INTERNATIONAL STANDARD

ISO 6249

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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

Reference number
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Contents

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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.

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.

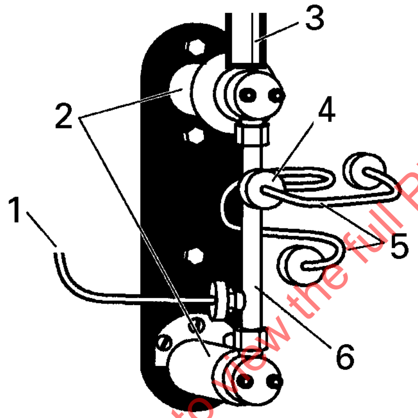
Do not reuse heater tubes.

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;

c) the result of the test (see clause 11);

d) any deviation, by agreement or otherwise, from the standard procedures specified;

e) the date of the test.

Annex A
(normative)

Apparatus

A.1 Test instrument

All models of JFTOT shall provide a means to pump sample once through the test system across the metal heater tube and through the test filter. There shall be a means to control and measure the tube temperature, system pressure and pressure drop across the filter.

A.2 General description

The instrument shall use a fixed volume of jet fuel that has been filtered, then aerated to provide a sample saturated with air. During the test, fuel shall be pumped at a steady rate through a prefilter and across a heated aluminium tube which is maintained at a relatively high temperature, typically 260 °C, but higher under some specifications.

NOTE The fuel, saturated with oxygen from the aeration, may degrade on the hot aluminium heater tube to form deposits as a visible film. The degraded materials of the fuel may flow downstream and be caught by the test filter. Both the increase in differential pressure across the test filter and the final heater-tube rating are used to determine the oxidative stability of the fuel.

A.3 Fuel system

Freshly filtered and aerated fuel shall be placed initially in a reservoir, then circulated once through the apparatus at a flow rate of 3,0 ml/min ± 10 % to a spent sample receptacle. This flow rate shall be maintained even if the pressure differential across the test filter reaches 3,33 kPa (25 mmHg).

NOTE 1 If filter blockage becomes severe, the by-pass valve located before the test filter can be opened to finish the test (see 10.3.2). Then, any deposit on the heater tube can be evaluated based on a complete test.

The tube-in-shell heat exchanger, or test section, shall hold the heater tube and direct the flow of fuel over it. The heater tube shall be aligned correctly in the housing as shown in Figure A.1. This component is critical to obtain consistent results and is a common component in all JFTOT models.

An assembly drawing of the heater-tube test section is shown in Figure A.2.

NOTE 2 Flared insulators in the heater section are not used in some model heater sections. The recess that is filled by the flared insulator can be part of the heater-tube housing.

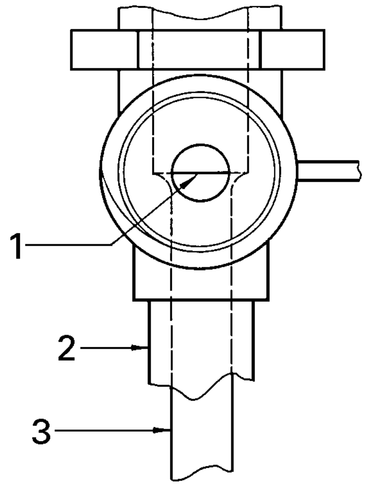
Fresh fuel shall be filtered immediately out of the reservoir through a membrane filter (5.6) before entering the heater test section. The heater tube shall be sealed in the heater test section by elastomer O-rings. The test filter shall be made of sintered stainless steel with a rated porosity of 17 µm.

NOTE 3 If blockage of this filter causes an increase in differential pressure, an alarm will sound (normally at 16,65 kPa or 125 mmHg) to alert the operator. By-pass of the filter can then be accomplished if required.

NOTE 4 JFTOT models 202, 203 and 215 use a single fuel reservoir with a floating piston to separate the fresh fuel (in the bottom) and spent fuel (on top). Models 230 and 240 use two reservoirs, one for fresh fuel and one for spent fuel.

NOTE 5 The flow of fuel in all models can be monitored by visually counting the drops of flow. JFTOT models 230 and 240 also allow volumetric measure of flow with time which is considered the most accurate measure of flow.

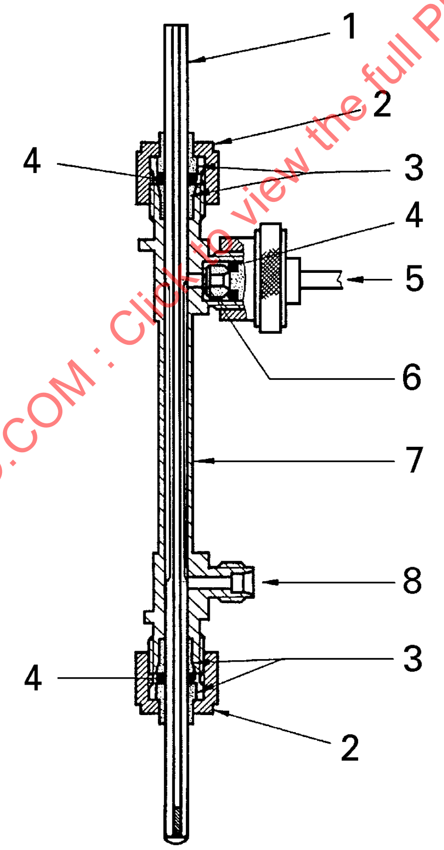
Diagrams of fuel flow through the three main configurations of JFTOT are shown in Figure A.3.



Key

1 Heater-tube shoulder at centre of discharge hole
2 Heater-tube housing
3 Heater tube

Figure A.1 — Alignment of heater tube



Key

1 Heater tube
2 Nut
3 Ceramic insulators
4 O-ring seal
5 Fuel outlet line assembly
6 Test filter
7 Heater-tube housing
8 Heater-tube fuel supply inlet

Figure A.2 — Assembly drawing of heater-tube test section

A.4 Control system for heating and temperature

The heater tube shall be resistively heated by the conductance of high-amperage, low-voltage current from a transformer through the aluminium tube. The heater tube shall be clamped to relatively heavy, water-cooled current-conducting busbars, which increase in temperature relatively little.

The temperature controller shall serve as an indicator and controller. In automatic mode, the controller shall provide a source of steady heat during the test, varying the power as necessary to maintain the target (setpoint) temperature. In manual mode, the controller shall provide a temperature indication only. The temperature range of operation shall be from ambient to a maximum of approximately 350 °C.

Temperature control shall be maintained using a thermocouple. The thermocouple itself shall be calibrated (see A.9) to ensure acceptable accuracy. The position of the tip shall be carefully placed so the temperature read during automatic control is the maximum (the hottest spot) for the heater tube.

NOTE Simple mechanical positioning allows easy and accurate placement of the thermocouple.

A diagram of the basic heating system is shown in Figure A.4.

A.5 Cooling system

NOTE In the normal operation of the JFTOT, some cooling is necessary to remove heat going into the busbars by conduction from the hot heater tube.

For JFTOT models 202, 203 and 215, cooling water shall be circulated through each busbar using laboratory tap water. For JFTOT models 230 and 240, an internally circulated and radiator-cooled liquid system shall be provided. Monitor these systems to ensure that they are working. Avoid the use of coolants that contain contaminants or salts that may eventually foul the system.

A.6 Pressurization

The system shall be operated under a total pressure of 3,5 MPa ± 0,1 MPa by either using nitrogen gas (JFTOT models 202, 203 and 215) or a hydraulic piston pump (JFTOT models 230 and 240).

NOTE 1 At the temperature of a normal JFTOT test, most test fuels typically boil at the temperature of the heater tube. This prevents accurate temperature control and interferes with natural deposit formation.

A pressure gauge or transducer shall be used to measure and allow monitoring of the total system pressure. The gas-pressurized systems shall be run closed after pressurization, whereas the hydraulically pressurized systems shall have a relief valve through which the fluid passes in a constant “leak” throughout the test. For the relief-valve control to operate uniformly for any fuel, a displacement cell shall be used where the spent fuel enters the top, displacing water out the bottom and through the relief valve.

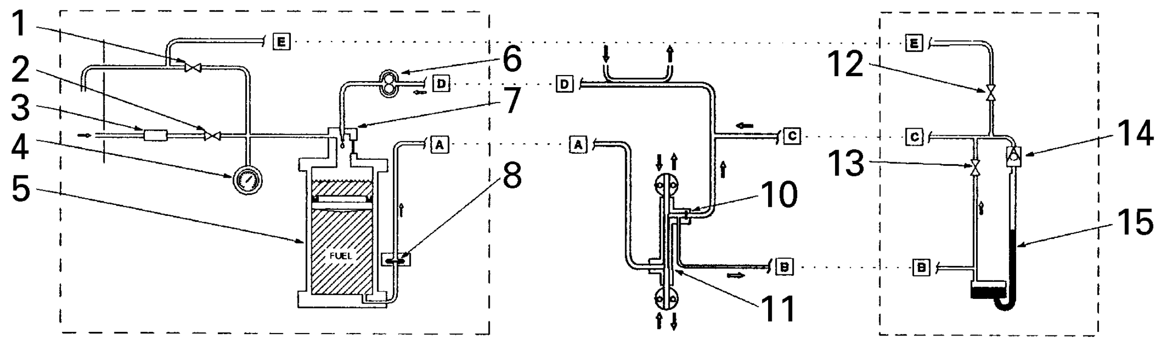
NOTE 2 Since the valve “sees” only water, it works consistently.

A.7 Differential-pressure measurement

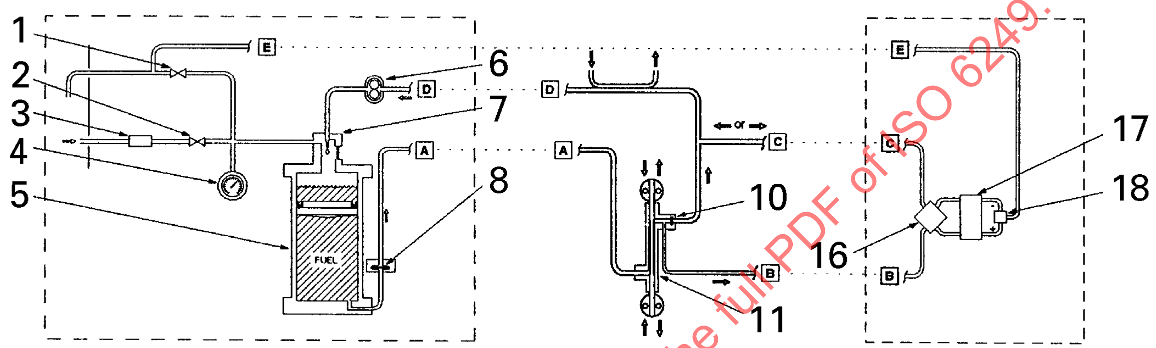
The differential pressure (Δp) across the test filter shall be measured during the test using either a mercury manometer with a possible strip-chart pressure-recording option, or an electronic pressure transducer (see Figure A.3).

NOTE By-pass and air bleeding are essential to ensure proper use of these differential measuring devices. The former allows the fuel flow to by-pass the filter.

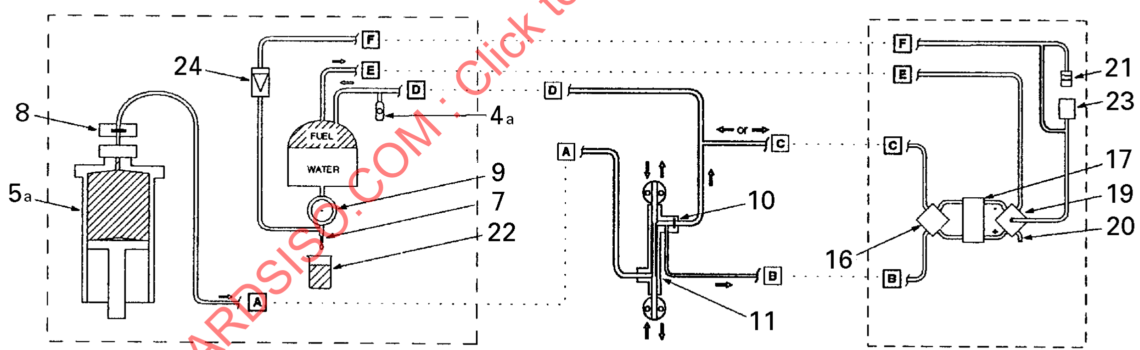
Air bleeding shall be used to remove air or nitrogen that at times may become trapped in the cell chambers. The manometer output shall be read as the height of the column of mercury and the transducer output shall be displayed digitally.



a) JFTOT — pneumatically pressurized/gear pump/mercury manometer/standard test section



b) JFTOT — pneumatically pressurized/gear pump/differential transducer/standard test section

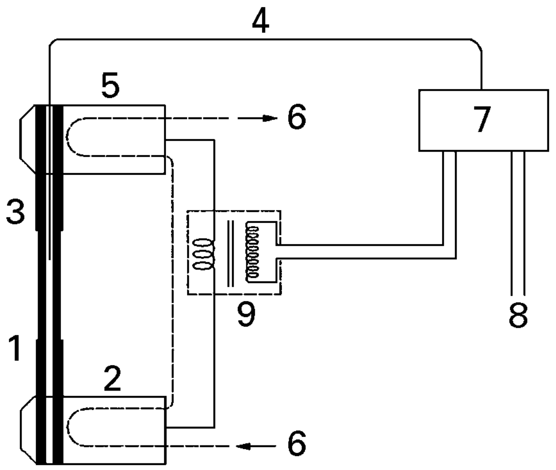


c) JFTOT — hydraulically pressurized/syringe pump/differential transducer/standard test section

Key

1 Nitrogen bleed valve
2 Nitrogen pressurize valve
3 Pressure limiter
4 Pressure gauge
4a Absolute pressure gauge (transducer)
5 Fuel reservoir with piston and seal
5a Hydraulic fuel reservoir
6 Constant speed metering pump
7 Drip flow indicator
8 Membrane prefilter
9 Pressure regulator
10 Test filter
11 Standard heater-tube test section
12 Manual bleed valve
13 Manual by-pass valve
14 Float check valve
15 Manometer
16 4-way by-pass valve
17 Liquid full-differential transducer
18 3-way vent (bleed) valve
19 5-way vent (bleed) valve
20 Plugged outlet
21 Air trap jar
22 Spent liquid
23 Accumulator
24 Check valve

Figure A.3 — Fuel system schematics



Key

1 Heater tube
2 Lower fixed bus
3 Movable thermocouple junction
4 Thermocouple lead
5 Upper fixed bus
6 Cooling water
7 Feedback control system
8 Power
9 Low voltage transformer

Figure A.4 — Heater tube and temperature control schematic

A.8 Calibration of the differential-pressure transducer cell

NOTE The calibration of the transducer system is internal and not normally accessible to the user. Calibration by the manufacturer ensures that the differential-pressure transducer (DPT) cell gives an equivalent pressure reading to that which would result from using the mercury manometer. When a static check is made to confirm that the DPT cell is functional, the reading includes the offset tare for the flow compensation and the bias due to use of a mercury/kerosine manometer. The readings, therefore, are only relative but should be consistent for each JFTOT.

A.8.1 To confirm that the DPT model is reading correctly, perform the following check using a standardization kit (levelling bottle, special tube fitting and detailed instructions) supplied with each JFTOT.

A.8.2 Select a typical fuel to be used in the standardization, and determine its density to three digits, in kilograms per cubic metre, by weighing, to the nearest 1 mg, a 10,0 ml pipetted portion. Ensure that the fuel temperature is within approximately 10 °C of the working temperature at which the DPT is to be checked.

A.8.3 Attach the fittings of the standardization kit to the JFTOT and fill it with the standardization fuel. Remove the air from the transducer system in accordance with the kit instructions.

The process of removing air from the system and replacing any residual fuel with the standardization fuel is essential to the procedure.

A.8.4 Bring the levelling bottle containing the standardization fuel to the same level as the negative transducer port and the top of the special fitting attached to the positive port. Set the transducer indicator to 0.0.

A.8.5 Raise the levelling bottle to create a head pressure (approximately 400 mm) on the negative port. Cover the positive port to stop flow. Read the transducer indicator. Record the height of the fuel above the negative port in millimetres.

A.8.6 Calculate the theoretical differential pressure, Δp_{th}, expressed in conventional millimetres of mercury (mmHg), using the following equation:

$$\Delta p_{\text{th}} = \frac{\rho \cdot h}{12\ 720}$$

where

ρ is the density of the standardization fuel, expressed in kilograms per cubic metre (kg/m^3);

h is the measured height of the fuel above the negative port, expressed in millimetres (mm).

If the result does not agree to within approximately 4 % of the reading from the transducer, this check indicates that the DPT cell has drifted in accuracy. Perform an electronic calibration as directed in the maintenance instructions provided with the JFTOT, or have the cell checked by the vendor.

NOTE The manometer system includes a bias due to the presence of fuel instead of the usual air over the mercury. This changes the value of pressure expressed in terms of column height of mercury such that a result approximately 6 % higher than the true value occurs. The transducer is not subject to this error, so in order to have manometer and transducer models read the same, a 6 % bias is added to the transducer.

A.8.7 When operated, the pressure-measuring device used shall be zeroed under actual flow conditions at the start of the test.

NOTE A small pressure drop is created across the system when fuel is flowing. Zeroing the transducer or manometer at the beginning of the test compensates for the flow.

A.9 Thermocouple calibration

Calibrate the thermocouple against materials of known freezing points using the manufacturer's instructions for the relevant model (see informative annex C for calibrator and thermocouple maintenance).

NOTE 1 For the purposes of this International Standard, the freezing point is taken to be equivalent to the melting point.

Calibrate JFTOT models 202, 203 and 215 using only pure tin (99 % minimum purity, freezing point 232 °C).

Carry out the calibration by immersing the thermocouple tip in the melted metal, then allow the metal to cool (see Figure A.5).

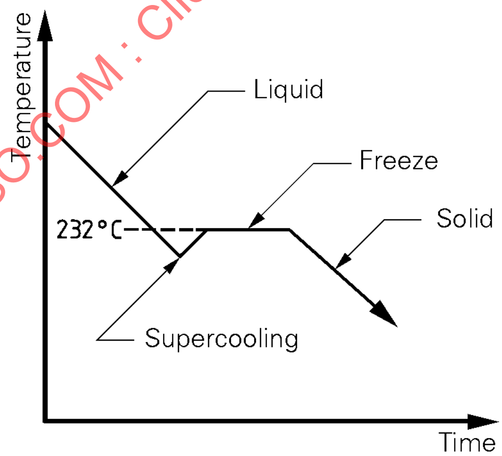


Figure A.5 — Freezing characteristics of tin

NOTE 2 As the metal goes through its freezing point, the temperature reading hesitates momentarily. This point should indicate the known freezing point of the metal.

Use any difference between the known freezing point of the metal and the temperature indicated as a correction for setting the test temperatures.

EXAMPLE When using tin with a known freezing point of 232 °C, if the temperature indicated is higher than 232 °C, the thermocouple reading is too high by that temperature difference. The applied correction lowers any test temperature by the same amount.

Using the same technique, calibrate JFTOT models 230 and 240 using the freezing points of pure tin (99 % minimum purity, freezing point 232 °C), pure lead (99,9 % minimum purity, freezing point 327 °C), and ice (freezing point 0 °C). However, in this case, the correction is calculated and applied automatically by the internal computer.

A.10 Fuel aeration system

All JFTOT models shall have the means to aerate the sample prior to testing.

NOTE 1 Without the presence of air in the sample, the test results will be invalid.

Filtered, dry air shall be metered through the sample at a rate of approximately 1,5 l/min for 6 min using the sparger (5.7).

NOTE 2 This 9 litres of air assures 97 % saturation of the sample.

A.11 Leakage check for filter by-pass valve (JFTOT models 202, 203 and 215)

Obtain a used test filter and plug the upstream side with any fast-drying glue such as industrial adhesive. Install this filter together with any heater tube in the test section. Circulate clean filtered fuel at 3,5 MPa ± 0,1 MPa with the filter by-pass valve in the open position (no heat applied). After steady flow is observed in the sight glass (20 drops in 9,0 s ± 1,0 s), close the filter by-pass valve and simultaneously start a stopwatch. Observe the time required for the differential pressure across the valve to reach 13,32 kPa (100 mmHg). Immediately open the by-pass valve to resume normal fuel flow. If the time measured to reach a pressure differential of 13,32 kPa (100 mmHg) is equal to or less than 60 s, assume that the filter by-pass valve and the fuel pump meet performance requirements. If the time measured to reach a pressure differential of 13,32 kPa (100 mmHg) exceeds 60 s, assume that either the filter by-pass valve is leaking or the fuel-metering pump performance is unsatisfactory. If the latter is the case, check the fuel-metering pump performance to determine if the pump or filter by-pass valve requires replacement.

A.12 Fuel-metering pump check (gear pumps only)

Install a plugged filter, used heater tube, and establish a normal fuel flow. After steady flow is established, adjust the filter by-pass valve to maintain a steady pressure differential of 3,33 kPa (25 mmHg). Measure the time with a stopwatch for a flow rate of 20 drops as observed in the sight glass. Assume that the fuel pump is performing satisfactorily if the time for a fuel flow of 20 drops is 9,0 s ± 1,0 s. Replace pumps that measure above 10 s. After installing a new pump, repeat the pump check. If a low flow persists, clean all lines and fittings from the test filter through the metering pump to the fuel reservoir with trisolvent (5.2). Replace the lines as necessary. Repeat the pump check.

Annex B
(normative)

Determination of the visual rating of used JFTOT tubes

B.1 General

The final result obtained from this International Standard is a tube colour rating based on an arbitrary scale established by ASTM for this test method, plus two additional yes/no criteria that indicate the presence of an apparent large excess of deposit or an unusual deposit or both.

This final tube rating is assumed to be an estimate of the condition of the degraded fuel deposit on the tube. This rating is one basis for judging the thermal oxidative stability of the fuel sample.

B.2 Terms and definitions

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

B.2.1
tube rating
10-step discrete scale from 0 to > 4, with intermediate levels for each number, starting with 1, described as less than the subsequent number

NOTE The scale is taken from the five colours, 0, 1, 2, 3, 4, on the ASTM colour standard. The complete scale is: 0, < 1, 1, < 2, 2, < 3, 3, < 4, 4, > 4. Each step is not necessarily of the same absolute magnitude. The higher the number, the darker the deposit rating.

B.2.2
peacock
multicolour, rainbow-like tube deposit

NOTE This type of deposit is caused by interference phenomena where deposit thickness is equal to multiples of a quarter wavelength of visible light.

B.2.3
abnormal
tube-deposit colour that is neither peacock nor like those of the colour standard; it refers to deposit colours such as blues and greys that do not match the colour standard

B.3 Principle

A specially constructed light box is used to view the heater tube. The tube is positioned in the box using a special tube holder. Uniformity of the new tube surface is judged under the optimum light conditions of the box (see 8.1.2). The colour of the tube after testing is judged under light and magnification, by comparing it with the colour standard plate slid into position immediately behind the tube.