



SURFACE VEHICLE RECOMMENDED PRACTICE

J1488™

NOV2024

Issued 1985-06
Revised 2024-11

Superseding J1488 OCT2010

Emulsified Water/Fuel Separation Test Procedure

RATIONALE

SAE J1488 was revised to meet the SAE Five-Year Review requirements and includes improvements to the test method as defined by the SAE Filter Test Method Committee (FTMC). Changes made bring the document up to current practices and include experience gained since implementing the prior revisions. These changes include: the acceptable test fuel interfacial tension (IFT) range has been reduced, the test fuel pre-treatment procedure has been refined, water content measurements were further clarified to parts per million by volume (ppmv), and comments regarding the use of biodiesel test fuels have been added.

FOREWORD

Water in fuels is one of the major causes of diesel engine maintenance problems. The effects of water in fuel are characterized by corrosion of fuel system parts, plugging of filters and orifices and, in some cases, failure of fuel injection equipment. Water in fuel often dissolves sulfur compounds, becomes acidic, and enhances corrosion in fuel injection systems, as well as in the engine itself. The presence of water also encourages microbiological growth, which generates orifice and filter restricting sludge. Further, due to displacement of fuel lubrication in close tolerance injector parts, and rapid expansion of heated water at the fuel injector tip, galling and more serious failures may also occur.

During transportation, transfer, and storage of fuel, water may become entrained in a variety of ways. The mode and timing of water entry in the handling sequence before use, as well as the chemistry of the fuel itself (additives and surfactants), will determine what form the contaminant takes. In systems where water and fuel pass through high shear pumps, fuel/water interfacial tension is relatively low, and settling time is minimized, fine emulsions may predominate. In systems where water enters before or after low shear pumps, or where there is a prolonged settling time in high interfacial tension fuel, larger water droplets may predominate. In some systems, both fine emulsions and large droplets may be present simultaneously. Generally, fine emulsions are more likely to predominate on the pressure side of high shear pumps, whereas larger water droplets are more likely to predominate on the suction side of pumps. (A water removal test procedure designed for applications where large water droplets predominate is also recommended. This procedure is given in SAE J1839.)

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The following test procedure is relevant to finely dispersed or emulsified water separation devices whether applied on the suction or discharge side of engine fuel transfer pumps. This procedure recommends pressure side location of the test unit for ease and convenience of testing only. The procedure is well suited to lower flow rates, although it may be applied with due caution to flow rates up to 100 L/min using parallel emulsion generating circuits. It has been designed to approximate field conditions in a practical manner. A 3500-rpm centrifugal pump is used to disperse water in the fuel, simulating most fuel loading pumps. The test fuel may be an actual fuel sample (with additives) that is to be used in the field, or it may be No. 2 fuel oil that has been clay treated (conditioned) so as to enable equal and reproducible laboratory comparisons of various test devices. Additionally, a fluid simulating a representative biodiesel is recommended, as biodiesel has been established as being particularly problematical for controlled water separation and water separation testing. Test fuel conditioning is recommended for laboratory comparisons only, as this treatment may yield water removal efficiency results, which are significantly different from those obtained using water separating devices in untreated fuel or biodiesel. Furthermore, testing unused "clean" water separators may provide water removal efficiencies that are far superior to those obtained from the same water separators after very short exposure to natural fuel and natural fuel contaminants.

1. SCOPE

To determine the ability of a fuel/water separator to separate emulsified or finely dispersed water from fuels. This test method is applicable for biodiesel fuel.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue 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 +1 724-776-4970 (outside USA), www.sae.org.

SAE J1839 Coarse Droplet Water/Fuel Separation Test Procedure

2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D971 Test Method for Interfacial Tension of Oil Against Water by the Ring Method

ASTM D4176 Test Method for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedure)

ASTM D6304 Test Method for Determination of Water in Petroleum Products, Lubricating Oils, and Additives by Coulometric Karl Fischer Titration

ASTM D7261 Standard Test Method for Determining Water Separation Characteristics of Diesel Fuel by Portable Separometer

3. TEST APPARATUS

A test system, as illustrated in Figure 1. This system generates test emulsion populations in ultra-low sulfur diesel fuel (IFT 16 to 18 mN/m). Test droplet size distribution in this procedure is controlled for changes in test flow rate at recommended interfacial tensions but may vary significantly in test fuels where interfacial tension is not controlled.

A test system, as illustrated in Figure 1, is to include:

- 3.1 A corrosion-resistant fuel container. If using a flat bottom container, ensure the fuel outlet is not less than 4 cm from the bottom of the container.

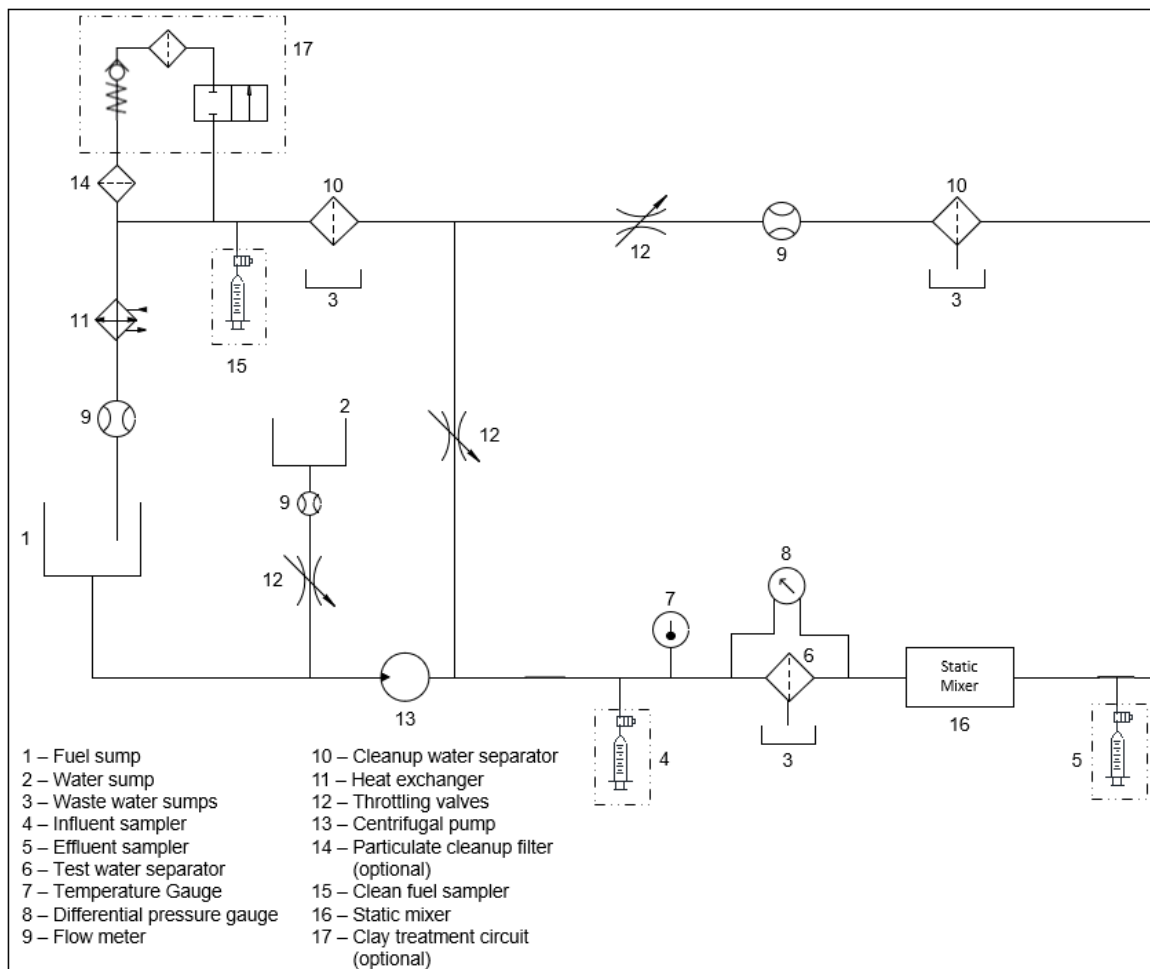


Figure 1 - Test system

- 3.2 A 3500 rpm $\pm$ 100 rpm, 1 hp centrifugal pump, Xylem Gould's model 1ST 1E_D4. The underscore represents the motor type. Motor type will have no effect on testing if it is operated at the specified 3500 rpm speed.
- 3.3 Fuel flow meter capable of measuring with an accuracy better than or equal to $\pm 5\%$ of the set flow rate.
- 3.4 Temperature indicator with an accuracy of ± 1.5 °C.
- 3.5 A cleanup water separator assembly such that not more than 50 ppmv higher than beginning of test dissolved water (see Appendix B) concentration values is recycled on an average basis under test conditions.
- 3.6 A corrosion-resistant water sump with an approximate capacity of 19 L.

- 3.7 Water flow meter with a flow regulating valve or a pump capable of a range from 0 to 100 mL/min (or as required) with an accuracy of $\pm 5\%$ of the set flow rate.
- 3.8 Automatic Karl Fischer coulometric titration apparatus for water content analysis.
- 3.9 In-line system static mixer to ensure emulsification of test fluid prior to effluent water sampler. Full flow must pass through the mixer.
- 3.10 The fuel/water separation stand's pipe should create an average flow velocity equal to or greater than 0.72 m/s. Any non-rusting and non-reacting pipe material may be used.
- 3.11 A differential pressure gauge with an accuracy of $\pm 5\%$ and a resolution of 340 Pa is recommended.
- 3.12 Syringe sampler in accordance with Figure 2. Note that the influent sampler does not have an in-line mixer, while the effluent sampler does. This is because the water at the influent section is emulsified and an in-line mixer at this point is not needed. The syringe sampler may be replaced with a beaker or vial to collect the sample. The sample should be sealed and sonicated before Karl Fischer analysis.

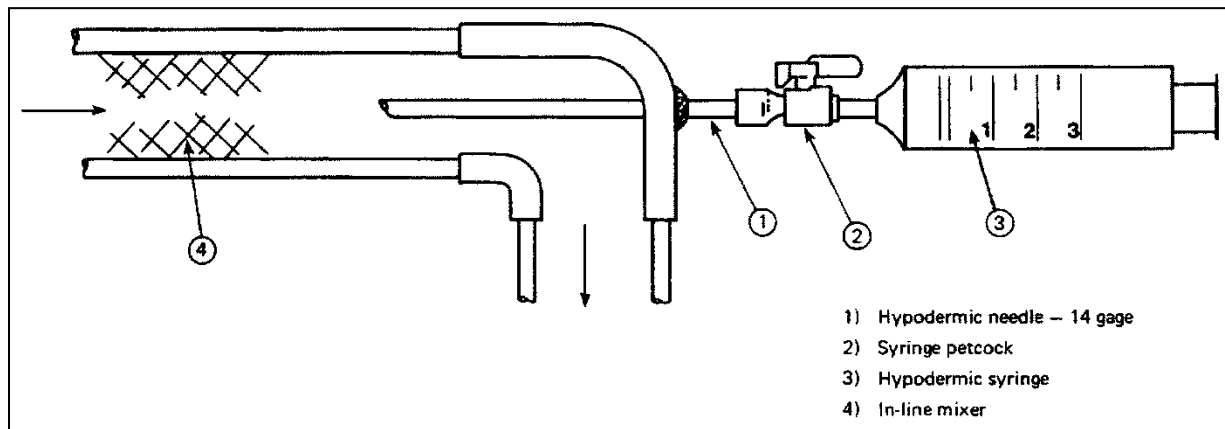


Figure 2 - Effluent sampler

- 3.13 Temperature control system capable of maintaining test temperature as specified in 5.2.
- 3.14 Double pipe heat exchanger (cooling and heating, if required) with fuel in the tube side. This should be a single pass, single tube, double pipe exchanger. If adequate cooling can be accomplished after the cleanup fuel/water separator (see Figure 1), then any type of heat exchanger may be used.
- 3.15 Fuel/water interfacial tension measuring device. A platinum ring detachment method (refer to ASTM D971) is recommended, although other correlatable methods may be used.
- 3.16 For testing at flow rates greater than 25 L/min it is required that separate emulsion generating circuit(s) with a common sump are connected in parallel to generate the emulsions for the test circuit.

4. TEST MATERIALS

4.1 Test Fluid

Since commercially available diesel fuel oil (particularly biodiesel) contains highly variable constituents that can significantly influence the outcome of emulsion removal testing, the test oil type should be categorized and recorded as one of the following:

- a. A sample of the fluid used in the application, as defined by user, to include biodiesel fuels
- b. Specially treated fluid, per Appendix A