Designation: D4308 – 21

An American National Standard

Standard Test Method for Electrical Conductivity of Liquid Hydrocarbons by Precision Meter[1]

This standard is issued under the fixed designation D4308; 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 and applies to the determination of the "rest" electrical conductivity of aviation fuels and other similar low-conductivity hydrocarbon liquids in the range from 1 pS/m to 2000 pS/m (see 3.1.2). This test method can be used in the laboratory or in the field.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 **WARNING**—Mercury has been designated by many regulatory agencies as a hazardous substance that can cause serious medical issues. Mercury, or its vapor, has been demonstrated to be hazardous to health and corrosive to materials. Use Caution when handling mercury and mercury-containing products. See the applicable product Safety Data Sheet (SDS) for additional information. The potential exists that selling mercury or mercury-containing products, or both, is prohibited by local or national law. Users must determine legality of sales in their location.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For specific warning statements, see 8.3 and Annex A1.

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D150 Test Methods for AC Loss Characteristics and Permittivity (Dielectric Constant) of Solid Electrical Insulation

D2624 Test Methods for Electrical Conductivity of Aviation and Distillate Fuels

D4306 Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination

E1 Specification for ASTM Liquid-in-Glass Thermometers

3. Terminology

3.1 *Definitions:*

3.1.1 *picosiemens per metre, n*—the unit of electrical conductivity is also called a conductivity unit (CU). A siemen is the SI definition of reciprocal ohm sometimes called mho.

$$1\ \text{pS/m} = 1 \times 10^{-12}\ \Omega^{-1}\ \text{m}^{-1} = 1\ \text{cu} = 1\ \text{picomho/m} \quad (1)$$

3.1.2 *rest conductivity, n*—the reciprocal of the resistance of uncharged fuel in the absence of ionic depletion or polarization. It is the electrical conductivity at the initial instant of current measurement after a dc voltage is impressed between electrodes.

4. Summary of Test Method

4.1 A sample of liquid hydrocarbon is introduced into a clean conductivity cell which is connected in series to a battery voltage source and a sensitive dc ammeter. The conductivity, automatically calculated from the observed peak current reading dc voltage and cell constant using Ohm's law, appears as a digital value in either a manual or automatic mode of meter operation.

5. Significance and Use

5.1 The generation and dissipation of electrostatic charge in fuel due to handling depend largely on the ionic species present

[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.J0.04 on Additives and Electrical Properties.

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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.

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

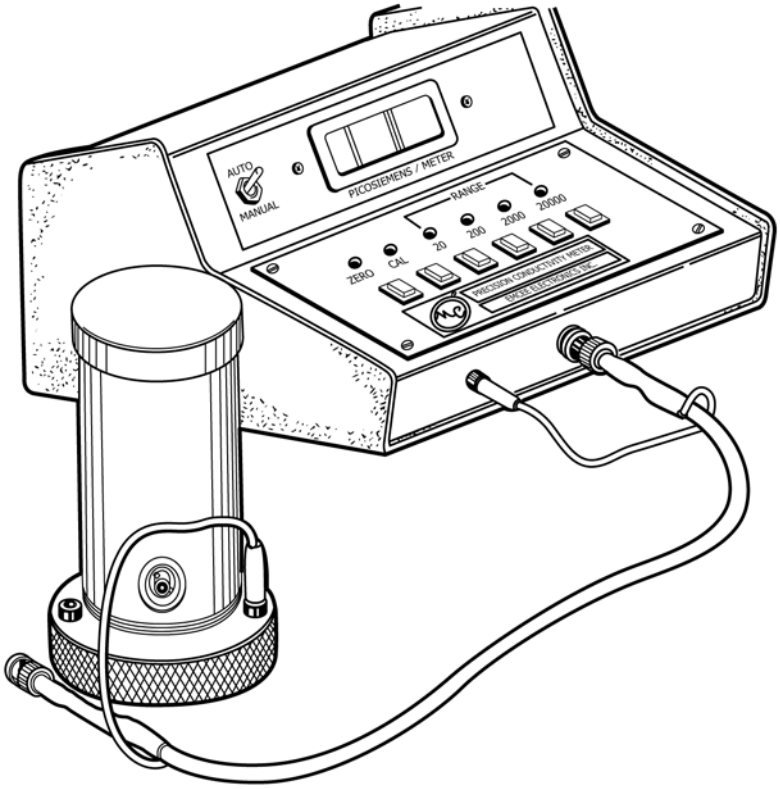

FIG. 1 Precision Conductivity Meter

which may be characterized by the rest or equilibrium electrical conductivity. The time for static charge to dissipate is inversely related to conductivity. This test method can supplement Test Method D2624 which is limited to fuels containing static dissipator additive.

NOTE 1—For low-conductivity fluids below 1 pS/m in conductivity, an ac measurement technique is preferable to a dc test method for sensing the electrical conductivity of bulk fluid.

6. Apparatus

6.1 *Conductivity Apparatus*—Components of the dc conductivity apparatus are shown in Fig. 1.[3]

6.1.1 The conductivity cell shown in Fig. 1 consists of an inner electrode and an outer electrode separated by an insulator. The outer electrode and cap provide a ground path and electrostatic (Faraday) shield.

6.1.2 The electrometer shown in Fig. 1 contains a battery which supplies a voltage to the cell and a bridge circuit which senses the flow of current and converts the output signal directly into conductivity units, that is, pS/m. A pushbutton selector allows selection of zero reading, calibration, and four range selections.

6.1.3 The cell and electrometer are connected by a triaxial cable as shown in Fig. 1.

6.2 *Thermometer,* general purpose type, having a range of 0 °C to 60 °C (see Specification E1). Temperature measuring devices that cover the temperature range of interest, such as an ASTM 1C thermometer, or liquid-in-glass thermometers, thermocouples, or platinum resistance thermometers that provide equivalent or better accuracy and precision than ASTM 1C thermometers may be used.

7. Reagents

7.1 *Cleaning Solvent,* isopropyl alcohol.

7.2 *Hydrocarbon,* for calibration. The dielectric constant must be known to ±5 % at the temperature of calibration.[4]

8. Sampling

8.1 The sample volume should be at least 0.7 L.

8.2 Use a clean epoxy-lined can, a new glass bottle, a new polytetrafluoroethylene bottle, or a new high density polyethylene bottle.

NOTE 2—Test method results are known to be sensitive to trace contamination from sampling containers. For recommended sampling containers refer to Practice D4306.

NOTE 3—Bottle samples should be *tested immediately*, since the glass surface tends to absorb from the fuel the conductive substances that the test method is intended to measure.

8.3 Rinse the container at least three times with portions of the hydrocarbon liquid to be sampled. (When testing diesel or

[3] The sole source of supply of the apparatus, Precision Conductivity Meter System, Emcee Model #1154, known to the committee at this time is Emcee Electronics, Inc., 520 Cypress Ave., Venice, FL 34285. 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.

[4] A standard, such as cyclohexane, with certified dielectric constant, may be obtained from the National Bureau of Standards and Technology (NIST), Gaithersburg, Maryland.

FIG. 2 Cleaned Cell Attached to Meter

aviation turbine fuels Jet A or A-1, **Warning—**Combustible. Vapor harmful. See Annex A1.1.) (When testing gasoline, aviation gasoline, or aviation turbine fuel Jet B, **Warning—** Extremely flammable. Harmful if inhaled. Vapors can cause flash fire. See Annex A1.2.) If possible, fill the container, let stand, then empty and refill. Avoid taking the sample for test by pouring from the container; pipet instead. The sample should be clean and bright when tested.

9. Preparation of Apparatus

9.1 *Cleaning the Cell*—The cleaning procedure to be used depends on the estimated conductivity of the sample to be tested.

9.1.1 For samples that are expected to exhibit conductivities above 1 pS/m, the conductivity cell still assembled should be rinsed three times with cleaning solvent, followed by drying with compressed air.

9.1.1.1 After cleaning, check the cleanliness of the cell by attaching it to the instrument and depressing the 0 button. The value should be lower than 1 pS/m.

NOTE 4—If a cell has been used to test samples of high-conductivity, that is, more than 1000 pS/m, it may have to be disassembled for thorough cleaning.

10. Calibration and Standardization

10.1 *Checking the Test Equipment:*

10.1.1 Remove cell and cable from the meter.

10.1.2 Depress the 20 pS/m switch. The digital reading should indicate 0.00 pS⁄m ± 0.01 pS⁄m after 3 s. If readings exceed ±0.01 either adjust zero or record the zero error for calculating final report value.

10.1.3 Depress the calibrate switch. The digital reading should indicate 1000 pS⁄m ± 3 pS⁄m.

10.1.4 If low battery indicator is displayed during measure or calibration, the internal batteries should be replaced.

10.2 *Checking the Cell Constant:*

10.2.1 A check on the cell constant is necessary only if the cell has been damaged. Two capacitance measurements are required with a precision ac bridge. Make a rigid two-terminal connection between the cell assembly and the bridge. Measure the total capacitance, C_E (picofarad) of the empty assembly. Without disturbing the connection, add 100 mL of a hydrocarbon standard and measure the new total capacitance, C_S (picofarad) and the temperature in the cell. Alternatively, the cell can be sent to the manufacturer for recalibration.

10.2.2 Calculate the actual capacitance, C_A, of the empty cell as follows:

$$C_A = (C_S - C_E)/(k - 1) \quad (2)$$

where:

k = dielectric constant of the hydrocarbon at test temperatures.

10.2.3 Calculate the cell constant as follows:

$$K = 8.854/C_A \quad (3)$$

10.2.4 The cell constant of a new conductivity cell is 1.0. Because of its configuration, the cell constant cannot change significantly unless there is gross damage.

11. Procedure

11.1 Attach the cleaned cell to the meter as shown in Fig. 2.

11.1.1 Depress the ZERO switch, the digital reading should indicate the same value recorded in 10.1.2.

11.1.2 Depress the CAL switch, the digital reading should indicate 1000 ± 5.

11.1.3 Rinse the cleaned cell three times with the sample, empty completely, then fill the outer chamber until sample overflows into the center receptacle. (Alternatively, the outer chamber can be filled by pipet with 100 mL of sample).

NOTE 5—Allow static charges generated by handling the sample to dissipate.

11.1.4 If the sample conductivity is expected to be in a certain range, select the corresponding range position. When the conductivity is unknown, first check the fuel on a 2000 pS⁄m range position, then read in a lower scale if appropriate.

11.1.5 Using the AUTO mode, depress the appropriate RANGE switch. In the AUTO mode, the reading is stabilized after 3 s and held on display for 9 s. Record the pS/m value.

11.1.6 Repeat readings can be taken after a 1 min delay.

11.1.7 Remove the cell cover and measure the temperature of the test samples to the nearest 1 °C with a clean thermometer.

12. Report

12.1 The report is to include the following:

12.1.1 The conductivity of the sample in pS/m. Note MANUAL or AUTO mode.

12.1.2 Temperature of sample.

NOTE 6—It is recognized that the electrical conductivity of a fuel varies significantly with temperature and that the relationship differs for various types of aviation and distillate fuel. If it is necessary to correct conductivity readings to a particular temperature, each laboratory would have to establish this relationship for the fuels and temperature range of interest.

13. Precision and Bias[5]

13.1 The precision of this test method is based on ILS #1616 and obtained by statistical examination of test results in the range between 1 pS⁄m and 2000 pS⁄m by operator/instrument pairs at a common test site as described in ASTM Research Report RR:D02-2015.

TABLE 1 *r* and r^1 at Specific pS/m Levels for Information

pS/m	*r*	r^1
25	2.0	2.2
100	6.1	6.6
200	10.7	11.5
500	22.3	23.9
900	35.6	38.3
1300	47.8	51.4
1800	62.0	66.7

NOTE 7—The data used to determine the precision of this test method were obtained using the auto mode.

13.1.1 *Repeatability (r)*—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time that would be exceeded, in the long run, in the normal and correct operation of the test method, in only one case in 20.

13.1.1.1 Repeatability can be interpreted as the maximum difference between two results, obtained under repeatability conditions that is accepted as plausible due to random causes under normal and correct operation of the test method.

$$\text{Repeatability } (r) = 0.1543\ (X)^{0.8}$$

where *X* is the average of the two results.

13.1.2 *Reproducibility (R)*—The difference between two single and independent results obtained by different operators applying the same test method at different laboratories (this ILS was performed at a single laboratory) using different apparatus on identical test material that would be exceeded, in the long run, in the normal and correct operation of the test method, in only one case in 20.

NOTE 8—At the time of this update, ASTM Form and Style requires single site generated reproducibility to be labeled as Intermediate Precision (r^1).

$$\text{Intermediate Precision } (r^1) = 0.1659\ (X)^{0.8}$$

where *X* is the average of the two results.

13.2 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method, therefore no statement on bias is being made

[5] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-2015. Contact ASTM Customer Service at service@astm.org.

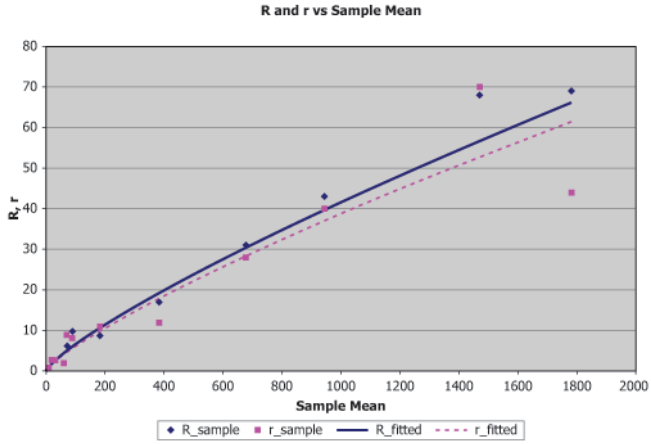

FIG. 3 Variation of Repeatabililty and Reproducibility with Conductivity Level

ANNEX

(Mandatory Information)

A1. WARNING STATEMENTS

A1.1 Aviation Turbine Fuel (Jet A or A-1)

A1.1.1 Keep away from heat, sparks, and open flame.
Keep container closed.
Use with adequate ventilation.
Avoid breathing vapor or spray mist.
Avoid prolonged or repeated contact with skin.

A1.2 Aviation Turbine Fuel (Jet B)

A1.2.1 Keep away from heat, sparks, and open flame.
Keep container closed.
Use with adequate ventilation.
Avoid buildup of vapors and eliminate all sources of ignition, especially non-explosionproof electrical apparatus and heaters.
Avoid breathing vapor or spray mist.
Avoid prolonged or repeated contact with skin.

SUMMARY OF CHANGES

Subcommittee D02.J0.04 has identified the location of selected changes to this standard since the last issue (D4308 – 13) that may impact the use of this standard (Approved Jan. 1, 2021.)

(1) Revised Note 1.
(2) Revised footnote 3.
(3) Revised Section 7, including deleting 7.1.1, 7.2, 7.2.1, 7.2.2, 7.2.3, and Note 2.
(4) Revised subsection 8.2.
(5) Revised Section 9, including deleting 9.1.1, 9.1.1.1, 9.1.1.2, 9.1.1.3, 9.1.1.1, 9.2, 9.2.1, and Note 6 (all other subsections revised).
(6) Revised subsection 10.2.4.
(7) Revised Note 5.
(8) Revised subsection 11.1.4.
(9) Deleted Section 12, Calculation and renumbered subsequent.
(10) Revised subsection 12.1.1.
(11) Replaced Section 13.
(12) Deleted subsections A1.1 and A1.2, and renumbered subsequent.