INTERNATIONAL

Designation: D3241 – 20c

Designation 323/20

Standard Test Method for Thermal Oxidation Stability of Aviation Turbine Fuels[1,2]

This standard is issued under the fixed designation D3241; 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 procedure for rating the tendencies of gas turbine fuels to deposit decomposition products within the fuel system.

1.2 The differential pressure values in mm Hg are defined only in terms of this test method.

1.3 The deposition values stated in SI units shall be regarded as the referee value.

1.4 The pressure values stated in SI units are to be regarded as standard. The psi comparison is included for operational safety with certain older instruments that cannot report pressure in SI units.

1.5 No other units of measurement are included in this standard.

1.6 *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 6.1.1, 7.1, 7.3, 12.1.1, and Annex A6.

1.7 *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:*[3]

D1655 Specification for Aviation Turbine Fuels

D4057 Practice for Manual Sampling of Petroleum and Petroleum Products

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

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

2.2 *ISO Standards:*[4]

ISO 3274 Geometrical Product Specifications (GPS)—Surface texture: Profile method—Nominal characteristics of contact (stylus) instruments

ISO 4288 Geometrical Product Specifications (GPS)—Surface texture: Profile method—Rules and procedures for the assessment of surface texture

2.3 *ASTM Adjuncts:*[5]

Color Standard for Heater Tube Deposit Rating

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *deposits, n*—oxidative products laid down on the test area of the heater tube or caught in the test filter, or both.

3.1.1.1 *Discussion*—Fuel deposits will tend to predominate at the hottest portion of the heater tube, which is between the 30 mm and 50 mm position.

3.1.2 *heater tube, n*—an aluminum coupon controlled at elevated temperature, over which the test fuel is pumped.

3.1.2.1 *Discussion*—The heater tube is resistively heated and controlled in temperature by a thermocouple positioned

[1] This test method is under the jurisdiction of ASTM International Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.J0.03 on Combustion and Thermal Properties. The technically equivalent standard as referenced is under the jurisdiction of the Energy Institute Subcommittee SC-B-8.

Current edition approved Dec. 1, 2020. Published December 2020. Originally approved in 1973. Last previous edition approved in 2020 as D3241 – 20b. DOI: 10.1520/D3241-20C.

[2] This test method has been developed through the cooperative effort between ASTM and the Energy Institute, London. ASTM and IP standards were approved by ASTM and EI technical committees as being technically equivalent but that does not imply both standards are identical.

[3] 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.

[4] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, http://www.iso.org.

[5] Available from ASTM International Headquarters. Order Adjunct No. ADJD3241. Original adjunct produced in 1986.

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

inside. The critical test area is the thinner portion, 60 mm in length, between the shoulders of the heater tube. Fuel inlet to the heater tube is at the 0 mm position, and fuel exit is at 60 mm.

3.2 *Abbreviations:*

3.2.1 *Δ*P—differential pressure.

4. Summary of Test Method

4.1 This test method for measuring the high temperature stability of gas turbine fuels uses an instrument that subjects the test fuel to conditions that can be related to those occurring in gas turbine engine fuel systems. The fuel is pumped at a fixed volumetric flow rate through a heater, after which it enters a precision stainless steel filter where fuel degradation products may become trapped.

4.1.1 The apparatus uses 450 mL of test fuel ideally during a 2.5 h test. The essential data derived are the amount of deposits on a heater tube, and the rate of plugging of a 17 µm nominal porosity precision filter located just downstream of the heater tube.

5. Significance and Use

5.1 The test results are indicative of fuel performance during gas turbine operation and can be used to assess the level of deposits that form when liquid fuel contacts a heated surface that is at a specified temperature.

6. Apparatus

6.1 *Aviation Fuel Thermal Oxidation Stability Tester*[6]—Five models of suitable equipment may be used as indicated in Table 1.

6.1.1 Portions of this test may be automated. Refer to the appropriate user manual for the instrument model to be used for a description of detailed procedure. A manual is provided with each test rig. (**Warning—**No attempt should be made to operate the instrument without first becoming acquainted with all components and the function of each.)

6.1.2 Certain operational parameters used with the instrument are critically important to achieve consistent and correct results. These are listed in Table 2.

[6] The following equipment, as described in Table 1 and RR:D02-1309, was used to develop this test method. The following equipment, as described in Table 1 and determined as equivalent in testing as detailed in RR:D02-1631, is provided by PAC, 8824 Fallbrook Drive, Houston, TX 77064. The following equipment, as described in Table 1 and determined as equivalent in testing as detailed in RR:D02-1728, is provided by Falex Corporation, 1020 Airpark Dr., Sugar Grove, IL, 60554-9585. This is not an endorsement or certification by ASTM International.

6.2 *Heater Tube Deposit Rating Apparatus:*

6.2.1 *Visual Heater Tube Rater (VTR),* the tuberator described in Annex A1.

6.2.2 *Standardization of Metrology Requirements:*

6.2.2.1 *Number of Measured Points*—1200 in the ratable area of the heater tube (between 5 mm and 55 mm above the bottom shoulder of the heater tube).

(1) Circumferential Resolution—(number of points measured on the heater tube circumference), 24 points equally spaced.

(2) Longitudinal Resolution—(number of points measured on the 50 mm ratable length of the heater tube), 50 points equally spaced.

6.2.2.2 *Standard Spot*—Thickest average deposit area described by either a 2×3 or 3×2 (longitudinal × circumferential) arrangement of adjoining thickness measurement points, amongst the 1200 measured by the metrology techniques.

6.2.3 *Interferometric (Heater) Tube Rater (ITR)*—the tuberator described in Annex A2.

6.2.4 *Ellipsometric (Heater) Tube Rater (ETR)*—the tuberator described in Annex A3.

6.2.5 *Multi-Wavelength Ellipsometric (Heater) Tube Rater (MWETR)*—the tuberator described in Annex A4.

6.3 Because jet fuel thermal oxidation stability is defined only in terms of this test method, which depends upon, and is inseparable from, the specific equipment used, the test method shall be conducted with the equipment used to develop the test method or equivalent equipment.

7. Reagents and Materials

7.1 Use methyl pentane, 2,2,4-trimethylpentane, or n-heptane as a general cleaning solvent. General cleaning solvent shall be 95 mol % purity, minimum. This solvent will effectively clean internal metal surfaces of apparatus before a test, especially those surfaces (before the heater tube test section) that contact fresh sample. (**Warning—**Extremely flammable. Harmful if inhaled (see Annex A6).)

7.2 Use a nylon bristle brush and trisolvent to clean internal (working) surface of heater tube test section only. Trisolvent is an equal mix of acetone (*1*), toluene (*2*), and isopropanol (*3*). All three components of trisolvent shall be 95 mol % purity, minimum. (**Warning—**(*1*) Extremely flammable, vapors may cause flash fire; (*2*) and (*3*) Flammable. Vapors of all three harmful. Irritating to skin, eyes, and mucous membranes.) Use a nylon bristle brush that makes stiff contact with the inner walls of the heater tube test section.

TABLE 1 Instrument Models

Instrument Model	Pressurize With	Principle	Differential Pressure by
230[A]	hydraulic	syringe	Transducer + Printout
240[A]	hydraulic	syringe	Transducer + Printout
230 Mk III[B]	hydraulic	dual piston (HPLC Type)	Transducer + Printout
F400[C]	hydraulic	dual piston (HPLC Type)	Transducer + Printout
230 Mk IV[D]	hydraulic	single piston (HPLC Type)	Transducer + Printout

[A] See RR:D02-1309.
[B] See RR:D02-1631.
[C] See RR:D02-1728.
[D] See RR:D02-1757.

TABLE 2 Critical Operating Characteristics of D3241

Item	Definition	
Test apparatus	Tube-in-shell heat exchanger as illustrated in Fig. 1 and dimensions in Fig. A5.1.	
Heater Tube:		
Heater tube [A, B, C, D, E]	Specially fabricated heater tube that produces controlled heated test surface; new one for each test.	
Heater Tube identification[E]	Each heater tube shall be physically identified with a unique serial number, identifying the manufacturer and providing traceability to the original material batch.	
Heater Tube metallurgy	6061-T6 Aluminum, plus the following criteria a) The Mg:Si ratio shall not exceed 1.9:1 b) The Mg_2Si percentage shall not exceed 1.85 %	
Heater Tube surface polish over circumference of center section	Rotational cut buffing technique with polishing compound to achieve mechanical surface finish.	
Heater Tube dimensions:	Dimension	Tolerance
Heater Tube length,[F] mm	161.925	±0.254
Center section length, mm	60.325	±0.051
Outside diameters, mm		
Shoulders	4.724	±0.025
Center section	3.175	±0.051
Inside diameter, mm	1.651	±0.051
Total indicator runout, mm, max	0.013	
Mechanical surface finish, nm, over circumference in center section in accordance with ISO 3274 and ISO 4288 using the mean of four 1.25–measurements	50 ± 20	
Test filter [6]	nominal 17 µm stainless steel mesh filter element to trap deposits; new one for each test	
Stainless Steel Mesh	Twilled Dutch Weave, 304 Stainless Steel, 165 × 1400 Mesh (tolerance; 4 % on 1400 and 2 % on 165) with Warp Diameter = 0.0028 in. and Shute Diameter = 0.0016 in.	
Instrument parameters:		
Sample volume	600 mL of sample is aerated, then 450 mL ± 45 mL of this aerated fuel shall be pumped during the heating phase for a valid test	
Aeration rate	1.5 L ⁄min dry air through sparger	
Flow during test	3.0 mL ⁄min ± 10 % (2.7 mL/min minimum to 3.3 mL/min maximum)	
Pump mechanism	positive displacement or piston syringe	
Cooling	bus bars fluid cooled to maintain consistent tube temperature profile	
Thermocouple (TC)	Type J, Inconel sheathed, or Type K, Inconel sheathed	
Operating pressure:		
System	3.45 MPa ± 10 % on sample by hydraulically transmitted force against control valve outlet restriction	
At test filter	differential pressure (ΔP) measured across test filter by electronic transducer in mm Hg	
Operating temperature:		
For test	as stated in specification for fuel	
Uniformity of run	maximum deviation of ±2 °C from specified temperature	
Calibration	Models 230 and 240T – Three point calibration including pure tin at 232 °C, pure lead at 327 °C for high point and ice + water for low point reference All other models – Two point calibration using pure lead at 327 °C for high point and ice + water for low point reference	

[A] D3241/IP 323 Thermal Stability is a critical aviation fuel test, the results of which are used to assess the suitability of jet fuel for aviation operational safety and regulatory compliance. The integrity of D3241/IP 323 testing requires that heater tubes meet the regulations of D3241 Table 2 and give equivalent D3241 results to the heater tubes supplied by the original equipment manufacturer (OEM).
[B] The following equipment, heater tubes, manufactured by PAC, 8824 Fallbrook Drive, Houston, TX 77064, was used in the development of this test method. This is not an endorsement or certification by ASTM International.
[C] A test protocol to establish equivalence of heater tubes is on file at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1550.
[D] The following equipment, heater tube and filter kits, manufactured by Falex Corporation, 1020 Airpark Dr., Sugar Grove, IL, 60554-9585, was run through the test protocol in RR:D02-1550 and determined as equivalent to the equipment used to develop the test method. This test is detailed in RR:D02-1714. This is not an endorsement or certification by ASTM International.
[E] An electronic recording device, such as a radio-frequency identification device (RFID), may be embedded into the heater tube rivet located at the bottom of the heater tube. Tube identification data may be stored on an electronic recording device, such as a RFID, embedded into the heater tube.
[F] Tube length measurements are only applicable to the aluminum portion of the heater tube. Additions, such as an RFID, do not contribute to the length measurement of the heater tube.