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Petroleum products — Determination of thermal oxidation stability of gas turbine fuels — JFTOT method

Produits pétroliers —Détermination de la stabilité à l'oxydation thermique des carburéacteurs — Méthode JFTOT

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 6249 was prepared by ISO/TC 28, *Petroleum products and lubricants*.

This second edition cancels and replaces the first edition (ISO 6249:1984), of which it constitutes a technical revision.

Annexes A and B form a normative part of this International Standard. Annex C is for information only.

Petroleum products — Determination of thermal oxidation stability of gas turbine fuels — JFTOT method

WARNING — The use of this International Standard may involve hazardous materials, operations and equipment. This International Standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this International Standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1 Scope

This International Standard specifies a procedure for rating the tendencies of gas turbine fuels to deposit decomposition products within the fuel system. It is applicable to middle distillate and wide-cut fuels, and is particularly specified for the performance of aviation gas turbine fuels.

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

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative references indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 3170:1988, *Petroleum liquids — Manual sampling.*

ISO 3170:1988/Amd. 1:1998.

ISO 3171:1988, *Petroleum liquids — Automatic pipeline sampling.*

3 Terms and definitions

For the purposes of this International Standard, the following terms and definitions apply.

3.1
heater tube
aluminium tube controlled at an elevated temperature, over which the test fuel is pumped; the tube is resistively heated and temperature controlled by a thermocouple positioned inside it

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

3.2
decomposition product
oxidative product laid down on the heater tube in a relatively small area of the thinner portion of the tube, typically between the 30 mm and 50 mm position from the fuel inlet, and that trapped in the test filter

4 Principle

The jet fuel thermal oxidation tester (JFTOT) subjects the test fuel to conditions which can be related to those occurring in gas turbine engine fuel systems. The fuel is pumped under pressure 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. The differential pressure across this filter is continuously monitored and an excess, indicating significant deposition on the filter, will cause a premature shut-down of the apparatus before the expiry of the normal test period. At the end of the test period, or after an earlier shut-down, the amount of deposit on the heater tube is rated with reference to a standard colour scale (see B.4.1).

5 Reagents and materials

5.1 Water, distilled or deionized, for use in the spent sample reservoir as required for JFTOT models 230 and 240.

5.2 Trisolvent, consisting of an equal mix of acetone, toluene and propan-2-ol.

5.3 Cleaning solvent, methylpentane, 2,2,4-trimethylpentane or heptane, of technical grade and 95 % minimum purity.

5.4 Drying agent: self-indicating silica gel, for use in the aeration dryer.

NOTE This granular material changes colour gradually from blue to pink indicating that its capacity to absorb water is exhausted.

5.5 Filter paper, of general purpose grade, retentive and qualitative.

NOTE Filter paper of 8 µm retention has been found satisfactory.

5.6 Membrane filter, with a diameter of approximately 25 mm, porosity 0,45 µm, and made of mixed esters of cellulose.

NOTE Filters of type HA manufactured by Millipore have been found satisfactory.

5.7 Sparger, of porosity 40 µm to 60 µm, which allows an air flow rate of approximately 1,5 l/min.

NOTE The sparger is supplied with the JFTOT apparatus. The porosity of the sparger may be checked using ASTM E 128 [1)].

6 Apparatus

6.1 Jet fuel thermal oxidation tester (JFTOT)[2)]**,** operated in accordance with the manufacturer's instructions. The operator shall first become acquainted with each component and its function. See annex A for a detailed description of the apparatus and calibration procedures.

NOTE Five types of suitable equipment are available. The main variants are indicated in Table 1.

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1) ASTM E 128-94, *Standard test method for maximum pore diameter and permeability of rigid porous filters for laboratory use.*

2) Available from ALCOR Petroleum Instruments Inc., Box 792222, San Antonio, Texas 78279-2222, USA. This information is given for the convenience of users of this International Standard and does not constitute an endorsement by ISO of this apparatus.

Table 1 — Models of JFTOT

JFTOT model	Pressurize with	Pump principle	Differential pressure by
202	Nitrogen	Gear	Mercury manometer; no record
203	Nitrogen	Gear	Mercury + graphical record
215	Nitrogen	Gear	Transducer + printed record
230	Hydraulic	Syringe	Transducer + printout
240	Hydraulic	Syringe	Transducer + printout

7 Samples and sampling procedures

7.1 Unless otherwise specified, the samples shall be taken using the procedures specified in ISO 3170 or ISO 3171, with the following additional requirements:

a) the sample size shall be as large as practicable, and not less than 600 ml;

b) containers shall be fully epoxy-lined cans or of polytetrafluoroethylene (PTFE) only (see the note below);

c) prior to sampling, all containers and their closures shall be rinsed at least three times with the fuel being sampled;

d) samples shall be tested as soon as possible after sampling.

NOTE Test method results are known to be sensitive to trace contamination during the sampling operation and from sample containers. New (previously unused) containers are recommended, but when used containers are the only ones available, they should be thoroughly rinsed with trisolvent (5.2), followed by cleaning solvent (5.3) and dried with a stream of air.

8 Preparation of apparatus

8.1 Cleaning and assembly of heater test section

8.1.1 Clean the inside surface of the heater test section to remove all deposits using a nylon brush saturated with trisolvent (5.2).

8.1.2 Check the heater tube to be used in the test for surface defects and straightness using the following procedure.

a) Inspect the heater tube between 5 mm and 55 mm above the bottom shoulder using the light box (see B.4.1). If a defect (e.g. scratch, dull or unpolished area) is seen, establish its size by comparison with Figure B.1. If it is equal to or larger than 2,5 mm^2, discard the tube. Discard the tube if the defect is smaller but is still visible in laboratory light.

b) Examine the tube for straightness by rolling the tube on a flat surface and observing the gap between the flat surface and the centre-section. Reject any bent tube.

8.1.3 During assembly of the heater section, handle the tube carefully so as not to touch the centre-part of the tube. If the centre of the heater tube is touched, reject the tube since the contaminated surface may affect the deposit-forming characteristics of the tube.

Assemble the heater section (see Figure 1) according to the manufacturer's instructions (see Figures A.1 and A.2) using the following new (previously unused) items:

a) a visually checked heater tube (see 8.1.2);

b) a test filter (installed coloured side out);

c) three O-rings.

Ensure that the insulators are undamaged and that the open end of the heater tube is uppermost. In addition, ensure that the shoulder of the tube is located at the centre of the fuel discharge hole and that the clamping nuts are finger tightened.

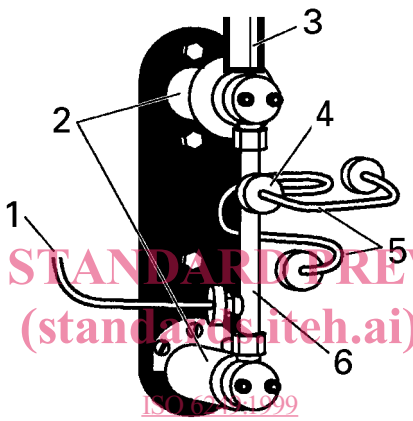
Do not reuse heater tubes.

NOTE Tests indicate that the magnesium component of the aluminium-based tube metallurgy migrates to the heater-tube surface under normal test conditions. Surface magnesium may reduce adhesion of deposits to reused heater tubes.

8.2 Cleaning and assembly of the remainder of the test components

8.2.1 Perform the steps given in 8.2.2 to 8.2.6 in consecutive order, prior to running a subsequent test.

NOTE It is assumed that the apparatus has been disassembled from any previous tests (see the appropriate operating manual for assembly/disassembly details).



Key

1 Fuel in
2 Cooled busbars
3 Thermocouple
4 Test filter
5 Fuel out
6 Heater test section

Figure 1 — Standard heater section

8.2.2 Inspect and, using the cleaning solvent (5.3), clean components that contact the test sample. Replace any seals that are faulty or suspect, especially the lip seal on the piston, and the O-rings on the reservoir cover, lines and prefilter cover.

8.2.3 Install the prepared heater section (see 8.1.3).

8.2.4 Assemble and install the prefilter.

8.2.5 Check the thermocouple to ensure that it is in the correct reference position and lower it into the standard operating position [see 10.1.11 b)].

NOTE Failure to insert the thermocouple may cause overheating of the heater test section and result in damage to the equipment.

8.2.6 On JFTOT models 230 and 240, ensure that the water beaker is empty.

9 Calibration and standardization

9.1 General

Perform checks of key components at the frequencies indicated in 9.2 to 9.6 (see normative annexes A and B for details).

9.2 Thermocouples

Calibrate a newly installed thermocouple (see A.9) and periodically thereafter after a maximum of 50 tests, or at least every 6 months.

9.3 Differential-pressure cell

Standardize once a year or when installing a new cell (see A.8).

9.4 Aeration dryer

Check at least monthly and change if the colour indicates significant absorption of water (see 5.4).

9.5 Metering pump

Perform two checks of flow rate during each test in accordance with 10.2.3 and 10.3.3.

9.6 Filter by-pass valve (JFTOT models 202, 203 and 215)

Check after a maximum of 50 tests, or at least every 6 months (see A.11).

10 Procedure

10.1 Preparation

10.1.1 Filter 600 ml of the test fuel, at a temperature of 15 °C to 32 °C, through a single layer of filter paper (5.5) into the reservoir. Aerate the filtered fuel for 6 min through the sparger (5.7) at an air flow rate of 1,5 l/min.

10.1.2 Allow no more than 1 h to elapse between the end of aeration and start of the test.

10.1.3 In accordance with the manufacturer's instructions, assemble the reservoir section, including the prefilter fitted with a new membrane (5.6).

10.1.4 Fit the reservoir to the equipment and attach to the heater-tube assembly.

10.1.5 For JFTOT models 230 and 240 only, fill and fit the water reservoir in accordance with the manufacturer's instructions. Place the receiver under the bleed assembly drip line.

10.1.6 Check the tightness of all screwed connections.

10.1.7 For JFTOT models 202, 203 and 215 only, carefully pressurize with nitrogen and check for and remedy any leakage. Apply power to the pump and ensure that cooling fluid is circulating through the busbars.

10.1.8 For JFTOT models 230 and 240 only, apply power to the syringe drive and check for and remedy any leakage.

10.1.9 For JFTOT model 215, bleed any air present in the lines to the pressure transducer.

10.1.10 Adjust the fuel system pressure to 3,5 MPa ± 0,1 MPa.

10.1.11 Check that the following standard operating conditions are used:

a) a minimum fuel quantity of 450 ml for testing and up to 150 ml for the system;

b) the thermocouple position is at 39 mm;

c) the heater-tube control is pre-set to the required temperature, taking into account any thermocouple correction (see A.9); the maximum deviation from this temperature shall be ± 2 °C;

d) a fuel flow rate of 3,0 ml total flow in 54 s to 66 s, or 20 drops of fuel in 9,0 s ± 1,0 s, and the volume of fuel pumped during a test is within the range 405 ml to 495 ml;

e) the test lasts for 150 min ± 2 min;

f) a cooling fluid flow rate of approximately 39 l/h or the centre of the green range on the cooling fluid flow meter;

g) a power setting of approximately 75 to 100 on JFTOT models 202, 203 and 215.

10.2 Start-up

10.2.1 For JFTOT models 230 and 240, start-up is automatic once air has been bled from the system and the required pressure has been reached. At that point, remove the receiver from the drip line and replace it with a clean one, and ensure that the coolant is circulating.

10.2.2 For JFTOT models 202, 203 and 215, switch the heater on when a steady drip rate is observed. When the heater tube reaches the control temperature, close the filter by-pass valve and ensure that the indicated differential filter pressure is set to zero.

10.2.3 Within the first 15 min of the test, check that the fuel flow rate satisfies the standard operating conditions given in 10.1.11 d) by either timing the flow for JFTOT models 230 and 240, or timing the drip rate for JFTOT models 202, 203 and 215.

10.3 Test

10.3.1 Record the filter differential pressure at least every 30 min if it is not recorded automatically.

10.3.2 If the filter differential pressure approaches 33,3 kPa (250 mmHg) before 150 min and continuation of the test is required, open the filter by-pass valve to prevent premature shutdown.

10.3.3 Recheck the fuel flow rate in accordance with 10.2.3 within the final 15 min of the test.

10.4 Heater-tube temperature profile

If the heater-tube temperature profile is required, follow the instructions given in C.3.

10.5 Shutdown

10.5.1 For JFTOT models 202, 203 and 215, switch off the heater, then switch off the pump. Close the nitrogen pressure valve and open the filter by-pass valve. Carefully open the nitrogen bleed valve.

10.5.2 For JFTOT models 230 and 240, the heater will switch off automatically when the test time is completed. When the test time is completed, remove the drip receiver and replace with another container. Slowly turn the system valve to vent.

10.6 Disassembly

10.6.1 Disconnect the fuel inlet line to the heater assembly; cap to prevent leakage.

10.6.2 Disconnect the heater section and remove the heater tube from the assembly, taking care to avoid touching the centre part of the tube. Discard the test filter. Flush the tube with cleaning solvent (5.3) from the top down while

grasping the tube at the bottom and holding it vertically. Store the heater tube in the original container, mark it for identification, and reserve it for evaluation within 120 min (see normative annex B).

10.6.3 For JFTOT models 202, 203 and 215, disconnect the reservoir. Using a measuring cylinder, measure the volume of fuel pumped during the test that is above the piston. Reject the test if the volume is outside the range specified in 10.1.11 d).

10.6.4 For JFTOT models 230 and 240, measure and record the volume of fluid exiting the bleed drip line during the test (see the note below). Reject the test if the volume is outside the range specified in 10.1.11 d).

NOTE This is equivalent to the volume of fuel pumped during the test.

10.6.5 Disassemble the remainder of the equipment in accordance with the manufacturer's instructions.

10.7 Heater-tube deposit rating

The heater-tube deposit shall be rated visually using the standard light box as described in annex B. If necessary, retain the tube in the original container.

11 Expression of results

Report the following:

a) the heater-tube control temperature;

b) the heater-tube deposit rating(s) (see 10.7);

c) the pressure differential across the test filter at the end of the test or the time required to reach a pressure differential of 3,33 kPa (25 mmHg). For JFTOT models 202 and 203, report the maximum recorded change in differential pressure;

d) if the normal test time of 150 min is not completed, for example, if the test is terminated because of pressure drop failure, the test time that corresponds to the heater deposit rating;

e) the volume of spent fuel at the end of a normal test (this will be the amount on top of the floating piston or the total fluid in the displaced water receptacle, depending on the JFTOT model used).

NOTE Either the tube rating, or change in pressure, or both, are used to determine whether a fuel sample passes or fails the test at a specified test temperature.

12 Precision

Precision is still being evaluated.

NOTE An inter-laboratory study of JFTOT testing was conducted in accordance with ASTM E 691 by 11 laboratories using 13 instruments, including the two types of JFTOT (gear and syringe), and with five fuels at two temperatures for a total of 10 materials. Each laboratory obtained two results from each material. (See ASTM Research Report No. D.02:1309.)

13 Test report

The test report shall contain at least the following information:

a) a reference to this International Standard;

b) the type and complete identification of the product tested;