



Standard Test Method for Determination of Water Separation Characteristics of Aviation Turbine Fuel by Small Scale Water Separation Instrument¹

This standard is issued under the fixed designation D8073; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers a procedure to rate the ability of aviation turbine fuels to release entrained and emulsified water when passed through a water-coalescing filter.

1.2 Results are expressed as a Water Separation Index (WSI).

1.3 The values stated in SI units are to be regarded as standard.

1.3.1 *Exception*—Units in WSI are included.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards*:²

[D1655 Specification for Aviation Turbine Fuels](#)

[D2550 Method of Test for Water Separation Characteristics of Aviation Turbine Fuels \(Withdrawn 1989\)](#)³

[D3602 Test Method for Water Separation Characteristics of Aviation Turbine Fuels \(Withdrawn 1994\)](#)³

[D3948 Test Method for Determining Water Separation Characteristics of Aviation Turbine Fuels by Portable Separometer](#)

[D4057 Practice for Manual Sampling of Petroleum and Petroleum Products](#)

[D4177 Practice for Automatic Sampling of Petroleum and Petroleum Products](#)

[D4306 Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination](#)

[D7224 Test Method for Determining Water Separation Characteristics of Kerosine-Type Aviation Turbine Fuels Containing Additives by Portable Separometer](#)

3. Terminology

3.1 *Definitions*:

3.1.1 *surfactant, n*—in petroleum fuels, surface active material (or surface active agent) that could disarm (deactivate) filter separator (coalescing) elements so that free water is not removed from the fuel in actual service.

3.1.1.1 *Discussion*—Technically, surfactants affect the interfacial tension between water and fuel, which affects the tendency of water to coalesce into droplets.

3.2 *Definitions of Terms Specific to This Standard*:

3.2.1 *sonicator, n*—a device that applies ultrasonic sound energy to the test specimen.

3.2.1.1 *Discussion*—The sonicator is used to emulsify the water and aviation fuel.

3.2.2 *water separation index (WSI), n*—a numerical rating indicating the ease of separating water from fuel by coalescence.

3.2.2.1 *Discussion*—A high WSI indicates a fuel that separates water easily and is relatively free from surfactants.

4. Summary of Test Method

4.1 A fixed volume of test specimen is poured into the test beaker. The apparatus is purged with the test specimen. A precise amount of water containing a specific dye is added to the test beaker. The test specimen and dyed water are emulsified using a sonicator. The resulting emulsion is passed at a constant rate directly to the detector, which is sensitive to the dye, to measure a reference value. The emulsion is then passed at the same constant rate to the detector by means of a filter cartridge that is designed to remove entrained water. Readings from the detector are taken. The water separation characteristic, the Water Separation Index (WSI), is calculated from the reference value and the detector readings. Results range from 0.0 WSI to 100.0 WSI. A high value such as

¹ This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.J0.05 on Fuel Cleanliness.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ The last approved version of this historical standard is referenced on www.astm.org.

100.0 WSI indicates a test specimen that coalesces water easily and that the test specimen is relatively free of surfactants.

5. Significance and Use

5.1 This test method provides an indication of the presence of surfactants in aviation fuel. Like Test Methods [D2550](#), [D3602](#), [D3948](#), and [D7224](#), this test method can detect carryover traces of refinery treating residues in fuel as produced. In addition, these test methods can detect surface active substances added to or picked up by the fuel during handling from point of production to point of use. Certain additives can affect the WSI. Some of these substances affect the ability of filter separators to separate free water from the fuel.

5.2 The small scale water separation tester has a measurement range from 0.0 WSI to 100.0 WSI.

NOTE 1—WSI values greater than 100.0 WSI can be caused by a reduction in the light transmittance (see [A1.1.5](#)) of the test specimen due to material that was removed during the testing process.

5.3 This test method was developed so refiners, fuel terminal operators, pipelines, and independent testing laboratory personnel can rapidly and precisely measure for the presence of surfactants, with a minimum of training, in a wide range of locations.

6. Apparatus

6.1 *General*—The apparatus, as detailed in [Annex A1](#), comprises a test beaker, test beaker holder, sonicator, filter cartridge, specific dye detector, integral computer, automatic solenoid valves, pumps, solvent container, waste container, particulate sieve, and temperature probe.

6.2 *Pipet*, single use, disposable, of suitable size.

6.2.1 The single use disposable pipet is used to adjust the volume of test specimen in the test beaker to 220 mL \pm 10 mL.

7. Reagents and Materials

7.1 *Dyed Water*⁴—Proprietary liquid containing water and a controlled amount of specific marker dye.

7.2 *Reference Materials*:

7.2.1 *Dispersing Agent*—Toluene solution containing 1 mg/mL of solid (100 % dry) bis-2-ethylhexyl sodium sulfosuccinate.

7.2.2 *Reference Fluid Base*—A surfactant-free aviation turbine fuel that is used to verify proper operation and is prepared in the manner detailed in [Appendix X1](#) and with a WSI by this test method of 97.5 WSI to 100.0 WSI.

7.2.3 *Reference Fluids*—For checking operational performance consisting of dispersing agent (7.2.1) added to reference fluid base (7.2.2) in concentrations, on a volume basis, ranging from 0 mL/L to 0.8 mL/L, in 0.1 mL/L increments. Reference fluids may be made up in situ in the graduated beaker on an ad-hoc basis, or supplied pre-made up in a suitable container. Typical values are shown in [Table 1](#).

⁴ The sole source of supply of the dyed water known to the committee at this time is Stanhope-Seta/D-2 Incorporated, Falmouth, MA. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,¹ which you may attend.

TABLE 1 Reference Fluid Dispersing Agent Concentrations

Concentration (mL/L)	WSI
0	100.0
0.2	97.6
0.4	79.8
0.6	75.4
0.8	68.8

7.3 *Cleaning Materials*, technical grade.

7.3.1 *Isopropyl Alcohol*.

7.4 *Filter Cartridge*, see [A1.1.11](#), individually packed.

8. Sampling and Test Specimen Preparation

8.1 Unless otherwise agreed, samples shall be taken in accordance with Practice [D4057](#) or Practice [D4177](#).

8.2 Collect the sample directly in a suitable container of a minimum volume of 1000 mL.

NOTE 2—The test method is known to be sensitive to trace contamination, for example from sampling containers or transfer glassware. For recommended sampling containers, refer to Practice [D4306](#).

8.2.1 Epoxy-lined containers shall be visually inspected to ensure that the lining has not been damaged and that the containers are not dented.

8.3 Do not pre-filter the sample as the filter media can remove the surfactants that the test method is designed to detect. If the test fuel contains particulate, then allow such materials to settle out before sub sampling.

8.4 Special precautions concerning sampling techniques are discussed in [Appendix X2](#). Wipe the container outlet thoroughly with a clean, lint-free wipe. Take extreme care when pouring the sample directly into the test beaker to avoid contamination from the top of the container.

8.5 If the sample for test is not within the temperature range 18 °C to 29 °C, then allow the sample to stand until it is within this range.

9. Preparation of Apparatus

9.1 *General*—Follow the manufacturer’s instructions for the correct set up, verification, calibration, and operation of the apparatus.

9.2 *Location of Apparatus*—Locate the apparatus on a solid surface in a well-ventilated area.

9.3 *Filter Cartridge*—At the beginning of each test, replace the filter cartridge and wipe the sample inlet tube, thermometer probe, and sonicator with a clean, lint-free wipe.

9.4 *Test Beaker*—Before each test, ensure that the test beaker is clean and dry.

NOTE 3—To avoid contamination, it is recommended to use a new test beaker for each test.

9.5 *Cleaning Solvent*—Check visually that there is sufficient isopropyl alcohol available in the solvent reservoir.

9.6 *Dyed Water*—Check visually that there is sufficient dyed water in the water reservoir to cover the inlet tube.

9.7 Switch on the apparatus in accordance with the manufacturer’s instructions.

9.8 Purge the dyed water into a waste container to remove trapped bubbles of air in accordance with the manufacturer's instructions.

10. Calibration, Verification and Standardization

10.1 Follow the manufacturer's instructions for verification and calibration of the mechanical and electronic systems in the apparatus.

10.2 Verification:

10.2.1 *Flow Rate*—Verify that the flow rate is 25 mL/min to 30 mL/min, at least once every six months according to the manufacturer's instructions. If the flow rate is not correct, follow the manufacturer's instructions to diagnose and adjust.

10.2.2 *Water Volume*—Verify that the correct volume of dyed water (0.060 mL \pm 0.005 mL) is dispensed following the manufacturer's instructions.

10.2.3 *Temperature Probe Calibration*—verify the temperature at 20 °C following the manufacturer's instructions. Recalibrate the temperature probe if the temperature measurement is not within 1 °C.

10.2.4 *Overall Operation*—Check the overall operation of the apparatus using a reference fluid containing 0.4 mL/L of dispersing agent, and with reference fluid containing 0 mL/L dispersing agent as required for quality control or at least every six months. Test the reference fluid following the procedure detailed in Section 11. Confirm that the value is between 75.0 WSI and 85.0 WSI for the 0.4 mL/L dispersing agent and between 97.5 WSI and 100.0 WSI for the 0 mL/L dispersing agent.

11. Procedure

11.1 Refer to the diagram for a description of the apparatus ([Appendix X1](#)).

11.2 Load a new filter cartridge into the holder.

11.3 Wipe the sonicator and inlet tube using a lint-free wipe.

11.4 Gently tumble the test specimen in its original container end over end five times.

11.5 Pour 220 mL \pm 10 mL of test specimen into a clean test beaker—if required, adjust the volume with a single use disposable pipet.

11.6 Put the test beaker into the test beaker holder on the apparatus.

11.7 Insert the inlet tube, sonicator and temperature probe—if required, wait for the temperature to be between 18 °C and 29 °C.

11.8 Press Start on the apparatus. The following steps occur automatically.

11.9 The test specimen is pumped into the apparatus to purge the previous sample.

11.10 An aliquot of dyed water, 0.06 mL \pm 0.01 mL, is added to the test specimen in the test beaker.

11.11 The sonicator cycles on and off for 3 min \pm 0.5 min to form a test specimen/dyed water emulsion.

11.12 The emulsion is pumped to the detector and on to the waste container. The detector reading is stored every second.

11.13 The detector is cleaned with isopropyl alcohol.

11.14 The emulsion is pumped through the filter cartridge and detector and then to the waste container.

11.15 The detector readings are stored continuously and the test is completed after 5.6 min \pm 0.2 min.

11.16 The result is automatically calculated and displayed.

NOTE 4—Users are advised to check that there is less than 50 mL (typical) left in the beaker at the end of the test.

12. Calculation

12.1 The Water Separation Index (WSI) is automatically calculated by an algorithm (Version 1.0) in the apparatus to the nearest 0.1.

13. Report

13.1 The test report shall contain at least the following information:

13.1.1 A reference to this standard.

13.1.2 All details necessary for complete identification of the product tested.

13.1.3 The result of the test (see Section 12) to the nearest 0.1.

13.1.4 Any deviations, by agreement or otherwise, from the procedures specified, and

13.1.5 The time and date of the test.

14. Precision and Bias

14.1 *General*—The precision values given in 14.2 and 14.3 were derived from a 2015 laboratory study that used eight instruments and individual operators at a single location, to test 16 samples in duplicate and in random order. The calculation method that converts individual detector readings into the final result was improved after the ILS. Further details are available in the research report.⁵

14.1.1 As the precision was determined from results obtained at a single location, the reproducibility may not be comparable when results obtained at different times and locations are compared, due to sampling, shipping, storage, and environmental factors. In practice, two results obtained from different locations would be within test method precision if their absolute difference did not exceed the published reproducibility.

14.1.2 The precision was obtained by statistical examination of the laboratory study test results according to ISO 4259(D6300) using ADJ6300 D2PP.

14.2 *Repeatability*—The difference between successive test results obtained by the same operator with the same apparatus under constant operating conditions on nominally identical test material would, in the normal and correct operation of the test method, exceed the value below only in one case in 20:

⁵ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1843. Contact ASTM Customer Service at service@astm.org.

$$\text{Repeatability} = 0.35 \cdot (105.66 - x) \text{ WSI} \quad (1)$$

where:

x = the average of the results being compared.

14.2.1 See **Table 2** for a tabular illustration and **Appendix X3** for a graphical illustration of this relationship.

14.3 *Reproducibility*—The difference between two test results independently obtained by different operators using

different apparatus on nominally identical test material would, in the normal and correct operation of the test method, exceed the value below only in one case in 20:

$$\text{Reproducibility (R)} = 0.41 \cdot (105.66 - x) \text{ WSI} \quad (2)$$

where:

x = the average of the results being compared.

14.3.1 See **Table 2** for a tabular illustration and **Appendix X3** for a graphical illustration of this relationship.

14.4 *Bias*—The procedure in this test method has no bias because the value of WSI is defined only in terms of this test method.

TABLE 2 Calculated Values for Repeatability and Reproducibility for Typical WSI Values

WSI	Calculated Repeatability (WSI)	Calculated Reproducibility (WSI)
100.0	2.0	2.3
90.0	5.5	6.4
80.0	9.0	10.5
70.0	12.5	14.6
60.0	16.0	18.7

15. Keywords

15.1 aviation fuel; AVTUR; surfactant; water separation; WSI

ANNEX

(Mandatory Information)

A1. APPARATUS DETAILS

A1.1 *General*—The apparatus⁶ as shown is self contained and operates automatically to measure the water separation index (WSI).

A1.1.1 *Sonicator*, 40 kHz Ultrasonic mixer to emulsify the water and test specimen.

A1.1.2 *Test Specimen Pump*, with the capacity to pump up to 40 mL/min (± 1 mL/min) with the ability to be controlled to a flow rate of 25 mL/min to 30 mL/min to pump the test specimen into the apparatus.

A1.1.3 *Water Pump*, 5 μL (± 1 μL) per revolution—to dispense the dyed water into the test specimen.

A1.1.4 *Solvent Pump*, with the capacity to pump up to 40 mL/min (± 1 mL/min) to dispense solvent to clean the detector.

A1.1.5 *Specific Dye Detector*, the detector measures the total fluorescence of a dye. The detector is tuned to be sensitive to the specific target dye contained in the applied dyed water.

A1.1.6 *Solenoid Valves*, to divert flow through the filter cartridge.

A1.1.7 *Waste Container*, to collect the test specimen and cleaning solvent after measurement.

A1.1.8 *Solvent Container*, to dispense solvent to the apparatus.

A1.1.9 *Temperature Probe*, platinum resistance thermometer to measure the sample temperature, capable of measuring temperature within 0.5 °C.

A1.1.10 *Test Beaker Holder*, to support the test beaker during the test.

A1.1.11 *Filter Cartridge*,⁶ containing a proprietary filter material, to remove water from the emulsified sample.

A1.1.12 *Test Beaker*,⁶ graduated 250 mL, accuracy ± 1 %, domed at the bottom (see **Fig. A1.3**).

A1.1.12.1 *Discussion*—The emulsification performance is critically dependent on the shape of the bottom of the beaker.

A1.1.12.2 *Discussion*—It is recommended that a new beaker is used for product certification testing.

A1.1.13 *Particulate Sieve*, to prevent large particles damaging the pump and solenoid valves.

⁶ The sole source of supply of the apparatus, beaker and filter cartridge, known to the committee at this time is Stanhope-Seta/D-2 Incorporated, Falmouth, MA. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee which you may attend.

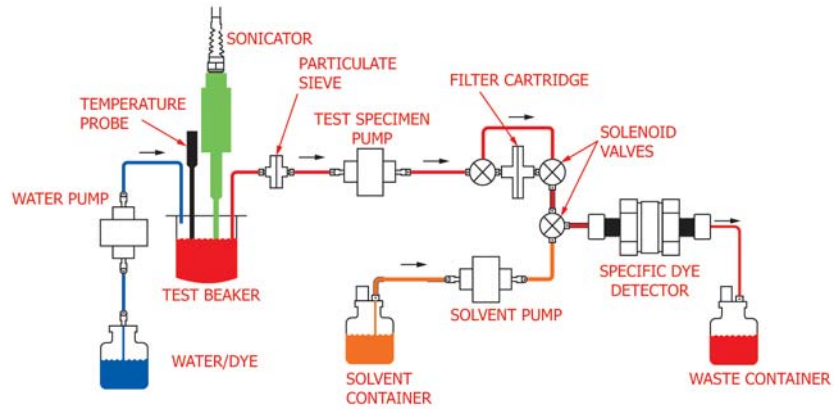


FIG. A1.1 Schematic Diagram of Water Separability Instrument

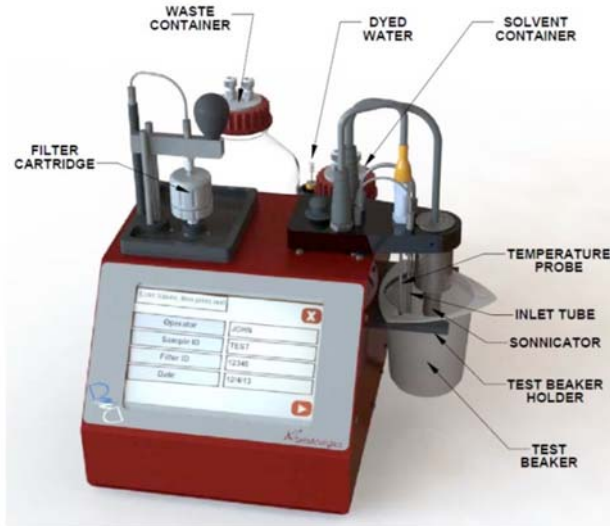


FIG. A1.2 Apparatus Exterior

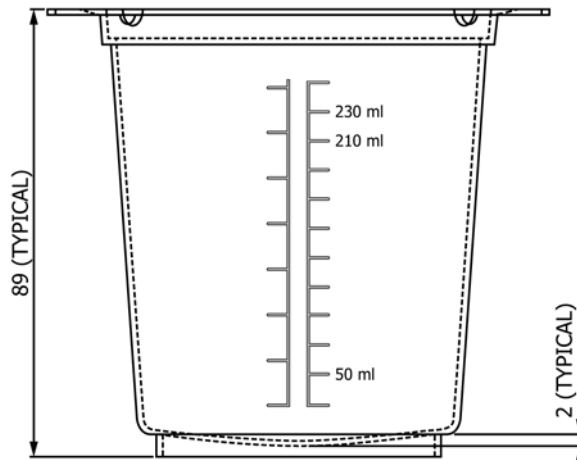


FIG. A1.3 Test Beaker

APPENDIXES
(Nonmandatory Information)
X1. PREPARATION OF REFERENCE FLUID BASE
X1.1 Scope

X1.1.1 This procedure describes the preparation within an 8 h day of a 20 L lot of reference fluid base. This procedure has been found to give a filtrate having a WSI of 100 WSI.

X1.2 Summary of Procedure

X1.2.1 A fuel is flowed at a constant rate through a fresh column of granular clay and collected in a clean storage receiver. The fuel should be in accordance with Specification **D1655** Jet A or Jet A-1.

X1.3 Apparatus

X1.3.1 *Glass Column*, containing a sealed-in coarse fritted glass disk near the bottom and with a 4 mm metering type TFE-fluorocarbon stopcock outlet at the bottom. The inside diameter of the column is 55 mm to 65 mm, and the length above the fritted disk shall be at least 1 m.

X1.3.2 *Siphon*, glass tubing having an outside diameter of 5 mm to 10 mm with the legs 100 mm to 150 mm apart. The suction leg shall be 380 mm to 400 mm long to reach the bottom of the feed container. The other leg shall be 50 mm to 100 mm longer.

X1.3.3 *Feed Container*, a standard square or round 20 L can in which the sample is obtained.

X1.3.4 *Receiver Can*, a new 20 L epoxy-lined can or one which has been used only with clay-filtered fuel. Plastic containers shall not be used.

X1.3.5 *Funnel*, with a 10 mm to 20 mm outlet.

X1.3.6 *Graduated Cylinder*, of 0.5 L to 1 L capacity.

X1.3.7 *Graduated Cylinder*, of 50 mL to 100 mL capacity.

X1.3.8 *Beaker*, 2 L capacity.

X1.4 Materials

X1.4.1 *Attapulugus Clay*, 30/60 mesh, LVM (calcined) grade or equal. Store the clay protected from atmospheric moisture and avoid handling that will cause particle size segregation.

X1.4.2 *Fine Glass Wool*.

X1.4.3 *Isopropyl Alcohol*, 99 %.

X1.4.4 *Toluene*, in a squeeze bottle. (**Warning**—Flammable. Vapor harmful.)

X1.4.5 *Water*, preferably distilled.

X1.4.6 *Salt*, rock salt or equivalent.

X1.5 Preparation of Apparatus

X1.5.1 Mount the column vertically.

X1.5.2 Measure approximately 500 mL of clay in the graduated cylinder, tapping gently to settle.

X1.5.3 Place the funnel on top, the column with its outlet centered. Quickly pour the clay into the funnel, aiming the funnel so that the clay falls in the center of the column. Remove the funnel and tap the column gently all around to settle and level the clay bed. Tamp a fist-sized wad of glass wool carefully down on top of the bed.

X1.5.3.1 When water washing of the fuel is required, place approximately 12.5 mm to 15.0 mm of salt on top of the wad of glass wool and then another wad of glass wool on top of the salt.

X1.6 Filtration Procedure

X1.6.1 Position a full 20 L feed container with its opening level with the top of the column. Remove the cap and insert the siphon, short leg in the can, longer leg in the column.

X1.6.2 Place the 2 L beaker under the column.

X1.6.3 Make sure the column stopcock is wide open. Put slight air pressure in the feed can to start the siphon. The glass wool packing should prevent the clay bed from being disturbed at startup.

NOTE X1.1—In a well-prepared column, the fuel may be seen to advance down the column in a nearly horizontal plane; no bubbles will rise through the clay. If the advancing front is tilted more than 45° or there is much bubbling, the quality of the percolation may be impaired.

X1.6.4 As soon as the fuel is flowing through the column outlet, adjust the metering screw to attain a rate of 50 mL/min to 60 mL/min. Check by measuring with the small graduated cylinder for 1 min or 2 min intervals.

X1.6.5 When at least 1 L has been collected, turn off the stopcock without disturbing the metering screw setting. Remove the beaker and support the 20 L receiver can under the column so that the outlet tube extends about 10 mm into the opening. Open the stopcock. Protect the opening from dirt.

NOTE X1.2—When percolating flammable fuel, seal between the outlet and receiver opening with aluminum foil, ground the receiver, and purge it with dry nitrogen before starting flow into it. A similar purge of the column before the step in **X1.6.3** is desirable.

X1.6.6 Recycle the beaker of filtrate to the feed can or discard it.

X1.6.7 When the level of fuel has dropped nearly to the top of the clay bed, turn off the stopcock, remove, and cap the receiver can.

X1.6.8 For lengthy storage, purge the receiver can with dry-nitrogen.

NOTE X1.3—At the specified flow rate, the 20 L percolation will be complete in 6 h to 6½ h running time.

X1.7 Clean the Column

X1.7.1 Drain the column.

X1.7.2 Dismount the column, open it over a solid waste can, and with the stopcock wide open, blow out the clay.

X1.7.3 With the column inverted over a liquid waste receiver, run alcohol from the squeeze bottle into the outlet. Tilt the column to rinse the entire disk area and the entire inside of the column. When the clay residue has been entirely rinsed out, disassemble and rinse the stopcock parts, dry and reassemble them, and blow the entire assembly dry.

X1.7.4 If the column still appears dirty, rinse it thoroughly with hot water, then with distilled water. Invert it and rinse as in X1.7.3 with alcohol, then with acetone and blow dry. This should seldom be necessary.

X2. SAMPLING TECHNIQUE

X2.1 For any test that seeks the presence of trace constituents, steps must be taken to ensure testing of a representative sample. Previous experience showed that flushing of the sampling container was most important. This indicates that trace amounts of surfactant material in aviation turbine fuels can be absorbed on, or desorbed from, metal surfaces. A suggested technique for taking samples follows; it has been found to give representative samples. Any similar approach should be satisfactory. The technique is shown here only as a guide to good practice.

X2.2 *Sample Container*—This should be a scrupulously clean metal can, preferably epoxy-lined or a glass bottle. The size will be governed by the number of replicate tests to be run. Alternately, containers recommended for aviation fuel testing in Practice D4306 can be used with the cleaning and use instructions as noted.

X2.2.1 *Sample Source*—Draw the sample from a moving stream of fuel whose source is removed from tank water bottoms by as great a distance as feasible.

X2.2.2 *Sample Line*—The line may consist of a short 6.4 mm to 12.7 mm diameter tube with its open end facing the moving stream. The other end (outside the pipe) should be equipped with a suitable shutoff valve and spout. In turbulent fuel streams, it has been determined that sampling taps flush with the pipe wall are satisfactory.

X2.2.3 *Taking the Sample*—Flush the sample line with at least 0.95 L of the fuel to be sampled. Open and close the sample valve several times. Rinse the sample can with three separate 0.95 L amounts of the fuel to be sampled. Include the cap and inner seal, if used, in the rinsing. Draw the sample and put the cap in place.

X3. REPEATABILITY AND REPRODUCIBILITY ILLUSTRATION

X3.1 See Fig. X3.1.

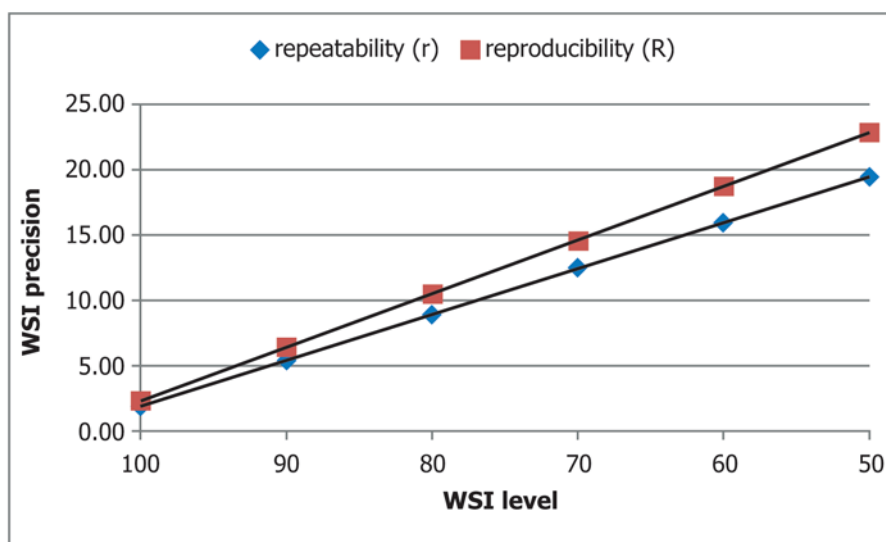


FIG. X3.1 Repeatability and Reproducibility for a Range of WSI Values

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