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Standard Test Method for Measurement of Thermal Stability of Aviation Turbine Fuels under Turbulent Flow Conditions (HiReTS Method)[1,2]

This standard is issued under the fixed designation D6811; 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.

ε[1] NOTE—Removed all instances of the acronym for Jet Fuel Thermal Oxidation Tester editorially in April 2010.

1. Scope

1.1 This test method covers a laboratory thermal process,[3] using a specified apparatus for measuring the tendencies of aviation turbine fuels to deposit insoluble materials and decomposition products, such as lacquers, within a fuel system. This test method provides a quantitative result for fuel under turbulent flow conditions in 65 or 125 min.

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

1.3 *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:*[4]

D3241 Test Method for Thermal Oxidation Stability of Aviation Turbine Fuels

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

E128 Test Method for Maximum Pore Diameter and Permeability of Rigid Porous Filters for Laboratory Use

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *capillary tube, n*—a coated resistively heated stainless steel tube through which fuel is pumped and controlled to give a predefined constant fuel exit temperature.

3.1.2 *deposits, n*—oxidative products, such as lacquers, laid down predominantly at the fuel exit end (hottest), on the inside of the heated capillary tube.

3.1.3 *HiReTS, n*—high Reynolds number thermal stability.

3.1.4 *HiReTS Peak (P) number and Total (T) number, n*—the quantitative results of the test.

3.1.5 *tubeways, n*—plastic and metal tubes through which fuel flows during cleaning and the test.

4. Summary of Test Method

4.1 Fuel is pumped, at pressure, through an electrically heated capillary tube at a constant rate. The heating of the capillary tube is controlled to maintain a constant fuel temperature of 290 ± 3°C at the exit of the capillary tube. A flow rate of greater than 20 mL/min and the specified capillary bore of less than 0.300 mm ensures that turbulent flow is maintained (see Appendix X1) within the capillary. The formation of lacquers and fuel degradation products act as a thermal insulator between the cooler fuel and hotter capillary tube, resulting in an increase in temperature of the capillary tube which is measured at a number of positions by a contactless pyrometer. The HiReTS Total (T) number is displayed during and at the end of the test. The HiReTS Peak (P) number can be determined from analysis of the results.

5. Significance and Use

5.1 The thermal stresses experienced by aviation fuel in modern jet engines may lead to the formation of undesirable and possibly harmful insoluble materials, such as lacquers, on heat exchangers and control surfaces, that reduce efficiency and require extra maintenance.

[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.14 on Stability and Cleanliness of Liquid Fuels.

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[2] This test method is being jointly developed with the Institute of Petroleum, where it is designated IP 482.

[3] This process is covered by a patent. Interested parties are invited to submit information regarding the identification of an alternative(s) to this patented item to the ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

[4] 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.

5.2 Aircraft fuel systems operate mainly under turbulent flow conditions. Most large-scale realistic test rigs operate in the turbulent flow regime but fuel volumes are very large and test times are very long.

5.3 This test method tests fuel under turbulent flow (high Reynolds number) conditions, and it gives a quantitative result under standard operating conditions of 65 or 125 min. Continuous analysis of results during the test allows performance of the fuel to be monitored in real time thus enabling the test time to be reduced manually or automatically, if required.

5.4 The results of this test method are not expected to correlate with existing test methods for all fuels, since the test methods and operating conditions are different (see Appendix X2).

6. Apparatus (see Annex A1)

6.1 *General*—(See Fig. A1.2.) Fuel contained in the sample vessel is drawn through the sample filter by a pump. The temperature of the fuel is checked by the input fuel electronic thermometer. The fuel is pumped at a constant rate, at pressure set by the back pressure valve, through an electrically heated capillary tube which has a blackened outer surface to give a high thermal emissivity. The heating of the capillary tube is controlled to maintain a constant fuel temperature, as measured by the capillary exit electronic thermometer, at the exit of the capillary tube. The waste fuel is then cooled to a temperature of less than 20°C above ambient, as measured by the waste fuel electronic thermometer, before being discharged to a waste container. During the test, the temperature of the outside of the capillary tube is scanned, checked and recorded every 5 min at 12 points along the exit end of the capillary tube using a contactless pyrometer which is located on a computer-controlled elevating platform.

6.2 The thermal stability apparatus[5] and capillary tube[5] is specified in detail in Annex A1.

6.3 *Sparger,* of porosity 40 to 80 µm, which allows an air flow of approximately 1.5 L/min.

NOTE 1—The porosity of the sparger can be checked using Test Method E128.

6.4 *Sample Filter,* 20-µm stainless steel.

6.5 *Aeration Dryer,* glass or other suitable transparent material, minimum height 250 mm, minimum diameter 50 mm, filled with dry calcium sulfate and cobalt chloride (see 7.4), which is used in conjunction with an air supply and the sparger (see 6.3) to aerate the test sample.

7. Reagents and Materials

7.1 *Heptane, $CH_3{\cdot}(CH_2)_5{\cdot}CH_3$,* technical grade 95 % purity, for cleaning the apparatus tubeways, and sampling vessels. (**Warning—**Extremely flammable; harmful if inhaled.)

7.2 *Trisolvent,* for cleaning sampling vessels. (**Warning—**Each of the components and the trisolvent is flammable; harmful if inhaled; irritating to skin, eyes and mucous membranes.) It consists of equal volumes of the following:

7.2.1 *Acetone, $CH_3 \cdot CO \cdot CH_3$*, technical grade, 95 % purity.

7.2.2 *Toluene, $C_6H_5 \cdot CH_3$*, technical grade, 95 % purity.

7.2.3 *Propan-2-ol, $(CH_3)_2 \cdot CH \cdot OH$*, technical grade, 95 % purity.

7.3 *Cleaning Solvent,* technical grade, 95 % purity, for cleaning sampling vessels. (**Warning—**Extremely flammable; harmful if inhaled.) It consists of one of the following:

7.3.1 *2-methylpentane.*

7.3.2 *3-methylpentane.*

7.3.3 *2,2,4-trimethylpentane.*

7.4 *Drying Components,* to dry the air used for aeration and to indicate the absorption of water by changes from blue to pink color. Use a mix, by volume or weight of the following:

7.4.1 *Calcium Sulfate Anhydrous Powder,* $CaSO_4$ (97 %).

7.4.2 *Cobalt Chloride Anhydrous,* $CoCl_2$ (3 %) granules.

7.5 *Air,* 1.5 L/min for aeration of the test sample.

8. Sampling and Sample Containers

8.1 Obtain samples for testing in accordance with Practices D4057 or D4177, with the following additional requirements:

8.1.1 Containers shall be fully epoxy lined or made of polytetrafluoroethylene (PTFE). See Note 2 and Practice D4306.

8.1.2 Prior to sampling, all containers and their closures shall be rinsed at least three times with the fuel being sampled.

8.1.3 Test samples as soon as possible after sampling.

NOTE 2—Test methods for measuring thermal stability are known to be sensitive to trace contamination during the sampling operation and from sample containers. New containers are recommended, but when only used containers are available, a thorough rinse with trisolvent (see 7.2) followed by cleaning solvent (see 7.1 and 7.3), and drying with a stream of air is recommended.

8.2 *Aeration of Test Sample*—Aerate the test sample, with dry air, through the sparger at an air flow rate of 1 to 2 L/min for 10 min.

8.3 *Sample Size*—Standard operating conditions are: 3 L for 13 scans (65–min test) and 5 L for 25 scans (125-min test).

9. Preparation of Apparatus

9.1 Prepare the instrument for operation in accordance with the manufacturer's instructions. (**Warning—**Installing and removing the capillary tube may result in exposure to fuel or solvent. It is recommended that impermeable gloves and safety glasses are worn.)

9.2 Remove the sample filter and inlet tubing and clean by rinsing with heptane and then by back flushing with heptane, and then refit.

9.3 Set the instrument in accordance with Table 1 and check that the correct standard operating conditions are in accordance with Section 10.

[5] The equipment, as listed in the research report being prepared, was used to develop the precision statement. The apparatus and capillary tubes described in Annex A1 are both supplied by Stanhope-Seta, Chertsey, Surrey KT16 8AP, UK. To date no other equipment has demonstrated through ASTM interlaboratory testing the ability to meet the precision of this test. This is not an endorsement or certification by ASTM. A research report is being prepared.