



Standard Test Method for Undissolved Water In Aviation Turbine Fuels¹

This standard is issued under the fixed designation D3240; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This test method covers the measurement of undissolved water in aviation turbine fuels in flowing fuel streams without exposing the fuel sample to the atmosphere or to a sample container. The usual range of test readings covers from 1 to 60 ppm of free water. This test method does not detect water dissolved in the fuel, and thus test results for comparable fuel streams can vary with fuel temperature and the degree of water solubility in the fuel.

1.2 *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. Terminology

2.1 *Definitions of Terms Specific to This Standard:*

2.1.1 *free water, n*—water not dissolved in the fuel.

2.1.2 *Free Water Independent of Pad Reader (FWIPR), n*—a calculated result which provides free water independent of test pad reader used for measurement. FWIPR equations were developed from the 2011 ILS data.²

3. Summary of Test Method

3.1 A measured sample of fuel is passed through an uranine dye-treated filter pad. Undissolved (free) water in the fuel will react with the uranine dye. When the pad is subsequently illuminated by ultraviolet (UV) light, the dye previously contacted by free water will fluoresce a bright yellow with the brightness increasing for increasing amounts of free water in the fuel. The light-illuminated pad is compared to a known

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 Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1804. Contact ASTM Customer Service at service@astm.org.

standard using a photocell comparator, and the free water in the fuel sample is read out in parts per million by volume. By varying the fuel sample size, the range of the test method can be increased.

4. Significance and Use

4.1 Undissolved (free) water in aviation fuel can encourage the growth of microorganisms and subsequent corrosion in the tanks of aircraft and can also lead to icing of filters in the fuel system. Control of free water is exercised in ground fueling equipment by use of filter-coalescers and water separators.

5. Apparatus

5.1 *Test Pad Rater (UV Source Device)*—A device^{3,4,5,6} for comparing the fluorescence of the test pad to a known standard, while both are illuminated by the same source of UV light, shall be used. The amount of UV light striking the standard shall be modulated until the total fluorescence of the test pad and the standard are equal; this shall be determined using a photocell bridge circuit null indicator. The light modulating device for controlling the UV light striking the standard shall provide a direct reading in parts per million by volume of free water.

³ The Aqua-Glo Series II instrument manufactured by Gammon Technical Products, Inc., P.O. Box 400, Manasquan, NJ 08736-0400 was used in the original precision test program (RR:D02-1195). The unit is currently available in a Series V configuration, which is changed only in the power supply. All water content measuring components remain of the same configuration as the Series II instrument. Manufacturers who wish to offer similar products are referred to Committee D02 Equipment Replacement Guidelines.

⁴ The sole source of supply of the apparatus known to the committee at this time is Gammon Technical Products Inc., P.O. Box 400, Manasquan, NJ 08736-0400.

⁵ The Digital Aqua-Glo (trademarked) instrument is manufactured by Gammon Technical Products, Inc., P.O. Box 400, Manasquan, NJ 08736-0400. At instrument start-up, the display of software version 5.0 indicates that the electronic settings of the prototype units utilized in the 2011 ILS are in use. Because the electronic settings were not optimized at the time of the 2011 ILS, these units are only permitted to display calculated FWIPR results. Gammon Technical Products is working toward ASTM approval of Digital Aqua-Glo instruments with optimized electronic settings.

⁶ 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.

*A Summary of Changes section appears at the end of this standard

5.2 *Test Pad Rater (LED Source Device)*—A device^{6,7} for rating the fluorescence of the test pad directly by illumination by a narrow band light source provided by colored LED's. The total fluorescence of the test pad is measured directly using a photo sensitive transistor. The intensity of the fluorescence measurement is converted by the device and shall provide a direct reading in parts per million by volume of free water.

5.3 *Test Pads*—Absorbent filter disks of 25 mm diameter shall be coated on one side with uranine (sodium fluorescein) dye at a concentration of 0.23 mg to 0.29 mg per 25 mm pad. The test pads^{4,8} shall be individually packaged in hermetically sealed envelopes or other suitable containers. Fresh, unused test pads shall have an orange color over the dyed surface. Any discoloration, unevenness in dye content, or faded (to a yellow color) appearance shall be cause for rejection.

5.4 *Test Pad Holder*^{4,9} and *Sampling Line*—A test pad holder and sampling line shall be used to draw the fuel sample through the test pad at a rate of 600 mL/min to 800 mL/min. Means shall be provided to flush the test pad sampling line and holder immediately prior to use. The test pad holder shall include an orifice of 1 mm (0.040 in.) diameter upstream of the pad to disperse water droplets in the fuel.

5.5 *Tweezers*—Suitable clean, dry tweezers shall be used at all times when handling the test pad.

5.6 *Blotting Paper*—Clean, dry, absorbent paper towels, blotters, etc., shall be provided for blotting the test pad prior to rating to remove excess fuel. The blotter paper shall neither impart color or stain nor leave any residue on the test pads.

5.7 *Sampling Valve Connection*, designed to meet the following requirements: (1) It shall be mounted in the sampling point and must incorporate a self-sealing quick action coupling designed to mate with a suitable connection leading to the selector valve of the sampling assembly. (2) It must be completely resistant to fuel and be leak proof up to the maximum working pressures to be encountered. (3) It must have a minimum of internal recesses which could cause the holdup of contaminant. (4) It must be provided with a dust cap.

5.8 *Calibrating Standard (UV Source Device)*—Field calibration of the instrument should be performed using a calibrating standard of known values.

5.9 *Calibrating Standard (LED Source Device)*—Factory calibration of the device shall be performed as prescribed in Section 8.

5.10 *Field Verification (LED Source Device)*—If the operation of the instrument needs to be verified, an unused pad may be inserted for reading; the value shall be less than 0.5 ppm. A reference target, available from the manufacturer, when inserted into the device shall read within the limits printed on the rear of the reference target.

⁷ The sole source of supply of the LED Source Device JF-WA1 instrument known to the committee at this time is manufactured by D-2 Incorporated, 19 Commerce Park Road, Pocasset, MA 02559. This instrument was used in a precision test program; reference Research Report RR:D02-1712.

⁸ Aqua-Glo test pads were used in the Precision Test Program.

⁹ A test pad holder was used in the Precision Test Program.

6. Sampling

6.1 The following procedure is applicable for dynamic line samples only; that is, taking the fuel sample directly from the test system and through the test pad without exposing the sample to the atmosphere or to a sample container. The use of sample containers such as bottles or cans for the temporary storage of the sample will result in large errors and is not recommended.

NOTE 1—The amount of free water in a sample is very sensitive to the temperature of the sample. The use of sample containers such as bottles or cans can result in large errors due to changes in sample temperature, adsorption of water on container walls, etc.

6.2 Attach the test pad holder assembly to the sampling port on the system.

6.3 Flush the test pad holder assembly immediately prior to sampling, displacing the sampling line with at least two volumes of test fuel.

6.4 Remove the sampling assembly, open the pad holder, and insert the new test pad using tweezers making sure that the treated side of the test pad is facing upstream. Installation of a three-way valve immediately upstream of the test pad holder will permit flushing with the test pad in place.

NOTE 2—Do not remove the test pad from the hermetically sealed package until ready for use. Do not allow any discrete water droplets to come into contact with the pad (from rain, sneezing, coughing, etc.). Exposure of the test pad to the atmosphere, especially on humid days, will also ruin the pad in a matter of minutes.

6.5 Pass 500 mL of fuel through the pad, accurately measuring the test sample quantity. Normal sample volume is 500 mL of test fuel, but if the reading is off scale (on high side), sample volumes down to 100 mL in volume may be used. In the latter case, a small graduated cylinder should be used to measure the sample volume.

6.6 Measure and record the temperature of the sample.

7. Calibration (UV Source Devices)

7.1 *Aqua-Glo*—The calibrating standard^{4,10} corresponding to a given undissolved water content is placed in the test pad window. Turn on the lamp and press the photocell comparator button. Zero the photocell comparator by adjusting the light modulating lever until there is a steady reading for 10 s to 15 s. This may take a minute or longer. Always move the light modulating lever in the same direction when zeroing the photocell comparator in calibration or testing to eliminate errors caused by play in the lever. If the reading obtained does not agree with the calibration pad rating, adjust the photocell comparator by removing the plug screw on the side of the photocell comparator at the 45° bend. Insert a small screwdriver, and adjust as necessary. Repeat the above procedure until the rating obtained agrees with the calibration pad rating. The instrument should be calibrated prior to use each day, after each hour of use, and when the ultraviolet light battery is replaced or recharged.

¹⁰ Replacement calibrating standards, but only if the fluorescing standard for the instrument is returned for comparison rating.

7.2 *Digital Aqua-Glo*—Internal calibration is conducted automatically prior to every test.

8. Calibration (LED Source Device)

8.1 The unit maintains a stable factory calibration for period in excess of one year due to the stability of the LED source and detector. Factory calibration should occur in accordance with the device manual, which is recommended on an annual basis. The JF-WA1 can be field calibrated using a calibration kit from the supplier, reference [Appendix X2](#) for details.

8.2 The JF-WA1 is provided with a verification shuttle. This shuttle has a standardized low and high reference source mounted on opposite sides. Insert the verification shuttle fully into the JF-WA1 shuttle slot; wait until a value is displayed (approximately 1 s to 2 s). Verify the value is the within the tolerance as marked on the verification shuttle. Remove the shuttle, turn over, and repeat for the second standard. Verify the second value is the within the tolerance as marked on the verification shuttle. If both values are within tolerance, the JF-WA1 is ready for use and will provide data in accordance with this method, consult [X2.1](#) for action if an out of tolerance condition is encountered.

9. Rating Procedure (UV Source Devices)

9.1 Remove the test pad from the sampling holder using tweezers and press between dry paper blotters or absorbent towels to remove excess fuel. To blot, press firmly (about 5 lb force) 3 or 4 times with heel of hand, moving the pad with tweezers each time.

9.1.1 For maximum accuracy the test pad should be read within 3 min after sampling is initiated. If the test pad is not read immediately after sampling, it must be placed in a desiccator to prevent moisture pickup from the air. However, ratings made on dried test pads, that is, not damp with fuel, should be avoided if possible since they will give high and erroneous results. Conversely, rating a pad which has not been well blotted will give a low reading as the excess fuel will absorb part of the UV light and decrease fluorescence.

9.2 *Aqua-Glo*:

9.2.1 Using tweezers, put the pad into the pad rating device. Turn on the lamp and press the photocell button. Continuously zero the photocell comparator by adjusting the light modulating lever until there is a steady reading for 10 s to 15 s. Always move the light modulating lever in the same direction when zeroing the photocell comparator to eliminate errors caused by backlash. This may take a minute or longer. Turn off the instrument light immediately after use to conserve battery power.

9.2.1.1 The ultraviolet light must be on to get a reading. This can be checked by moving the light modulating lever from one extreme to another. The photocell comparator meter needle should swing violently when this is done.

9.2.2 Record the instrument reading (estimated to the nearest tenth) and the sample volume. Record the temperature of the fuel.

9.2.3 Visual observation of the used test pad is often of value. This is easily accomplished by removing the photocell comparator assembly and viewing the test pad. Free water in

fuel is normally well dispersed and will form an even distribution of many, small points of yellow fluorescence on the test pad when illuminated by ultraviolet light. Large water drops, however, will form a few, large spots of yellow fluorescence on the pad. These large spots may give erroneous readings; the result should be disregarded and a new sample tested.

9.3 *Digital Aqua-Glo*:

9.3.1 Open instrument case and turn on by sliding the power switch to the left.

9.3.2 To test a sample, use the cursor up/down buttons to indicate "sample" on the instrument screen.

9.3.3 Press the Mode Select button, then follow instructions on the screen.

10. Rating Procedure (LED Source Device)

10.1 Remove the test pad from the sampling holder using tweezers and press between dry paper blotters or absorbent towels to remove excess fuel. To blot, press firmly (about 5 lb force) 3 or 4 times with heel of hand, moving the pad with tweezers each time.

10.1.1 For maximum accuracy the test pad should be read within 3 min after sampling is initiated. If the test pad is not read immediately after sampling, it shall be placed in a desiccator to prevent moisture pickup from the air. However, ratings made on dried test pads, that is, not damp with fuel, should be avoided if possible since they can give high and erroneous results.

10.2 Using tweezers, put the pad into the pad rating device shuttle. Slide the shuttle fully into its measurement slot in the front of the device.

10.3 Allow the unit to fully update (1 s to 2 s) after the shuttle is fully installed, record the instrument reading read from the front panel display in ppm. Report the result as displayed in ppm by volume of undissolved water in fuel, the sample volume used in the test, and the temperature of the sample when tested.

11. Calculation

11.1 The instruments read directly if the sample volume is 500 mL. Correct the readings for other sample volume by multiplying reading by 500/sample size in millilitres:

$$\text{Free water, ppm (volume corrected)} = \frac{\text{(meter reading, ppm)} (500)}{\text{(sample volume, mL)}}$$

12. Report

12.1 Report the result to the nearest whole number as ppm by volume of undissolved water in fuel, and also the sample volume used in the test. Report the temperature of the sample if available.

13. Precision and Bias²

13.1 The precision ([Note 3](#), [Note 5](#)) of this test method as determined by statistical examination of test results obtained by operator-instrument pairs at a common test site is as given in this section. Each operator used a separate instrument.

13.1.1 *Repeatability*—The difference between successive results obtained by the same operator with the same apparatus

under constant operating conditions on identical test material would, in the long run, in the normal and correct operation of the test method exceed the following values only in one case in twenty.

Aqua-Glo: Repeatability, $r = 0.4155 \times x^{0.8058}$ ppm
 Digital Aqua-Glo: Repeatability, $r = 0.3454 \times x^{0.5771}$ ppm
 JF-WA1: Repeatability, $r = 0.1591 \times x^{0.8784}$ ppm

where x = average of two results in parts per million volume over the range from 1 ppm V through 60 ppm V (Note 6).

13.1.2 *Reproducibility*—The difference between two single and independent results obtained by different operators working at a common test site on identical test material would, in the long run, exceed the following values only in one case in twenty.

Aqua-Glo: Reproducibility, $R = 0.5408 \times x^{0.8058}$ ppm
 Digital Aqua-Glo: Reproducibility, $R = 0.4070 \times x^{0.5771}$ ppm
 JF-WA1: Reproducibility, $R = 0.3691 \times x^{0.4997}$ ppm

NOTE 3—The repeatability and reproducibility values above were determined from results obtained at the same location and on the same day

by multiple operator/instruments testing identical samples. See Note 4. In the case of this test method, it is not possible to obtain meaningful results when fuels are shipped to different locations since water would separate during shipment.

NOTE 4—In this study, there were seven individuals rating the pads, seven JF-WA1 instruments, seven traditional Aqua-Glo instruments, and six Digital Aqua-Glo instruments.

NOTE 5—The presence of fuel additives such as corrosion inhibitors, fuel system icing inhibitors, and antistatic materials may affect the calibration of the test.

NOTE 6—Sample size was not found to be a significant factor in precision. Data were analyzed using a log transformation but the repeatability results are expressed in untransformed units.

13.1.3 *Bias*—Since there is no accepted reference material suitable for determining the bias for the procedure in Test Method D3240 for measuring the undissolved water in aviation turbine fuels, bias has not been determined.

14. Keywords

14.1 calibrating standard; fluorescence; fluorescing standard; free water; sodium fluorescein; undissolved water; uranine

APPENDIXES

(Nonmandatory Information)

X1. FWIPR EQUATIONS

X1.1 Free Water Independent of Pad Reader (FWIPR) equations developed from the 2011 ILS data for the Aqua-Glo and JF-WA1 test pad readers follow.²

Aqua-Glo: FWIPR = $0.971 \times x + 0.853$
 JF-WA1: FWIPR = $0.846 \times x + 0.523$

X2. USE OF VERIFICATION SHUTTLE FOR JF-WA1 PAD READER

X2.1 The JF-WA1 pad reader can be field recalibrated using the standardized shuttle and calibration kit available from the manufacturer.

X2.2 The standardization shuttle has two precision color references that simulate a low value and high value of free water as detected by the JF-WA1 instrument. Data from the unit as connected via the USB port combined with a software

program from the manufacturer can be used to adjust the internal electronically stored calibration values. Consult the user's manual and the manufacturer for complete details. Note the standardized shuttle is provided in a protective sleeve in which it should be maintained. The sleeve provides protection from color bleaching that might occur due to prolonged, direct exposure to sunlight.

SUMMARY OF CHANGES

Subcommittee D02.J0 has identified the location of selected changes to this standard since the last issue (D3240 – 101 that may impact the use of this standard. (Approved June 15, 2015.)

- (1) Added new subsection **2.1.2**.
- (2) Added new subsection **9.3**.
- (3) Revised subsections **13.1.1** and **13.1.2**.
- (4) Revised subsections **8.1** and **8.2**.
- (5) Revised **Note 3** and added **Note 4**.
- (6) Revised **Appendix X1**.
- (7) Added new **Appendix X2**.

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