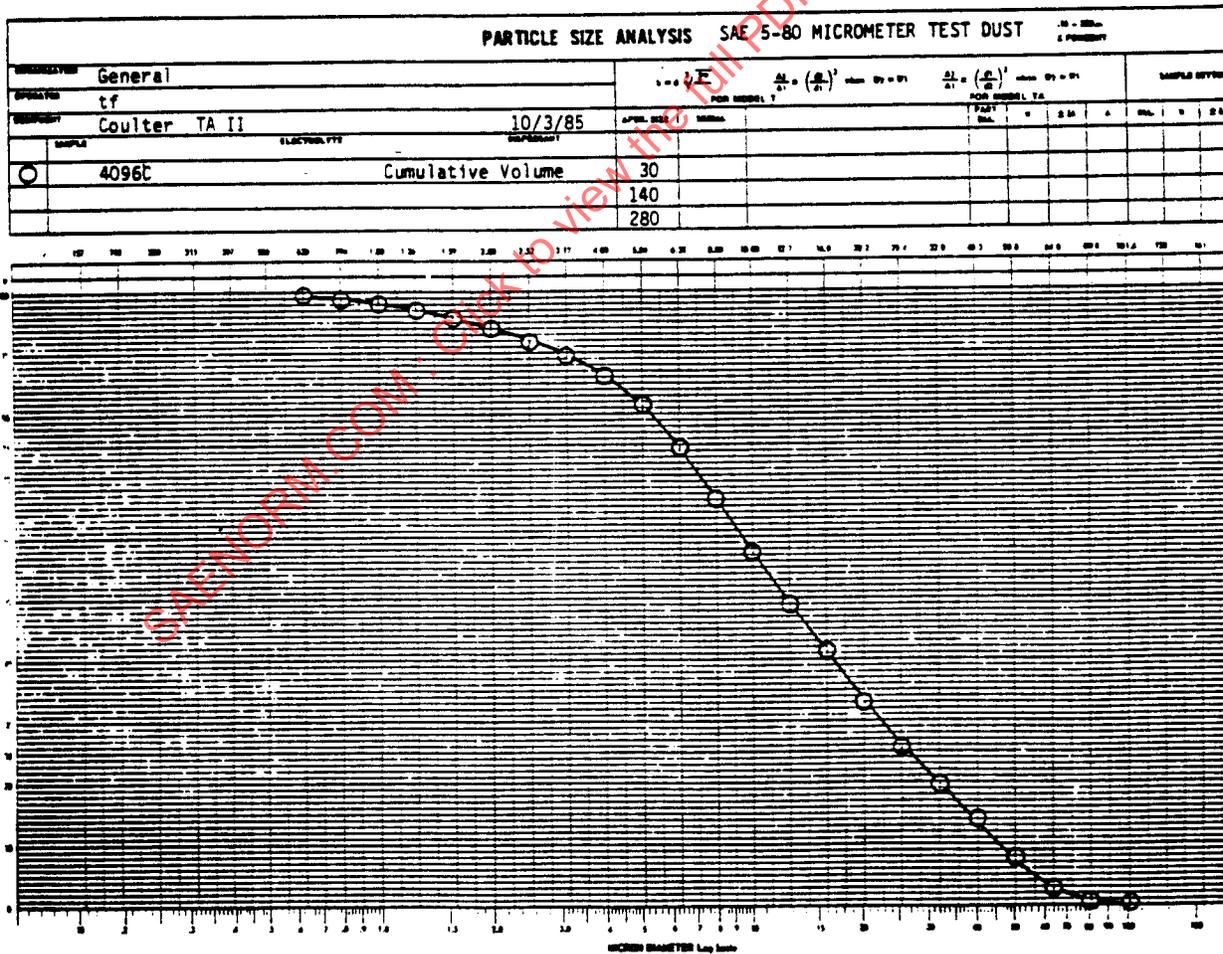


FIGURE 2—