TC 28

International Standard ISO 6249

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

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

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

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ISO 6249-1984 (E)

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. Every 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council. They are approved in accordance with ISO procedures requiring at least 75 % approval by the member bodies voting.

International Standard ISO 4589 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants.*

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

1 Scope and field of application

1.1 This International Standard specifies a procedure for rating the tendencies of gas turbine fuels to deposit decomposition products within the fuel system.

1.2 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.

NOTE — The maximum heater control temperature (see 7.2.5) should be selected to suit each application of this method and specified when this method is called up.

2 Principle

This method for measuring the high temperature stability of gas turbine fuels uses the Jet Fuel Thermal Oxidation Tester (JFTOT), which subjects the test fuel to conditions which 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 are retained.

The apparatus requires 600 ml of test fuel for a 150 min test. The essential data derived are the level of deposits on an aluminium heater tube, and the rate of plugging of a 17 µm nominal pore size precision filter located just downstream of the heater tube.

3 Apparatus

3.1 Jet Fuel Thermal Oxidation Tester[1] (JFTOT)

Either of two models can be used, Recording Model or Non-Recording Model. Both are the same size : 914 mm high, 762 mm wide, and 305 mm deep, and designed to sit upon a standard height chemical laboratory bench. Annex A gives a detailed description of the apparatus, which shall be used without modification.

NOTE — No attempt should be made to operate the JFTOT without first becoming acquainted with all components and the function of each.

3.2 Heater tube deposit rating apparatus

The level of deposits on the heater tube are rated by either the Mark 8A Tube Deposite Rater[1] or a Tuberator[1] and the Colour Standard for tube deposit rating.[1]

3.3 Materials, supplies and spares

3.3.1 The following items are supplied with each JFTOT :

3.3.1.1 Magnifying assembly for tuberator.

3.3.1.2 Tuberator adapter for heater tube.

3.3.1.3 AutoCal heater assembly.

3.3.1.4 Piston puller.

3.3.1.5 Cap seal.

3.3.1.6 Aeration tube.

3.3.1.7 Clear plastic tubing for aeration tube.

3.3.1.8 Aeration tube holder.

3.3.1.9 Funnel holder.

3.3.1.10 Nut driver, 12,7 mm.

3.3.1.11 Socket head (Allen) screw driver, 4 mm.

3.3.1.12 Power cord.

3.3.1.13 Constant-voltage transformer, 60 or 50 Hz.

3.3.1.14 Step-down transformer, 230-115 V.

NOTE — These are supplied only with 230 V-50 Hz (JFTOT).

3.3.1.15 Protector, sight glass.

1) Suitable apparatus is available commercially. Details of suppliers may be obtained from the Secretariat of ISO/TC 28 or from the ISO Central Secretariat.

3.3.2 The following items are required to be replaced with each test and therefore must be stocked in accordance with the volume of testing involved :

3.3.2.1 Heater tube and filter kit.

3.3.2.2 Pre-filter element.

3.3.2.3 Data sheets (see table 1).

3.3.2.4 General-purpose, retentive, qualitative filter paper.

3.3.3 The following supplies are spare parts needing periodic replacement as required and should therefore be stocked in accordance with the volume of testing involved.

3.3.3.1 Ceramic insulators (4/sets).

3.3.3.2 Lip seal, reservoir piston.

3.3.3.3 O-ring, reservoir.

3.3.3.4 O-ring, sight-glass.

3.3.3.5 O-ring, retention screw.

3.3.3.6 O-ring, line connections.

3.3.3.7 O-ring, pre-filter.

3.3.3.8 Thermocouple assembly.

3.3.3.9 Tin, 99,99 % pure pellets in capsules containing 1,6 ± 0,5 g.

3.3.3.10 Metering pump.

3.3.3.11 Chart paper, ΔP recorder.

3.3.3.12 Aeration tube.

3.3.4 The following additional items are not supplied with the JFTOT but are required for normal operation.

3.3.4.1 ALCOR Mark 8A Tube Deposit Rater.

3.3.4.2 EPPI Tuberator.

3.3.4.3 Nitrogen, compressed in a cylinder.

3.3.4.4 Pressure regulator, 0 to 7 MPa[1)].

3.3.4.5 Solvent, may be methyl pentane, *n*-heptane or 2,2,4 trimethyl pentane, technical grades, 95 mol percent minimum purity.

3.3.4.6 Disposable gloves.

3.3.4.7 Trisolvent, (equal parts by volume of toluene, acetone, and propan-2-ol, 99 % purity).

3.3.4.8 Wash bottle, polyethylene.

3.3.4.9 Cleaning pan, stainless steel (250 mm by 350 mm minimum).

3.3.4.10 Brush, polyamide 40 mm by 100 mm.

3.3.4.11 Brush, polyamide 15 mm by 75 mm.

3.3.4.12 Funnel, glass.

3.3.4.13 Thermometer, accurate to 1 °C with which temperatures between 15 and 32 °C can be read (e.g. ISO 1770 C or D).

3.3.4.14 Tweezers, flat bladed, non-serrated.

3.3.4.15 Rubber squeeze bulb.

3.3.4.16 Extractor for ceramic insulators.

3.3.4.17 Silicone grease.

3.3.4.18 Paper tissues.

3.3.4.19 Aluminium foil, about 450 mm wide.

3.3.4.20 Graduated cylinder, capacity 100 ml.

4 Sampling

Take a representative sample of the product to be tested according to ISO 3170 or ISO 3171 (or other relevant method).

5 Standard operating conditions

Standard conditions of test are as follows :

5.1 Test portion volume, 600 ml.

5.2 Preparation of test portion.

Filter through a single layer of filter paper (3.3.2.4) followed by a 6 min aeration at 1,5 l/min air flow rate.

5.3 Fuel system pressure, 3,45 MPa[1)] gauge.

5.4 Maximum heater tube temperature, preset as specified for the fuel under test.

5.5 Fuel flow rate, 3,0 ml/min.

1) 1 MPa = 10 bar.

5.6 Test duration, 2 h 30 min.

6 Preparation for test

6.1 Disassembly

All the steps for disassembly of the test section, if required, are given in clause 8.

6.2 Calibration of the heater tube temperature controller

6.2.1 The AutoCal Calibrator is used for calibrating the heater tube temperature controller. This calibrator is a nickel-plated heater tube which has a small well containing pure tin. This method utilizes the freezing point of tin, 232 °C, as the calibration temperature.

6.2.2 Install the AutoCal Calibrator by placing the hollow end of the calibrator flush with the top surface of the upper fixed bus-bar and tighten both socket head (Allen) screws.

6.2.3 Secure the plugged end of the calibrator by raising the lower floating bus-bar to the upper limit of its travel and tighten both socket head (Allen) screws.

6.2.4 Lower the thermocouple through the upper section of the calibrator and coat the thermocouple tip with silicone grease to prevent sticking to the tin.

6.2.5 Lower the thermocouple into the well to press lightly against the upper surface of the solid tin.

6.2.6 Set digital readout on HEATER TUBE TEMPERATURE CONTROL at 232 °C.

6.2.7 Set the POWER CONTROL at zero.

6.2.8 Switch the CONTROL MODE to MANUAL position.

6.2.9 Switch the POWER to ON.

6.2.10 Check that the water pressure indicator is in the green arc. Adjust the WATER FLOW CONTROLLER so that the indicator is in the green arc (this corresponds to 38 ± 8 l/h).

6.2.11 Switch the AUTOCAL to ON.

6.2.12 Switch HEATER to ON.

6.2.13 Set POWER CONTROL to 75 to 80 setting.

NOTE — A higher setting may be required for some instruments. First ensure good contact at low voltage connections and then, if required, adjust removable stop at rear of power controller (see A.4.2).

6.2.14 Wait at least 2 min before proceeding with the calibration check to allow for temperature stabilization and warm-up of the temperature controller.

6.2.15 Depress the AUTOCAL pushbutton for 3 s and observe the deviation meter needle of the HEATER TUBE TEMPERATURE CONTROL. Repeat at short intervals until the deviation meter needle swings to full right. This indicates that the tin is molten.

6.2.16 While the temperature deviation meter needle is deflected full right, carefully lower the thermocouple to the bottom of the well, noting the total distance of travel on the thermocouple positioning indicator and then raise it 2,5 mm. Ensure that the thermocouple is centred in the well.

If the travel of the thermocouple is not at least 5 mm, refill the well with a new charge of tin pellets (3.3.3.9) in accordance with the instructions in annex D and repeat as above, starting with 6.2.2.

6.2.17 If the temperature deviation meter needle is now less than full right, depress the AUTOCAL button until the needle is again full right scale deflection and then release. The deviation meter needle will slowly move from right to left, stop, and then abruptly reverse to the right and pause for about 3 to 5 s. During the time the needle is stationary, adjust the digital readout to centre the needle. The pause period constitutes the freezing point, the change of state from liquid to solid tin. The drop in temperature below freezing point and abrupt reversal is due to the super-cooling characteristic of tin (see figure 1). If the deviation meter needle does not remain completely stationary for a minimum of 3 s, the tin is contaminated and needs replacement. See annex D for replacement instructions.

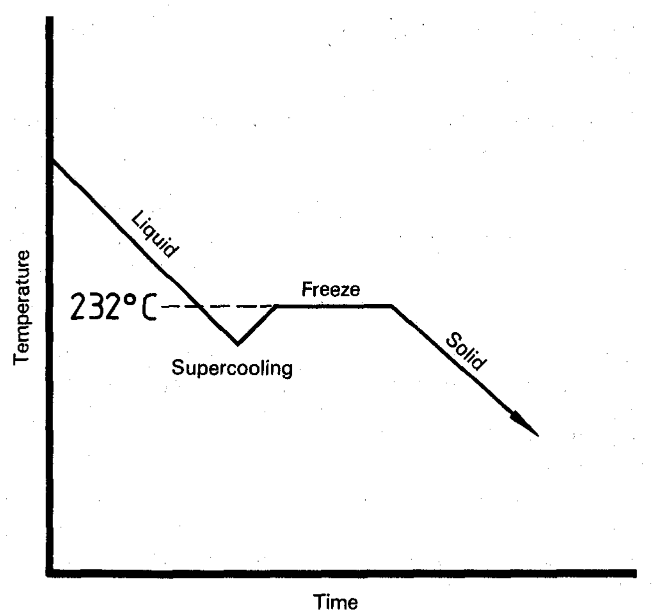


Figure 1 — Freezing characteristics of tin

6.2.18 Repeat this procedure as necessary until the deviation meter needle is centred during the pause without the need for adjustment of the controller digital setting. Observe and record on a data sheet (3.3) the "indicated freezing point of tin", that is, the digital setting to centre the needle during the pause.

NOTE — Although the calibration procedure involves a determination of "freezing point", the value obtained is reported as "melting point" because this term is traditionally used on the data sheets (see table 1).

6.2.19 When the "indicated freezing point of tin" has been satisfactorily determined, refreeze the tin by depressing the AUTOCAL pushbutton to obtain a full right scale deflection of the temperature deviation meter needle. Then release the push-button and immediately raise the thermocouple tip so as to be accessible and remove all residual traces of silicone and tin by wiping the tip with paper tissue. Inspect the tip closely for cleanliness.

6.2.20 Switch the HEATER to OFF.

6.2.21 Switch the AUTOCAL to OFF.

6.2.22 Raise the thermocouple to the extreme upper limit and remove the AutoCal calibrator.

6.3 Inspection of components

6.3.1 Inspect the reservoir cover O-ring and all O-rings used on the line fittings including the nitrogen and fuel return lines for cuts, abrasion and excessive swelling and replace as necessary.

6.3.2 Inspect the ceramic insulators and replace if they are cracked or chipped.

6.3.3 Inspect all stainless steel components for damage and replace as necessary.

6.4 Inspection and testing of reservoir piston lip seal

6.4.1 Inspect the lip seal for cuts, abrasion, or excessive swelling and replace as necessary.

6.4.2 When required to install a lip seal on the piston, ensure that the inner lip is properly placed under the retaining shoulder of the piston. See figure 2 for the correct lip seal assembly position.

6.4.3 With the thumbs, gently push the sealing edge of the lip seal outward from the centre of the reservoir piston while slowly rotating the piston in the hands. This will minimize leaks past the seal.

6.4.4 Attach the piston puller (3.3.1.4) to the piston. Wet the lip seal and reservoir wall with fuel and insert the piston so that the top of the lip seal is about 25 mm from the top of the reservoir.

6.4.5 Close the outlet of the reservoir with the cap seal (3.3.1.5).

6.4.6 Pour fuel on top of the piston to a depth of 6 mm.

6.4.7 Press downward on the piston puller until air leaks past the lip seal as evidenced by the appearance of air bubbles.

6.4.8 Release the pressure and observe whether air leakage past the lip seal stops. Change to a new lip seal if the air leakage does not stop immediately.

6.4.9 Remove the cap seal from the outlet and observe whether the piston moves downward with the piston puller in place. Change to a new lip seal if the piston does not move downward and repeat the lip seal test procedure, commencing with 6.4.2.

6.5 Cleaning

6.5.1 Wear protective gloves (3.3.4.6) because of the possibility of skin irritation from solvents.

6.5.2 Position the cleaning pan (3.3.4.9) to catch solvent during cleaning operations.

6.5.3 Place a new piece of aluminium foil (3.3.4.19) about 450 mm square on the bench on which to place all test section components after cleaning.

6.5.4 Using the wash bottle (3.3.4.8) filled with solvent (3.3.4.5), flush the reservoir cover O-ring.

6.5.5 Flush all inside surfaces of the reservoir with solvent while scrubbing the surfaces with a brush (3.3.4.10).

6.5.6 Flush all inside surfaces of the reservoir with solvent without brushing, and place the reservoir upside down on the aluminium foil.

6.5.7 Using the squeeze bulb (3.3.4.15), blow out the reservoir fuel outlet exit fitting on the bottom of the reservoir to remove the remaining solvent.

6.5.8 Handling the reservoir piston with a piston puller, repeat 6.5.4 and 6.5.5 for the reservoir piston, being careful not to brush or damage the lip seal.

6.5.9 Flush the reservoir cover assembly with solvent.

6.5.10 Flush the heater tube fuel supply line and heater tube fuel outlet line with solvent and thoroughly blow dry using the squeeze bulb.

6.5.11 Flush the pre-filter components with solvent.

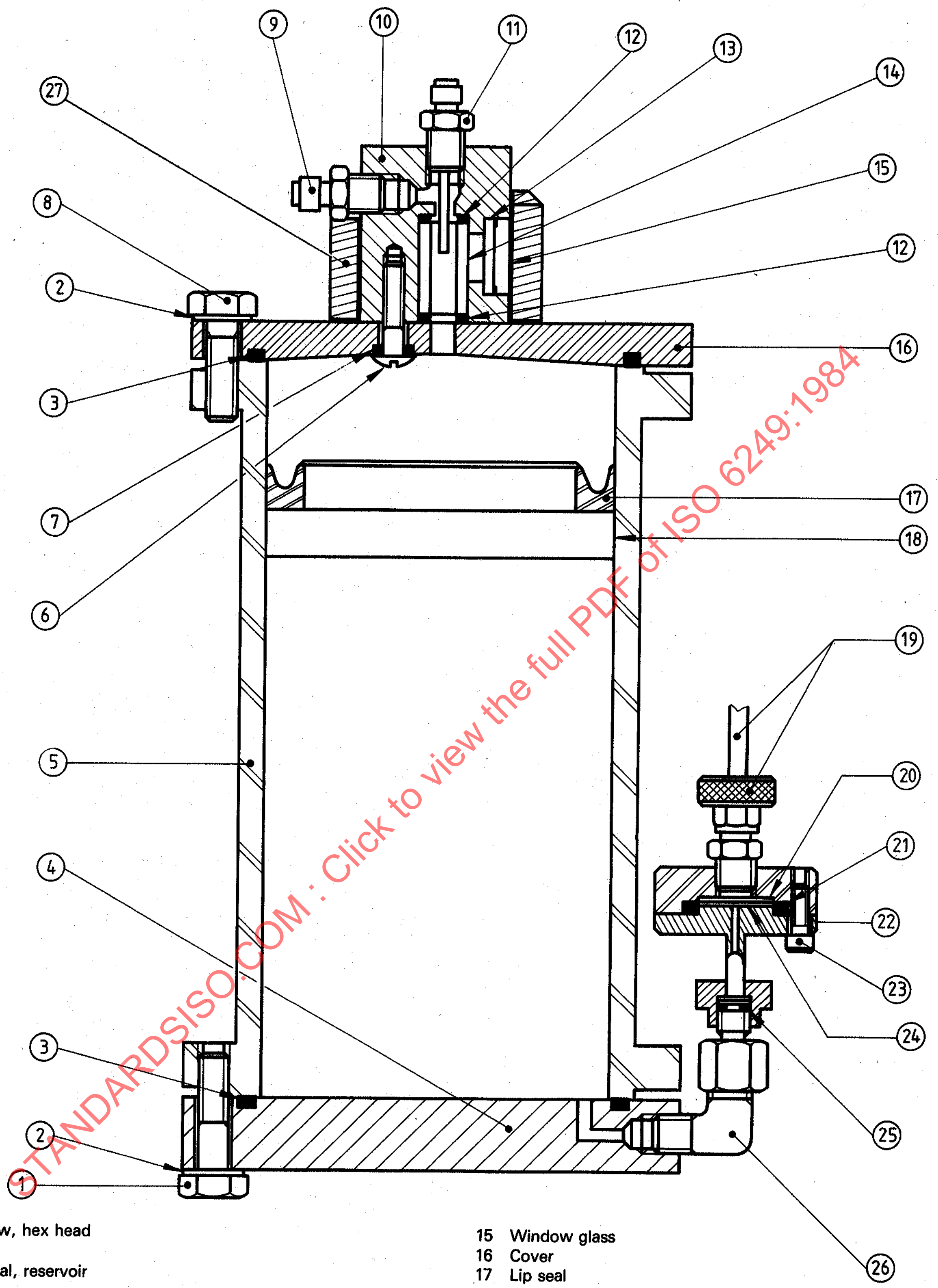
6.5.12 Using a polyamide brush (3.3.4.11) saturated with the trisolvent (3.3.4.7) brush the inside surfaces of the heater tube housing.

NOTE — This is the only component that requires cleaning with trisolvent.

6.5.13 Flush the heater tube housing and filter bypass line with solvent and blow dry with the squeeze bulb. Visually inspect the inner surfaces of the heater tube housing for cleanliness and repeat 6.5.12 as required to remove all deposits.

6.5.14 Flush the four ceramic insulators and heater tube housing nuts with solvent.

6.5.15 Flush the glass filter funnel (3.3.4.12) and glass aeration tube with solvent.



1 Cap screw, hex head
2 Washer
3 O-ring seal, reservoir
4 Base
5 Cylinder
6 Screw, truss head
7 O-ring seal, ret screw
8 Cap screw, hex head
9 Nitrogen inlet fitting
10 Housing, drop flow indicator
11 Drop tube fitting
12 O-ring seal, sight glass
13 Retaining ring
14 Sight glass
15 Window glass
16 Cover
17 Lip seal
18 Piston
19 Heater tube fuel supply line assembly
20 Filter back-up screen
21 O-ring seal, pre-filter
22 Housing, pre-filter
23 Cap screw, Allen head
24 Membrane filter
25 O-ring seal
26 Reservoir fuel outlet fitting
27 Protector, sight glass

Figure 2 — Reservoir and pre-filter assembly

6.6 Assembly of heater tube section

6.6.1 A new heater tube, test filter, and three new high temperature O-rings are required for each test.

6.6.2 During assembly, be sure to have CLEAN hands or wear clean, dry gloves.

6.6.3 Hold the heater tube at one end and insert it carefully, open end upwards, into the heater housing, the lower end can be recognized by the presence of the drive screw which closes it. (See figure 3 for correct assembly of the heater tube and heater tube housing.)

NOTE — If the centre test section is touched, reject the tube as it will affect the deposit-forming characteristics on the tube.

6.6.4 Onto one end of the heater tube, sequentially install a flared ceramic insulator (flared end out), high temperature O-ring, shoulder ceramic insulator (large end first), and hexagon nut. Lightly finger tighten the nut with the heater tube approximately centred in the housing (see figure 3).

6.6.5 Repeat the above procedure for the other end of the heater tube.

6.6.6 Observe the heater tube through the fuel discharge hole of the heater tube housing. Align heater tube shoulder with the centre of the fuel discharge hole (see figure 4). Tighten the hexagon nuts firmly with fingers only. DO NOT USE A WRENCH.

6.6.7 Using clean tweezers (3.3.4.14), install the test filter, RED-COLOURED SIDE OUT, in the outlet chamber of the heater tube housing.

6.6.8 Place a new O-ring on top of the test filter, pushing the O-ring in until it bottoms against the filter.

6.6.9 Connect the fuel outlet line assembly to the heater tube housing outlet. Finger tighten lightly.

6.6.10 Using paper tissue (3.3.4.18), wet with solvent (3.3.4.5), clean the contact areas of the bus-bars.

6.6.11 Raise the thermocouple to the uppermost position.

6.6.12 Place the heater tube section between the bus-bars. Check the alignment, connect and tighten the heater tube fuel outlet and bypass lines to the bulkhead fittings on the rear wall of the test section, being sure the O-rings on these fittings are in place.

6.6.13 If the bus-bar caps have been removed, check for proper mating. Numbers are stamped on inside faces and these must be the same and must face each other.

NOTE — Normally the caps are not removed entirely from their bus-bars during disassembly.

6.6.14 Tighten both socket head (Allen) screws of the upper fixed bus-bar cap, after making sure that the upper end of the heater tube is flush with the top surface of the upper fixed bus-bar.

6.6.15 Raise the lower floating bus-bar until it touches the lower ceramic insulator of the heater tube test section and tighten both socket head (Allen) screws of the lower floating bus-bar cap.

6.6.16 Check the thermocouple for correct position by raising the position indicator to the thermocouple reference line, (see figure 5). The thermocouple tip must be flush with the top of the heater tube and the top of the upper fixed bus-bar. If the thermocouple tip is not flush, see annex D.

6.6.17 Insert the thermocouple into the upper end of the heater tube and lower to the 38,7 mm position.

6.7 Assembly and installation of pre-filter

6.7.1 For each test, use a new 0,45 µm nominal pore size membrane filter element of 25 mm diameter.

6.7.2 Using clean tweezers (3.3.4.14), install the filter element back-up screen in the pre-filter housing recess.

6.7.3 Using clean tweezers, place the 0,45 µm nominal pore size filter element on the back-up screen.

6.7.4 Install the O-ring on the other half of the pre-filter housing.

6.7.5 Assemble the two housing sections, insert the three screws and tighten.

6.7.6 Connect the pre-filter assembly to the reservoir outlet and finger tighten firmly.

6.7.7 Connect the heater tube fuel supply line to the pre-filter and finger tighten firmly.

6.7.8 Install the cap seal at the end of the heater tube fuel supply line.

6.8 Preparation of test portion

6.8.1 Place a filter paper (3.3.2.4) into a glass funnel and set the funnel (3.3.4.12) into the funnel holder (3.3.1.9) that attaches to the reservoir.

6.8.2 Measure the test portion of 600 ml of the laboratory sample using a clean graduated cylinder (3.3.4.20).

NOTE — Because it is necessary to have the test portion at a temperature between 15 and 32 °C after filtration, it is desirable to have it within this temperature range at this time.

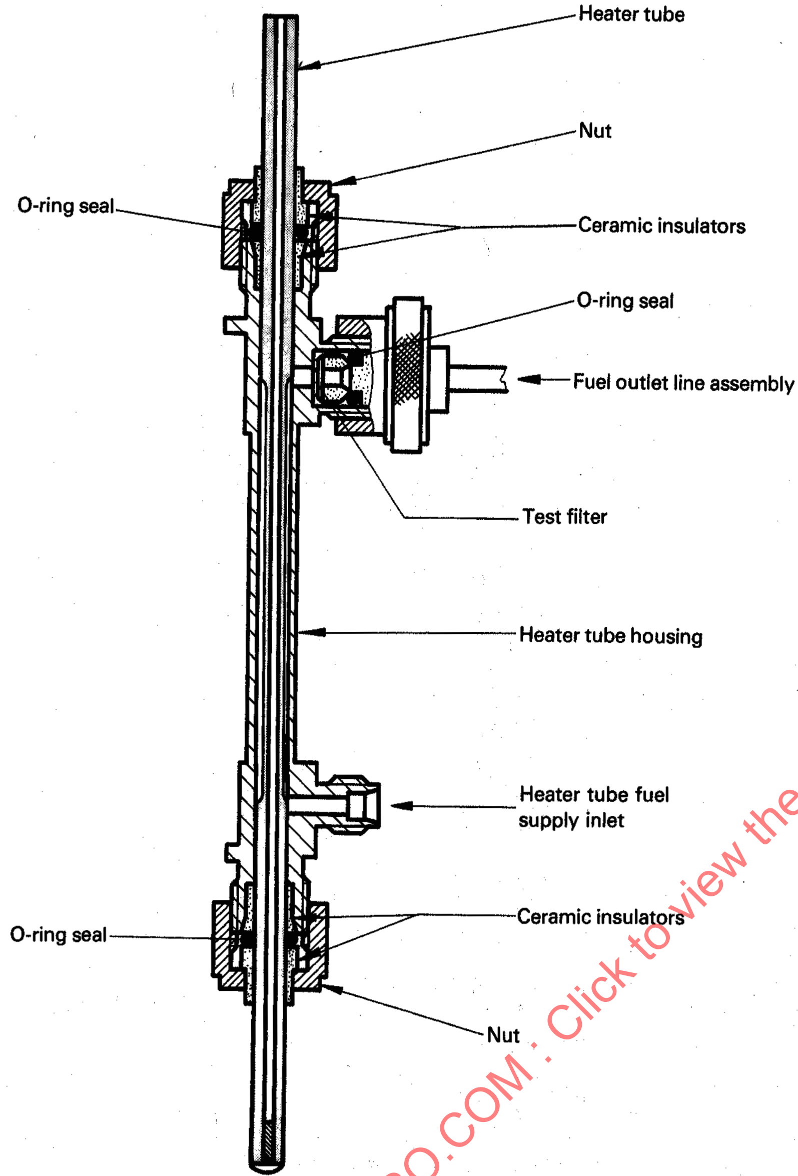


Figure 3 — Assembly drawing of heater tube section

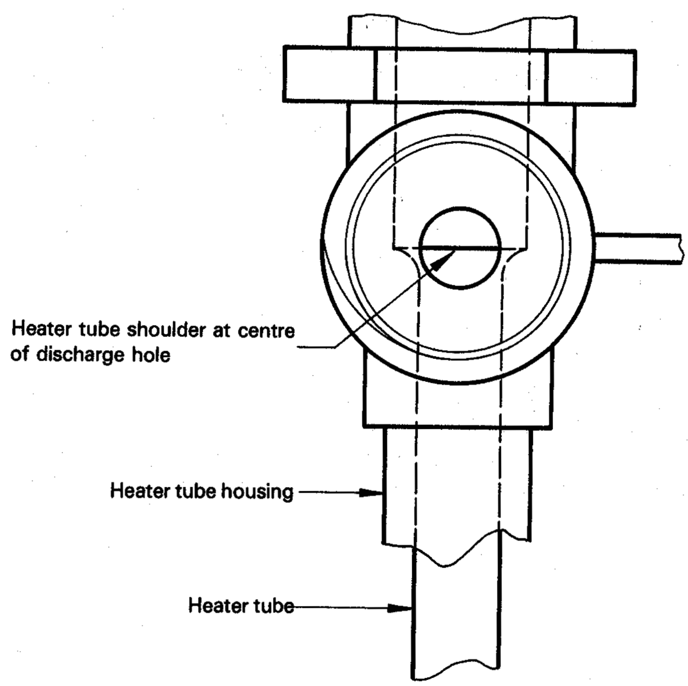
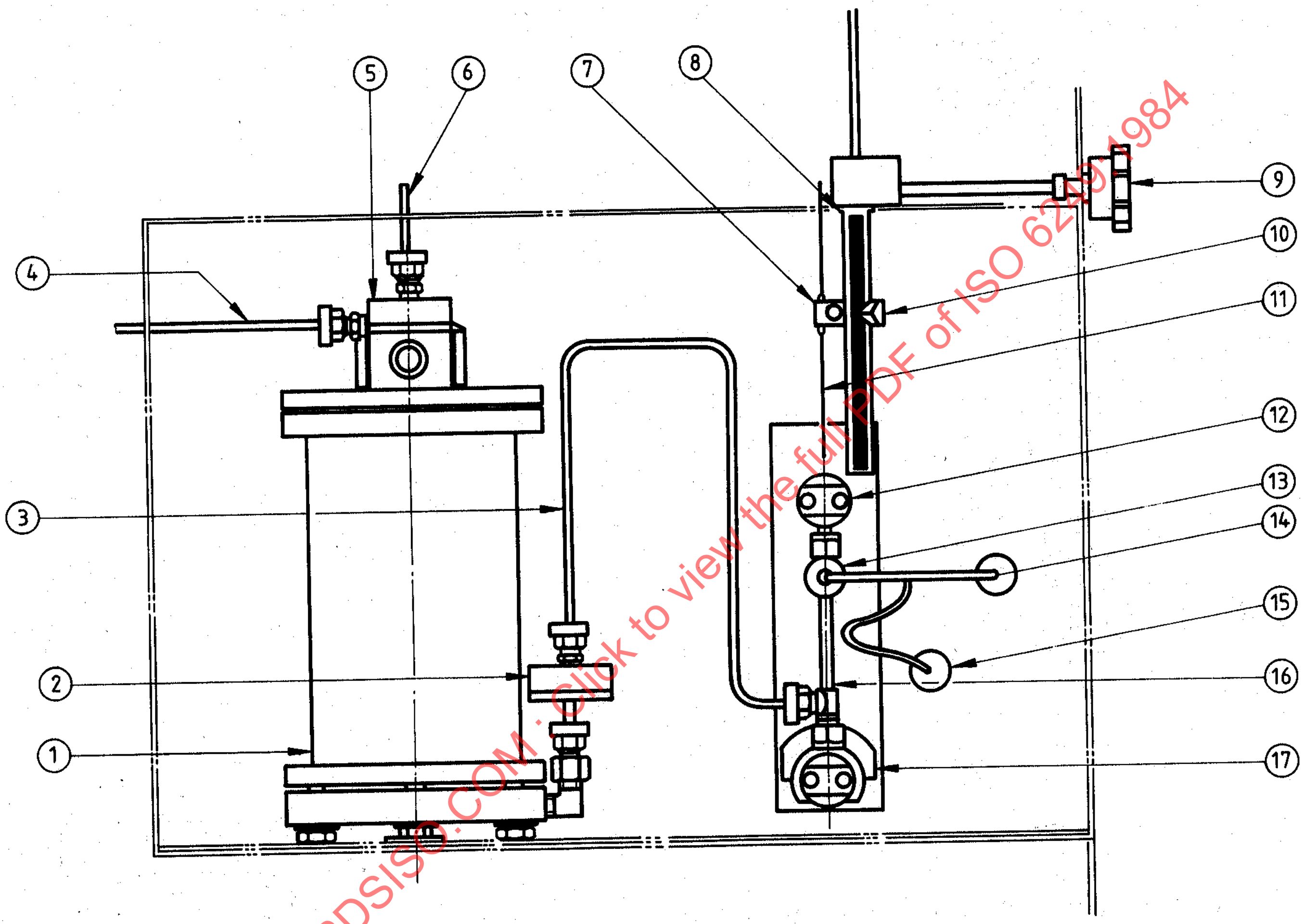


Figure 4 — Alignment of heater tube



1 Reservoir
2 Pre-filter
3 Heater tube fuel supply line
4 Nitrogen inlet line
5 Drop flow indicator
6 Spent fuel return line
7 Thermocouple clamp
8 Thermocouple reference line
9 Thermocouple position control
10 Thermocouple position indicator
11 Thermocouple
12 Upper fixed bus-bar
13 Test filter housing
14 Heater tube fuel outlet line
15 Filter bypass line
16 Heater tube housing
17 Lower floating bus-bar

Figure 5 — Test section compartment

6.8.3 Pour the test portion into the filter and allow it to flow into the reservoir.

6.8.4 Remove the funnel holder.

6.8.5 Insert a clean thermometer (3.3.4.13) and measure the temperature of the test portion. The temperature of the test portion shall be between 15 and 32 °C. If the fuel temperature is outside these limits, a suitable way to change the temperature is to set the reservoir containing the filtered test portion into a hot or cold water bath as required to bring the test portion temperature within limits.

6.8.6 Insert into the reservoir the sintered glass aeration tube (3.3.16) attached to the aeration tube holder (3.3.18). Position the diffuser so that it is touching the bottom of the reservoir.

6.8.7 Using clean, dry flexible plastics tubing, connect the aeration tube to the METERED AIR outlet on the left side of the JFTOT.

6.8.8 Open the AIR FLOW FLOATING INDEX INDICATOR control valve approximately 1/8 of a turn to avoid possible excessive pressure build-up.

6.8.9 Switch the POWER to ON.

6.8.10 Turn the AERATION TIMER control to 6 min.

6.8.11 Using the AIR FLOW valve, adjust the air flow so that the indicator float is in the green range on the flowmeter (this corresponds to approximately 1,5 l/min).

6.8.12 Record on the data sheet the clock time at which aeration is complete. No more than 1 h should elapse between this time and the time at which the heater switch is turned on.

6.8.13 When the AERATION TIMER has shut off the air flow, remove the aeration tube and its holder from the reservoir. Use the test portion dripping from the aeration tube to wet the piston lip seal in 6.9.1.

6.9 Assembly of reservoir section

6.9.1 With the reservoir piston puller (3.3.1.4) attached to the piston, wet the lip seal with filtered test portion dripping from the aeration tube in accordance with 6.8.13.

6.9.2 Insert the piston into the reservoir.

6.9.3 Push down on the piston puller, applying a gentle rocking motion, moving the piston downward until air leakage past the seal is replaced by fuel leakage; that is, eliminate all air below the piston and lip seal. Loosen the cap seal at the end of the heater tube fuel supply line. Apply a slight downward pressure on the piston puller until fuel appears at the cap seal, and retighten the cap seal. Remove the piston puller.

6.9.4 Wet the reservoir O-ring with any fuel and place the O-ring into the cover groove.

6.9.5 Place the reservoir cover on top of the fuel reservoir, taking care that the O-ring stays in the groove. Turn the cover so that the nitrogen inlet fitting on the drip flow indicator is diametrically opposite to the pre-filter fitting.

Ensure that the PROTECTOR SIGHT GLASS is mounted properly over the drip flow housing.

6.9.6 Insert the cap screws into the reservoir cover holes and tighten uniformly with the nut driver (3.3.1.10).

6.9.7 Flush the outside of the reservoir with solvent (3.3.4.5) to remove fuel.

6.9.8 Place the reservoir assembly into the cabinet with the pre-filter section turned toward the heater tube section so that the fore and aft bottom cap screw heads drop into positioning recesses.

6.9.9 Connect the nitrogen inlet line to the side of the drip flow indicator and finger tighten firmly.

6.9.10 Connect the fuel return line to the top of the drip flow indicator and finger tighten firmly.

6.9.11 Remove the cap seal from the heater tube fuel supply line and immediately connect the line to the heater tube housing inlet. The time between removal of the cap seal and connecting should be a minimum to reduce loss of test portion.

6.9.12 Recheck all eight knurled fittings to be sure they are tightened firmly. Recheck that the thermocouple is in the 38,7 mm position.

6.9.13 The apparatus is now ready for the test.

7 Test procedure

7.1 Fuel system pressurization

7.1.1 Check that the NITROGEN PRESSURIZE valve is CLOSED.

7.1.2 Check that the NITROGEN BLEED valve is CLOSED.

7.1.3 Check that the MANOMETER BYPASS valve is OPEN.

7.1.4 Adjust the nitrogen supply pressure to 3,45 MPa[1)] on the pressure regulator control gauge.

7.1.5 Open and close the NITROGEN PRESSURIZE valve to obtain a pressure of approximately 0,2 to 0,3 MPa[1)]. Immediately check the test section for any obvious fitting leaks.

1) 1 MPa = 10 bar.

7.1.6 If a leak is apparent, immediately open the NITROGEN BLEED valve and take corrective action. Close the BLEED valve and recheck the leaks in accordance with 7.1.5.

7.1.7 Slowly open the NITROGEN PRESSURIZE valve to allow the pressure rise to 3,45 MPa[1)] at a rate of 0,2 to 0,3 MPa/s.

7.1.8 Readjust the nitrogen pressure regulator if required. When making a reduction in pressure, it is necessary to have the BLEED valve cracked open during the adjustment.

7.2 Setting of controls

7.2.1 Switch the POWER to ON.

7.2.2 Adjust the WATER FLOW to the centre of the green range (this corresponds to 38 ± 8 l/h).

7.2.3 Set the TIMER to 2 h 30 min.

7.2.4 Set the digital elapsed time indicator to zero.

7.2.5 Set the HEATER TUBE TEMPERATURE CONTROL to the specified maximum heater tube control temperature after applying correction for any error determined in 6.2.18. If the "indicated freezing point" of tin is below 232 °C, subtract the error from specified maximum heater tube temperature. Conversely, if the "indicated freezing point" of tin is above 232 °C, add the error to the specified maximum heater tube temperature.

7.2.6 Turn the control mode switch to AUTOMATIC.

7.2.7 Set the POWER CONTROL at 75 to 80 setting (see the note to 6.2.13).

NOTE — The following two steps are required for Recording Model JFTOT's only.

7.2.8 Switch the ΔP ALARM switch to ON. The red indicating light will come on indicating that the alarm system is armed.

7.2.9 Remove the ΔP RECORDER cover plate and check that there is an adequate chart paper. Unroll about 25 mm of chart paper to indicate the proper index for the start of test. Push the chart mechanism back into position, lock, and turn the switch to green (ON). Replace the cover.

7.3 Start-up

7.3.1 Switch the PUMP to ON. Observe the drip flow indicator to see that flow has started, usually after 10 to 15 s.

7.3.2 Switch the HEATER to ON. Full power, approximately 250 W, is initially applied to the heater tube for a few seconds and then is automatically cut back to limit temperature overshoot. The controller generally will bring the heater tube to the desired control temperature in less than 90 s.

7.3.3 When the temperature deviation meter needle reaches the centre of the scale, close the MANOMETER BYPASS valve.

NOTE — Incorrect readings for pressure drop increase can occur if the manometer bypass valve leaks. This valve should be checked routinely for leakage after every 30 consecutive tests in accordance with clause D.3 of annex D.

7.3.4 Adjust the manometer to zero. Use the top of the coated magnet floating on the mercury as the reference datum for the Recording Model JFTOT.

7.3.5 Record, on the data sheet, the clock time the HEATER switch was turned ON. This time shall not be later than 1 h after completion of fuel aeration (6.8.12).

7.3.6 Determine the fuel flow rate with a stop watch, measuring the time for 20 drops. This time will be 9,0 ± 1,0 s, and will vary with test fuel viscosity and surface tension.

7.3.7 When using the Non-Recording Model JFTOT, record the filter pressure drop on the data sheet every 30 min.

7.3.8 In the Recording Model JFTOT, the ΔP events are recorded automatically and transferred to the data sheet at the end of the test. See annex B.

7.3.9 In Recording Model JFTOT, if the ΔP ALARM is armed as in 7.2.8, the warning horn will sound when ΔP approaches 1,66 MPa[1)]. To stop the horn, switch the ΔP ALARM OFF.

7.3.10 If the ΔP approaches 3,32 MPa[1)] before 150 min and it is desired to continue the test, open the manometer BYPASS valve at 3,26 MPa[1)], otherwise the tester will automatically shut down.

NOTE — If the tester shuts down at 33,3 kPa[2)] (250 mmHg) and it is desired to continue the test, OPEN MANOMETER BYPASS valve and momentarily actuate the POWER switch OFF-ON. This will reset both the ΔP limit cut-off and the timer, resulting in resumption of the test. However, manual shutdown is required for this condition unless the timer is set for the remaining time for finishing the test.

7.3.11 Heater tube temperature profile : if the heater tube temperature profile is specified, obtain in accordance with annex C.

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1) 1 MPa = 10 bar.

2) 1 kPa = 10^{-2} bar.

7.4 Shutdown

7.4.1 Switch the HEATER to OFF.

7.4.2 Switch the PUMP to OFF.

7.4.3 Switch the POWER to OFF.

7.4.4 CLOSE the NITROGEN PRESSURIZE valve.

7.4.5 OPEN the MANOMETER BYPASS valve.

7.4.6 Slowly open the NITROGEN BLEED valve and allow the pressure to decrease to zero at an approximate rate of 0,15 MPa/s or a time period of about 15 s to 30 s.

8 Disassembly

8.1 Disconnect the heater tube fuel supply line fitting from the heater tube housing and quickly install the cap seal.

8.2 Disconnect the nitrogen and fuel return line fittings. Remove the reservoir from the test compartment, placing the reservoir in the cleaning pan (3.3.4.9).

8.3 Disconnect and remove the heater tube fuel outlet line.

8.4 Disconnect the filter bypass line.

8.5 Raise the heater tube thermocouple to the top reference mark.

8.6 Remove the right-hand socket head (Allen) cap screws from each bus-bar.

8.7 Loosen the left-hand socket head (Allen) cap screws three to four turns each but do not remove them.

8.8 Rotate the bus-bar caps and remove the heater tube test section.

8.9 Using the tweezers (3.3.4.14), remove the test filter and O-ring from the discharge chamber and discard.

8.10 CAREFULLY remove the hexagon nuts and shoulder insulators.

8.11 Slide the heater tube out of the housing. DO NOT TOUCH THE AREA OF THE TUBE THAT COMES INTO CONTACT WITH THE FUEL. Remove and discard the O-rings. Save the ceramic insulators.

8.12 Holding the heater tube so that it points upwards from fingers, flush with solvent (3.3.4.5).

8.13 After the solvent has evaporated from the heater tube, replace the heater tube in the original container and seal with a cap. MARK WITH APPROPRIATE IDENTIFICATION.

8.14 Remove the reservoir cover and empty the fuel into a waste disposal suitable for flammable liquids.

8.15 Remove the cap seal fitted in 8.1, then using a piston puller, remove the piston from the reservoir and empty any remaining fuel into a waste disposal suitable for flammable liquids.

8.16 Disconnect the inlet line from the pre-filter.

8.17 Disconnect the pre-filter section from the reservoir outlet and disassemble it by removing three socket head (Allen) screws. Discard the filter element.

9 Heater tube deposit rating

9.1 Visual method

9.1.1 Snap the upper end of the heater tube into the clamp of the adapter for the heater tube.

9.1.2 Push the heater tube against the stop of the adapter for the heater tube.

9.1.3 Slide the adapter with the heater tube over the guide rod into the Tuberator equipped with a magnifying glass assembly.

9.1.4 Insert the colour standard[1)] into the Tuberator.

9.1.5 Rotate the adapter and turn the heater tube so that the side with the maximum deposit is visible.

9.1.6 Compare the maximum heater tube deposit with the colour standard. When the maximum deposit corresponds exactly to a standard colour, that number should be recorded. If the maximum heater tube deposit being rated is in an obvious transition state between any two adjacent standard colours, the rating should be reported as less than the darker (that is, the higher number) standard colour.

9.1.7 Return the heater tube to its original container.

1) The colour standard for tube deposit rating is available commercially. Details may be obtained from the Secretariat of ISO/TC 28 or from the ISO Central Secretariat.

9.2 Mark 8A Tube Deposit rating methods

9.2.1 Preparation of calibration tube

9.2.1.1 Place the Mark 8A Tube Deposit Rater (TDR) on a table or bench, extend the front support, plug it into a suitable power point, and turn the POWER switch to ON position. Approximately 2 min are required for warm-up.

9.2.1.2 Remove the calibration tube from its container by pulling on the yellow cap which is attached to the calibration tube. DO NOT touch the tube's centre section, otherwise it will affect the calibration of the TDR.

9.2.1.3 Holding the calibration tube by its yellow cap, insert it into the rating rack on top of the TDR. It is necessary that the tube be pushed down firmly until it bottoms.

9.2.1.4 Turn the POWER switch to SPIN position.

9.2.1.5 Turn the TUBE POSITION control to set indicator at 35 position.

9.2.1.6 Turn the LOW-CAL control to obtain a tube deposit rating in accordance with the calibration printed on the calibration tube.

9.2.1.7 Turn the TUBE POSITION control to set indicator at 53 position.

9.2.1.8 Turn the HIGH-CAL control to obtain a tube deposit rating in accordance with the calibration printed on the calibration tube.

9.2.1.9 Turn the TUBE POSITION control to obtain the maximum TDR reading in the vicinity of 22 position. If the position indicator does not read 22 for the maximum TDR reading, then the calibration tube is not fully inserted or the tube position dial needs correction. See the maintenance manual for adjustment of the tube position dial.

9.2.1.10 Turn the POWER switch from SPIN to ON position.

9.2.1.11 Remove the calibration tube and insert the tube into its storage container.

9.2.2 Rating of the heater tube deposit

9.2.2.1 Remove the JFTOT heater tube to be rated from its container by inserting the rod of the rotation knob fully, being very careful not to touch the centre section.

9.2.2.2 Holding the rotation knob, insert the heater tube into the rating rack on top of the TDR. It is necessary that the heater tube be pushed down firmly until it bottoms.

9.2.2.3 Turn the POWER switch to SPIN position.

9.2.2.4 To obtain the SPUN deposit rating for any position, set the TUBE POSITION index to the desired position and read the meter.

9.2.2.5 To obtain the maximum SPUN deposit rating, slowly scan from a TUBE POSITION indicator reading of 15 to 55, stopping at the position of maximum reading. Record this reading as the maximum SPUN deposit rating. Do not change the TUBE POSITION knob.

9.2.2.6 Turn the POWER switch to ON position.

9.2.2.7 Slowly rotate the heater tube manually counterclockwise through 360° stopping when the maximum obtainable meter reading is observed. Record this meter reading as the maximum SPOT deposit rating.

9.2.2.8 Replace the test heater tube in its original container and seal with a cap.

10 Expression of results

The results of this test shall be expressed as outlined in the JFTOT data sheet (see table 1), and shall include at least the following:

a) the maximum heater tube temperature;

b) the heater tube deposit rating or ratings;

c) the pressure drop across the filter at the end of the test or the time required to reach a pressure differential of 33,3 kPa[1] (250 mmHg). For the Recording Model JFTOT report, the maximum recorded ΔP shall be considered the ΔP at the end of test.

10.1 Precision

Precision data relating to this method have not yet been established.

11 Test report

The test report shall contain at least the following information:

a) the type and identification of the product tested;

b) a reference to this International Standard or to a national standard;

c) the result of the test expressed as in clause 10 and recorded in the form outlined in table 1;

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

e) the date of the test.

1) 1 kPa = 10^{-2} bar.

Annex A

Jet Fuel Thermal Oxidation Tester (JFTOT)

(Forms part of the Standard.)

A.1 Apparatus

A.1.1 The apparatus described in this annex is known as the JFTOT (Jet Fuel Thermal Oxidation Tester). It consists essentially of a closed loop fuel system with a heater tube section including a test filter together with associated equipment for controlling and measuring the heater tube temperature. Two models are available, Recording Model and Non-Recording Model. The only differene in the two models is the absence of the ΔP recorder from the latter model.

A.1.2 Certain essential accessories and materials supplied with the tester are listed in 3.3.1, 3.3.2, 3.3.3. Others not supplied with the tester are listed in 3.3.4.

A.2 General description

Figure 2 is an assembly drawing of the reservoir and pre-filter.

Figure 3 is an assembly drawing of the heater tube section.

Figure 5 is a drawing of the test section compartment.

Figure 6 is a schematic diagram of the fuel system.

Figure 7 is a schematic diagram of the heater tube power and temperature control systems.

A.3 Fuel system

A.3.1 Test fuel contained in the reservoir is passed through the test section by a constant displacement pump located downstream of the heater tube section to preclude contamination by pump wear particles. The pump is driven by a constant speed motor so as to have a displacement of 3,0 ml/min.

A.3.2 From the reservoir outlet, the fuel flows through a 0,45 µm nominal pore size membrane type filter, thence to the lower (inlet) part of the heater tube section. The heater tube is connected between two bus-bars and is electrically insulated from the outer housing by means of a ceramic ferrule/O-ring seal combination. The fuel rises vertically in the annular space between the aluminium heater tube and its outer stainless steel housing. A low-voltage, high-alternating current signal is passed through the heater tube section, the fuel passes through a test filter having an element made from stainless steel cloth with a nominal pore size of 17 µm.

A.3.3 A mercury manometer is connected so as to measure pressure drop across this filter. In the ΔP Recorder Model, the ΔP versus time relation is automatically recorded. The test filter can be bypassed at any time; normally this is done when ΔP reaches 33,3 kPa[1] (250 mmHg). The fuel reaches the cooler either directly or through the bypass and proceeds through the metering pump to return to the fuel reservoir. A sight gauge drip flow indicator allows visual monitoring of the flow rate. Return fuel is isolated from the test fuel by a piston with a lip seal.

A.4 Heating and temperature control system

A.4.1 The heater tube is heated by the passage of an electrical current of approximately 200 to 300 A at 0,3 to 0,5 V. The heater tube is clamped at each end into bus-bars having gold plated contact surfaces. The bus-bars are cooled by internal water lines. The bus-bars receive electrical power from a low voltage transformer having a step-down ratio to match the electrical resistance of the heater tube.

A.4.2 When the tester is operated in the automatic mode the temperature is under automatic control and the control unit also acts as the temperature indicator. When the tester is operated in the manual mode the control unit acts only as a temperature indicator and the temperature is controlled manually by operation of the POWER CONTROL. The input signal to the controller is from a thermocouple inserted through the top of the heater tube and positioned at the point of maximum temperature.

This thermocouple can be positioned at any point along the heated portion of the tube for the purpose of obtaining a temperature profile. An indicator is provided to define the position of the thermocouple junction with 0,0 station being the heater tube's lower shoulder. A wattmeter measures electrical power supplied to the low voltage transformer and, therefore, indicates total power consumed by the heater tube plus bus connecter, transformer, and line losses. A variable voltage transformer, labelled POWER CONTROL, having a dual function, controls the maximum voltage and is the only control when in the manual mode. The POWER CONTROL has a removable stop to limit the power so as to prevent melting of the heater tube in the event that the operator neglects to insert the thermocouple into the heater tube. When the desired maximum tube temperature control (greater than about 434 °C) cannot be obtained with the POWER CONTROL against this stop, it may be removed. A constant-voltage transformer is supplied with each tester to compensate for line voltage fluctuations.

A.5 Cooling system

Ordinary tap water at any pressure between 200 and 700 kPa[1] is required for bus-bar connector cooling. The JFTOT has a flow adjustment valve and a floating index type flow indicator to set the rate at 38 ± 8 l/h. After entering the cabinet, the water flows through a filter adequate to remove any solid

1) 1 kPa = 10^{-2} bar.

particles that could plug the lines with time or interfere with the operation of the solenoid valve which is normally closed and opens when the power switch is turned on. A water pressure switch is in the power line to the pump motor and heater and is normally open, closing only when the water pressure rises above 140 kPa[1] and opening (turning heater and pump off) if the water pressure drops below this value. The water next flows through a heat exchanger used to cool the fuel prior to entering the pump. After this, the water passes through copper tubing internally silver soldered to the bus-bars. The water lines are electrically insulated from the bus connectors by means of polyethylene tubing.

A.6 Fuel pressurization system

Compressed nitrogen from a cylinder fitted with a pressure regulator is used to provide a pressure of 3,45 MPa[2] in the fuel system. All system components have been tested to 7 MPa[2].

For safety, an adjustable pressure limiter is provided in the nitrogen inlet line and is set at approximately 4 MPa[2]. Two nitrogen control needle valves marked "Pressurize" and "Bleed" are provided. Their function is evident from the schematic diagram, figure 6.

A.7 Manometry system

A.7.1 A single leg 305 mm mercury manometer is connected across the test filter to measure filter pressure drop as the filter fouls with products of fuel degradation. A manual valve labelled MAN.BYPASS permits the fuel to bypass the test filter when 33,3 kPa[1] (250 mmHg) ΔP occurs before the time set to obtain heater tube deposits for the full test period.

A float type check valve in the low pressure leg of the manometer prevents mercury from "going over the top" during abnormally high differential pressure surges and consequently contaminating the fuel system. This could happen only by applying an excessively rapid rate of pressurization or failure of the automatic system to shut the rig down at 33,3 kPa[1] (250 mmHg) ΔP. A manual valve labelled MAN.BLEED is provided to bleed and eliminate readily any air or nitrogen from the manometer system whenever required.

A.7.2 In the Recording Model, automatic recording of ΔP versus time is obtained with a 10-channel event recorder which has two speeds of 60 and 360 mm/h. Normal speed is 60 mm/h. Reed-type switches at stations 0,27 — 1,33 — 1,99 — 3,33 — 6,67 — 9,99 — 16,7 and 33,3 kPa[1] (2, 10, 15, 25, 50, 75, 125 and 250 mmHg) respectively are mounted adjacent to the manometer tube and are activated by a small plastics-enclosed magnet floating on top of the mercury column. As ΔP increases, the magnet activates each switch in turn and the resulting signal records the event on the appropriate channel of the event recorder. A ΔP warning system sounds a horn when the ΔP reaches 16,7 kPa[1] (125 mmHg) to alert the operator of impending shutdown at 33,3 kPa[1] (250 mmHg). The ΔP alarm system controls are located at the top of the manometer cover and consist of an ON-OFF switch, a red light to show that the system is armed, and a high frequency horn. When the ΔP reaches 33,3 kPa[1] (250 mmHg), the reed switch action cuts off the power to the metering pump, heater tube and timing devices; all other devices such as the blower and solenoid remain ON until the power switch is turned manually to OFF.

A.8 Thermocouple calibration system

The AutoCal calibration system provides for a reliable check of the calibration of the entire temperature indication system by utilizing the freezing point, 232 °C, of 99,99 % pure tin as the standard. The AutoCal calibrator consists of a special heater tube which has at its middle section a small well containing pure tin into which the thermocouple is immersed. The test thermocouple is introduced into the tin after raising the temperature above the melting point and the cool-down temperature-time characteristic is observed by the operator who notes the temperature indication at which the temperature controller deviation meter needle pauses. Any difference between this reading and 232 °C is the error in the temperature measurement system and must be applied as a correction when setting the maximum heater tube control temperature and when plotting a heater tube temperature profile.

A.9 Fuel aeration system

A system is provided to air saturate the test portion in the reservoir prior to test. A floating index flow control and automatic timer cut-off are set to pass dry, filtered air at 1,5 l/min for 6 min. The 9,0 l thus passed through the fuel ensure at least 97 % of air saturation.

A.10 Elapsed test time measurement

There are two indications of elapsed test time in the manual model, a digital readout indicator (to nearest 0,1 min) and a timer cut-off (to nearest 3 min) which can be set to cutt off at any specified time up to 5,0 h. In the Recording Model JFTOT, the automatic ΔP recorder provides yet a third measure of elapsed test time.

A.11 Laboratory installation requirements

A.11.1 The tester should be placed on a level laboratory bench, allowing 200 to 300 mm wide bench area in front of the tester. Ready access to the rear of the tester should be provided for normal maintenance and service requirements. Ensure that the vent on top of the JFTOT cabinet is not obstructed during installation or use. The constant-voltage transformer must be plugged into the left side of the tester and can be placed either adjacent to the tester or preferably under the bench. Single-phase electrical power 115 V-60 Hz-15 A or optional 220 V-50 Hz-8 A with a ground (earth) outlet is required.

A.11.2 A nitrogen cylinder with a suitable regulator capable of supplying 3,45 MPa[2] should be placed conveniently and connected with 3,2 mm diameter tubing to the tester. A suitable 6,4 mm diameter line needs to be connected from the WATER INLET connection to a 200 to 700 kPa[1] water supply and a 6,4 mm diameter line needs to be connected from the WATER DRAIN to a drain having a minimum capacity to receive 80 l/h.

1) 1 kPa = 10^{-2} bar.

2) 1 MPa = 10 bar.

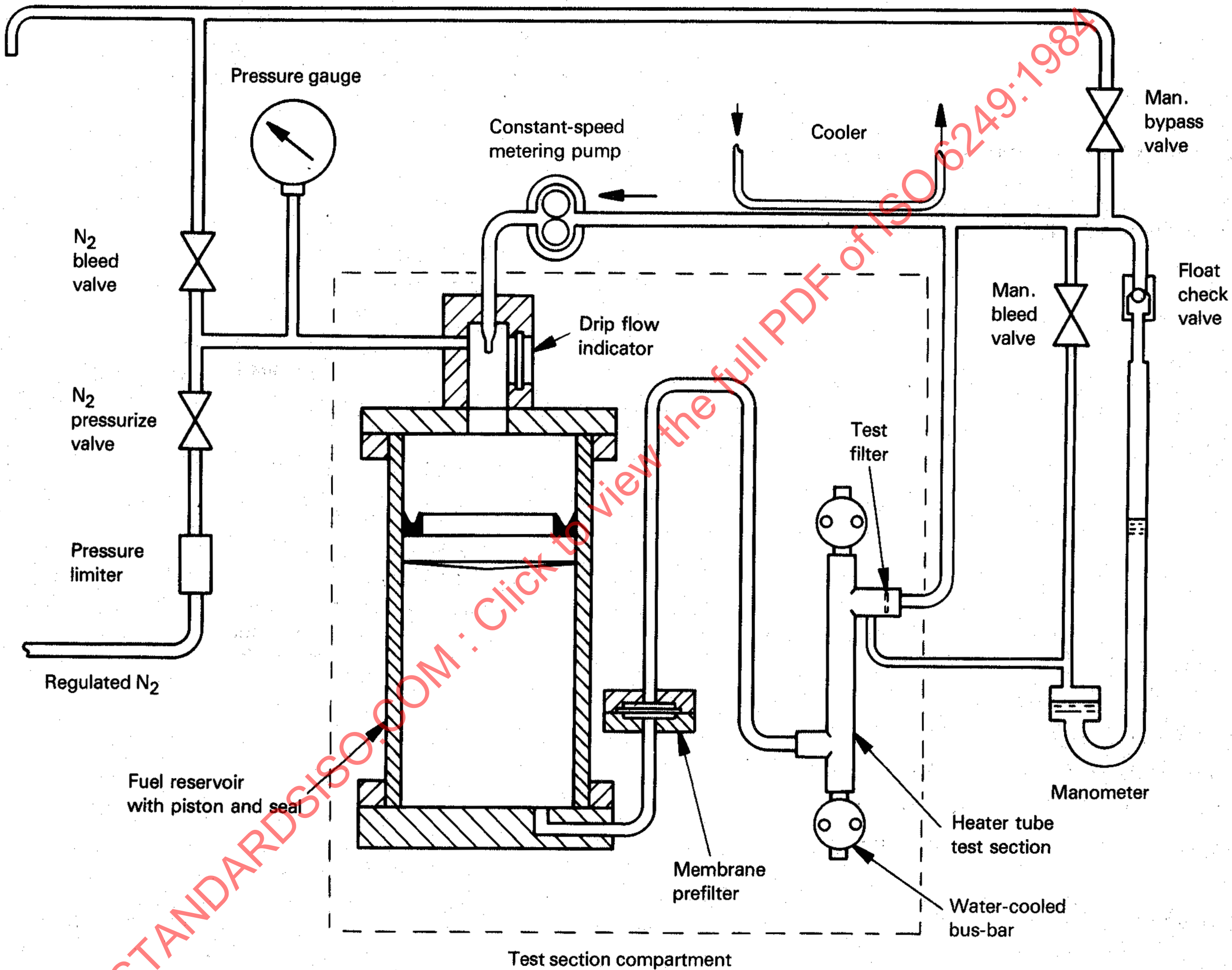

Figure 6 — Fuel system schematic diagram

Table 1 — JFTOT data sheet — Thermal oxidation stability test using Jet Fuel Thermal Oxidation Tester

Date . . . . **Fuel description** . . . . **Test No** . . . .

Name of testing laboratory . . . .

Controller calibration

Indicated freezing point . . . . °C

True freezing point . . . . . . 232 . . . . . . °C

Controller error . . . .

Maximum heater tube temperature

Specified °C . . . .

Controlled error, °C . . . .

Controller setting, °C . . . .

Clock time

Fuel aerated . . . .

Heater on . . . .

Fuel temperature at aeration . . . .

Filter pressure drop data

Test time min	Filter ΔP mmHg	Recorded ΔP kPa (mmHg)	Test time min
0	. . . .	0,27 (2)	. . . .
30	. . . .	1,33 (10)	. . . .
60	. . . .	1,99 (15)	. . . .
90	. . . .	3,33 (25)	. . . .
120	. . . .	6,67 (50)	. . . .
150	. . . .	9,99 (75)	. . . .
. . . . .	. . . .	16,7 (125)	. . . .
. . . . .	. . . .	33,3 (250)	. . . .

Heater tube deposit data

Maximum visual deposit rating, ASTM Code Number . . . .

Maximum Mark 8A TDR spun deposit rating . . . .

Maximum Mark 8A TDR spot deposit rating . . . .

Remarks : . . . .

. . . .

. . . .

Annex B

ΔP event recorder

(Forms part of the Standard.)

Before utilizing the ΔP event recorder, familiarization with the instruction manual for the Model 2755 Ten Channel Event Recorder is required. This manual is furnished with each JFTOT. The ΔP events are recorded in sequence by styli which move at right angles to the chart's direction of motion. Normal chart speed is 60 mm/h with chart subdivisions spacing every 5 min. Channel 1 records the start and the end of the test; that is, HEATER ON and OFF events. The chart drive is also actuated by the HEATER ON or OFF function. Channels 2 to 8 record 0,27 — 1,33 — 1,99 — 3,33 — 6,67 — 9,99 and 16,7 kPa[1)] (2, 10, 15, 25, 50, 75 and 125 mmHg) ΔP respectively. If ΔP reaches 33,3 kPa[1)] (250 mmHg) automatic shutdown is actuated, which also stops recorder chart drive. After completion of test, remove that portion of the chart that is applicable to the test and with pencil or pen emphasize locations where styli are first activated by movement to the right. Read off the time after start of test that activation occurred for each ΔP channel and record on the data sheet.

1) 1 kPa = 10^{-2} bar.

Annex C

Heater tube temperature profile

(Forms part of the Standard.)

C.1 Data are presented in table 2 to permit establishing the heater tube temperature profile for maximum heater tube temperatures from 200 to 370 °C. If it is desired to measure the heater tube temperature profile, the following procedure should be followed after the second half hour of the test or before a significant ΔP has been obtained.

C.2 Observe the wattmeter reading and simultaneously switch the controller mode to MANUAL and reduce POWER CONTROL to previously observed wattmeter reading. Fine-adjust the POWER CONTROL to place temperature deviation meter needle at exact centre of the scale and let it stabilize. If no temperature drift is observed for 30 s, proceed to the next step.

C.3 Move the thermocouple in sequence to the following positions to obtain their temperature :

mm
56
50
44
38,7
32
26
18
10

At each position, adjust the digital set point control on the temperature indicator to centre the deviation meter needle. Allow at least 5 s for temperature stabilization before recording the indicated temperature.

C.4 If the temperature at the 38,7 mm position has drifted more than ± 2 °C from the initial value, readjust the POWER CONTROL and begin again at the 56 mm position after the temperature at the 38,7 mm position has become stable at the initial value. If drift is less than ± 2 °C, readjust POWER CONTROL and proceed to the 32 mm position.

C.5 Return the thermocouple to the 38,7 mm position. Again, if this temperature hs drifted in excess of ± 2 °C, reset manually and repeat the above procedure.

C.6 Simultaneously switch the temperature controller to AUTOMATIC mode and adjust the POWER CONTROL to 75 to 80 setting (see the note to 6.2.13).

C.7 Correct recorded temperatures for error in accordance with 7.2.5.

C.8 Continue the test.

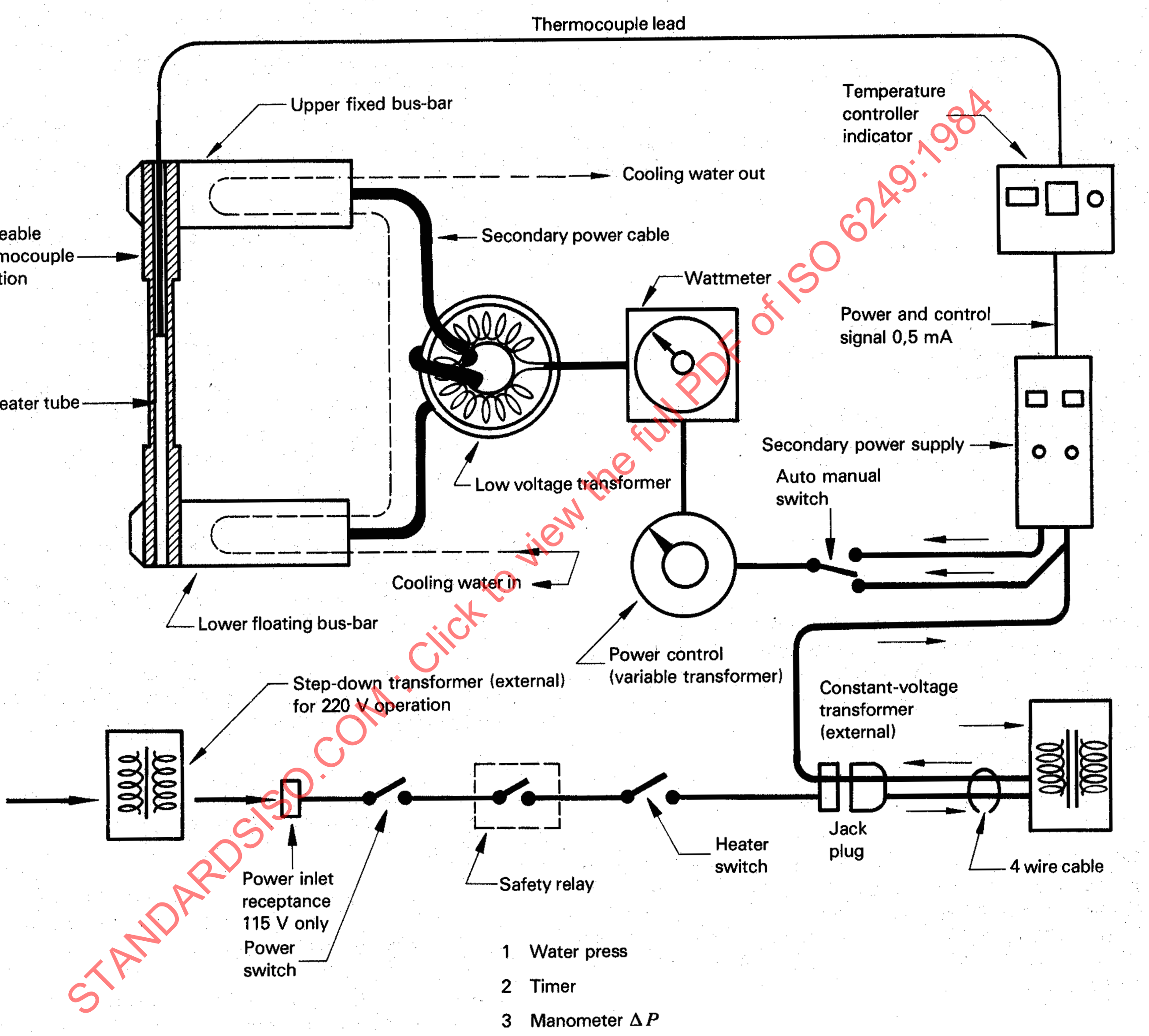

Figure 7 — Heater tube power and temperature control schematic diagram

Annex D

Maintenance

(Forms part of the Standard.)

D.1 AutoCal Calibrator tin replacement

D.1.1 The tin in the well of the AucoCal Calibrator must be replaced whenever the quantity is below the minimum or when the tin has become contaminated.

D.1.2 To remove the tin, install the AutoCal Calibrator INVERTED between the upper fixed bus-bar and the lower floating bus-bar.

D.1.3 Place a paper tissue or rag under the well to catch the molten tin.

D.1.4 Apply power to the AutoCal Calibrator in accordance with 6.2 and at the same time gently tap the well until all molten tin has dropped out.

D.1.5 Remove the AutoCal Calibrator and install it in upright position and refill with new tin charge (3.3.3.9).

D.2 Thermocouple replacement and position adjustment

D.2.1 The thermocouple used for measuring and controlling the temperature of the JFTOT heater tube needs replacement at intervals due to insulation abrasion or other damage to the insulation or thermocouple element.

D.2.2 To remove the thermocouple, loosen the thermocouple clamp, support clamp and thermocouple connections on back of the temperature controller.

D.2.3 Install a new thermocouple following the same routing as old thermocouple. Replace and tighten screws. When tightening the socket head (Allen) screw of thermocouple clamp, the tip of the thermocouple must be flush with the top of upper fixed bus-bar when the position indicator is set at the reference mark.

D.2.4 Check for proper thermocouple indexing under actual test operating conditions.

D.2.5 Operate the JFTOT at some control temperature with the new thermocouple at the 38,7 mm position. The control temperature chosen is not critical, but must be between 200 and 370 °C.

D.2.6 Change to the manual mode for temperature control following the instructions in C.2 and observe the temperature at the 18 mm position in accordance with C.3. If the observed temperature at the 18 mm position is not within 1 °C of the value in table 2, adjustment of the thermocouple position is necessary.

D.2.7 To adjust the thermocouple, loosen the socket head (Allen) screw of the thermocouple clamp. Without moving the position index, move the thermocouple until a reading within 1 °C of the table 2 value is obtained. Tighten the socket head (Allen) screw firmly.

D.2.8 Return index to the 38,7 mm position and observe temperature. If the observed temperature differs by more than 0,5 °C from the value selected in D.2.5, readjust the POWER CONTROL to obtain the selected control temperature. If a power adjustment was necessary, recheck the temperature at the 18 mm position which should be within 1 °C of the table 2 value.

D.2.9 Repeat steps D.2.7 and D.2.8 until alternate readings at the 38,7 mm and 18 mm positions are within 0,5 and 1 °C, respectively, of the table values.

D.3 Manometer bypass valve leakage check

This check should be performed every 30 consecutive tests.

D.3.1 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.

D.3.2 Circulate clean filtered fuel at 3,45 MPa with manometer bypass valve in the open position.

D.3.3 After steady flow is observed in the sight glass (20 drops in 9,0 ± 1,0 s), close the manometer bypass valve and simultaneously start a stopwatch.

Observe the time required for the manometer float to reach 100 mm ΔP. Immediately open the manometer bypass valve to resume normal fuel flow.

D.3.4 If the time measured to reach 100 mm ΔP is equal to or less than 60 s, the manometer bypass valve and the fuel pump meet normal performance requirements.

D.3.5 If the time measured to reach 100 mm ΔP exceeds 60 s, either the manometer bypass valve is leaking or the fuel metering pump performance is unsatisfactory. In this case, the fuel metering pump performance should be checked to determine if the pump or manometer bypass valve needs replacement.