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An American National Standard

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

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 **WARNING**—Mercury has been designated by many regulatory agencies as a hazardous material that can cause central nervous system, kidney and liver damage. Mercury, or its vapor, may be hazardous to health and corrosive to materials. Caution should be taken when handling mercury and mercury containing products. See the applicable product Material Safety Data Sheet (MSDS) for details and EPA's website—http://www.epa.gov/mercury/faq.htm—for additional information. Users should be aware that selling mercury and/or mercury containing products into your state or country may be prohibited by law.

1.7 *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.* For specific warning statements, see 6.1.1, 7.2, 7.2.1, 7.3, 11.1.1, and Annex A5.

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1655 Specification for Aviation Turbine Fuels

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:*[3]

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:*[4]

Color Standard for 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 tube is resistively heated and controlled in temperature by a thermocouple positioned inside. The critical test area is the thinner portion, 60 mm in length,

[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.J0.03 on Combustion and Thermal 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.

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

[4] 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**

between the shoulders of the tube. Fuel inlet to the tube is at the 0-mm position, and fuel exit is at 60 mm.

3.2 *Abbreviations:*

3.2.1 ΔP—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 an aluminum 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*[5]—Eight 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.

6.2 *Heater Tube Deposit Rating Apparatus:*

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

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

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

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 distilled (preferred) or deionized water in the spent sample reservoir as required for Model 230 and 240 instruments.

7.2 Use methyl pentane, 2,2,4-trimethylpentane, or n-heptane (technical grade, 95 mol % minimum purity) as general cleaning solvent. This solvent will effectively clean internal metal surfaces of apparatus before a test, especially those surfaces (before the test section) that contact fresh sample. (**Warning** —Extremely flammable. Harmful if inhaled (see Annex A5).)

7.2.1 Use trisolvent (equal mix of acetone (*1*), toluene (*2*), and isopropanol (*3*)) as a specific solvent to clean internal (working) surface of test section only. (**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.)

7.3 Use dry calcium sulfate + cobalt chloride granules (97 + 3 mix) or other self-indicating drying agent in the aeration dryer. This granular material changes gradually from blue to pink color indicating absorption of water. (**Warning—**Do not inhale dust or ingest. May cause stomach disorder.)

## 8. Standard Operating Conditions

8.1 Standard conditions of the test method are as follows:

[5] 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.

**TABLE 1 Instrument Models**

| Instrument Model | Pressurize With | Principle | Differential Pressure by |
|---|---|---|---|
| 202[A] | nitrogen | gear | Hg Manometer; No Record |
| 203[A] | nitrogen | gear | Manometer + Graphical Record |
| 215[A] | nitrogen | gear | Transducer + Printed Record |
| 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 Instruments**

| Item | Definition | |
|---|---|---|
| Test apparatus | Tube-in-shell heat exchanger as illustrated in Fig. 1. | |
| Test coupons: | | |
| Heater tube [A, B, C, D] | Specially fabricated aluminum tube that produces controlled heated test surface; new one for each test. 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 | Each heater tube may be physically identified with a unique serial number, identifying the manufacturer and providing traceability to the original material batch. This data may be stored on an electronic recording device, such as a RFID, embedded into the heater tube. | |
| Tube metallurgy | 6061-T6 Aluminum, plus the following criteria<br>a) The Mg:Si ratio shall not exceed 1.9:1<br>b) The $Mg_2Si$ percentage shall not exceed 1.85 % | |
| Tube dimensions: | Dimension | Tolerance |
| Tube length, 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, in accordance with ISO 3274 and ISO 4288 using the mean of four 1.25–measurements | 50 ± 20 | |
| Test filter [5] | nominal 17-µm stainless steel mesh filter element to trap deposits; new one for each test | |
| Instrument parameters: | | |
| Sample volume | 600 mL of sample is aerated, then this aerated fuel is used to fill the reservoir leaving space for the piston; 450 ± 45 mL may be pumped in a valid test | |
| Aeration rate | 1.5 L/min dry air through sparger | |
| Flow during test | 3.0 ± 10 % mL/min (2.7 min to 3.3 max) | |
| Pump mechanism | positive displacement, gear or piston syringe | |
| Cooling | bus bars fluid cooled to maintain consistent tube temperature profile | |
| Thermocouple (TC) | Type J, fiber braid or Iconel sheathed, or Type K, Iconel sheathed | |
| Operating pressure: | | |
| System | 3.45 MPa ± 10 % on sample by pressurized inert gas (nitrogen) or by hydraulically transmitted force against control valve outlet restriction | |
| At test filter | differential pressure (∆P) measured across test filter (by mercury manometer or 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 | pure tin at 232°C (and for Models 230 and 240 only, 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 (test coupons) 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.

8.1.1 *Fuel Quantity,* 450-mL minimum for test + about 50 mL for system.

8.1.2 *Fuel Pre-Treatment*—Filtration through a single layer of general purpose, retentive, qualitative filter paper followed by a 6-min aeration at 1.5 L/min air flow rate for a maximum of 1000 mL sample using a coarse 12-mm borosilicate glass gas dispersion tube.

8.1.3 *Fuel System Pressure,* 3.45 MPa (500 psi) ±10 % gauge.

8.1.4 *Thermocouple Position,* at 39 mm.

8.1.5 *Fuel System Prefilter Element,* filter paper of 0.45-µm pore size.

8.1.6 *Heater Tube Control Temperature,* preset as specified in applicable specification.

8.1.7 *Fuel Flow Rate,* 3.0 mL/min ± 10 %.

8.1.8 *Minimum Fuel Pumped During Test,* 405 mL.

8.1.9 *Test Duration,* 150 ± 2 min.