SASO 2263/2023

AVIATION TURBINE FUELS

(FOR CIVIL USE ONLY)

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ICS

Date of SASO Board of Directors Approval : XX/XX/143XH (XX/XX/20XX)
Date of Publication in the Official Gazette :
Date of Enforcement of this Standard :

AVIATION TURBINE FUELS

1. SCOPE AND FIELD OF APPLICATION

1.1 This is the standard for fuels mainly used in aviation gas turbine engines as aviation turbine fuel, kerosene type.

1.2 This standard defines the requirements for Jet A-1 type of aviation turbine fuels for civil use only in the satisfactory operational performance, and certification of appropriate aircraft or gas turbine engines. The specification can be used as a standard in describing the quality of aviation turbine fuels from the manufacturing site (refinery) through the distribution supply chain to the airport as the end user.

1.3 This standard does not include all fuels satisfactory for aviation turbine engines such as military jet fuels. Certain equipment or conditions may permit a wider or require a narrower range of hydrocarbon characteristics of the aviation turbine fuels for use than is prescribed in this standard.

1.4 Aviation turbine fuels defined by this standard may be used in applications other than aviation gas turbine engines that are specifically designed and certified for this type of fuel.

1.5 This standard, unless otherwise provided, prescribes the quality requirements (test property specifications) of aviation turbine fuels at the time and place of delivery.

1.6 This standard does not purport to address all the safety concerns associated with the use of aviation turbine fuels, kerosene type. It is the responsibility of the user of this standard to establish appropriate safety and health practices, and determine the applicability of regulatory requirements or limitations relating to health and safety at work prior to handling aviation turbine fuels.

2. COMPLEMENTARY REFERENCES

2.1 SASO-ASTM D4176 "Standard Test Method for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures)"

2.2 SASO-ASTM D156 "Standard Test Method for Saybolt Color of Petroleum Products (Saybolt Chromometer Method)"

2.3 SASO-ASTM D6045 "Standard Test Method for Color of Petroleum Products by the Automatic Tristimulus Method"

2.4 SASO-ASTM D5452 "Standard Test Method for Particulate Contamination in Aviation Fuels by Laboratory Filtration"

2.5 IP 423 "Determination of Particulate Contaminant in Aviation Turbine Fuels by laboratory filtration"

2.6 IP 565 "Determination of the Level of Cleanliness of Aviation Turbine Fuels - Portable Automatic Particle Counter Method"

2.7 IP 577 "Determination of the Level of Cleanliness of Aviation Turbine Fuel -

Automatic Particle Counter Method using Light Extinction"

2.8 ASTM D7619 "Standard Test Method for Sizing and Counting Particles in Light and Middle Distillate Fuels, by Automatic Particle Counter"

2.9 ASTM D3242 "Standard Test Method for Acidity in Aviation Turbine Fuel"

2.10 IP 354 "Determination of the Acid Number of Aviation Turbine Fuels - Color-Indicator Titration Method"

2.11 SASO-ASTM D1319 "Standard Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption"

2.12 IP-156 "Determination of Hydrocarbon Types in Petroleum Products – Fluorescent Indicator Adsorption Method"

2.13 SASO-ASTM D6379 "Standard Test Method for Determination of Aromatic Hydrocarbon Types in Aviation Fuels and Petroleum Distillates—High Performance Liquid Chromatography Method with Refractive Index Detection"

2.14 IP 436 "Determination of Aromatic Hydrocarbon Types in Aviation Fuels and Petroleum Distillates – High Performance Liquid Chromatography Method with Refractive Index Detection"

2.15 SASO-ASTM D1266 "Standard Test Method for Sulfur in Petroleum Products (Lamp Method)"

2.16 SASO-GSO-ASTM D2622 "Standard Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry"

2.17 SASO-ASTM D4294 "Standard Test Method for Sulfur in Petroleum and Petroleum Products by Energy Dispersive X-ray Fluorescence Spectrometry"

2.18 SASO-ASTM D5453 "Standard Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence"

2.19 IP 336 "Petroleum Products - Determination of Sulfur Content - Energy-Dispersive-X-Ray Fluorescence Method"

2.20 SASO-ASTM D3227 "Standard Test Method for (Thiol Mercaptan) Sulfur in Gasoline, Kerosine, Aviation Turbine, and Distillate Fuels (Potentiometric Method)"

2.21 IP 342 "Petroleum Products - Determination of Thiol (Mercaptan) Sulfur in Light and Middle Distillate Fuels - Potentiometric Method"

2.22 SASO-ASTM D4952 "Standard Test Method for Qualitative Analysis for Active Sulfur Species in Fuels and Solvents (Doctor Test)"

2.23 IP 30 "Detection of Mercaptans, Hydrogen Sulfide, Elemental Sulfur and Peroxides - Doctor Test Method"

2.24 ASTM D7797 "Standard Test Method for determination of the Fatty Acid Methyl Esters Content of Aviation Turbine Fuel using Flow Analysis by Fourier Transform Infrared Spectroscopy – Rapid Screening Method"

2.25 IP 585 "Determination of Fatty Acid Methyl Esters (FAME), derived from bio-diesel fuel, in Aviation Turbine Fuel – GC-MS with Selective Ion Monitoring/ Scan Detection Method"

2.26 IP 583 "Determination of the Fatty Acid Methyl Esters content of Aviation Turbine Fuel using Flow Analysis by Fourier Transform Infrared Spectroscopy – Rapid Screening Method"

2.27 IP 590 "Determination of Fatty Acid Methyl Esters (FAME), derived from biodiesel fuel, in Aviation Turbine Fuel – HPLC Evaporative Light Scattering Detector Method”

2.28 IP 599 “Determination of Fatty Acid Methyl Esters (FAME) in Aviation Turbine Fuel by Gas Chromatography using Heart-cut and Refocusing Method”

2.29 ASTM D7872 “Standard Test Method for Determining the Concentration of Pipeline Drag Reducer Additive in Aviation Turbine Fuels chemical concentration”

2.30 SASO-ASTM D86 “Standard Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure”

2.31 SASO-ASTM D7345 “Standard Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure (Mini Method) atmospheric distillation~ automated”

2.32 IP 123 “Petroleum Products - Determination of Distillation Characteristics at Atmospheric Pressure”

2.33 IP 406 “Petroleum Products - Determination of Boiling Range Distribution by Gas Chromatography”

2.34 SASO-ASTM D2887 “Standard Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography”

2.35 SASO-ASTM D56 “Standard Test Method for Flash Point by Tag Closed Cup Tester”

2.36 SASO-ASTM D3828 “Standard Test Methods for Flash Point by Small Scale Closed Cup Tester”

2.37 IP 170 “Petroleum Products and other Liquids - Determination of Flash Point - Abel Closed Cup Method”

2.38 IP 523 “Determination of Flash Point - Rapid Equilibrium Closed Cup Method”

2.39 SASO-GSO-ASTM D93 “Test Method for Flash Point by Pensky - Martens Close Cup Tester”

2.40 SASO-ASTM D7236 “Standard Test Method for Flash Point by Small Scale Closed Cup Tester (Ramp Method)”

2.41 IP 534 “Determination of flash point - Small scale closed cup ramp method”

2.42 SASO-ASTM D1298 “Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method”

2.43 SASO-ASTM D4052 “Standard Test Method for Density, Relative Density, or API Gravity of Liquids by Digital Density Meter”

2.44 IP 160 “Crude Petroleum and Liquid Petroleum Products - Laboratory determination of Density - Hydrometer Method”

2.45 IP 365 “Crude Petroleum and Petroleum Products - Determination of Density - Oscillating U-tube Method”

2.46 ASTM D2386 “Standard Test Method for Freezing Point of Aviation Fuels”

2.47 SASO-ASTM D5972 “Standard Test Method for Freezing Point of Aviation Fuels (Automatic Phase Transition Method)”

2.48 SASO-ASTM D7153 “Standard Test Method for Freezing Point of Aviation Fuels (Automatic Laser Method)”

2.49 SASO-ASTM D7154 “Standard Test Method for Freezing Point of Aviation Fuels (Automatic Fiber Optical Method)”

2.50 IP 16 “Petroleum Products - Determination of the Freezing Point of Aviation Fuels”

2.51 IP 435 “Determination of the Freezing Point of Aviation Turbine Fuels by the Automatic Phase Transition Method”

2.52 IP 528 “Determination of the Freezing Point of Aviation Turbine Fuels - Automated Fibre Optic Method”

2.53 IP 529 “Determination of the Freezing Point of Aviation Turbine Fuels - Automated laser Method”

2.54 SASO-ASTM D445 “Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)”

2.55 IP 71 “Petroleum Products – Transparent and Opaque Liquids – Determination of Kinematic Viscosity and Calculation of Dynamic Viscosity”

2.56 SASO-ASTM D7042 “Standard Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic Viscosity)’’

2.57 ASTM D7945 “Standard Test Method for Determination of Dynamic Viscosity and Derived Kinematic Viscosity of Liquids by Constant Pressure Viscometer”

2.58 SASO-ASTM D3338 “Standard Test Method for Estimation of Net Heat of Combustion of Aviation Fuels”

2.59 ASTM D4809 “Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)”

2.60 IP 12 “Determination of Specific Energy”

2.61 IP 355 “Estimation of Net Specific Energy of Aviation Turbine Fuels using Hydrogen Content Data”

2.62 SASO-ASTM D1322 “Standard Test Method for Smoke Point of Kerosine and Aviation Turbine Fuel”

2.63 IP 598 “Determination of the Smoke Point of kerosene, manual and automated procedures”

2.64 SASO-ASTM D1322 “Standard Test Method for Smoke Point of Kerosine and Aviation Turbine Fuel”

2.65 ASTM D1840 “Standard Test Method for Naphthalene Hydrocarbons in Aviation Turbine Fuels by Ultraviolet Spectrophotometry”

2.66 IP 598 “Determination of the Smoke Point of kerosene, manual and automated procedures”

2.67 SASO-GSO-ASTM D130 “Standard Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test”

2.68 IP 154 “Petroleum Products - Corrosiveness to Copper - Copper Strip Test”

2.69 SASO-ASTM D3241 “Standard Test Method for Thermal Oxidation Stability of Aviation Turbine Fuels”

2.70 IP 323 “Petroleum Products – Determination of Thermal Oxidation Stability of Gas Turbine Fuels”

2.71 ASTM D381 “Standard Test Method for Gum Content in Fuels by Jet

Evaporation”

2.72 IP 540 “Determination of the Existent Gum Content of Aviation Turbine Fuel – Jet Evaporation Method”

2.73 SASO-ASTM D3948 “Standard Test Method for Determining Water Separation Characteristics of Aviation Turbine Fuels by Portable Separometer”

2.74 SASO-ASTM D2624 “Standard Test Methods for Electrical Conductivity of Aviation and Distillate Fuels”

2.75 IP 274 “Petroleum Products – Aviation and Distillate Fuels – Determination of Electrical Conductivity”

2.76 SASO-ASTM D5001 “Standard Test Method for Measurement of Lubricity of Aviation Turbine Fuels by the Ball-on-Cylinder Lubricity Evaluator (BOCLE)”

2.77 IP 568 “Determination of the static dissipater additives (SDA) in aviation turbine fuel and middle distillate fuels - HPLC method”

2.78 ASTM D7524 “Standard Test for Standard Test Method for Determination of Static Dissipater Additives (SDA) in Aviation Turbine Fuel and Middle Distillate Fuels—High Performance”

2.79 SASO-ASTM D5006 “Standard Test Method for Measurement of Fuel System Icing Inhibitors (Ether Type) in Aviation Fuels”

2.80 SASO-ASTM D4171 “Standard Specification for Fuel System Icing Inhibitors”

2.81 ASTM E29 “Practice for Using Significant Digitals in Test Data to Determine Conformance with Specifications”

2.82 SASO-ASTM D4057 “Standard Practice for Manual Sampling of Petroleum and Petroleum Products”

2.83 SASO-ASTM D4306 “Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination”

2.84 UK Ministry of Defense – Defense Standard 91-091, Issue 14, Date 7 March, 2022

2.85 American Society for Testing and Materials, ASTM D1655 (Latest Issue), “Standard Specification for Aviation Turbine Fuels”

3. CLASSIFICATION

3.1 The main categories of aviation turbine fuels are differentiated by the flash points and freezing points. The other properties are equally important and generally govern finer parameters imposed chiefly by the engine manufacturers for safe and reliable operation of aircraft engines.

3.2 Aviation turbine fuels for civil use shall be classified into the following two types:

3.2.1 **Jet A and Jet A-1** – Kerosene-type jet fuels with the same flash point of minimum 38°C but different freezing point specifications (Maximum -40°C for Jet A vs. -47°C for Jet A-1). Jet A fuel is used for almost all commercial aviation flights within, or originating from the United States. Jet A-1 fuel is widely used outside of the United States and is applicable for local use in the Kingdom of Saudi Arabia.

4. REQUIREMENTS

4.1 Materials

4.1.1 Aviation turbine fuel, except as otherwise specified herein, shall consist of refined hydrocarbons derived from conventional sources including crude oil, natural gas liquid condensates, heavy oil, shale oil, and oil sands, and qualified additives as listed in section 4.2.

4.1.2 The use of jet fuel blends containing synthetic hydrocarbon components from non-conventional sources shall be restricted to specifically approved synthetic processes and is permitted only in accordance with Annex A1.

4.1.3 Fuels used in certified engines and aircraft are ultimately approved by the certifying authority subsequent to formal submission of evidence to the authority as part of the type certification program for that aircraft and engine model.

4.1.4 Additives to be used as supplements to an approved fuel must also be similarly approved on an individual basis.

4.2 Additives

Fuel additives of qualified formulations may only be added to aviation turbine fuels in the recommended amount and of the composition specified in this section. The quantities and types must be declared by the fuel supplier and agreed to by the purchaser. Only additives approved by the aircraft certifying authority are permitted for use in the fuel on which an aircraft is operated.

4.2.1 Antioxidants

4.2.1.1 The total active ingredient(s) concentration of any qualified antioxidant shall not to exceed 24.0 mg/l (not including weight of solvent).

4.2.1.2 The following antioxidant formulations are qualified for aviation fuel use:

a. 2,6-ditertiary-butyl-phenol

b. 2,6-ditertiary-butyl-4-methyl-phenol

c. 2,4-dimethyl-6-tertiary-butyl-phenol

d. 75% minimum, 2,6-ditertiary-butyl-phenol, plus

25% maximum, mixed tertiary and tritertiary-butyl-phenols

e. 55% minimum, 2,4-dimethyl-6-tertiary-butyl-phenol, plus

15% minimum, 2,6- ditertiary-butyl-4-methyl phenol, plus

Remainder 30% maximum, mixed monomethyl and dimethyl-tertiary-butyl-phenols

f. 72% minimum, 2,4-dimethyl-6-tertiary-butyl- phenol

28% maximum, mixed tertiary-butyl-methyl-phenols and tertiary-butyl-dimethyl-phenols

4.2.2 Metal Deactivator Additive (MDA)

4.2.2.1 An MDA as fuel additive may be used to either counteract the adverse effects of known metals such as Copper, Cadmium, Zinc, Cobalt and Iron to the aviation fuel thermal stability, or to recover thermal stability in case of unproven metallic contamination.

4.2.2.2 Initial Dosing - An MDA of approved formulation shall not exceed 2.0 mg/l concentration of active material(s) on initial dosing at the manufacturing site – refinery (not including weight of solvent).

4.2.2.3 Retreatment - Cumulative concentration of MDA’s active material(s) when retreating aviation fuel shall not exceed 5.7 mg/l.

4.2.2.4 The following MDA formulation is qualified for aviation fuel use:

N,N’-disalicylidene- 1,2-propanediamine

4.2.3 Electrical Conductivity Improver or Static Dissipator Additive (SDA)

4.2.3.1 The following SDA formulations are qualified for aviation fuel use:

- Stadis 450
- AvGuard SDA

4.2.3.2 When loss of fuel conductivity necessitates treatment with electrical conductivity additive, the following concentration limits apply:

	At Manufacture:
Initial dosing	3 mg/l maximum
	During Distribution/ Supply chain
Retreatment	cumulative total 5 mg/l maximum

4.2.4 Fuel System Icing Inhibitor

4.2.4.1 Diethylene Glycol Monomethyl Ether (DiEGME), conforming to the requirements of Saudi Standard (2.80) may be used in concentrations of 0.10 to 0.15 volume %.

4.2.4.2 Saudi Standard mentioned in (2.79) may be used to determine the concentration of DiEGME in aviation fuels.

4.2.5 Lubricity Improver Additive (LIA)

4.2.5.1 LIA qualified materials from various manufacturers along with recommended minimum and maximum treat rates are listed below:

<table>
<tr><th></th><th></th><th colspan="2">Treat Rates (mg/l)</th></tr>
<tr><th>Product</th><th>Manufacturer</th><th>Minimum</th><th>Maximum</th></tr>
<tr><td>Spec Aid 8Q22</td><td>GE Betz</td><td rowspan="4">9</td><td rowspan="4">23</td></tr>
<tr><td>Octel DCI-4A</td><td>Innospec LLC</td></tr>
<tr><td>Unicor J</td><td>Dorf Ketal Chemicals</td></tr>
<tr><td>Nalco 5405</td><td>Nalco Chemical Co.</td></tr>
<tr><td>Octel DCI-6A</td><td>Innospec LLC</td><td>9</td><td>15</td></tr>
<tr><td>Nalco 5403</td><td>Nalco Chemical Co.</td><td>12</td><td>23</td></tr>
<tr><td>Hitec 580</td><td>Afton Chemical Ltd.</td><td>15</td><td>23</td></tr>
</table>

4.2.6 **Leak Detection Additive**

4.2.6.1 Tracer A (LDTA-A) is qualified material for use in aviation fuel where necessary to detect the leakage(s) in the associated handling system.

4.2.6.2 This additive may be added to the fuel in amounts not to exceed 1 mg/kg.

4.2.7 Biocidal additives are available for controlled usage. Where such an additive is used in the fuel, the approval status of the additive and associated conditions must be checked for the specific aircraft and engines to be operated.

4.3 **Quality Specifications**

4.3.1 The aviation turbine fuel quality shall conform to the requirements prescribed in Table-1.

4.3.2 No allowance shall be made for the precision of the test methods. To determine the conformance to the specification requirement, a test result may be rounded to the same number of significant figures as in Table-1 using Saudi Standard listed as 2.81.

4.3.3 The aviation turbine fuel herein specified shall be visually free from suspended matter, sediments, and undissolved water at ambient fuel temperature. The visual appearance check of the aviation fuel is an industry best practice for quality assurance and is a key requirement for aviation turbine fuels throughout the fuel supply chain. Additional handling procedures including extended settling and/or filtration steps shall be warranted in case the aviation fuel contains visual particulates or exceeds the applicable particulate contamination threshold.

4.3.4 The odor of the fuel shall not be nauseating or irritating.

4.3.5 No substance of known dangerous toxicity under usual conditions of fuel handling and use, shall be present except as permitted herein.

5. SAMPLING

5.1 Aviation turbine fuel sampling shall be undertaken after the settling time has elapsed. In case of urgent sampling requirement, allow the relaxation time for aviation turbine fuel to dissipate the electrostatic charges for safety reasons. The relaxation time for aviation grade fuels is estimated at a minimum of 30 minutes after the end of transfer run down.

5.2 Because of the importance of proper procedures in establishing fuel quality, use the appropriate procedure in Saudi standard listed as 2.82.

5.3 A number of jet fuel properties, including thermal stability, water separation, electrical conductivity, and others, are very sensitive to trace contamination which can originate from sample containers. For recommended sample containers refer to Saudi standard listed as 2.83.

6. TEST METHODS

The following tests shall be carried out in accordance with Saudi Standards prescribed in items 2.1 to 2.80:

6.1 Visual Inspection.

6.2 Determination of Fuel Color.

6.3 Determination of Particulate Contamination.

6.4 Determination of Total Acidity.

6.5 Determination of Aromatic Content.

6.6 Determination of Total Sulfur Content.

6.7 Determination of Mercaptan Sulfur Content.

6.8 Determination of Distillation Characteristics.

6.9 Determination of Flash Point.

6.10 Determination of Density.

6.11 Determination of Freezing Point.

6.12 Determination of Kinematic and Dynamic Viscosities.

6.13 Determination of Net Heat of Combustion/ Specific Energy.

6.14 Determination of Smoke Point.

6.15 Determination of Naphthalene Content.

6.16 Corrosion of Copper Strip Test.

6.17 Determination of Thermal Stability.

6.18 Determination of Existent Gum Content.

6.19 Determination of Water Separation Characteristics.

6.20 Determination of Electrical Conductivity.

6.21 Determination of Lubricity.

6.22 Determination of Fuel System Icing Inhibitor Additive.

7. MARKING

7.1 The following information shall be legibly and indelibly marked in a conspicuous space on each aviation turbine fuel pump and container in Arabic or Arabic and English languages.

7.1.1 Name and classification.

7.1.2 Net volume (for container only).

7.1.3 Name of manufacturer or its abbreviation.

7.1.4 Date of manufacture or its abbreviation (for container only).

7.1.5 Country of Origin.

7.1.6 Precaution “Avoid Environmental Pollution” or put the international symbol for “No Pollution”.

7.2 For tank wagons, tankers, tank lorries or others where marking is difficult, however, those may be marked in invoice.

8. RULES OF ACCEPTANCE AND REJECTION

8.1 Each consignment of aviation turbine fuels shall be accompanied with a certificate stating its compliance with this standard.

Table 1

Quality Requirements for Aviation Turbine Fuels
Jet A-1

TEST	GUARANTEE	METHOD
Appearance	Clear, bright and visually free from solid matter and un-dissolved water at ambient fuel temperature	2.1 (SASO-ASTM D4176) or Visual (Note 1)
Color	Report	2.2 (SASO-ASTM D156) or 2.3 (SASO-ASTM D6045) (Note 2)
Particulate contamination, mg/l OR Particulate, cumulative channel particle counts, ISO Code and Individual Channel Counts	Max 1.0 Channel counts/ISO code	2.4 (SASO-ASTM D5452) 2.5 (IP 423) (Note 3)
≥ 4 µm(c) ≥ 6 µm(c) ≥ 14 µm(c) ≥ 21 µm(c) ≥ 25 µm(c) ≥ 30 µm(c)	Report / Max 19 Report / Max 17 Report / Max 14 Report Report Report / Max 13	2.6 (IP 565) or 2.7 (IP 577) 2.8 (ASTM D7619) (Note 3) (Note 4)
Total Acidity, mg KOH/g	Max 0.015	2.9 (ASTM D3242) 2.10 (IP 354)
Aromatics, vol% or Total Aromatics, vol%	Max 25.0 Max 26.5	2.11 (SASO-ASTM D1319) 2.12 (IP 156) 2.13 (SASO-ASTM D6379) 2.14 (IP 436) (Note 7)
Total Sulfur, wt%	Max 0.30	2.15 (SASO-ASTM D1266) 2.16 (SASO-GSO-ASTM D2622) 2.17 (SASO-ASTM D4294) 2.18 (SASO-ASTM D5453) 2.19 (IP 336)
Sulfur, Mercaptan, wt% or Doctor Test	Max 0.0030 Negative	2.20 (SASO-ASTM D3227) 2.21 (IP 342) 2.22 (SASO-ASTM D4952) 2.23 (IP 30) (Note 8)

Refinery Components at point of manufacture: Non Hydroprocessed Components, vol% Severely Hydroprocessed Components, vol% Synthetic Components, vol%	 Report (incl. 'nil' or '100%') Report (incl. 'nil' or '100%') Report (incl. 'nil' or '50%')	(Note 6) (Note 9) (Note 5)
Incidental Materials		(Note 10)
Distillation, ºC IBP 10 vol% recovered 50 vol% recovered 90 vol% recovered End Point Residue, vol% Loss, vol%	 Report Max 205.0 Report Report Max 300.0 Max 1.5 Max 1.5	2.30 (SASO-ASTM D86) 2.31 (SASO-ASTM D7345) 2.32 (IP 123) (Note 11) or 2.33(IP 406) 2.34 (SASO-ASTM D2887) (Note 12)
Flash Point, ºC	Min 38.0	2.35 (SASO-ASTM D56) 2.36 (SASO-ASTM D3828) 2.37 (IP 170) 2.38 (IP 523) 2.39 (SASO-GSO-ASTM D93 Procedure A) 2.40 (SASO-ASTM D7236) 2.41 (IP 534)
Density at 15 ºC, kg/m³	Min - Max 775.0 - 840.0	2.42 (SASO-ASTM D1298) 2.43 (SASO-ASTM D4052) 2.44 (IP 160) 2.45 (IP 365)
Freezing Point, ºC	Max -47.0	2.46 (ASTM D2386) 2.47 (SASO-ASTM D5972) 2.48 (SASO-ASTM D7153) 2.49 (SASO-ASTM D7154) 2.50 (IP 16) 2.51 (IP 435) 2.52 (IP 528) 2.53 (IP 529) (Note 13 and 14)
Viscosity at -20 ºC, mm2/s (cSt)	Max 8.000	2.54 (SASO-ASTM D445) 2.55 (IP 71) 2.56 (SASO-ASTM D7042) (Note 15) 2.57 (ASTM D7945)

Specific Energy, net, MJ/kg	Min 42.80	2.58 (SASO-ASTM D3338) 2.59 (ASTM D4809) 2.60 (IP 12) 2.61 (IP 355) (Note 16)
Smoke Point, mm or Smoke Point, mm, and Naphthalenes, vol%	Min 25.0 Min 18.0 Max 3.00	2.62 (SASO-ASTM D1322) 2.63 (IP 598) (Note 17) 2.64 (SASO-ASTM D1322) 2.65 (ASTM D1840) 2.66 (IP 598)
Corrosion, Copper strip, classification (2 hours +/- 5 min. at 100ºC +/- 1 ºC)	Max 1	2.67 (SASO-GSO-ASTM D130) 2.68 (IP 154)
Thermal Stability (JFTOT) Control Temperature, °C Filter Pressure Differential, mm Hg One of the following requirements shall be met: (1) Annex B VTR (2) Annex C ITR or Annex D ETR, nm average over area of 2.5mm2	Min 260 Max 25 Less than 3, no “Peacock” or Abnormal color deposits Max 85	2.69 (SASO-ASTM D3241) 2.70 (IP 323) (Note 18)
Existent Gum, mg/100 ml	Max 7	2.71 (ASTM D381) 2.72 (IP 540)
Microseparometer (MSEP), rating Fuel with Static Dissipator Additive or Fuel without Static Dissipator Additive	 Min 70 Min 85	2.73 (SASO-ASTM D3948) (Note 19)
Electrical Conductivity, pS/m	Min – Max 50 - 600	2.74 (SASO-ASTM D2624) 2.75 (IP 274) (Note 20)
Lubricity BOCLE wear scar diameter, mm	Max 0.85	2.76 (SASO-ASTM D5001) (Note 21)

ADDITIVES (Names and approval code from DEF- STAN 91-091/14 should be quoted on quality) certificates		
Antioxidant, mg/l In final batch (Optional)	Max 24.0	(Note 22)
Metal Deactivator, mg/l (Optional)* First Doping Cumulative concentration after field re-doping	 Max 2.0 Max 5.7	(Note 23)
Static Dissipator, mg/l* First Doping Cumulative concentration after field re-doping	 Max 3.0 Max 5.0	Suitable methods include; In- line injection system with flow metering, 2.77 (IP 568) 2.78 (ASTM D7524)
Fuel System Icing Inhibitor, vol% (By Agreement Only)	Min - Max 0.10 - 0.15	2.79 (SASO-ASTM D5006) (Note 24)

Antioxidants are mandatory for synthetic blend components and shall be added prior to or during release from the designated manufacturing site of the SASO-ASTM D7566 component.

Fuel System Icing Inhibitor is not permitted unless agreed by all the participants in a joint system (see also Note 24).

Lubricity Improver (LI) additive may be added to the fuel without prior consent of the joint system participants (see also Note 21).

The types and concentrations of all additives used shall be shown on the original Certificates of Quality and on all other quality documents when they are added downstream of the point of manufacture. When additives are diluted (with hydrocarbon solvent only) to improve handling properties prior to addition, it is the concentration of active ingredient that shall be reported. See Annex A of DEF STAN 91-091/14 for detailed advice

See Note 25 about requirements for management of change in refineries.
* When the original dosage of additives is unknown, it has to be assumed that first doping was applied at maximum dose rate.

NOTES:

1) The method for visual appearance in DEF STAN 91-091 is Visual (assessment). Alternative methods are SASO-ASTM D4176 procedure 1 and SASO-ASTM D6986 Procedure A, Section 8.1.1.1.
2) The requirement to report Saybolt Color shall apply at point of manufacture. Unusual or atypical colors should also be noted and investigated. For further information on the significance of color see Annex F in DEF STAN 91-091/14.
3) This limit shall apply at point of manufacture only. For more information on particulate contamination refer to Annex F of DEF STAN 91-091 Issue 14. For guidance on contamination limits for into plane fueling refer to 7th Edition IATA Guidance Material (Part III).
4) This requirement shall apply at point of manufacture only. Both the number of particles and the number of particles as a scale number as defined by Table 1 of ISO 4406:1999 shall be reported. It is the Specification Authority's intention to replace the gravimetric Millipore test with Particle Counting at the earliest opportunity.
5) Attention is drawn to DEF STAN 91-091 Issue 14, which approves both Semi-Synthetic and Fully Synthetic Jet Fuel produced by SASOL. It also approves all the generic components listed in the Annexes of SASO-ASTM D7566. For these fuels, additional testing requirements apply and reference should be made to DEF STAN 91-091/14 Annex B. These particular semi- and fully synthetic fuels may be certified against this Issue of Check List.
6) The Coprocessing of mono-, di- and triglycerides, free fatty acids and fatty acid esters and the Coprocessing of hydrocarbons derived from synthesis gas via Fisher Tropsch process have been approved in Defence Standard 91-091 Issue 14 in alignment with ASTM D1655. The requirements for coprocessing are detailed in Annex B4 of Defence Standard 91-091 Issue 14 and Annex A1.1.2.2 of ASTM D1655.
   The Certificate of Quality (CoQ) shall include wording to reflect that the batch may contain up to 5 % by volume co-hydroprocessed synthesized kerosene.
7) Round robin testing has demonstrated the correlation between total aromatics content measured by IP 156 / SASO-ASTM D1319 and IP 436 / SASO-ASTM D6379. Bias between the two methods necessitates different equivalence limits as shown. In cases of dispute IP 156/ SASO-ASTM D1319 shall be the referee method. It is the intention of the DEF STAN 91-091 Technical Authority to change the referee method to IP 436 at a later date.
   Due to technical issues, the proprietary dyes with lot numbers 3000000975 through to and including 000000982 are unacceptable for use when conducting IP156/SASO-ASTM D1319 and shall not be used in conjunction with these test methods.

   When the aromatic level is needed to be determined, Jet A-1 fuel will only meet the aviation fuel operating limitations of airplanes certificated to operate on Jet A-1 fuel and the requirements of Def Stan 91-091 if:
   1. the fuel has been tested for aromatics concentration in accordance with SASO-ASTM D1319/ IP156 with a dye other than from lot number 3000000975 through 3000000982

   Or

   2. the fuel has been tested for aromatics concentration in accordance with the alternative test methods SASO-ASTM D6379/ IP436.

   No other alternative test method, or method of deriving the aromatic content, is acceptable.

8) The Doctor Test is an alternative requirement to the Sulfur Mercaptan Content. In the event of conflict between the Sulfur Mercaptan and Doctor Test results, the Sulfur Mercaptan result shall prevail.
9) The need to report the vol% of non-hydroprocessed, severely hydroprocessed and synthetic components (including “nil” “50%” or “100%” as appropriate) on refinery Certificates of Quality for Jet A-1 to Checklist derives from DEF STAN 91-091/14. Each refinery component used in the makeup of the batch shall be reported on the certificate of quality as a percentage by volume of the total fuel in the batch.
10) Table 2 – Incidental Materials

Material	Maximum Permitted Level	Detection Level	Test Methods
Fatty Acid Methyl Ester (FAME), mg/kg (Notes a,b,c)	50 mg/kg		2.24 (ASTM D7797) 2.25 (IP 585) 2.26 (IP 583) 2.27 (IP 590) 2.28 (IP 599)
Pipeline Drag Reducer (DRA) (Note a)	Nil	72µg/l (Notes e,f)	2.29 (ASTM D7872)

a) Post manufacture each custodian shall undertake a risk assessment to quantify the potential risk of incidental material carry over. Where such assessments indicate that there could be a potential risk in jet fuel supplies, additional quality assurance procedures shall be introduced to increase control in order to mitigate the risk. Where the risk of incidental material carryover exists and it is not possible to control with additional quality assurance procedures, testing shall be instigated.
b) For the purposes of meeting this requirement, FAME is defined as material meeting the limits of EN14214 or specification SASO-ASTM D6751. Fatty acid methyl esters that fail to meet biodiesel standards are not permitted in jet fuel.
c) On an emergency basis, up to 100 mg/kg FAME is permitted in jet fuel when authorized by the airframe and engine manufacturers and managed in compliance with airframe and engine requirements. For Military purposes an emergency basis can be defined as an unexpected and unforeseen situation that requires prompt action. For example, where FAME contamination has been introduced into part of an airport distribution system where it cannot be quickly segregated or isolated for remediation without halting airport refueling operations. All such instances should be raised through the procurement Authority, Duty Holder or Aircraft Operator. For commercial operators refer to SAIBNE-09-25R2 dated May 19, 2016, which provides corrective actions and procedures to be followed in the event of FAME contamination.
d) Test method IP585 shall be the referee method.
e) DRA is not an approved additive for jet fuel. This level is accepted by approval authorities as the functional definition of ‘nil addition’.
f) There is no need to report the DRA level at the point of manufacture. However, DRA content testing is required as part of a Risk Assessment where DRA is or is to be added into other products in a multi-product pipeline system which is also transporting jet fuel.

11) In methods IP 123 and SASO-ASTM D86 all fuels certified to this specification shall be classed as group 4, with a condenser temperature of zero to 4 °C. Where SASO-ASTM D7345 is used, results shall be corrected for relative bias as described in test method.
12) If IP 406 or SASO-ASTM D2887 are used to produce IP 123 equivalent or SASO-ASTM D86 correlated data, residue or loss shall be reported as ‘not applicable’ (NA).

13) These automatic methods are permitted; IP 16 / ASTM D2386 remains the referee method.
14) During downstream distribution if the freezing point of the fuel is very low and cannot be reported when measured by IP 16 the limit is max -65 degrees C. If no crystals appear during cooling of the fuel and when the thermometer indicates a temperature of –65°C, the freezing point shall be recorded as below –65°C. This limit does not apply if the freezing point is measured by IP435/ SASO-ASTM D5972, IP 529/ SASO-ASTM D7153, IP528 or SASO- ASTM D7154.
15) Test method SASO-ASTM D7042 results shall be converted to bias-corrected kinematic viscosity results as described in the precision and bias section of SASO-ASTM D7042.
16) ASTM D 4529/IP 381 may be used where local regulations permit.
17) The IP 598 test for smoke point includes both the standard manual method and an automatic method, with the automated method in IP 598 being the referee method.
18) The annexes referred to in the Table 1 and this note correspond to those in IP323. If the technically equivalent ASTM D3241 test method is used, the same protocol shall be followed using the appropriate annex that corresponds to the visual (VTR), interferometric (ITR) or ellipsometric (ETR) method. Tube deposit ratings shall be measured by IP323 Annex C ITR or Annex D ETR, when available. If the Annex C ITR device reports “N/A” for a tube’s volume measurement, the test shall be a failure and the value reported as >85 nm. Visual rating of the heater tube by the method in IP323. Annex B is not required when Annex C ITR or Annex D ETR deposit thickness measurements are reported. In case of dispute between results from visual and metrological methods, the metrological method shall be considered the referee. Examination of the heater tube to determine the Visual Tube Rating using the Visual Tube Rater or deposit thickness by ETR or ITR shall be carried out within 120 minutes of completion of the test.
19) Water separation property testing by ASTM D3948 is a mandatory requirement only at point of manufacture. Note that neither of the primary Standards mandate the testing of water separation properties downstream of the point of manufacture. Where it is required by JIG Standards for the purposes of product quality management, the following methods and limits should apply:

Test Method	Limit
SASO-ASTM D7224	85 min
ASTM D8073	88 min

Alternatively, testing may also be conducted using SASO-ASTM D3948 (still the intent of JIG to withdraw this method in the future). For further information on water separation testing refer to JIG Bulletins 129 and 142-Testing Water Separation Properties of Jet Fuel (Revised MSEP Protocol)

This protocol is also referenced in Note 18 of Def Stan 91-091/14.

20) Due to the requirements of DEF STAN 91-091/14, conductivity limits are mandatory for product to meet this specification. However, it is acknowledged that in some manufacturing and distribution systems it is more practical to inject SDA further downstream. In such cases, the Certificate of Quality for the batch should be annotated thus: “Product meets the requirements of Defense Standard 91-091/14 except for electrical conductivity”. In some situations, the conductivity can decrease rapidly and the fuel can fail to respond to additional dosing with Static Dissipator Additive(s). In such cases, fuel may be released with conductivity down to a minimum of 25pS/m provided that the fuel is fully tested against the specification and the Tank Release Note

is annotated with the explanation “Product released below 50pS/m due to conductivity loss as per Annex F of DEF STAN 91-091/14”.

21) This requirement comes from DEF STAN 91-091/14. The requirement to determine lubricity applies only to fuels whose composition is made up of a) at least 20% of severely hydroprocessed components and less than 5% non-hydroprocessed components or b) includes synthetic fuel components. The limit applies only at the point of manufacture. For important advisory information on the lubricity of aviation turbine fuels see Annex F of DEF STAN 91-091/14. CI/LI additive (also known as LIA) may be used to improve lubricity; only those additives listed in Table 2 of ASTM D1655-/ Annex A of DEF STAN 91-091/14 are permitted. Note that two additional additives have been added to the list in DEF STAN91-091/14. Refer also to Appendix A.5 of DEF STAN 91-091/14 for advice on point of addition. When injecting CI/LI downstream of point of manufacture, care shall be taken to ensure that maximum dose rates are not exceeded.
22) The use of anti-oxidant is optional for jet fuels containing only conventional components. Anti-oxidant continues to be mandatory as part of the production process for synthetic components (see SASO-ASTM D7566), If antioxidant is added the maximum limit is 24 mg/l in the finished fuel. Approved antioxidant additives are listed in Annex A.2.5 of DEF STAN 91-091/14, together with the appropriate RDE/A/ XXX-Qualification Reference for quoting on Certificates of Quality or Certificates of Analysis.
23) The approved Metal Deactivator Additive (MDA), RDE/A/650 appears in Annex A.3 of DEF STAN 91-091/14 Annex A3.1 of DEF STAN 91-091/14 contains restrictions on the use of MDA at the point of manufacture and also directs the producer to the reporting requirements when MDA is used at the point of manufacture. Note that routine use of MDA (>5% of batches) at the point of manufacture is not permitted. The use of MDA at the point of manufacture is limited to 2.0 mg/l, except when copper contamination within the supply chain is known. See also Annex A.3.1 for the use of MDA in the supply chain, which includes the need to report thermal stability before and after MDA use.
24) Concentrations of Fuel System Icing Inhibitor (FSII) less than 0.02% by volume may be considered negligible and do not require agreement/notification. The assent to allow these small quantities of FSII without agreement/notification is to facilitate the changeover from fuels containing FSII to those not containing FSII where the additive may remain in the fuel system for a limited time. This does not permit the continuous addition of FSII at these low concentrations. Attention is drawn to the new note in Annex A.6 in DEF STAN 91-091/14 highlighting that filter monitors cannot be used with fuel containing FSII.
25) Attention is drawn to the guidance in DEF STAN 91-091/14 and ASTM D1655 concerning the need for appropriate management of change measures in refineries manufacturing jet fuel. The implications of any changes to feedstock, processing conditions or process additives on finished product quality and performance shall be considered (for example, experience has shown that some process additives might be carried over in trace quantities into aviation fuels).
26) Test certificates shall state conformance to a primary specification. Checklist is not a specification and manufacturing locations shall not release fuel only to Checklist. If reference to Checklist is to be made the following statement should be used if the fuel meets the requirements of this bulletin.

    “It is certified that the samples have been tested using the Test Methods stated and that the Batch represented by the samples conforms with DEF STAN 91-091 Issue 14 and AFQRJOS Checklist Issue 33”

Or

"It is certified that the samples have been tested using the Test Methods stated and that the Batch represented by the samples conforms with ASTM D1655 and AFQRJOS Checklist Issue 33"

The minimum requirements of information to be included on the fuel's refinery batch certificate of quality shall be:

- Specification name, issue and any amendment number;
- Name, telephone number, fax number, email address and postal address of testing laboratory;
- Tank number;
- Batch number or unique identifier;
- Quantity of fuel in the batch;
- Properties tested and including specification limit, test method and result of test;
- Additives, including qualification reference and quantity added;
- Name and position of authorized test certificate signatory or an electronic signature;
- Date of certification.

ANNEX

(Mandatory Information)

A1. FUELS FROM NON-CONVENTIONAL SOURCES

A1.1 Introduction

A1.1.1 Jet fuels solely derived from petroleum sources have been previously allowed under this standard. It has been recognized that the use of fuels containing synthetic hydrocarbon components represents a departure from experience and from key assumptions on which the fuel property quality requirements as defined in Table 1 have been based.

A1.1.2 The longer term strategy is to revise this standard to fully encompass fuels from non-conventional sources, but this has yet to be defined. As an interim solution, it has been deemed necessary to recognize, on an individual basis, fuels from non-conventional sources whose quality characterization and performance complies with the intent of this standard.

A1.2 Acceptable fuels from non-conventional sources

Al.2.1 This Standard approves Sasol semi-synthetic aviation fuel blends and fully-synthetic aviation fuel in alignment with reference 2.84. Sasol semi-synthetic jet fuel represents synthetic Iso-Paraffinic Kerosine (IPK) stream either by itself or combined with Sasol Heavy Naphtha #1, and are manufactured at the Secunda plant by the Fischer-Tropsch process. The semi-synthetic aviation turbine fuel is produced by blending together a maximum of 50% synthetic product with conventional kerosine stream to produce an approved Sasol semi-synthetic aviation turbine fuel. Sasol fully synthetic aviation fuel is also manufactured at the Secunda plant and is comprised of light distillate, heavy naphtha and IPK streams.

APPENDIX

(Non-mandatory Information)

A. PERFORMANCE CHARACTERISTICS OF AVIATION TURBINE FUELS

A.1 Introduction

A.1.1 This appendix describes the performance characteristics of aviation turbine fuels.

A.2 Significance and Use

A.2.1 This standard defines one type of jet fuel for civil use. Limiting values for the fuel covered are placed on fuel properties believed to be related to the performance of the aircraft and engines in which it is most commonly used.

A.2.2 The safe and economical operation of aircraft requires fuel that is essentially clean and dry and free from any contaminations prior to use. It is possible to measure a number of jet fuel characteristics related to quality.

A.2.3 The significance of standard tests for fuel properties may be summarized for convenience in terms of the technical relationships with performance characteristics as shown in Table (A.l).

A.2.4 The acceptability of additives for use must ultimately be determined by the engine and aircraft type certificate holder and must be approved by his certifying authority.

A.3 Thermal Stability

A.3.1 Stability to oxidation and polymerization at the operating temperatures encountered in certain jet aircraft is an important performance requirement. The thermal stability measurements are related to the amount of deposits formed in the engine fuel system on heating the fuel in a jet aircraft. Commercial jet fuels derived from conventional sources shall pass the thermally stability test at a minimum of 260°C as prescribed in Table 1. Such fuels have been demonstrated to have inherent storage stability.

Table (A.1)
Performance Characteristics of Aviation Turbine Fuels

Performance Characteristics	Test Method	Items
Engine fuel system deposits and coke	Thermal stability	A.3
Combustion properties	Smoke point Aromatics Percent naphthalenes	A.4.2.1 A.4.2.2 A.4.2.3
Fuel metering and aircraft range	Density Net heat of combustion	A.5.1 A.5.2
Fuel atomization	Distillation Viscosity	A.6.1 A.6.3
Fluidity at low temperature	Freezing point	A.7.1
Compatibility with elastomer and the metals in the fuel system and turbine	Mercaptan sulfur Sulfur Copper strip corrosion Acidity	A.8.1 A.8.2 A.8.3 A.8.4
Fuel storage stability	Existent gum	A.9.1
Fuel cleanliness, handling	Flash point Water separation characteristics Free water and particulate contamination Particulate matter	A.10.1 A.10.3 A.10.4 A.10.5
Conductivity	Electrical conductivity	A.10.8
Fuel lubricating ability (lubricity)	Fuel lubricity	A.11
Miscellaneous	Additives Sample containers	A.12.1 A.12.2

A.4 Combustion

A.4.1 Jet fuels are continuously burned in a combustion chamber by injection of liquid fuel into the rapidly flowing stream of hot air. The fuel is vaporized and burned at near stoichiometric conditions in a primary zone. The hot gases so produced are continuously diluted with excess air to lower their temperature to a safe operating level for the turbine. Fuel combustion characteristics relating to soot formation are emphasized by current specification test methods. Other fuel combustion characteristics not covered in current standard are burning efficiency and flame-out.

A.4.2 In general, paraffin hydrocarbons offer the most desirable combustion cleanliness characteristics for jet fuels. Naphthenes are the next most desirable hydrocarbons for this use. Although olefins generally have good combustion characteristics, their poor gum stability usually limits their use in aircraft turbine fuels. Aromatics generally have the least desirable combustion characteristics for aircraft turbine fuel. In aircraft turbines they tend to burn with a smoky flame and release a greater proportion of their chemical energy as undesirable thermal radiation than the other hydrocarbons. Naphthalenes or bicyclic aromatics produce more soot, smoke, and thermal radiation than monocyclic aromatics and are, therefore, the least desirable hydrocarbon class for aircraft jet fuel use. All of the following measurements are influenced by the hydrocarbon composition of the fuel and, therefore, pertain to combustion quality: smoke point, percent naphthalenes, and percent aromatics.

A.4.2.1 Smoke Point - This method provides an indication of the relative smoke-producing properties of jet fuels and is related to the hydrocarbon-type composition of such fuels. Generally, the more highly aromatic the jet fuel, the more smoky the flame. A high smoke point indicates a fuel of low smoke-producing tendency.

A.4.2.2 Aromatics - The combustion of highly aromatic jet fuels generally results in smoke and carbon or soot deposition, and it is therefore desirable to limit the total aromatic content as well as the naphthalenes in jet fuels.

A.4.2.3 Percent Naphthalenes - This method covers measurement of the total concentration of naphthalene, acenaphthene, and alkylated derivatives of these hydrocarbons in jet fuels containing no more than 3 vol% of such compounds.

A.5 Fuel Metering and Aircraft Range

A.5.1 Density - Density is a property of a fluid and is of significance in metering flow and in mass-volume relationships for most commercial transactions. It is particularly useful in empirical assessments of heating value when used with other parameters such as aniline point or distillation. A low density may indicate low heating value per unit volume.

A.5.2 Net Heat of Combustion - The design of aircraft and engines is based on the convertibility of heat into mechanical energy. The net heat of combustion provides a knowledge of the amount of energy obtainable from a given fuel for the performance of useful work; in this instance, power. Aircraft design and operation are dependent upon the availability of a certain predetermined minimum amount of energy as heat. Consequently, a reduction in heat energy below this minimum is accompanied by an increase in fuel consumption with corresponding loss of range. Therefore, a minimum net heat of combustion requirement is incorporated in this standard. The determination of net heat of combustion is time consuming and difficult to conduct accurately. This led to the development and use of the aniline point and density relationship to estimate the heat of combustion of the fuel. This relationship is used along with the sulfur content of the fuel to obtain the net heat of combustion.

A.6 Fuel Atomization

A.6.1 Distillation – The fuel volatility and ease of vaporization at different temperatures are determined by distillation. The 10% distilled temperatures are limited to ensure easy starting. The end point limit excludes heavier fractions that would be difficult to vaporize.

A.6.2 Viscosity – The viscosity of a fuel is closely related to pumpability over the temperature range and consistency of nozzle spray patterns. The ability of fuel to lubricate a pump may also be related to the viscosity.

A.7 Fluidity at Low Temperatures

A.7.1 Freezing Point – The freezing point is particularly important and must be sufficiently low to preclude interference with flow of fuel through filter screens to the engine at temperatures prevailing at high altitudes. The temperature of fuel in an aircraft tank decreases at a rate proportional to the duration of flight. The maximum freezing point allowed for the fuel is therefore related to the type of flight. For example, long duration flights would require fuel of lower freezing point than short duration flights.

A.8 Compatibility with Elastomer and the Metals in the Fuel System and Turbine

A.8.1 Mercaptan Sulfur - Mercaptans are known to be reactive with certain elastomers. A limitation on mercaptan content is specified to preclude such reactions and to minimize the unpleasant mercaptan odor.

A.8.2 Sulfur - Control of sulfur content is significant for jet fuels because the sulfur oxides formed during combustion may be corrosive to turbine metal parts.

A.8.3 Copper Strip Corrosion - A requirement that jet fuel must pass the copper strip test ensures that the fuel will not corrode copper or any copper-base alloys in various parts of the fuel system.

A.8.4 Total Acidity - Some petroleum products are treated with mineral acid or caustic, or both, as part of the refining procedure. Any residual mineral acid or caustic is undesirable. Neither impurity is likely to be present. However, a determination of acidity confirms this when inspecting new or unused fuel. It also measures organic acids if present.

A.9 Fuel Storage Stability

A.9.1 Existent Gum - Gum is a nonvolatile residue left on evaporation of fuel. A steam jet is used as an evaporating agent for fuels that are to be used in aircraft equipped with turbine engines. The amount of gum present is an indication of the condition of the fuel at the time of test only. Large quantities of gum are indicative of contamination of fuel by higher boiling oils or particulate matter and generally reflect poor fuel handling practices.

A.10 Fuel Cleanliness and Handling

A.10.1 Flash Point - The flash point is an indication of the maximum temperature for fuel handling and storage without serious fire hazard. The shipment, storage, and handling precautions regulated by municipal, state, or kingdom laws and insurance requirements are a function of the flash point for the particular fuel being utilized.

A.10.2 Water Separation Characteristics - The ease of coalescence of water from fuels as influenced by surface active agents (surfactants) is assessed by the Saudi standard (2.73) is designed to be used as a field or laboratory method. A high rating suggests a fuel free of surfactants; a low rating indicates that surfactants are present. Surfactants, which may be contaminants or deliberately added materials, may gradually disarm filter coalescers, allowing fine water droplets and particulate contaminants to pass separators in ground handling equipment.

A.10.3 Free Water and Particulate Contamination in Distillate Fuels (Clear and Bright Pass/Fail Procedures) - The procedures in the Saudi standard (2.1) provide rapid but non-quantitative methods for detecting contamination in a distillate fuel. Other following methods in A.10.4 permit quantitative determinations.

A.10.4 Particulate Matter - The presence of solid particulate contaminants such as rust may be detected by filtration of the jet fuel through membrane filters under prescribed conditions. The Saudi Standard (2.4) and (2.5) describe a suitable technique.

A.10.5 Static Electricity - The generation and dissipation of static electricity can create problems in the handling of aviation fuels. Electrical conductivity additives can be added to dissipate charge more rapidly. This is most effective when the fuel conductivity is in the range from 50 to 600 pS/m.

A.10.6 Microbial Contamination - Uncontrolled microbial contamination in fuel systems may cause or contribute to a variety of problems including corrosion, odor, filter plugging, decreased stability and deterioration of fuel/ water separation characteristics. In addition to system component damage, off-specification fuel can result.

A.11 Fuel Lubricity

A.11.1 Aircraft/engine fuel system components and fuel control units rely on the fuel to lubricate their moving parts. The effectiveness of a jet fuel as a lubricant in such equipment is referred to as its lubricity. Differences in fuel system component design and materials result in varying degrees of equipment sensitivity to fuel lubricity. Similarly, jet fuels vary in their level of lubricity. In-service problems experienced have ranged in severity from reductions in pump flow to unexpected mechanical failure leading to in-flight engine shutdown.

A.11.2 The chemical and physical properties of jet fuel cause it to be a relatively poor lubricating material under high temperature and high load conditions. Severe hydroprocessing removes trace components resulting in fuels that tend to have lower lubricity than straight-run or wet-treated fuels. Certain additives, for example, corrosion inhibitors, can improve the lubricity and are widely used in military fuels. They have been used occasionally in civil jet fuel to overcome aircraft problems but only as a temporary remedy while improvements to the fuel system components or changes to fuel were achieved. Because of their polar nature, these additives can have adverse effects on ground base filtration systems and on fuel water separation characteristics.

A.11.3 Some modern aircraft fuel system components have been designed to operate on low lubricity fuel. Other aircraft may have fuel system components that are sensitive to fuel lubricity. In these cases, the manufacturer can advise precautionary measures, such as the use of an approved lubricity additive to enhance the lubricity of a particular fuel. Problems are more likely to occur when aircraft operations are confined to a single refinery source where fuel is severely hydroprocessed and where there is no comingling with fuels from other sources during distribution between refinery and aircraft.

A.11.4 The Saudi Standard (2.76) for BOCLE is a test for assessing fuel lubricity and is used for in-service trouble shooting, lubricity additive evaluation, and in the monitoring of low lubricity test fluid during endurance testing of equipment.

However, BOCLE may not accurately model all types of wear that cause in-service problems. Therefore, other methods may be developed to better simulate the type of wear most commonly found in the field.

A.12 Miscellaneous

A.12.1 Additives—Antioxidants and metal deactivators are used to prevent the formation of oxidation deposits in aircraft engine fuel systems, to counteract the catalytic effects of active metals in fuel systems, and to improve the oxidation stability of fuels in storage. Other additives are available to inhibit the corrosion of steel in fuel systems, to improve the fuel lubricity, to increase the electrical conductivity of fuel, to combat microbiological organisms, and to prevent the formation of ice in fuel systems containing water, and to assist in detecting leaks in fuel storage, delivery and dispensing systems. The chemical names or registered trade names of approved additives and the maximum quantities permitted are shown in section 4.2 of this standard.

A.12.2 Sample Containers - A practice for sampling aviation fuel for tests affected by trace contamination can be found in the Saudi standard (2.83).

A.12.3 Color - Color is a useful indicator of fuel quality. Normally fuel color ranges from water white (colorless) to a straw/pale yellow. Other fuel colors may be the result of crude oil characteristics or refining processes. Darkening of fuel or a change in fuel color may be the result of product contamination and may be an indicator that the fuel is off-specification, which could render it unfit and unacceptable for aircraft/engine use. Fuel having various shades of color, that is, pink, red, green, blue or a change in color from the supply source should be investigated to determine the cause of color change to ensure suitability for aircraft/engine use and should be documented prior to final delivery to airport storage.

B. CLEANLINESS GUIDELINES

B.1 Introduction

B.1.1 The cleanliness of aviation turbine fuels is an essential performance requirement to minimize long term problems, such as wear, corrosion, or plugging of filters or orifices (cleanliness here is defined as the relative absence of free water and solid particulates). However, unlike many other fuel properties, fuel cleanliness changes during transportation. Jet fuel should be maintained in as clean a condition as possible right up to and in airport storage. Airport control of cleanliness must be such as to ensure that only clean fuel is delivered into aircraft.

B.2 Cleanliness at Time of Fuel Custody Transfer at the Airport

B.2.1 Because this standard is primarily used in the sale and purchase of aviation turbine fuel, the point of custody transfer best describes the location at which cleanliness should be checked. The test methods in (B.3) have proven beneficial in evaluating the cleanliness of aviation turbine fuel.

B.3 Test Methods

B.3.1 Particulate Contaminants - The Saudi standards (2.4, 2.5)

B.3.2 Water Separation Rating - the Saudi standard (2.73)

C. FORM FOR REPORTING INSPECTION DATA ON AVIATION TURBINE FUELS

C.1 Introduction

C.1.1 Many airlines, government agencies, and petroleum companies make detailed studies of inspection data provided on production aviation turbine fuels. Because a large number of inspections or inspection locations, or both, is generally involved, these studies are frequently made with the aid of a computer. Without a standardized form for reporting data from different sources, transcribing the reported data for computer programming is laborious. An individual must search each different data sheet for desired information because of the random ordering of results by different reporting laboratories. One objective, therefore, of a standard reporting form is to provide a precise ordering of inspection test data being reported.

C.1.2 The inspection form shown in Table (B.1) incorporates the requirements of the most commonly used international fuel standards, including this standard, British Specification DERD 2494, and the Guidance Material Published by the International Air Transport Association (IATA).

C.1.3 Specific users of aviation turbine fuels sometimes find it necessary to specify properties that are not included in this standard, which are provided as a basis for formulating their own specifications. Another objective of a standard form is to list all tests that might be included in the large number of individual aviation turbine fuel specifications. The fact that a particular test is listed in the standard reporting form does not in itself indicate that there is a universal need for a specification limit. For example, a high-performance military aircraft might have fuel requirements not applicable to subsonic commercial aircraft

C.1.4 The third objective to meet future electronic commerce needs is to establish the industry standard to be used to electronically transmit aviation turbine fuel quality data from one location to another.

C.2 Dimensions of Standard Form

C.2.1 A standard reporting form for aviation turbine fuels is shown in Table (B.1).

C.3 Description of Standard Form

C.3.1 The top of the form (Header Section) provides a method for entering pertinent information regarding description and identity of the fuel being tested and the laboratory performing the tests. Items in italic print are mandatory items. Fill in only those data elements necessary to cover the individual testing situation. Explanation of non-self-explanatory Entries is provided below:

C.3.1.1 Manufacturer/Supplier - Agency or activity who has possession of the fuel to be tested.

C.3.1.2 Product Code/Grade - Accepted code for product being tested.

C.3.1.3 Sampling Location - Place where sample was collected, as specific as possible.

C.3.1.4 Batch Number - If sample was taken from the storage tank, this number should be the batch number of the product in the tank. If the sample is a composite of a shipment, this number should be the batch number or cargo number that represents the shipment.

C.3.1.5 Destination - Location to which the product will be shipped. If more than one location, write Multiple in this block and list locations in the Comments block at the bottom of the form.

C.3.1.6 Crude Source - If required by contract or other agreement, list the crude(s) and percentages used to refine the product. This is done in an attempt to correlate fuel properties with types of crude.

C.3.1.7 Processing Method - If required by contract or other agreement, list the crude processing technique(s) used to refine the product. Examples are hydrotreating, caustic wash, hydrocracking, Merox, and so forth. (All assume atmospheric distillation.) Used in conjunction with the crude source, this information can be used to correlate fuel properties with crude processing technique.

Table (B.1)

Standard form for Reporting inspection data on aviation turbine fuels

INSPECTION DATA ON AVIATION TURBINE FUEL

(Item in bold type are referenced in the specification)

MANUFACTURE/SUPPLIER:	**DATE SAMPLED:**
PRODUCT CODE/GRADE:	**DATE RECEIVED AT**
SPECIFICATION:	**LAB:** CONTRACT NO.:
SAMPLE NUMBER:	ORDER NO.:
DATE SAMPLED:	TANK NO.:
SAMPLING LOCATION:	DESTINATION:
BATCH NO.:	CRUDE
QUANTITY LITTERS @ 15°C:	SOURCE:
QUANTITY U.S. GALLONS at 60°F:	PROCESSING
LABORATORY:	METHOD: REMARKS:

Method			Result
		APPEARANCE:	
010	2.2	Color (Saybolt)	00
020	2.3	Color	00
030	2.1	Visual (“Pass or “Fail”)	0
		COMPOSITION:	
100A	2.9	Acidity, total (mg KOH/g)	0.000
100B	2.10	Acidity, total (mg KOH/g)	0.000
110A	2.11	Aromatics (vol %)	00.0
110B	2.12	Aromatics (vol %)	00.0
110C	2.13	Total Aromatics (vol %)	00.0
110D	2.14	Total Aromatics (vol %)	00.0
120	2.65	Naphthalene (vol %)	0.00
130A	2.20	Sulfur, Mercaptan (wt %)	0.00
130B	2.21	Sulfur, Mercaptan (wt %)	0.00
140A	2.22	Doctor Test (P = pos. N = Neg)	0
140B	2.23	Doctor Test (P = pos. N = Neg)	0
150A	2.15	Sulfur, Total (wt %)	0.00
150B	2.16	Sulfur, Total (wt %)	0.00
150C	2.17	Sulfur, Total (wt %)	0.00
150D	2.18	Sulfur, Total (wt %)	0.00
150E	2.19	Sulfur, Total (wt %)	0.00
		VOLATILITY:	
200A	2.30	Distillation by auto/manual (°C)	
200B	2.31	Distillation by auto/manual (°C)	
200C	2.32	Distillation by auto/manual (°C)	
200D	2.33	Distillation by GC (°C)	
200E	2.34	Distillation by GC (°C)	
201		Distillation initial BP (°C)	000.0
202		Distillation at 10 vol% Rec (°C)	000.0
203		Distillation at 50 vol% Rec (°C)	000.0
204		Distillation at 90 vol% Rec (°C)	000.0
205		Distillation Final BP (°C)	000.0
206		Residue (vol %)	0.0
207		Loss (vol %)	0.0
220A	2.35	Flash Point, Tag Closed (°C)	00.0
220B	2.36	Flash Point, SC Closed (°C)	00.0
220C	2.37	Flash Point, Abel Closed (°C)	00.0
220D	2.38	Flash Point, Rapid Equilibrium Closed (°C)	00.0
220E	2.39	Flash Point, PM Closed (°C) Procedure A	00.0
220F	2.40	Flash Point, Ramp Closed (°C)	00.0
220G	2.41	Flash Point, Ramp Closed (°C)	00.0
230A	2.42	Density @ 15°C (kg/m^3)	000.0
230B	2.43	Density @ 15°C (kg/m^3)	000.0
230C	2.44	Density @ 15°C (kg/m^3)	000.0
230D	2.45	Density @ 15°C (kg/m^3)	000.0
231A	2.42	API Gravity @ 60°F	00.0
231B	2.43	API Gravity @ 60 °F	00.0
		FLUIDITY:	
300A	2.46	Freezing Point (°C)	– 00.00
300B	2.47	Freezing Point (°C)	– 00.00
300C	2.48	Freezing Point (°C)	– 00.00
300D	2.49	Freezing Point (°C)	– 00.00
300E	2.50	Freezing Point (°C)	– 00.00
300F	2.51	Freezing Point (°C)	– 00.00
300G	2.52	Freezing Point (°C)	– 00.00
300H	2.53	Freezing Point (°C)	– 00.00

Method			Brand	Result
310A	2.54	Viscosity @ -20°C (mm^2/s)		00.000
310B	2.55	Viscosity @ -20°C (mm^2/s)		00.000
310C	2.56	Viscosity @ -20°C (mm^2/s)		00.000
310D	2.57	Viscosity @ -20°C (mm^2/s)		00.000
311	2.54	Viscosity @ other Temp (mm^2/s)		00.000
312	2.54	Temp (°C) of item 311		00.0
		COMBUSTION:		
400A	2.58	Specific Energy, net (MJ/kg)		00.000
400B	2.59	Specific Energy, net (MJ/kg)		00.000
400C	2.60	Specific Energy, net (MJ/kg)		00.000
400D	2.61	Specific Energy, net (MJ/kg)		00.000
420A	2.62	Smoke point (mm)		00.0
420B	2.63	Smoke point (mm)		00.0
		CORROSION:		
500A	2.67	Copper Strip		00
500B	2.68	Copper Strip		00
		STABILITY:		
600A	2.69	Thermal Stability (JFTOT)		
600B	2.70	Thermal Stability (JFTOT)		
601		Control Temperature, °C		0000
602		Filter Pressure Differential, mm Hg		00.0
603A		TDR Annex B VTR, nm		0
603B		TDR Annex C ITR or Annex D ETR, nm		00
		CONTAMINANTS:		
700A	2.71	Existent Gum (mg/ 100 ml)		000
700B	2.72	Existent Gum (mg/ 100 ml)		000
710A	2.4	Particulate (mg/L)		0.00
710B	2.5	Particulate (mg/L)		0.00
720		Filtration Time (minutes)		00
730	2.73	Microseparometer (MSEP), rating		00
731	2.73	MSEP (With SDA)		00
732	2.73	MSEP (Without SDA)		00
		ADDITIVES:	**Brand**	
800		Antioxidant (mg/L)	[ ]	00.0
810		Metal Deactivator (mg/L)	[ ]	0.0
820A	2.77	Static Dissipator Additive (mg/L)	[ ]	0.0
820B	2.78	Static Dissipator Additive (mg/L)	[ ]	0.0
830	2.79	FSII (vol%)	[ ]	0.00
840		Corrosion Inhibitor (mg/L)	[ ]	00.0
		OTHER TESTS:		
900	2.22	Conductivity (pS/m)		0000
901	2.22	Conductivity Test Temperature (°C)		00.0

Comment and/or Additional Tests:

CERTIFIED BY:

C.3.2 The body of the form provides for entering test results. There are four columns provided for each test.

C.3.2.1 The first column shows the item number or code assigned to each specific test result. The number assignment for each grouping of fuel characteristics is as follows:

10-99	Appearance
100-199	Composition
200-299	Volatility
300-399	Fluidity
400-499	Combustion
500-599	Corrosion
600-699	Stability
700-799	Contaminants
800-899	Additives
900-999	Other Tests

The code designations are derived from a master list of codes assigned to tests performed for all products. Under these general-categories, item numbers or codes increase either by one unit, five units, ten units, or an alpha character. For each property to be measured under a category, the code increases by five or ten units, depending on the number of characteristics that fall under that general category. The alpha codes represent the various methods allowed by specification to measure that characteristic. This may be a change of test method (see total sulfur as an example) or a change in test conditions (see JFTOT as an example). When the code varies by one unit, this is intended to indicate more than one reported measurement or evaluation for that particular test method (see distillation and water reaction as examples). This system allows for the coding of test methods with their equivalents and for the introduction of newly approved methods systematically into the standardization data sheet.

C.3.2.2 The second column lists the applicable SASO method number. Where there is no SASO method number, the applicable international number is shown.

C.3.2.3 The third column presents word descriptors for each test.

C.3.2.4 The fourth column presents diamonds for entering the results of each test with location of the decimal point shown where applicable.

C.3.3 The lower right-hand pan of the form provides space for comments or for entering other test results that are not listed in the main body of the form.

C.4 Instructions for Executing Column 4

C.4.1 General Instructions:

C.4.1.1 This form is intended for use with kerosene based aviation fuels and provides choice of test methods. Individual laboratory analysis reports should cite only the required or relevant data for the top of the form and reference the assigned item number or code for each characteristic analyzed. Number of decimal places or significant figures, or both, is meant to reflect that which is appropriate for the test method. When determining compliance of the data reported with the requirements of the cited specification, however, the specification values (and rules died for rounding, if any) shall prevail. If a characteristic is determined by a method not cited in the standard form, enter the method identification and result in Comments and/or Additional Tests item.

C.4.2 Detailed Instructions:

C.4.2.1 Item 10 and 20, Color (Saybolt) - Enter either a (+) or a (-) sign in the first square. Example: + 15.

C.4.2.2 Item 30, Visual - According to the Saudi standard (2.1) report result as Pass or Fail, using the criteria outlined in the test method.

C.4.2.3 Item 200, Distillation - This method has a choice of methods and more than one measurement to be made per run. Selection of A, B, C, D or E for item 200 selects which method is used. All of the subsequent measurements will be referenced to the selected method. Select, using an x in the appropriate A, B, C, D or E item, which test method is used, and whichever items or codes apply to the particular situation or specification being reported.

C.4.2.4 Items 230 and 231 - For those contracts or instances that require reporting in units of API Gravity, Items 231 reports API Gravity and Items 230 reports density, either as an alternate or concurrent measurement, using the Saudi standards (2.42, 2.43, 2.44, and 2.45).

C.4.2.5 Items 310 and 311, Viscosity - For aviation turbine fuels, viscosity is measured at -20°C; therefore, the value for item 311 will always be -20. If the test is performed at some other temperature, use item number 311 to report this temperature.

C.4.2.6 Items 601 - 603, JFTOT - Select the temperature at which the JFTOT was performed. Item 601, as appropriate, refer to the data for that specific test temperature. If results for runs at different temperature are reported, then use the data with the appropriate suffix consistent for the temperature. In this manner, results for JFTOT at 245°C and 275°C, for example, can be kept separate and reported simultaneously on the same report. For colors that match the Color Standards, report the color code number. If the color falls somewhere between two colors, report an L for less than followed by the higher code number of the two between which the color falls. If there are only abnormal or peacock deposits as defined in the Saudi standard (2.69 and 2.70), report an A or P, respectively. If there are both peacock and abnormal deposits, report both an A and P. If the darkest deposit on a tube matches a color code number but there is also an abnormal or peacock deposit, report the code number followed by an A or P, respectively. If the darkest deposit on a tube falls between two color code numbers and there are also abnormal or peacock deposits, or both, record the color as L, followed by the higher of the two code numbers, followed by A, P, or AP, as applicable.

C.4.2.7 Items 800, 810, 820, 830, and 840 - Enter the manufacturer's brand name in the square provided. If there is insufficient room in the square provided, indicate by entering asterisks and provide the information on brand name in the REMARKS item.

REFERENCES:

MAIN REFERENCES:

- American Society for Testing and Materials, ASTM D-1655-Latest Issue “Standard Specification for Aviation Turbine Fuels”.
- Saudi Aramco Product Specification No. A-418, issued date 09/13/2022 “JET A-1”
- Ministry of Defense Standard 91-091 Issue 14.

المراجع:

المراجع الرئيسة:

الجمعية الأمريكية لاختبار المواد، رقم دي ١٦٥٥/النسخة الأخيرة " المواصفة القياسية لوقود الطائرات التوربينية"

مواصفات أرامكو السعودية للمنتجات رقم أ-٤١٨

مواصفات وزارة الدفاع البريطانية ٠٩١-٩١ " وقود التوربين، كيروسين الطائرات "

مراجع أخرى:

المقاييس اليابانية الصناعية " وقود الطائرات النفاثة"