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INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

# SURFACE VEHICLE STANDARD

SAE J1985

ISSUED OCT93

Issued 1993-10

Submitted for recognition as an American National Standard

## FUEL FILTERS—INITIAL SINGLE-PASS EFFICIENCY TEST METHOD

***Foreword***—This Document has not changed other than to put it into the new SAE Technical Standards Board format.

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.

***1. Scope and Field of Application***—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.

***2. References***

**2.1 Applicable Publications**—The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply.

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

SAE J905—Fuel Filter Test Method

2.1.2 ASTM PUBLICATION—Available from ASTM, 1916 Race Street, Philadelphia, PA 19103-1187.

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

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

ISO 2942—Hydraulic fluid power—Filter elements—Determination of fabrication integrity
ISO 3722—Hydraulic fluid power—Filter elements—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 4402-1977Hydraulic fluid power—Calibration of liquid automatic particle count instruments—Method using SAE fine test dust





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## *3. Test Equipment*

**3.1** Use test fluid conforming to SAE J905 L4264V at 40 °C ± 5 °C.

**3.2** Use Fine Test Dust or equivalent.

**3.3** Use automatic particle counter calibrated per ISO 4402-1977 or other approved calibration method.

**3.4** If bottle counting, use clean bottles containing less than 1.5 particles >5 μm/mL of bottle volume as qualified per ISO 3722.

NOTE—If particle sizes less than 5 μm are to be counted, bottle cleanliness should be less than 1.5 particles > x μm/mL of bottle volume.

**3.5** Use a filter performance test circuit comprised of a "filter test system" and a "contaminant injection system" as shown in Figure 1.

**3.6** The filter test system consists of:

3.6.1 A reservoir constructed with a conical bottom having an included angle of not more than 90 degrees and where the fluid entering 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.

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

WARNING—Pumps exhibiting excessive flow pulses cause erroneous results.

3.6.3 System clean-up filters necessary to obtain initial system cleanliness level of less than 15 particles >5 μm/mL or smallest size of interest if less than 5 μm.

3.6.4 Pressure gages, temperature indicator, and controller and flow meters.

3.6.5 Pressure taps in accordance with ISO 3968.

3.6.6 Upstream and downstream sampling means in accordance with ISO 4021.

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

## *4. Contaminant Injection System*

**4.1** A reservoir, see 3.6.1.

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

**4.3** A hydraulic pump (centrifugal or other type which does not alter the contaminant particle size distribution).

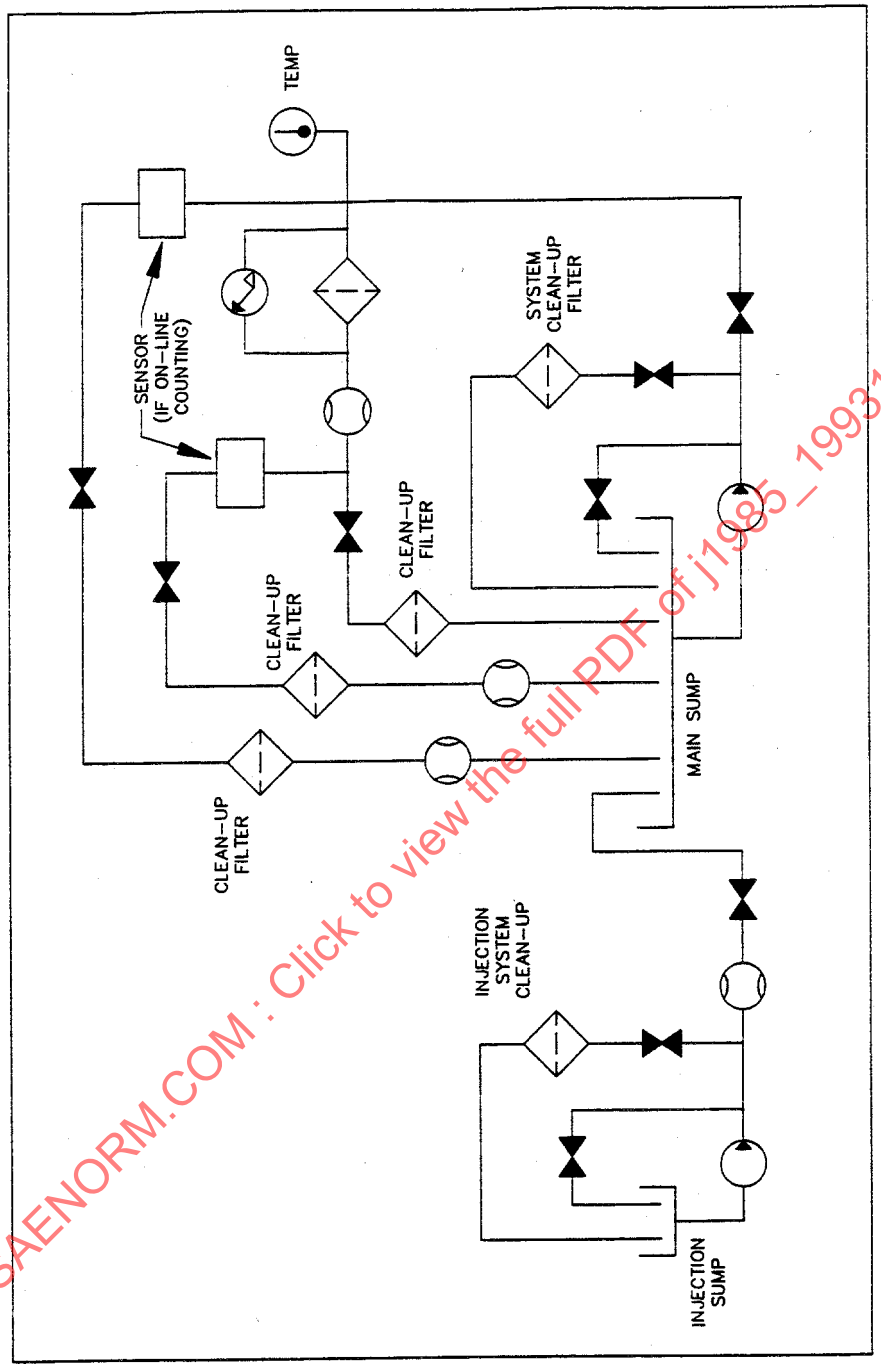




FIGURE 1—FILTER PERFORMANCE TEST CIRCUIT

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

**4.5** Interconnecting lines which ensure that turbulent mixing conditions exist throughout the injection system and avoid silting areas and contaminant traps.

NOTE— Alternate contaminant injection system may be used provided that injection system meets validation requirement.

## *5. Test Condition Accuracy*

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

**TABLE 1—EQUIPMENT ACCURACY LIMITS**

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

## *6. 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.

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

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

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

**6.3** Start main system flow and circulate to clean fluid to the appropriate cleanliness level (see 3.6.3).

**6.4** Contaminate the test system fluid to the calculated gravimetric level of 5 mg/L using Fine Test Dust.

**6.5** Circulate the fluid in the test system for 1 h and extract the fluid samples at 15, 30, 45, and 60 min.

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

**6.7** Accept the validation only if:

6.7.1 The average for all 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.

6.7.2 The average for all particle counts per mL at >5 µm is not less than 3300 nor more than 3700.

6.7.3 The average for all particle counts per mL at >20 µm is not less than 100 nor more than 140.

## *7. Validation of Contaminant Injection System*

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

**7.2** Add the required quantity of contaminant in slurry form to the injection system fluid and circulate for 2 h.

**7.3** Extract fluid samples from the by-pass loop at 30, 60, 90, and 120 min and analyze each sample gravimetrically.

**7.4** 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.

## *8. Preliminary Preparation*

### 8.1 Test Filter Assembly

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

8.1.2 Subject the test filter to a fabrication integrity test in accordance with ISO 2942 using L4264V fluid prior to the single-pass test or following the test if the element is not readily accessible as in a spin-on configuration.

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

## *9. Contamination Injection System*

**9.1** 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:

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

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

NOTE— Lower injection flow 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.

**9.2** Calculate the gravimetric level (Y′, mg/L) of the injection system fluid using Equation 2:

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

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

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

**9.4** Adjust the injection flow rate at stabilized temperature (40 °C) to within ±5% of the value selected in 9.1 and maintain throughout the test.

**9.5** Adjust the total volume of the contaminant injection system to the value determined in 9.1.

**9.6** Circulate the fluid in the contaminant injection system through its system clean-up filter until a contaminant level of less than 15 particles >5 µm/mL and a gravimetric level of <2% of the value determined in 9.2 are attained.

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

**9.8** Add in slurry form the quantity of contaminant (grams) as determined in 9.3 to the injection system reservoir.

**9.9** Measure the fluid conductivity at 40 °C per ASTM D 4308-89. If the conductivity is below 500 pS/m, add DuPont Stadis 450 anti-static additive to produce a conductivity between 500 and 1000 pS/m. Circulate the fluid at a minimum of 15 min to thoroughly disperse the contaminant and anti-static.

## *10. Filter Test System*

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

**10.2** Adjust the total fluid volume of the filter 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.

**10.3** 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.

**10.4** Circulate the fluid in the filter test system through the clean-up filter until the contaminant level of <15 particles >5 µm/mL is achieved.

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

**10.5** When bottle counting or on-line counting make sure upstream and downstream sampline 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.

## *11. Single-Pass Filter Efficiency Test*

**11.1** 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 4308-89. If the conductivity is below 500 pS/m, add DuPont Stadis 450 anti-static additive to produce a conductivity between 500 and 1000 pS/m.

**11.2** 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).

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

**11.4** Choose and let stabilize the injection flow.

**11.5** Obtain a fluid sample from the contaminant injection system.

**11.6** Record the initial injection system volume.

**11.7** Initiate the filter test as follows:

11.7.1 By-pass the system clean-up filter.

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

11.7.3 Allow the injection flow to enter the filter test system at the suction side of the pump Figure 1.

11.7.4 Start the timer.

11.7.5 Start the upstream and downstream sample flow.

11.7.6 Allow 1 to 2 min of injection before taking the first sample.

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

**11.9** 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 s of sampling should be obtained for each count.

**11.10** Conclude the test after 60 min by stopping the injection flow and the element flow.

**11.11** Obtain a final fluid sample from the injection system.

**11.12** Record the final injection system volume.

## *12. Data Accuracy*

**12.1** 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 | ±0.5 mg/L |

## *13. Calculations*

**13.1** Analyze the bottle samples extracted from the filter test system by determining the number of particles >5, 7, 10, 12, and 20 µm or as specified with a particle counter calibrated per ISO 4402 or any other approved method.

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.

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

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

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

**13.4** Calculate and record the injection flow by averaging the measurement taken at the beginning and end of test.

13.4.1 Accept the test only if this value is equal to the selected value ±5%.

**13.5** 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 13.4 and dividing by the test flow (L/min).

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

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

13.6.1 Record these calculated ratios and efficiencies as shown in Figure 2.

## *14. Data Presentation*

**14.1** Record the following information as a minimum for filter elements evaluated using this method.

14.1.1 Present all test data and calculation results as shown in Figure 2.

14.1.2 Report the values of the gravimetric levels obtained in 13.3.

## *15. Criteria for Acceptance*

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

**15.2** Filter restriction did not exceed a predetermined maximum value at any time during the 60 min test.