SAE International	SURFACE VEHICLE STANDARD	J1985	REV. AUG2006
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(R) Fuel Filter—Initial Single-Pass Efficiency Test Method

RATIONALE

The rationale for revising J1985 is twofold. First it was up for the standard five year review. The second reason is to take advantage of advances in technology and other updated documents. The technology of on-line optical particle counting has been substantiated in ISO 11943: 1999. Advances in technology of characterizing the performance and calibration of optical particle counters has been addressed with the new ISO 11171: 1999. Lastly two documents which define materials used for testing: ISO 12103-1 Test Dusts and SAE J1696 Standard Fuel Filter Test Fluid.

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1. SCOPE

This SAE Standard is intended for all sizes of fuel filters, so a variety of test stands may be required depending upon flow rate. The low contamination level, downstream clean-up filter, and short duration of the test, ensures that the particle retention ability of the filter is measured in a single pass as no appreciable loading or regression will occur.

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1.1 Purpose

The purpose of this test code is to provide a method to determine the ability of a fuel filter to retain a given size of particle in a single pass.

2. REFERENCES

2.1 Applicable Publications

The following publications form a part of this specification to the extent specified herein. The latest issue of these publications shall apply.

2.1.1 SAE Publication

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or 724-776-4970 (outside USA), www.sae.org.

SAE J1696 Standard Fuel Filter Test Fluid

2.1.2 ASTM Publication

Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D 4308 Test method for Electrical Conductivity of Liquid Hydrocarbons by Precision Meter

2.1.3 ISO Publications

Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 2942 Hydraulic fluid power—Filter elements verification of fabrication integrity and determination of the first bubble point

ISO 3722 Hydraulic fluid powder—Filter elements fluid sample containers—Qualifying and controlling cleaning methods

ISO 3968 Hydraulic fluid power—Filters evaluation of differential pressure versus flow characteristics

ISO 4405 Hydraulic fluid power—Fluid contamination—Determination of particulate contamination by the gravimetric method

ISO 4021 Hydraulic fluid power—Particulate contaminant analysis—Extraction of fluid samples from lines of an operating system

ISO 11171 Hydraulic fluid power—Calibration of automatic particle counters for liquids

ISO 11943 Hydraulic fluid power—On-line automatic particle counting systems for liquids—Methods of calibration and validation

ISO 12103-1 Road Vehicles—Test dust for filter evaluation—Part 1: Arizona test dust

3. TEST MATERIAL AND EQUIPMENT

3.1 Test Fluid

Use test fluid conforming to SAE J1696 @ 40 °C ± 5 °C.

3.2 Test Contaminant

Use ISO 12103-1, A2 Fine test dust.

3.3 Filter Performance Test Circuit

Use a filter performance test circuit comprised of a “filter test system” and a contaminant “injection system” as shown in Figure 1.

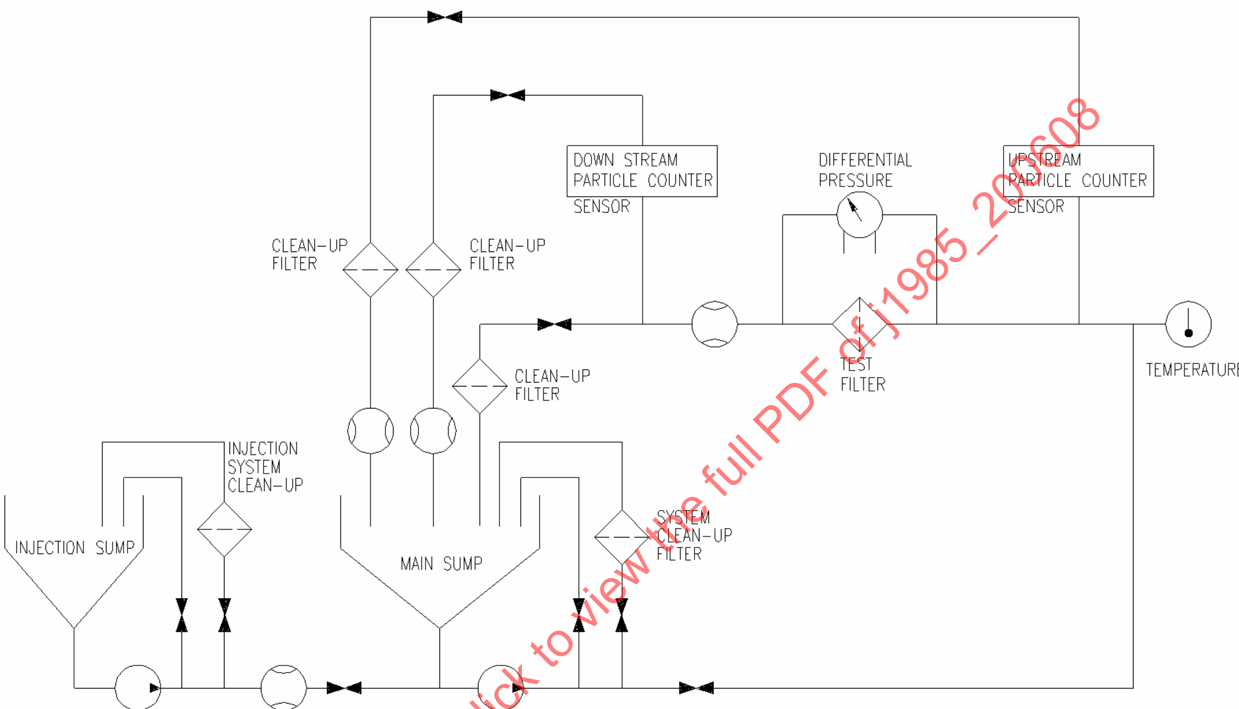

FIGURE 1 - FILTER PERFORMANCE TEST CIRCUIT

3.4 Filter Test System

3.4.1 Reservoir

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

NOTE: This reservoir design avoids a horizontal bottom and minimizes contaminant settling while the subsurface diffusion reduces the entering of air and gives good mixing capabilities.

3.4.2 Pump

The pump(s) should be insensitive to the contaminant.

WARNING: Pumps exhibiting excessive flow pulses causes erroneous results.

3.4.3 System Clean-up Filters

The system clean-up filters necessary to obtain initial system cleanliness level of less than 15 particle/mL ≥ 5 μm(c) or smallest size of interest if less than 5 μm

3.4.4 Instrumentation

Pressure gauges, temperature indicator and flow meters in locations as shown in Figure 1.

3.4.5 Pressure Taps

Pressure taps in accordance with ISO 3968.

3.4.6 Sampling

Upstream and downstream sampling means in accordance with ISO 4021.

3.4.7 Interconnecting lines

Interconnecting lines which ensure turbulent mixing conditions exist throughout the filter test system and avoids silting areas and contaminant traps.

3.4.8 Particle Counter

Use automatic particle counter calibrated per ISO 11171.

3.4.9 Bottle Counting

If bottle counting, use clean bottles counting less than 5 particles/mL ≥ 5 μm(c) as qualified per ISO 3722.

NOTE: If particle sizes less than 5 μm(c) are to be counted, bottle cleanliness should be less than 5 particles/mL.

3.4.10 On-Line Counting System

The on-line counting system shall be in accordance with ISO 11943

3.5 Contaminant Injection System

3.5.1 Reservoir

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

NOTE: This reservoir design avoids a horizontal bottom and minimizes contaminant settling while the subsurface diffusion reduces the entering of air and gives good mixing capabilities.

3.5.2 Pump

Use a hydraulic pump (centrifugal or other type) which does not alter the contaminant particle size distribution.

3.5.3 System Clean-up Filters

A system clean-up filter capable of providing an initial system contamination level less than 15 particles/mL ≥ 5 μm(c) and a gravimetric level less than 2% of the calculated level at which the test is being conducted.

3.5.4 Instrumentation

Flow meter in location as shown in Figure 1.

3.5.5 Pressure taps

Pressure taps shall be in accordance with ISO 3968.

3.5.6 Sampling

A sampling means for the extraction of a small flow (injection flow) from a point in the contaminant injection system where active circulation of fluid exists. Sample per ISO 4021.

3.5.7 Interconnecting lines

Interconnecting lines which ensure turbulent mixing conditions exist throughout the filter test system and avoids silting areas and contaminant traps.

NOTE: Alternate contaminant injection system may be used provided that injection system meets validation requirements.

4. TEST CONDITION ACCURACY

Set up and maintain equipment accuracy within limits given in Table 1.

TABLE 1 - EQUIPMENT ACCURACY LIMITS

Test Conditions	Unit	Maintain Within ± of True Value
Flow	L/min.	2%
Pressure	kPa	2%
Temperature	°C	5 °C
Volume	L	2%

5. VALIDATION OF TEST CIRCUIT

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

5.1 Validate at the minimum flow that the filter test system will be operated.

NOTE: Use straight pipe in place of filter during the validation.

5.2 Adjust the total test system volume to be above the diffuser so that turbulence will not add air to the fluid.

5.3 Start main system flow and circulate to clean fluid to the appropriate cleanliness level (see 3.5.3).

5.4 Contaminate the test system fluid to the calculated gravimetric level of 5 mg/L using ISO 12103-1, A2 Fine Test Dust.

5.5 Circulate the fluid in the test system for 1 hour and extract the fluid samples at 15, 30, 45, and 60 minutes.

5.6 Analyze fluid samples at 5 µm(c), 10 µm(c), 15 µm(c), 20 µm(c), or more if desired. A minimum of three samples per period should be taken when bottle counting.

5.7 Accept the validation only if:

5.7.1 Particle counts obtained for a given size from each bottle or on-line count does not deviate by more than 10% from the average particle counts for that size or larger.

5.7.2 The average for all particle counts per mL at ≥ 5 µm(c) is less than 6000 nor more than 7300.

5.7.3 The average for all particle counts per mL at ≥ 20 µm(c) is not less than 77 nor more than 105.

6. VALIDATION OF CONTAMINANT INJECTION SYSTEM

6.1 Validate at the maximum gravimetric level and the maximum injection circuit volume to be used.

6.2 Add the required quantity of contaminant in slurry form to the injection fluid and circulate for 2 hours.

6.3 Extract fluid samples from the by-pass loop at 30, 60, 90, and 120 minutes and analyze each sample gravimetrically per ISO 4405.

6.4 Accept the validation test only if the gravimetric level of each sample is within ±10% of the average of the four samples and ±10% of the known gravimetric value.

7. PRELIMINARY PREPARATION

7.1 Test Filter Assembly

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

7.1.2 Subject the test filter to a fabrication integrity test in accordance with ISO 2942 using SAE J1696 fluid prior to the single-pass test or following the test if the element is not readily accessible as in a spin-on configuration.

7.1.3 Disqualify the element from further testing if it fails to meet the designated fabrication integrity value.

8. CONTAMINANT INJECTION SYSTEM

8.1 To calculate the minimum volume required for operation of the contaminant injection system (V, liters) which is compatible with a value for the injection flow (0.5 L/min), use Equation 1:

$$V = 1.2 * 60\ (\text{min}) * \text{injection flow}\ (\text{L/min}) \quad \text{(Eq. 1)}$$

NOTE: The volume calculated in Equation 1 will ensure a sufficient quantity of contaminated fluid for the test.

NOTE: Lower injection rates may be used provided that the base upstream gravimetric level of the test system of 5 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.

8.2 Calculate the gravimetric level (Y', mg/L) of the injection system fluid using Equation 2:

$$Y' = \frac{5\ (\text{mg/L}) * \text{test flow}\ (\text{L/min})}{\text{injection flow}\ (\text{L/min})} \quad \text{(Eq. 2)}$$

8.3 Calculate the quantity of contaminant (W, grams) needed for the contaminant injection system using Equation 3:

$$W = \frac{Y'\ (\text{mg/L}) * \text{injection system vol}\ (\text{L})}{1000} \quad \text{(Eq. 3)}$$

8.4 Adjust the injection flow rate at stabilized temperature (40 °C) to within ±5% of the value selected in 8.1and maintain throughout the test.

8.5 Adjust the total volume of the contaminant injection system to the value determined in 8.1.

8.6 Circulate the fluid in the contaminant injection system through its system clean-up filter until a level of less than 15 particles/mL ≥ 5 µm(c).

8.7 Bypass the system clean-up filter after the required initial cleanliness has been achieved.

8.8 Add in slurry form the quantity of contaminant (grams) as determined in 8.3 to the injection system reservoir.

8.9 Measure the fluid conductivity at 40 °C per ASTM D 4308. If the conductivity is below 1000 pS/m, add DuPont Stadis 450 anti-static additive to produce a conductivity level of 1500 pS/m ± 500 pS/m. Circulate the fluid at a minimum of 15 minutes to thoroughly disperse the contaminant and anti-static.

9. FILTER TEST SYSTEM

9.1 Install the filter housing (without the test element) in the filter test system.

9.2 Adjust the total fluid volume of the test system (exclusive of the system clean-up filter) to a level where no air entrapment can occur and can accommodate the injection fluid during the test.

9.3 Circulate the fluid in the filter test system at the rated flow and a stabilized temperature of 40 °C ± 5 °C and record the pressure drop of the empty filter housing.

9.4 Circulate the fluid in the filter test system through the clean-up filter until the contaminant level of less than 15 particles/mL ≥ 5 µm(c) is achieved.

9.5 When bottle counting or on-line counting, make sure upstream and downstream sampling lines have continuous flow throughout the test. Silting in the sampling lines is to be avoided by sizing the tubing bore to maintain the right line velocity.

NOTE: All fluid flow not being sampled should be returned to the main sump and dispersed below the test fluid level.

10. SINGLE-PASS FILTER EFFICIENCY TEST

10.1 Install the filter element in its appropriate place. Horizontal or vertical (specify), and subject the assembly to the specified test conditions (test flow with test temperature of 40 °C ± 5 °C). Prior to conducting a test, measure the fluid conductivity at 40 °C per ASTM D 4308. If the conductivity is below 1000 pS/m, add DuPont Stadis 450 anti-static additive to produce a conductivity level of 1500 pS/m ± 500 pS/m.

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 or the spin-on without the element pressure drop).

10.3 Obtain a sample upstream of the test filter element to determine the system initial contamination level.

10.4 Select the injection flow rate and allow it to stabilize.

10.5 Obtain a fluid sample from the contaminant injection system.

10.6 Measure and record the injection flow rate

10.7 Record the initial injection system volume.

10.8 Initiate the filter test as follows:

10.8.1 By-pass the system clean-up filter.

10.8.2 Ensure that the downstream clean-up filter is in the flow circuit.

10.8.3 Allow the injection flow to enter the filter test system at the suction side of the pump as shown in Figure 1.

NOTE: Older versions of this document allow contaminant injection into the sump. It has been shown that injection of the contaminant into the pump provides better particle count stability. This stability provides better consistency in the test results.

10.8.4 Start the timer.

10.8.5 Start the upstream and downstream sample flow.

10.8.6 Allow 1 to 2 minutes of injection before taking the first sample.

10.9 Extract upstream and downstream samples simultaneously when using bottle sampling. Sample at 2, 5, 10, and every 10 minutes thereafter until 60 minutes after initiation of the test.

10.10 Divert the upstream and downstream sampling flow into the on-line particle counting system when using on-line sampling. The sampling flow should be per recommended sensor flow. A minimum of 20 seconds of sampling should be obtained for each count.

10.11 Conclude the test after 60 minutes by stopping the injection flow and the element flow.

10.12 Obtain a final fluid sample from the injection system.

10.13 Measure and record the final injection flow rate.

10.14 Record the final injection system volume.

11. DATA ACCURACY

11.1 Select and maintain instrumentation so that data accuracy is within the limits of Table 2, unless otherwise specified.

TABLE 2 - DATA ACCURACY LIMITS

Quantity	Unit	Accuracy within True Value
Injection Flow Rate	L/min	±5%
Base Upstream Gravimetric Level	mg/L	±0.5mg/L

12. DATA ANALYSIS

12.1 Analyze the bottle samples extracted from the filter test system by determining the number of particles ≥ 5, 7, 10, 12, and 20 µm(c) or less as specified with a particle counter calibrated per ISO 11171.

NOTE: In most cases, dilution is not necessary because the 5 mg/L upstream gravimetric level is below the saturation level of most automatic particle counters.

12.2 Conduct a gravimetric analysis on the two samples extracted from the contaminant injection system.

12.3 Calculate the average (Y') of the gravimetric levels for the two samples (initial and final) from the contaminant injection system.

12.3.1 Accept the test only if the gravimetric level of each sample is within ±10% of the calculated level.

12.4 Calculate and record the injection flow rate by averaging the measurement 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 ±5%.

12.5 Calculate and record the actual base upstream gravimetric level by multiplying the average injection gravimetric level (Y, mg/L) by the average injection flow rate (L/min) per 12.4 and dividing by the test flow (L/min).

12.5.1 Accept the test only if this value is equal to 5 mg/L ± 0.5 mg/L.