Fuel Filter Test Methods

RATIONALE

Parts of this document have been revised to address changes to fuel systems and fuel chemistries that have taken place in the industry since the previous revision in 1999.

1. SCOPE

The purpose of this fuel filter test method is to provide standardized methods for evaluating the performance characteristics of fuel filters by bench test methods. This, combined with data obtained from application tests, may be used to establish standards of performance for filters when tested by these standard methods. Many variations in requirements of filtration to protect fuel supply equipment on engines and variations in operating conditions make it difficult to specify meaningful "in-service" performance standards by which a filter may be judged. By the use of these standard test methods, test conditions are always the same, and comparisons of the laboratory performance of filters may be made with a high degree of confidence. Once the requirements of a particular application are known, performance standards for suitable filters may be established by these test methods, and adequacy of performance of filters for the job may be determined.

In order to achieve the highest degree of reliability of test results, the procedures and equipment must conform to those specified in this code. No minimum performance requirements for filters have been specified, since these are the responsibility of the user and manufacturer. Only the methods of determining, interpreting, and reporting performance characteristics are the proper province of this SAE Standard.

Separate chapters cover the test methods necessary to evaluate the several functional capabilities and mechanical properties of the filter. Each chapter is complete with recommended materials, apparatus, and procedures for testing and evaluation. The chapters are:

a. Chapter 1—Resistance to Flow (Section 3)

b. Chapter 2—Filter Capacity and Contaminant Removal Characteristics (Section 4)

c. Chapter 3—Media Migration Test (Section 5)

d. Chapter 4—Collapse Test (Section 6)

e. Chapter 5—Ability to Meet Environmental Conditions (Section 7)

f. Chapter 6—Installation and Removal (Section 8)

g. Chapter 7—Mechanical Tests (Section 9)

h. Chapter 8—Material Compatibility (Section 10)

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To simplify the chapters covering test methods, information of importance but not directly involved in test methods is covered in appendices as follows:

a. Methods for Sample Analysis (Appendix A)

1.1 Test Condition Accuracy

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

TABLE 1 - TEST CONDITION ACCURACY LIMITS

Test Condition	Units	Measurement Accuracy	Allowed Variability During Test
Flow	L/min	±2%	±5%
Pressure	Kilopascal	±5%	—
Temperature	°C	±1%	±2%
Volume	Liters	±5%	±10%

2. REFERENCES

2.1 Applicable Publications

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest version of SAE publications shall apply.

2.1.1 SAE Publications

Available from SAE International, 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 J200 Classification System for Rubber Materials

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

SAE J1260 Standard Oil Filter Test Oil

SAE J1696 Standard Fuel Filter Test Fluid

SAE HS-806 SAE Oil Filter Test Procedure, 2001 Edition

2.1.2 ISO Publications

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

ISO 1219-1 1991 Fluid power systems and components—Graphic symbols and circuit diagrams—Part 1: Graphic symbols

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

2.1.3 ANSI Publications

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

ANSI/Y32.10 Graphic Symbols

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this document.

2.2.1 SAE Publication

Available from SAE International, 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 J1985 Fuel Filter—Initial Single-Pass Efficiency Test Method

2.2.2 ISO Publications

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

ISO 2941 Hydraulic fluid power—Filter elements—Verification of collapse/burst resistance

ISO 2942 Hydraulic fluid power—Filter elements—Verification of fabrication integrity

ISO 3722 Hydraulic fluid power—Filter elements—Fluid sample containers—Qualifying and cleaning methods

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

ISO 19438 Diesel fuel and petrol filters for internal combustion engines—Filtration efficiency using particle counting and contaminant retention capacity

3. CHAPTER 1—RESISTANCE TO FLOW

3.1 Scope

The resistance to flow test determines the pressure loss, which will result when standard test fluid is passed through the filter under standard conditions of flow and fluid viscosity. This procedure may be used to establish flow capacities, and is the method for measuring resistance to flow of sample filters against an established performance standard.

3.2 Test Materials

3.2.1 Test Fluid

SAE J1696 Standard Fuel Filter Test Fluid.

3.3 Test Apparatus

3.3.1 Fuel filter flow test stand (or equivalent). A pump, flowmeter, thermometer, and manometers or differential pressure gauge are necessary as shown in Figure 1. It is usually convenient to use the fuel filter test stand as described in 4.4.1.

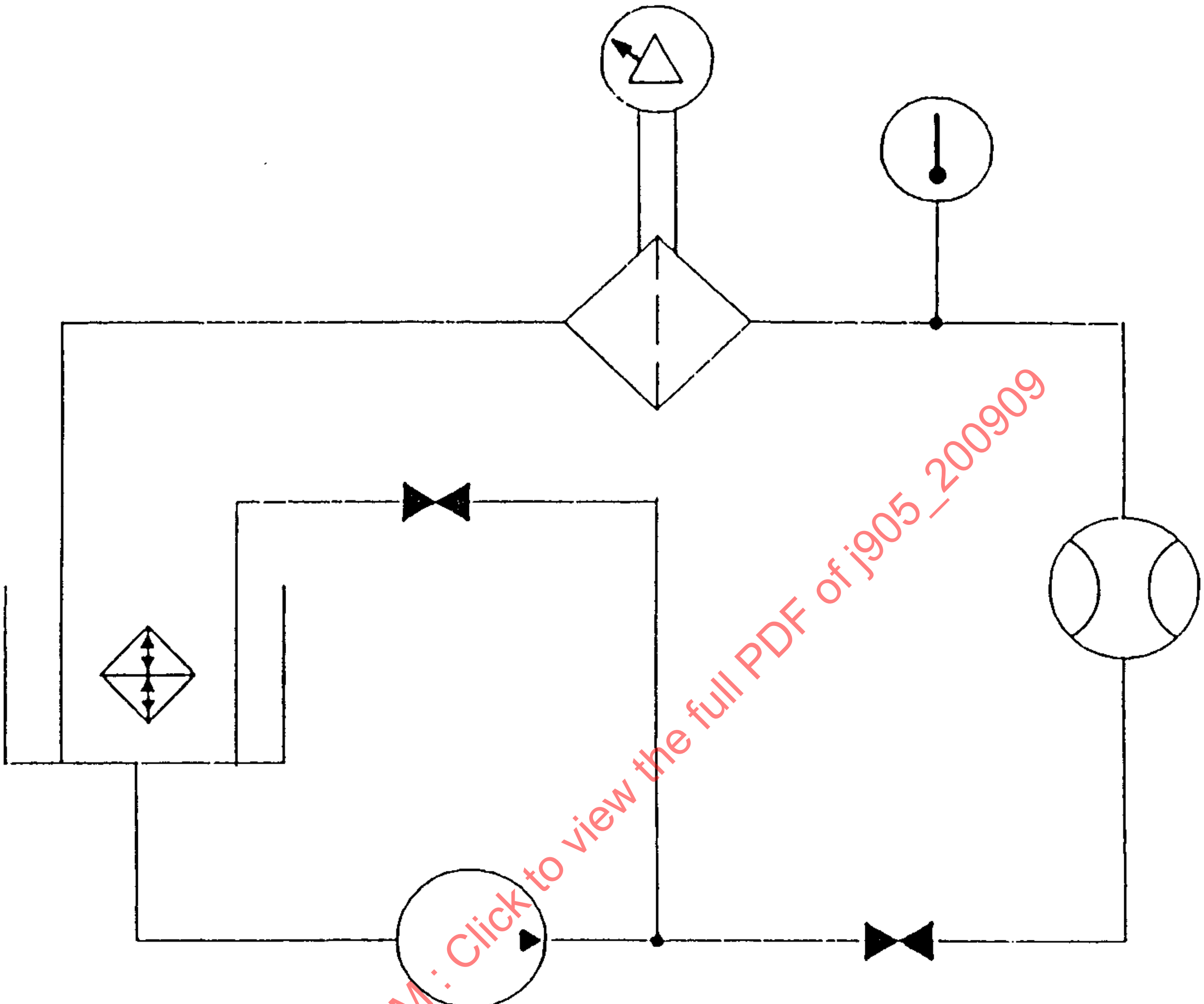


FIGURE 1 - FLOW TEST STAND

3.3.2 Filter housing or mounting plate with pressure taps located to give pressure loss across the filter element (or across the entire filter unit, in the case of "spin-on" and "in-line" filters). See Figures 2 and 3 for housing and mounting plate details.

3.3.3 If special housings are necessary or desirable, care must be exercised to locate inlet and outlet pressure taps to obtain true pressure values.

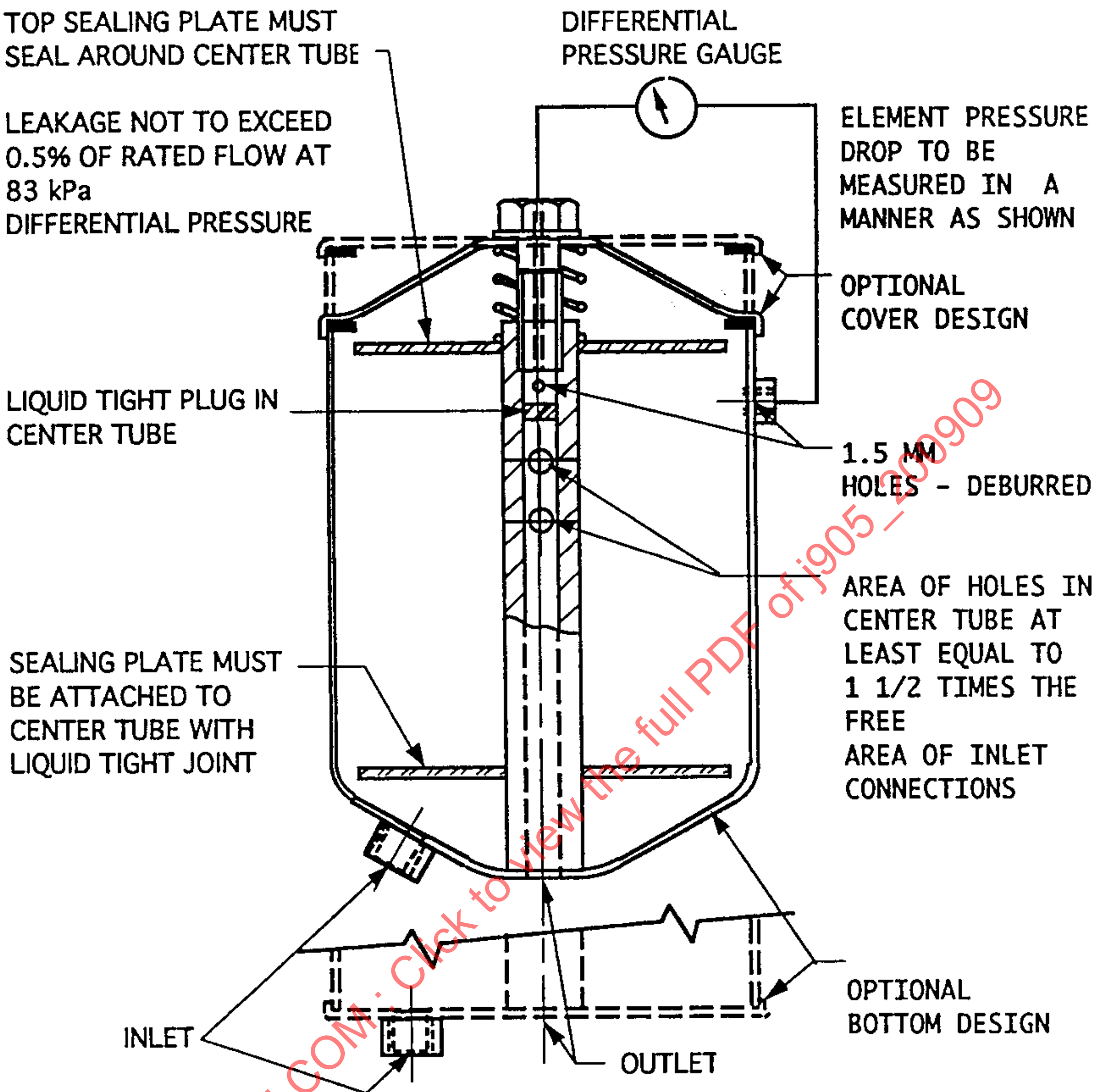


FIGURE 2 - TEST FILTER HOUSING FOR FULL-FLOW ELEMENTS

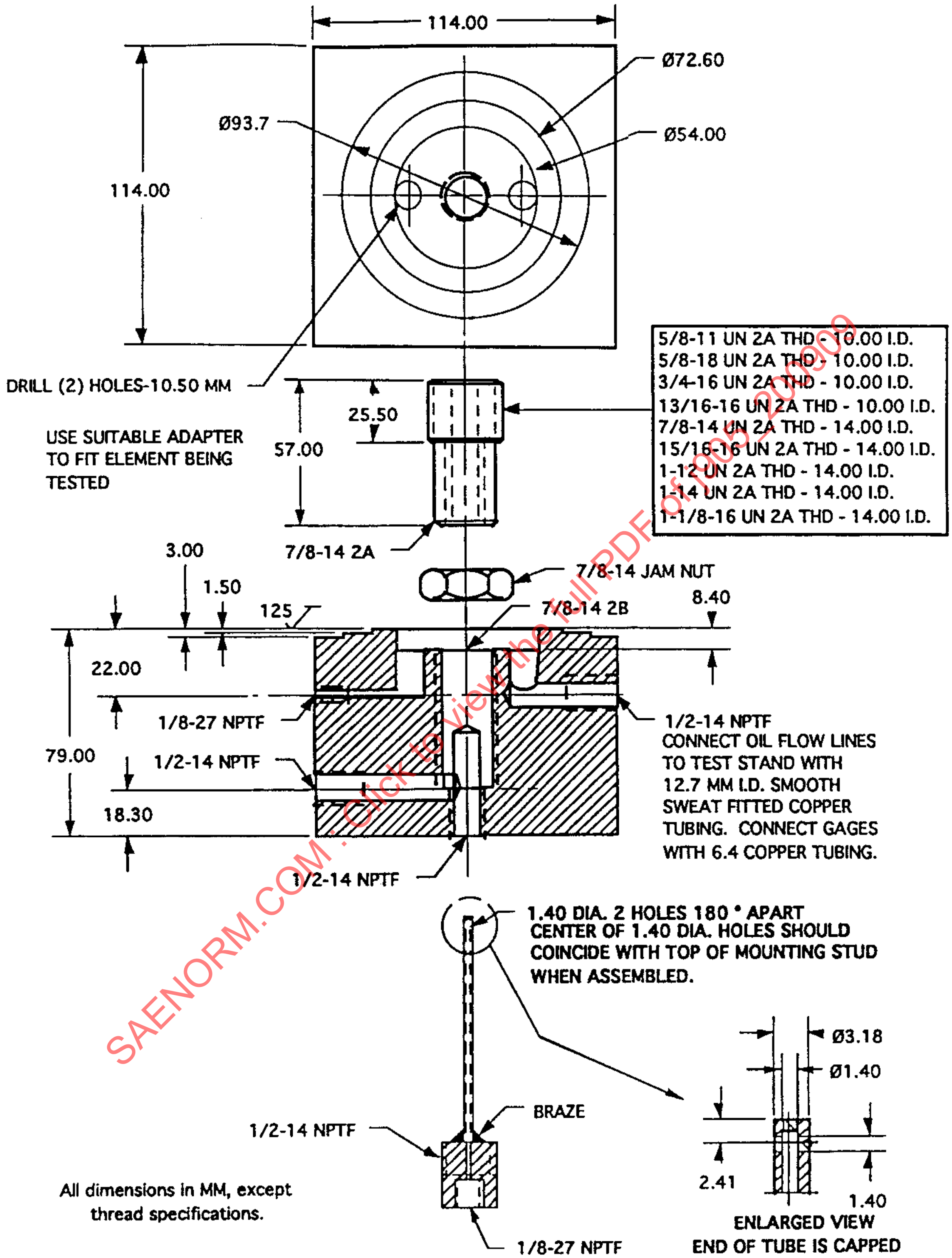


FIGURE 3 - UNIVERSAL TEST FIXTURE FOR SPIN-ON ELEMENTS

3.4 Test Preparation

3.4.1 Install a cleanup filter on the test stand and add 20 L of prefiltered test fluid.

3.4.2 Circulate test fluid through the bypass system until the specified temperature is reached; 40 °C is the recommended test temperature.

3.4.3 Circulate the test fluid through a cleanup filter until the test fluid cleanliness is less than 2 mg/L (see Appendix A for methods for sample analysis). Remove the cleanup filter and install the test filter.

3.5 Test Procedure

3.5.1 Circulate the test fluid through the test filter and adjust flow rate to 20% of the flow rate specified for the Capacity and Contaminant Removal test, at the specified test temperature. When the temperature and flow rate have stabilized, record the pressure differential. Adjust the flow rate in increments of 20% of the specified test flow rate, to a maximum of 120%, and record pressure differential after stabilization at each increment.

3.5.2 If the filter housing does not have pressure taps located to read element pressure only, an empty housing pressure differential must be obtained. The difference between the pressure loss for the empty housing and for the housing with elements is the pressure loss for the element only. For "spin-on" and "in-line" filters, pressure loss for the complete unit may be the only value of interest, in which case pressure loss for the element only will not be required.

3.6 Presentation of Data

3.6.1 Tabulate pressure differential at each required flow and temperature.

3.6.2 Plot a curve of flow rate versus pressure differential using the ordinate for pressure differential and the abscissa for flow rate.

4. CHAPTER 2—FILTER CAPACITY AND CONTAMINANT REMOVAL CHARACTERISTICS

4.1 General Information

This procedure has been developed to provide a standard method for evaluating filter performance in terms of contaminant holding capacity and ability to maintain effluent cleanliness within specified contamination limits. These characteristics are defined as follows:

4.1.1 Contaminant Holding Capacity

The amount of abrasive contaminant removed from a recirculating flow of test fluid and held by the filter before a specified pressure drop across the filter is reached. The limiting pressure drop is specified by the user and is related to the limitations of the fuel system served by the filter.

4.1.2 Fluid Cleanliness

The measure of the level of contaminant remaining in the filter effluent fluid samples at specified time intervals during the test with abrasive contaminant.

Cleanliness is specified in terms of mass of contaminant per unit volume of fluid, or mass of contaminant per unit mass of fluid.

Test fluids and contaminants have been selected because their characteristics are closely controlled so that, used in accordance with standard procedures contained in this document, test results will be repeatable and comparable among laboratories using these test procedures. Producers of the test materials will not alter any characteristics unless they have first ascertained that the proposed change will have negligible effect on all tests in which they are used. No changes are made without consultation with the SAE Filter Test Methods Committee.

4.1.3 Cautionary Notes

Prior standard tests incorporated in SAE J905 used a nondispersant fluid for the tests of filtration efficiency and dirt capacity. The test fluid specified for the tests in this chapter has significant dispersancy. For this reason, apparent filtration efficiency and capacity by this revision will be significantly lower than if the same filter was evaluated by the older method. These results are more realistic than earlier test results and are more repeatable and reliable.

This test is an evolution of the previously used test, which was derived from years of experience in the testing of fuel filters. However, the procedure is limited strictly to the laboratory comparison of filters. Test results are not directly relatable to the field performance of the filter.

The differences between laboratory results and field experience are attributable to the types of contaminant used in the test procedure and that found in the field. General experience is that fuel filters in the field become restricted rapidly due to asphaltenic type materials in the fuel. Asphaltenic materials are micron or submicron particles of carbon with a resinous coating. The abrasive contaminant used in this test procedure provides a poor approximation of this type of clogging action. This is supported by the experience that plugged field filters have only a small fraction of the contaminant weight gain as one would expect from this test procedure.

The SAE Filter Test Methods Committee has ongoing programs to evaluate new test methods for the investigation of fuel filter capacity and efficiency. These programs address the contaminant problem and the relation of test results to field performance. In addition, testing avenues such as particle counting are being used for fuel filtration evaluation. Consideration will be given to new technology and testing methods, as they become known to the FTMC.

This test procedure has been included in the interim because there are years of background and data, which have been generated through its use. Most users have significant experience with the procedure and have developed special in-house methods to extend the test results to field applications. Although this is not the optimal situation, the FTMC feels that this procedure will be useful in the interim, as long as users continue to exercise care in the interpretation of the test results.

Test results using ultrasonically dispersed test dust show slightly lower efficiency and dirt capacity than when the Waring blender is used. The differences in results between these two methods are within the normal expected variation among laboratories. The Waring blender is specified because it will reliably disperse the test dust adequately. Other blenders have been tried, and results show that the dust was not well dispersed. Blenders, which can be demonstrated to disperse contaminant as well as the Waring, verified by test results, which correlate well with test results using a Waring blender, may be used. The Committee has no evidence to recommend other blenders, but some may be available.

4.2 Scope

This test determines the abrasive contaminant holding capacity and abrasive contaminant removal characteristics of fuel filters. While the test is generally applied to filters intended to handle fuel oils for diesel engines, it is equally applicable to filters for other classes of liquid fuel. The specified test fluid has viscosity characteristics similar to No. 2 diesel fuel.

In the construction of the test stand, care must be taken to insure that any contaminant added to the test sump is properly dispersed and fully presented to the test filter. To insure validation, the system must not have any traps or settling zones where contaminant could be lost, nor should the pumping system alter the contaminant in any way. The test apparatus recommendations are made with these points in mind.

4.3 Test Materials

4.3.1 Test Fluid

SAE J1696 Standard Fuel Filter Test Fluid.

4.3.2 Test Contaminant

ISO 12103-1, A2 Fine Grade.

4.4 Test Apparatus

4.4.1 Fuel Filter Test Stand, as shown in Figure 4, with or without optional continuous contaminant feeder.

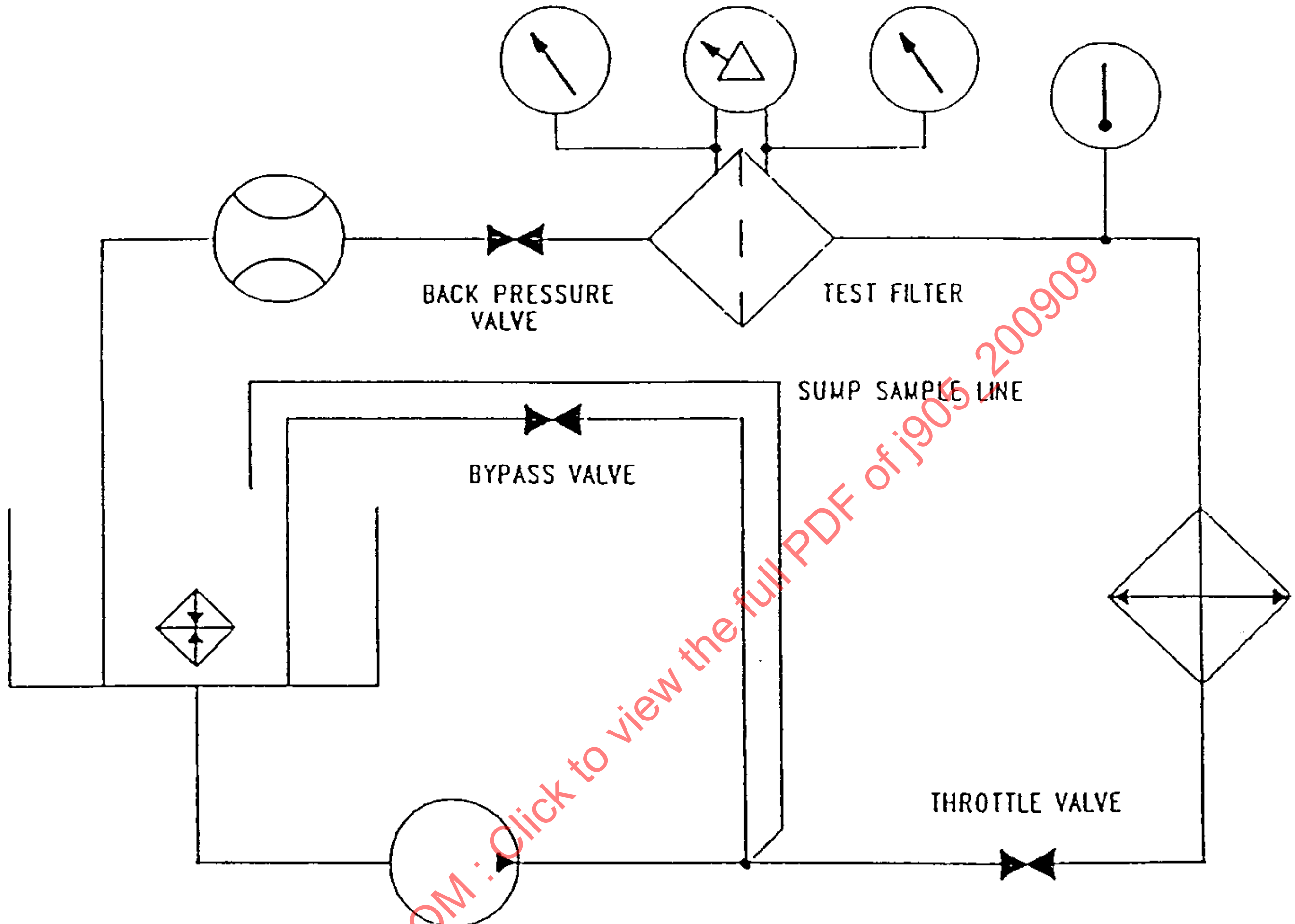


FIGURE 4 - FUEL FILTER TEST STAND

4.4.1.1 Pump

Progressive cavity type (Moyno pump or equivalent).

4.4.1.2 Heat Exchanger

Water-jacketed length of system tubing.

4.4.1.3 Sump Sample Line

Positioned to deliver a constant flow from the pump outlet, returning to the sump.

4.4.1.4 System Tubing and Fittings

16 mm I.D tubing recommended; all fittings should be of such construction that they do not create any contaminant traps.

4.4.2 Appropriate housing or standard mounting base for spin-on filters (Figures 2 and 3).

4.4.3 Ultrasonic Bath (0.78 w/cm^2) with slurry beaker suspended 13 mm above the tank bottom (see Figure 5). Use the following or proven equivalent: Branson Model S8340-12 120 V Generator 500 W and Branson C1012-40-12 transducerized tank having inside dimensions of 25 cm x 25 cm x 25 cm.

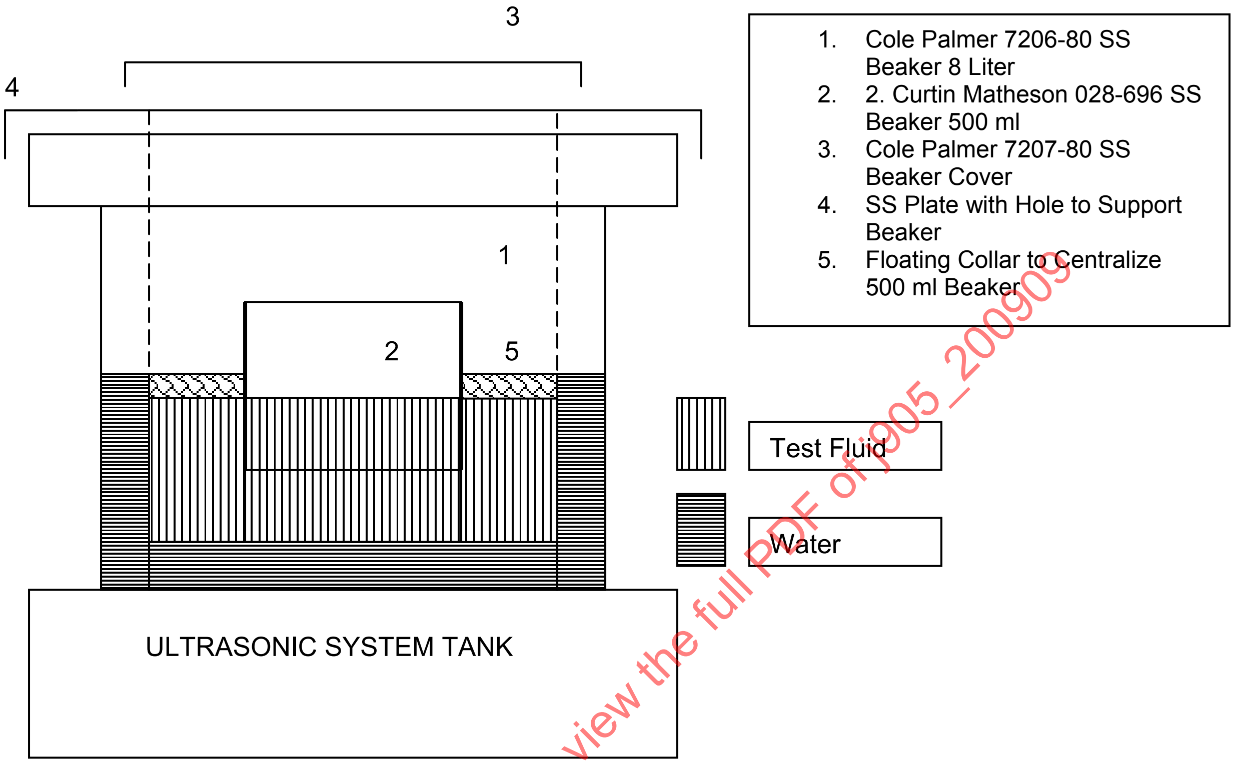


FIGURE 5 - ULTRASONIC SLURRY PREPARATION BATH

Alternately, a heavy-duty laboratory Waring Blender may be used. Use the following or proven equivalent: Waring Blender Model 7011S, 2 speed, with Blender Container SS610, 1-L Bakelite bottom with drawn one-piece shell. Blender speed 21 000 rpm, no load.

NOTE: Blade wear may cause inconsistent dispersion; based on use, blades should be replaced at periodic intervals.

Report the specific type and model of the contaminant dispersing device when reporting test results. Test results may not be consistent between the two recommended methods. The use of devices other than those recommended may compound the problem.

4.4.4 Analytical apparatus for effluent sample analysis (see Appendix A).

4.5 Validation of Test Circuit

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

4.5.2 Adjust the total test system volume to 20 L. Insure that turbulence will not add air to the fluid.

4.5.3 Start the main system flow and circulate to clean the fluid to the appropriate cleanliness level (see 4.7.1)

4.5.4 Contaminate the test system fluid to the highest gravimetric level expected during testing using ISO 12 103/1 Part 1 A-2 (Fine) contaminant. Follow contaminant preparation method 4.6.2 or 4.6.3.

4.5.5 Circulate the contaminated fluid in the test system for 1 h and extract fluid samples from the upstream sample line at 15, 30, 45, and 60 min.

4.5.6 Analyze the fluid samples gravimetrically (see Appendix A).

4.5.7 Accept the validation test only if:

4.5.7.1 The gravimetric level of each sample is within ±10% of the average of the four samples and ±10% of the known gravimetric level.

4.6 Preparation of Contaminant Slurry

4.6.1 Prepare the contaminant slurry using either the ultrasonic or the alternate blender dispersion method. Equipment is as described in 4.4.

NOTE: Dry the test contaminant in an open container in a convection oven at a temperature of 110 to 150 °C for 2 h. The depth of the test dust in the drying container should be less than 25 mm. Store the dried dust in a desiccator prior to use.

4.6.2 Ultrasonic Dispersion Method

4.6.2.1 Place the specified mass of dried contaminant required for a 5 min incremental addition in the 500 mL beaker shown in Figure 5.

4.6.2.2 Mix test contaminant with 50 mL of test fluid using a rubber policeman for 15 s.

4.6.2.3 Dilute the mixture to 350 to 400 mL, total volume with test fluid. Test fluid used should be taken from the test stand in use for the test.

4.6.2.4 Place beaker with contaminant/fluid mixture in the ultrasonic bath and disperse for 2.5 min ± 0.5 min. The preparation of the slurry should be performed in the 5 min interval between slurry additions to the test system.

4.6.3 Blender Dispersion Method

Place the specified mass of dried contaminant required for a 5 min incremental addition in the blender container.

4.6.3.1 Add approximately 700 mL of test fluid to the contaminant and blend at high speed (21 000 rpm, no load) for 2.5 min ± 0.5 min. The preparation of the slurry should be performed in the 5 min interval between slurry additions to the test system.

4.7 Test Procedure

4.7.1 Fill the test stand sump with 20 L of test fluid. Install a cleanup filter in the test filter location and circulate the test fluid until a 100 mL sample has an insoluble concentration of less than 2 mg/L.

4.7.2 Remove the cleanup filter and install the test filter.

4.7.3 Adjust the test sump fluid volume to 20 L using test fluid prefiltered to a level of less than 2 mg/L insolubles.

4.7.4 Start the pump and adjust the flow rate to 200 LPH or to a flow rate as agreed upon by the supplier and user. Adjust the fluid temperature to 40 °C and maintain throughout the test.

4.7.5 Close the throttling valve to stop flow to the test filter. Adjustment of the back pressure or bypass valves should not be necessary.

4.7.6 Add to the test sump 2 g of contaminant prepared as in 4.6.2 or 4.6.3. Modified addition rates may be used as agreed upon by the user and supplier. Wash all the contaminant from the slurry container with test fluid from the sump sample line.

4.7.7 After 2 min of mixing, open the throttling valve. The test flow rate should re-establish itself if the bypass valve has not been adjusted. Maintain required flow rate throughout the test.

4.7.8 The instant of opening the valve to start flow through the test filter is time zero.

4.7.9 Take effluent samples of 100 mL each at times of 0.5, 1.0, 2.0, and 4.5 min from time zero.

4.7.10 Replenish the test system with 100 mL of prefiltered (<2 mg/L) fluid immediately after removing each sample.

4.7.11 At time zero plus 5 min, add 1 g of contaminant prepared as in 4.6.2 or 4.6.3. Rinse the container as in 4.7.5. Modified add rates may be used as agreed upon by the user and supplier.

4.7.12 Repeat each 5 min of the test until the terminating pressure drop is reached (70 kPa if no limit is specified).

4.7.13 Take effluent fluid samples of 100 mL each, 1 min before each slurry addition after the initial charge until the pressure drop reaches 25% of the terminating value, then at 50% and 75% of the limiting value. Replenish the test system with 100 mL of clean test fluid (<2 mg/L) immediately after taking these samples.

4.7.14 Record the pressure drop across the filter just prior to removing each effluent fluid sample.

4.7.15 Take a final 100 mL effluent fluid sample and a 100 mL sump fluid sample just prior to shutdown of the test when the terminating pressure drop has been reached.

4.7.16 Analyze the fluid samples and present the data as specified in 4.8 and 4.9.

4.7.17 For larger filters, rated at higher flow rates and greater capacities than covered by this procedure, the test flow rate should be adjusted in relation to filter size, and the contaminant add rate should be increased so as to complete the test in 60 to 90 min.

4.7.18 For smaller fuel filters, rated at lower flow rates and lower capacity than this procedure covers, the test flow rate should be adjusted in relation to the filter size, and the contaminant addition rate should be adjusted so as to complete the test in 30 to 60 min. For smaller filters, the following 5 min incremental contaminant additions are suggested as options to meet the 30 to 60 min requirement:

a. 1 g ± 0.050 g

b. 0.5 g ± 0.025 g

c. 0.25 g ± 0.0125 g

d. 0.10 g ± 0.005 g

4.7.19 This test may be modified to provide for a continuous contaminant feeding system. The system must satisfy 4.7.20.1 of this test method.

4.7.19.1 To calculate the minimum volume (V, liters) needed to complete the test, which is compatible with a value for the delivery rate (0.020 L/min.), use Equation 1;

$$V = 1.2 * T(\text{desired test time in min}) * \text{delivery rate } (0.020 \text{ L/min}) \quad \text{(Eq. 1)}$$

NOTE: The volume calculated in Equation 1 will insure there is a sufficient quantity of contaminated fluid for the test. Larger volumes may be used provided the delivery system satisfies 4.7.20.1.

4.7.19.2 To calculate the gravimetric level (Y', gms/L) of the contaminant delivery system fluid using the apparent capacity (C', gms) of the test filter, follow Equation 2;

$$Y' = \frac{C'}{T'\,(\text{min}) * 0.020\text{L}/\text{min}} \qquad \text{(Eq. 2)}$$

4.7.19.3 To calculate the quantity of contaminant (W, grams) needed for the contaminant delivery system, follow Equation 3;

$$W = (Y', \text{gms}/\text{L}) * (V, \text{liters}) \qquad \text{(Eq. 3)}$$

4.7.19.4 The contaminant is prepared by adding the calculated weight of contaminant found in 4.7.19.3 to 500 mL of clean test fluid, taken from the contaminant delivery system reservoir and dispersed in the ultrasonic bath for 10 min. Transfer the slurry to the delivery system reservoir. Rinse the beaker thoroughly to insure all the contaminant is transferred. Constant agitation of the reservoir is needed to maintain homogeneity.

Time of feeding of the contaminant until test termination determines the quantity of solids added (i.e., 20 mL/min at 10 g/L = 1 g solids per 5 min). Start flow through the test filter (timed) after 2 g of contaminant have been dispensed into the test sump. For tests with altered contaminant concentrations, dispense into the sump for 10 min before starting the test. Modified feed rates may be used as agreed upon by the user and supplier.

Conduct continuous feed tests in accordance with 4.7.7, 4.7.8, 4.7.9 (modified), 4.7.12 (modified), 4.7.13, 4.7.14, and 4.7.15.

Modify 4.7.9 to read "replenish the system with 100 mL of clean (<2 mg/L) fluid immediately after the removal of each sample.

Modify 4.7.12 to read "take effluent samples of 100 mL each, 1 minute before the 10 min contaminant addition and 1 minute before each contaminant addition thereafter until the pressure drop reaches 25% of the terminating value, then at 50% and 75% of the limiting value." "Replenish the sump with 100 mL of prefiltered (<2 mg/L) fluid after each of these samples is taken."

4.7.20 Validation of Contaminant Continuous Feed System

4.7.20.1 Validate at the maximum gravimetric level and the maximum feed system volume to be used.

4.7.20.2 Add the required quantity of contaminant in slurry form to the continuous feed system fluid and circulate for 2 h.

4.7.20.3 Extract fluid samples from the continuous feed system at 30, 60, and 90 min and analyze each sample gravimetrically.

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

4.8 Sample Analysis

4.8.1 Analyze all samples by the membrane filtration method specified in Appendix A.

4.9 Data Presentation

4.9.1 Record all data on appropriate data reporting sheet.

4.9.2 Plot pressure drop versus contaminant added and mg/L or percent insolubles versus contaminant added.

4.9.3 Report capacity, calculated as:

Capacity = total grams of contaminant added to the system minus ((gms/L contaminant in final sump sample times liters of fluid in test system) + total weight of contaminants removed in effluent sampling during test).

5. CHAPTER 3—MEDIA MIGRATION TEST

5.1 Scope

The purpose of this test is to determine if the filter introduces contaminant into the fuel system downstream of the filter. This contaminant is referred to as media migration, although its source is not necessarily the filter media. Any of the filter components or the manufacturing techniques used in building the filter can also be a source of contamination.

The test method consists of clean test fluid flowing through several filters and collecting the contaminant from the effluent on a wire cloth screen from which weight determination and visual observations may be made.

5.2 Test Materials

5.2.1 Test Fluid

SAE J1696 Standard Fuel Filter Test Fluid.

5.2.2 Four test filters

5.2.3 Petroleum solvent, analytical grade

5.3 Test Apparatus

5.3.1 Test Stand

See Figure 6.

5.3.2 Media Migration Filter Screen

5.3.3 Wire Cloth Screen

40 µm nominal.

5.3.4 Analytical Equipment

See Appendix A.

5.4 Test Preparation

5.4.1 Install wire cloth screen in holder in series with and downstream of the test filter location. Fill sump with test fluid. Install a cleanup filter in place of the test filter.

5.4.2 Circulate test fluid through the system at rated flow and 40 °C and determine the system cleanliness by method described in 5.5.4. Repeat as often as necessary to achieve a cleanliness level of 2 mg maximum.

5.5 Test Procedure

5.5.1 After satisfying 5.4.2, install a test filter.

5.5.2 Install clean wire cloth screen in holder.

5.5.3 Flow test fluid through test filter at rated flow 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 test sump. Discard any spillage that occurs in changing test filters. Do not replenish the sump with any make-up fluid.

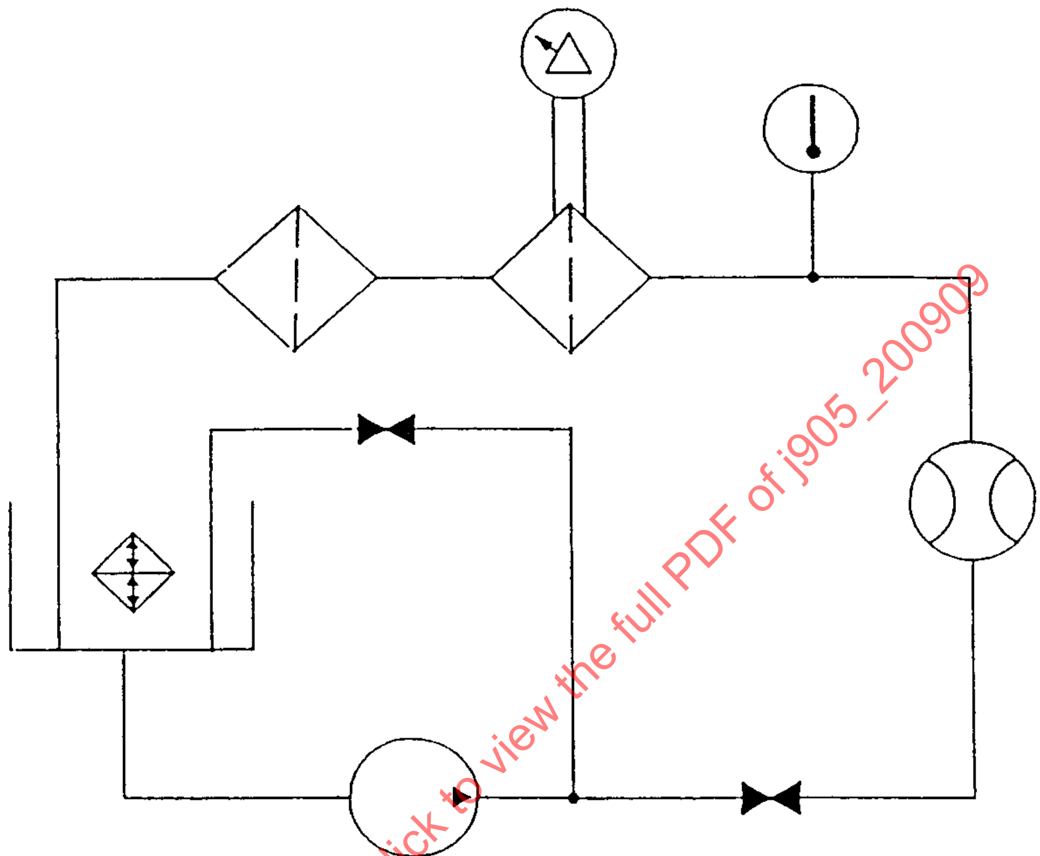


FIGURE 6 - MEDIA MIGRATION TEST STAND

5.5.4 Carefully remove the wire cloth screen from the holder and wash collected migration from the screen into a clean beaker with pre-filtered analytical grade solvent. No less than 300 mL of solvent should be used for thorough washing. Filter the washing through a tared 0.8 µm, 47 mm diameter analytical membrane filter disc following the techniques recommended in Appendix A. Determine the total weight of contaminant contained in the washing to the nearest 0.1 mg.

5.5.5 Analyze the contaminant to determine its nature.

5.6 Presentation of Data

5.6.1 To obtain media migration per filter, divide the total weight of media migration, (contaminant from washing), by the number of filters tested.

5.6.2 Report the nature of the contaminant from the test filters.

5.7 Determination of Inorganic Material of Migration

5.7.1 Test Apparatus

5.7.1.1 Evaporating dish or crucible made of platinum, silica, or porcelain of 90 to 120 mL capacity.

5.7.1.2 Electric muffle furnace capable of maintaining a temperature of 775 °C ± 25 °C.

5.7.2 Procedure

5.7.2.1 Heat empty evaporating dish or crucible at 775 to 800 °C for 30 min. Cool for 30 min to room temperature and weigh to the nearest 0.1 mg. Repeat until no weight change occurs.

5.7.2.2 Weigh the evaporating dish or crucible with the membrane filter from the media migration determination to the nearest 0.1 mg. Heat in furnace at 775 °C ± 25 °C for 30 min. Cool container for 30 min to room temperature and reweigh. Repeat the heating and reweighing until consecutive weights are within 0.2 mg.

5.7.3 Calculation of Results

5.7.3.1 Report results as shown in Equation 4:

$$\text{Inorganic (\%)} = \frac{W_a}{W_b} \times 100 \qquad \text{(Eq. 4)}$$

where:

W_a = mass of ash in grams
W_b = mass of contaminant on membrane filter

6. CHAPTER 4—COLLAPSE TEST

6.1 Scope

The purpose of this test is to assure that a filter element will withstand the anticipated maximum differential pressure without bypassing due to breakage or collapse while filtering. The test method will determine element strength by means of pumping contaminated fluid through the element until collapse occurs or the anticipated maximum differential pressure is reached.

6.2 Test Materials

6.2.1 Test Fluid

SAE J1260, Standard Oil Filter Test Oil (RM99) or SAE J1696 Standard Fuel Filter Test Fluid.

6.2.2 Contaminant

ISO 12 103/1 Test Dust For Filter Evaluation or other suitable choking type contaminant.

6.3 Test Apparatus

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

6.3.2 A pump and motor capable of pumping the test fluid at maximum specified collapse pressure.

6.3.3 A reservoir of sufficient size.

6.3.4 Necessary piping, fittings, and valves to flow fluid and control flow to the test filter (see Figure 1).

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

6.3.6 If an elevated temperature is desired, use a device for heating and controlling the temperature of the test fluid.

6.3.7 The fuel filter test stand (Figure 4) may be used for this test.

6.4 Test Preparation

6.4.1 The filter element to be tested may be one previously subjected to a capacity and contaminant removal test or a new element. The test element should be examined for any apparent damage before the collapse test is performed.

6.4.2 Block or eliminate relief valve, if present.

6.5 Test Procedure

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

6.5.2 With the main valve closed and the bypass valve open, start the pump and circulate the test fluid until the desired temperature is reached.

6.5.3 Open the main valve and close the bypass valve as needed to establish flow through the test element. All air must be bled from the housing at this time.

6.5.4 After the air has been bled from the housing, start adding contaminant to the test sump; this may be done manually or automatically.

6.5.5 When a differential pressure of approximately 50% of the specified minimum collapse pressure across the test element is reached, stop the contaminant addition and allow the pressure to increase. If the pressure drop increase stops, add additional contaminant until the pressure drop starts to rise again. Adjust the bypass valve as needed to maintain flow through the test element.

6.5.6 Differential pressure should be increased until the element collapses as evidenced by a sudden drop in differential pressure, or until the specified minimum collapse pressure is reached.

6.6 Presentation of Data and Evaluation of Results

6.6.1 The report shall include the following information:

6.6.1.1 Pretreatment of filter element, i.e., capacity test, preflow, or new element.

6.6.1.2 Maximum differential pressure attained.

6.6.1.3 Reason for terminating test.

6.6.1.4 Condition of filter element after test.

7. CHAPTER 5—ABILITY TO MEET ENVIRONMENTAL CONDITIONS

7.1 Scope

This test method evaluates the effects of water in fuel upon the performance characteristics of fuel filters.

7.2 Test Method for the Effect of Water in Fuel on Filter Capacity

7.2.1 Test Materials

7.2.1.1 Distilled or de-ionized water.

7.2.1.2 SAE J1696 Standard Fuel Filter Test Fluid.

7.2.2 Test Apparatus

7.2.2.1 Fuel Filter Test Stand (Figure 4)

7.2.2.2 Water Addition System (Figure 7).

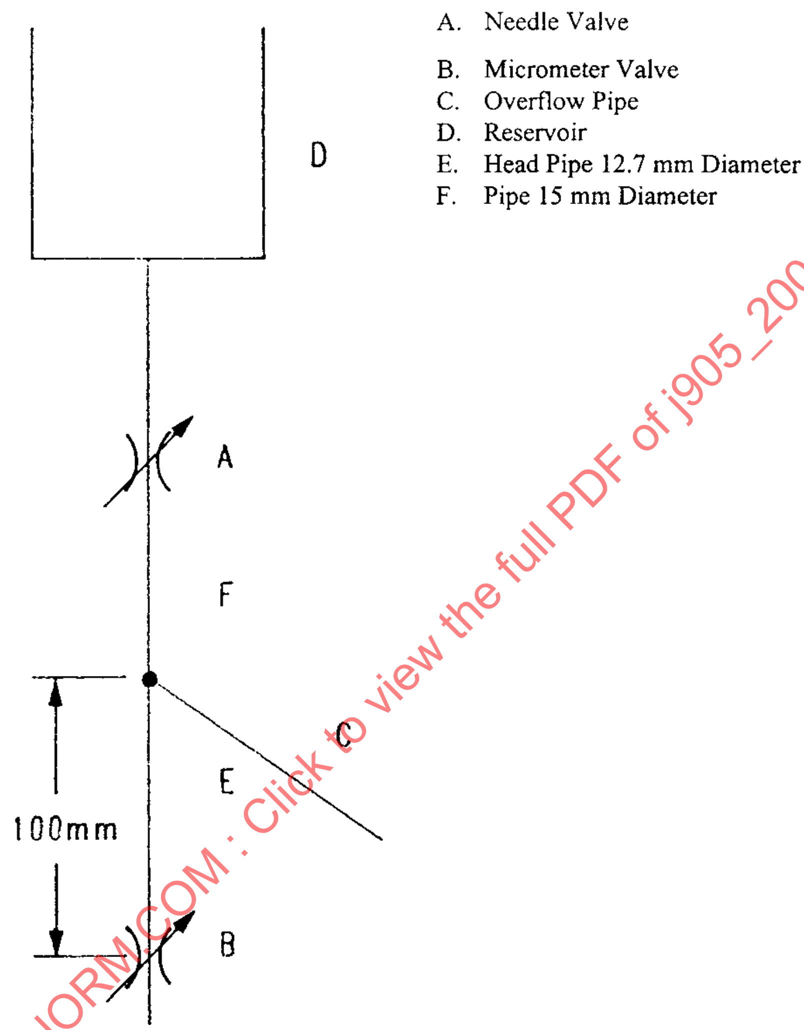


FIGURE 7 - WATER ADDITION SYSTEM

7.2.3 Test Preparation

7.2.3.1 Prepare the test stand as described in 4.4.

7.2.3.2 Install the water addition system in place above the sump of the test stand and fill water addition system with distilled or de-ionized water.

7.2.4 Calibration and Adjustment of Water Addition System

7.2.4.1 Partially open needle valve "A" (see Figure 7) so that water is delivered to the head pipe and flow control valve. Divert flow from control valve "B" into a suitable container.

7.2.4.2 Open the micrometer flow control valve "B" so that the zero of the vernier is in line with the "1" on the scale.

7.2.4.3 Adjust the needle valve "A" so that there is a very small, constant flow from the overflow drain pipe "C." This provides a constant head pressure to the control valve.

7.2.4.4 Record the time required to deliver a predetermined volume of water through valve "B." Calculate the delivery rate in suitable units (i.e., L/h).

7.2.4.5 Repeat 7.2.4.2 through 7.2.4.4 for other micrometer dial settings until the full range has been covered.

7.2.4.6 Plot micrometer setting versus delivery rate. From this plot, the approximate micrometer setting for any desired delivery rate can be obtained. Final adjustments can then be made to obtain the exact delivery rate.

7.2.5 Test Procedure

Set up test capacity and contaminant removal test as described in Chapter 4 (Section 6).

7.2.5.1 With needle valve "A" closed, empty any water from the head pipe and control valve. Set the micrometer to deliver the desired flow rate.

7.2.5.2 With effluent from the control valve diverted to a suitable container, open needle valve "A" and adjust flow so that there is a very small, constant flow from overflow drain pipe "C."

7.2.5.3 Divert the flow from control valve into test sump at test time zero.

7.2.5.4 Recommended water delivery rate is 0.5% of the test fluid flow rate to the test filter.

7.2.6 Presentation of Data

7.2.6.1 Results should be reported as in 4.9 with the additional notation of the amount of water added during the test.

8. CHAPTER 6—INSTALLATION AND REMOVAL

8.1 Seal Test

8.1.1 Scope

This test assures that the seal material is suitable for the intended application.

8.1.2 Submit three seals to tests as specified by SAE J200 to assure that they meet the requirements of the specified rubber type.

8.2 Installation Sealing Torque

8.2.1 Scope

This test method relates to the static sealing characteristics of spin-on fuel filters. Results indicate the ability of the filter to seal at the sealing surface of the mounting head when installed with the specified torque.

8.2.2 Test Material

SAE J1696 Standard Fuel Filter Test Fluid or No. 2 Diesel Fuel.

8.2.3 Test Apparatus

(See Figure 8)

8.2.3.1 Test apparatus used for generating and measuring pressure is the same as that specified in 9.2.3.

8.2.3.2 Torque wrench readable to 0.56 Nm.

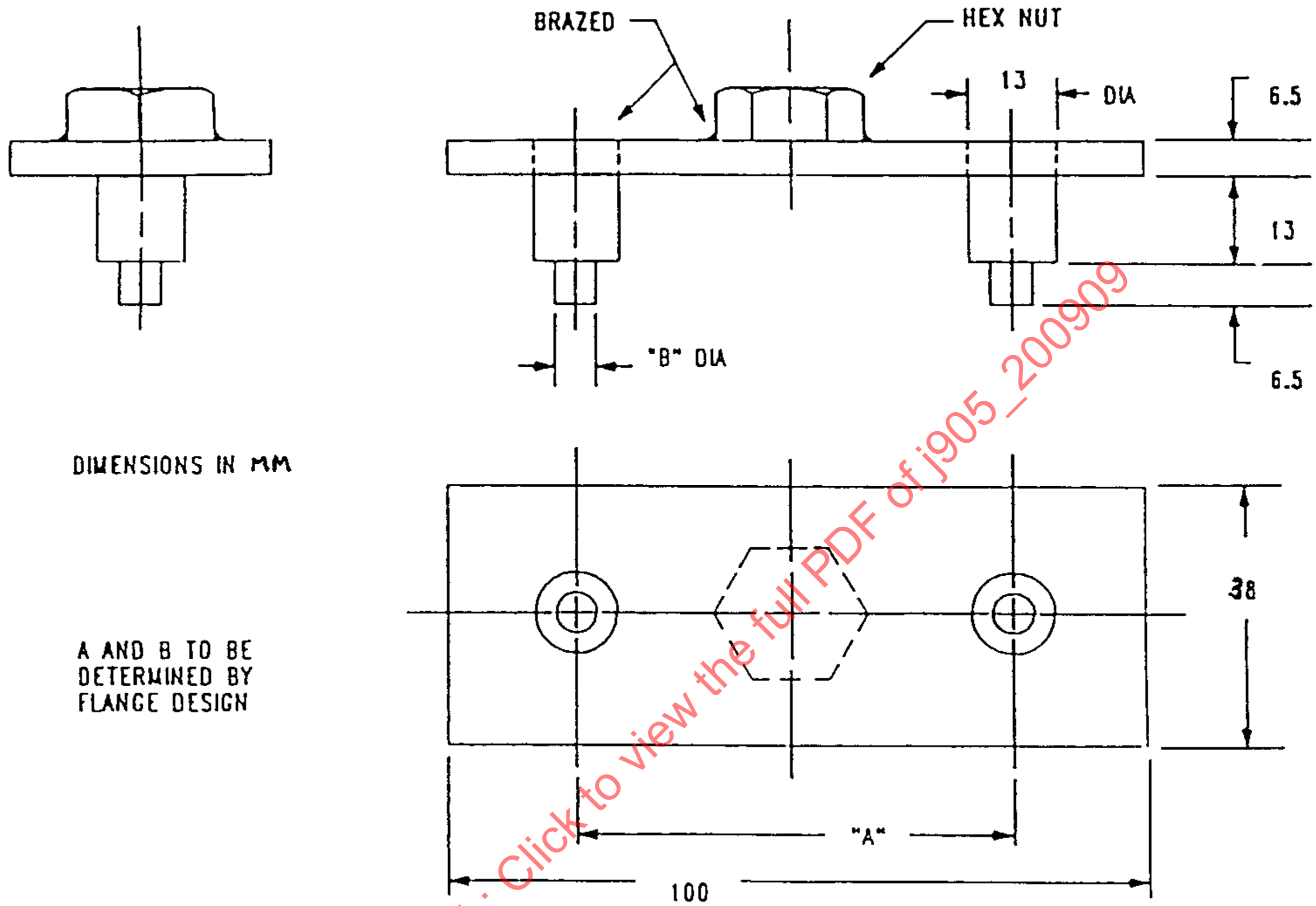


FIGURE 8 - TORQUE WRENCH ADAPTER

8.2.4 Test Preparation

8.2.4.1 Check that gasket is bottomed out in filter gasket retaining groove.

8.2.4.2 Measure the filter flange to determine dimensional relationship of gasket groove and threaded mounting hole of filter.

8.2.5 Test Procedure

8.2.5.1 Apply thin film of ASTM #3 oil to gasket surface and fill test filter with test fluid.

8.2.5.2 Screw filter onto mounting head until the gasket makes contact.

8.2.5.3 Tighten the filter to the test fixture with the application of 2.82 Nm of torque.

8.2.5.4 Position the plastic shield between the test filter and the operator.

8.2.5.5 Using the hydraulic pump, pressurize the assembly until the first sign of leakage. Record leak pressure.

8.2.5.6 Determine leakage pressure at increasing torque intervals of 2.82 Nm until the recommended torque or number of turns from gasket contact has been reached.

8.2.5.7 Remove filter from fixture and remeasure to determine if any permanent deformation of the filter flange has occurred.

8.2.6 Presentation of Data

8.2.6.1 Graph the data collected as follows: abscissa—torque; ordinate—pressure to produce leakage.

8.2.6.2 Report any deformation of the filter flange and the maximum pressure reached.

8.2.6.3 Record torque required to attain the desired seal pressure.

8.3 Removal Torque Test Method

8.3.1 Scope

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

8.3.2 Test Material

ASTM #3 oil, or as otherwise specified.

8.3.3 Test Apparatus

8.3.3.1 Constant temperature oven, capable of maintaining 52 °C.

8.3.3.2 Thermometer (immersion type) with a temperature range of 0 to 120 °C.

8.3.3.3 Torque wrench with a torque range of 0 to 56.5 Nm readable to 0.56 Nm.

8.3.3.4 Torque wrench adapter. Suggested design is shown in Figure 8.

8.3.3.5 Filter Test Base

Use manufacturer's specified base.

8.3.3.6 Product to be Evaluated

Gasket and spin-on filter flange assembly (unit end plate assembly, nut plate assembly, etc.).

8.3.4 Test Preparation

8.3.4.1 Preheat oven to 52 °C.

8.3.4.2 Secure the filter base in a vise; be sure that threads are clean and properly sized.

8.3.4.3 Check that gasket is fully seated in gasket retainer groove.

8.3.5 Test Procedure

8.3.5.1 Apply a light film of ASTM #3 oil to gasket surface.

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

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

8.3.5.4 Place total assembly in oven for 24 h minimum.

8.3.5.5 Remove assembly and allow it to cool to room temperature.

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

8.3.5.7 Comparisons should be made based on a minimum of three tests conducted.

8.3.6 Presentation of Data

Tabulate the following information:

8.3.6.1 Installation torque used.

8.3.6.2 Filter head used.

8.3.6.3 Removal torque required.

8.3.6.4 Revolutions (fractions of turn) to attain the installation torque.

8.3.6.5 Whether or not gasket remained in retaining groove.

8.3.7 Definition of Terms

8.3.7.1 Removal Torque

The maximum torque required to remove the filter flange assembly from the filter test head.

8.3.7.2 Installation Torque

Manufacturer's specified torque to achieve a good seal.

8.3.7.3 Filter Flange Assembly

Threaded inlet and outlet support plate and gasket retainer assembly.

8.3.7.4 Filter Test Base

Manufacturer's recommended base to be used for this test. Sealing surface should have specified finish (micrometer).

9. CHAPTER 7—MECHANICAL TESTS

9.1 General Information

This chapter describes laboratory tests, which evaluate the structural adequacy of spin-on and in-line type fuel filters. While the test conditions are generally more severe than actual on-engine operating conditions, they will indicate, in an acceptable test time, the capability of the filter assembly to retain its integrity throughout its useful life under normal operating conditions. The danger of fire which may result from any fuel leak, especially one under pressure, necessitates rigorous tests which, if the tested filters meet specified requirements, will insure high probability that leaks will not develop in normal engine operation.

The test conditions have been found to be adequate for the operating conditions of most engines. However, if maximum reliability is to be assured, each engine application should be investigated to determine the particular pressure levels and pressure cycle range to which the filter will be subjected. Test conditions should be modified, if necessary, to account for operating conditions more severe than average.

Filter mounting brackets and other hardware must be capable of withstanding the same test conditions. Usually, it will be advantageous to include these items in the installations for pressure cycle testing and vibration testing unless previous tests have established their adequacy.

9.2 Burst Test

9.2.1 Scope

This test determines the capability of the filter to withstand maximum fuel system surge pressure.

9.2.2 Test Materials

9.2.2.1 Test Fluid

SAE J1260, or similar fluid compatible with the test apparatus and filter seals.

9.2.3 Test Apparatus

9.2.3.1 High-pressure hydraulic pump.

9.2.3.2 High-pressure tubing, hose, fittings, and valves, all rated for 6900 kPa minimum.

9.2.3.3 Pressure measuring device, with a peak pressure indicator for the pressure range required—maximum graduation 50 kPa.

9.2.3.4 Test filter mounting base.

9.2.3.5 Plexiglas (or equivalent) enclosure around filter and base under test.

9.2.3.6 Apparatus connected as shown in Figure 9.

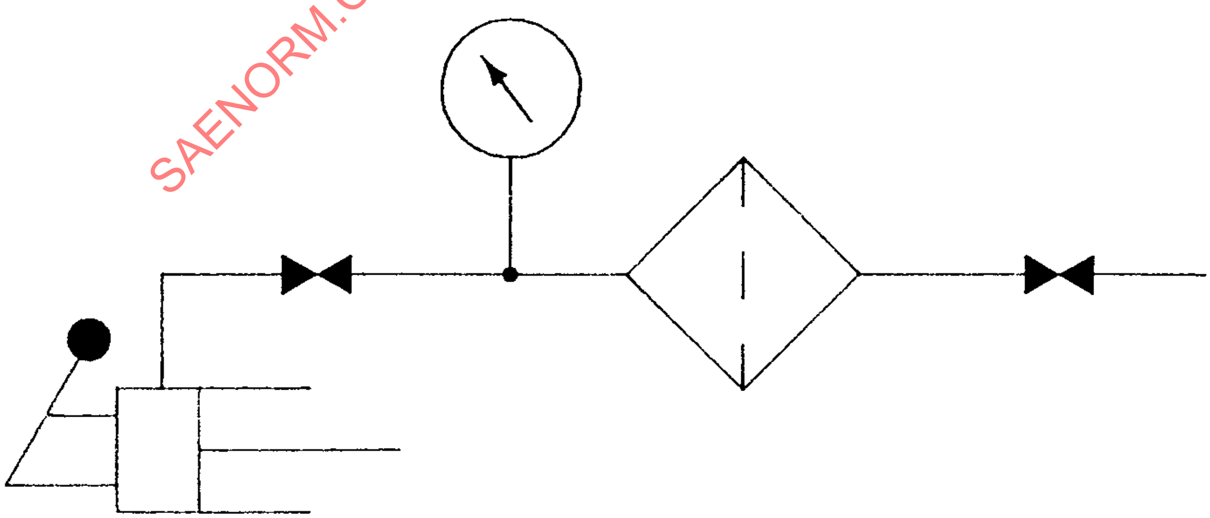


FIGURE 9 - BURST TEST STAND

9.2.4 Test Preparation

9.2.4.1 Fill test the filter with test oil, then connect to test system. Follow the specified installation instructions for tightening the filter on the base.

9.2.4.2 Apply a small amount of pressure to fill the system completely with test oil and vent off all air.

9.2.4.3 Position the shield between the operator and the test filter.

9.2.5 Test Procedure

9.2.5.1 With all vents shut off, apply pressure in increments of no greater than 70 kPa. (If approximate burst pressure for the test filter is known, the initial pressure increment may be 50% of the expected burst pressure).

9.2.5.2 Continue increasing pressure, holding at each increment for about 1 min, until failure occurs by leakage from the test filter. Note the pressure at which failure occurs and the mode of failure.

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

9.2.6 Presentation of Data

9.2.6.1 Report failure pressure and mode of failure. Mode of failure is preferably by seal displacement.

9.2.6.2 Completely report all other test conditions.

9.3 Pressure Cycle Test

9.3.1 Scope

This test determines the capability of the filter to resist mechanical or structural failure due to pressure cycles in the system.

9.3.2 Test Materials

9.3.2.1 Test Fluid

SAE J1696 Standard Fuel Filter Test Fluid or as specified by customer.

9.3.3 Test Apparatus

See Figure 10.

9.3.3.1 Pump capable of producing at least 2100 kPa.

9.3.3.2 Sump with heater and heat exchanger capable of maintaining 49 °C.

9.3.3.3 Pump drive motor.

9.3.3.4 Pressure relief valve.

9.3.3.5 Servo valve with associated electronics.

9.3.3.6 Signal Generator—range of 0.1 to 100 Hz minimum.

9.3.3.7 Pressure Transducer—range to 2100 kPa.

9.3.3.8 Oscilloscope

9.3.3.9 Filter mounting base(s)

9.3.3.10 Leak catch sump(s) with level detector(s)

9.3.3.11 Piping, tubing, fittings, etc. to complete apparatus per Figure 10.

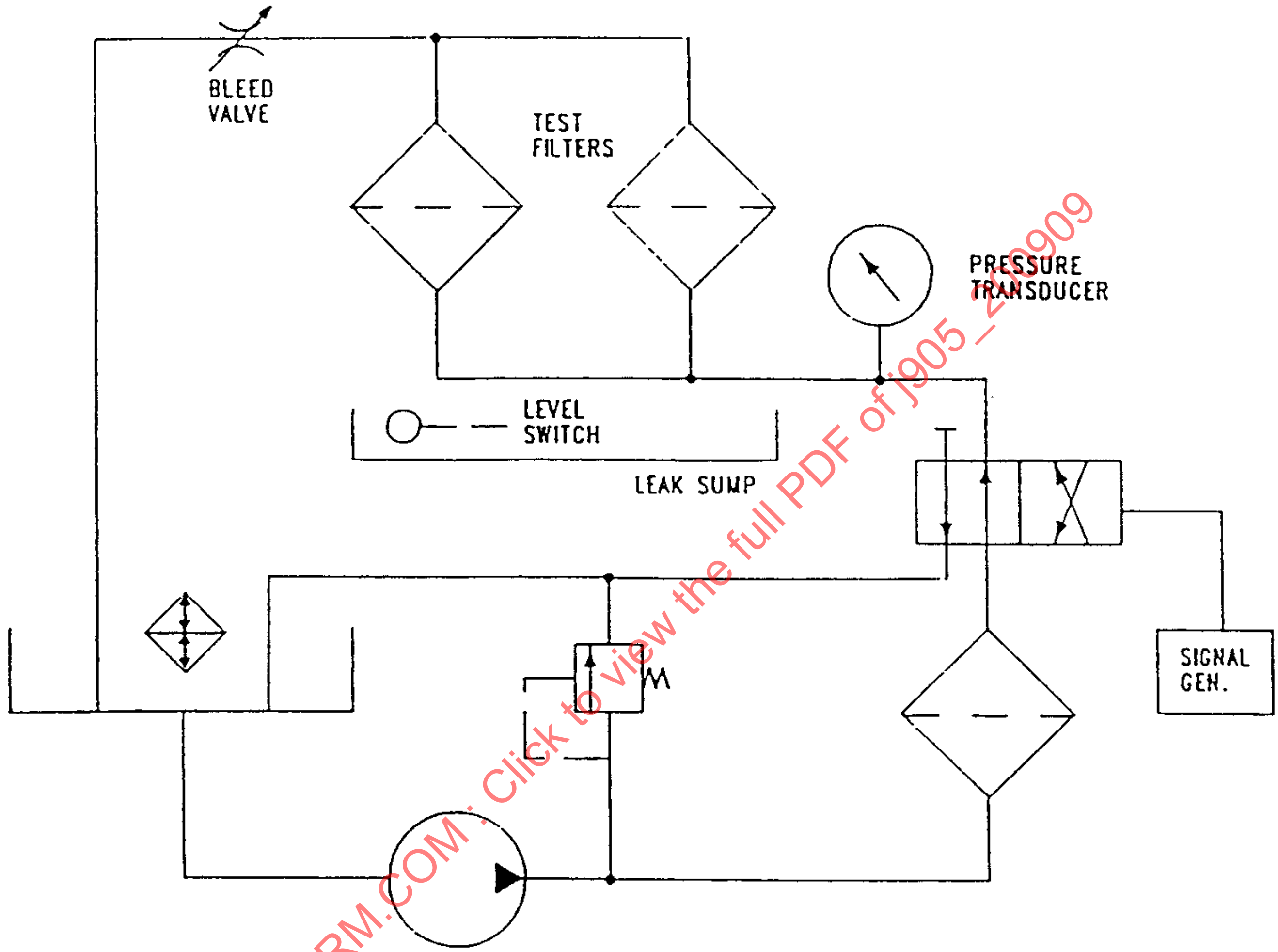


FIGURE 10 - PRESSURE CYCLE TEST STAND

9.3.4 Test Procedure

9.3.4.1 Mount a test filter on each test base. Fill each test filter with test fluid before installing.

9.3.4.2 Start pump and at low pressure bleed air from test filters through bleed valve. This valve may be left slightly open during test to vent any entrained air.

9.3.4.3 Using pressure hydraulic pressure control and signal generator electrical controls, adjust pressure pulse to the specified amplitude, offset, and frequency as monitored by the pressure transducer and oscilloscope.

9.3.4.4 When the specified pressure pulse is obtained, set cycle counters to zeros.

9.3.4.5 Terminate a filter test when that filter fails (leaks) or when the specified number of cycles is reached.

9.3.5 Test Conditions

Test conditions should be established to reflect the most severe operating conditions anticipated or measured for the filter in service. The following are suggested test conditions, which may be applied when actual service conditions are not known. The specified waveform applies to all test conditions.

9.3.5.1 The pressure waveform should be approximately square, with no pressure spikes. The slopes of the pressure wave form should be 100% of pressure rise in 15% of the cycle time and 100% of pressure decay in 10% of the cycle time. The waveform is very critical to the fatigue life of the test filter and must be closely duplicated. See SAE HS-806 figure for Impulse Pressure Cycle Waveform.

9.3.5.2 Pressure cycle should be 0 kPa to 1.5 x normal fuel system mean operating pressure, or 0 kPa to the maximum fuel system pressure observed under any operating conditions, whichever is greater.

9.3.5.3 If cyclic pressure variations of the fuel system have been measured for the engine on which the filter is used, the pressure cycle may be the normal mean system pressure varied by ±3 times the observed pressure variations.

9.3.6 Presentation of Data

9.3.6.1 If a failure occurs, report the number of cycles to failure, failure mode, and location on the test filter. Report all test conditions.

9.3.6.2 If no failure occurs before specified number of cycles, report test conditions, number of cycles completed, and that no failure occurred.

9.4 Vibration Fatigue Test

9.4.1 Scope

This test determines the ability of the filter to withstand the vibratory forces that occur during engine operation.

9.4.2 Test Fluid

SAE J1696 Standard Fuel Filter Test Fluid or as specified by customer.

9.4.3 Test Apparatus

a. Vibration test machine with automatic variable frequency control

b. Mounting fixtures, lines, valves, pressure source, and gauges as required

c. Ultraviolet light source

9.4.4 Test Preparation

9.4.4.1 Fill filter with test fluid and mount to vibration table following manufacturer's instructions.

9.4.4.1.1 Test filter including the mounting base and any brackets must be rigid so that the vibration table movement is transmitted to the test filter undiminished.

9.4.4.1.2 Filter should be mounted so that the direction of vibration simulates as closely as possible the motion experienced on the engine.

9.4.4.2 Set the vibration machine controls to obtain vibration amplitude of 0.76 mm with a frequency varied from 10-50-10 Hz once per minute, or as otherwise specified.

9.4.4.3 Connect pressure line to filter assembly and adjust to obtain 480 kPa or as specified.

9.4.4.4 If it is desired that the filter be tested at resonant frequency, the frequency cycling controls can be shut off and the test conducted continuously at the filter's resonance frequency as determined by a measurement of filter amplitude versus frequency.

9.4.5 Test Procedure

9.4.5.1 Pressurize filter and begin cycling at time zero.

9.4.5.2 Observe motion of filter using a stroboscopic light if required. The acceleration of the filter during test may be measured using an accelerometer coupled to a vibration meter.

9.4.5.3 The ultraviolet light source may be used to examine the filter for leaks during the test, as the test fluid will fluoresce.

9.4.5.4 Continue the test until the filter fails or the specified number of test hours has been completed. 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 mountings, which would render it unacceptable for further use.

9.4.6 Presentation of Data

9.4.6.1 Report hours of failure and location and mode of failure. If there is no failure in the required test period, report this.

9.4.6.2 Completely report all other test conditions.

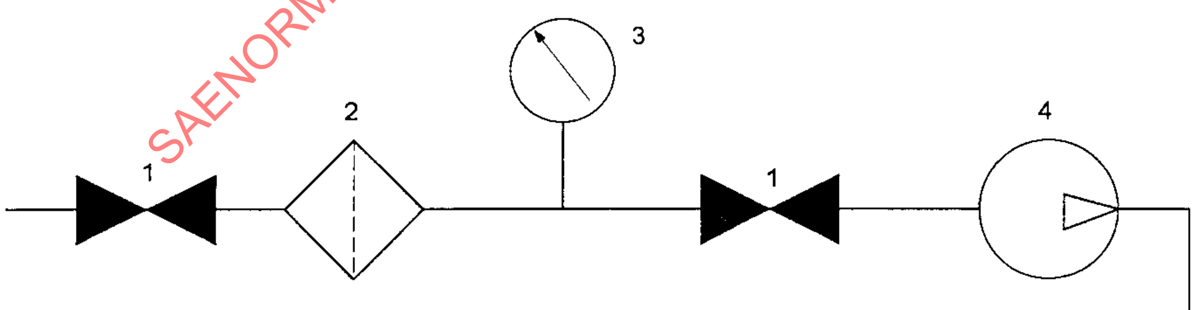
9.5 Vacuum Test

9.5.1 Scope

This test determines the ability of the filter to maintain vacuum, as required by systems with the filter in the suction line.

9.5.2 Test Apparatus

See Figure 11.



1. Valve
2. Test filter
3. Vacuum gauge
4. Vacuum pump

FIGURE 11 - VACUUM TEST APPARATUS