Ministry of Defence

Defence Standard 91-91

Issue 7 **Date: 18 February 2011**
Incorporating Amendment 3 **Date: 2 February 2015**

(Note: Amendment 3 Implementation date 02 May 2015)

Turbine Fuel, Kerosine Type, Jet A-1

NATO Code: F-35
Joint Service Designation: AVTUR

Contents

Foreword

AMENDMENT RECORD

Amd No	Date	Text Affected	Signature and Date
3	02 Feb 2015	Clause 0 Introduction; MOD Technical Authority details updated. Clause 5.6; amended to reflect FAME limit of 50 mg/kg. Clause 5.6.1; deleted. Table 1 Test 12; Identified Incidental Materials added. Table 1 Note 5; updated, moved to note 19. Table 1 Note 20; added. Table 2 Test 12.1; added. Annex G clause G.4.2, G.4.3 and G.4.4; updated. Annex G clause G.4.5; deleted Annex K; updated to include new normative references.	G. Cook 02 Feb 2015

REVISION NOTE

This Standard is raised to Issue 7 Amendment 3 to relax the Fatty Acid Methyl Ester (FAME) content limit to 50 mg/kg from <5 mg/kg.

HISTORICAL RECORD

This standard supersedes the following:

Def Stan 91-91 Issue 7	Amendment 2 dated 01 December 2012
Def Stan 91-91 Issue 7	Amendment 1 dated 16 December 2011
Def Stan 91-91 Issue 7	dated 18 February 2011 (implementation date 18 May 2011)
Def Stan 91-91 Issue 6	Amendment 1 dated 25 August 2008
Def Stan 91-91 Issue 6	dated 8 April 2008 (implementation date 8 July 2008)
Def Stan 91-91 Issue 5	Amendment 2 dated 9 March 2007
Def Stan 91-91 Issue 5	Amendment 1 dated 31 March 2006
Def Stan 91-91 Issue 5	dated 8 February 2005
Def Stan 91-91 Issue 4	Amendment 1 dated 30 January 2004
Def Stan 91-91 Issue 4	dated 14 June 2002
Def Stan 91-91 Issue 3	dated 12 November 1999
Def Stan 91-91 Issue 2	dated 8 May 1996
Def Stan 91-91 Issue 1	dated 1 September 1994
DERD 2494 Issue 10	dated 30 June 1988

a) This standard provides requirements for Aviation Turbine Fuel, Kerosine Type.

b) This standard has been produced on behalf of the Ministry of Defence (MOD) by the UK Aviation Fuels Committee (AFC) under the governance of the DSFA and the Military Aviation Authority (MAA) Fuels, Lubricants and Gases Airworthiness Advisory Group (FLAAG).

c) This standard has been agreed by the authorities concerned with its use and is intended to be used whenever relevant in all future designs, contracts, orders etc. and whenever practicable by amendment to those already in existence. If any difficulty arises which prevents application of the Defence Standard, DStan shall be informed so that a remedy may be sought.

d) Please address any enquiries regarding this standard, whether in relation to an invitation to tender or to a contract in which it is incorporated, to the responsible technical or supervising authority named in the invitation to tender or contract.

e) Compliance with this Defence Standard shall not in itself relieve any person from any legal obligations imposed upon them.

f) This standard has been devised solely for the use of the MOD and its contractors in the execution of contracts for the MOD. To the extent permitted by law, the MOD hereby excludes all liability whatsoever and howsoever arising (including, but without limitation, liability resulting from negligence) for any loss or damage however caused when the standard is used for any other purpose.

0 Introduction

Defence Standard 91-91 is the standard for aviation turbine fuel, which the United Kingdom Civil Aviation Authority (CAA) has agreed is under the technical authority of the Defence Strategic Fuels Authority ..

Note. The Technical Authority is the Defence Strategic Fuels Authority, Larch 3B, #2317, MOD Abbey Wood, Bristol, BS34 8JH, United Kingdom.

Turbine Fuel, Aviation Kerosine Type, JET A-1; NATO Code: F-35; JSD: AVTUR

1 Scope

This Defence Standard specifies the requirements for one grade of kerosine type aviation turbine fuel intended for use in aircraft gas turbine engines. Fuel provided to this specification shall possess satisfactory performance and properties when used in appropriate aircraft or engines operated by the Crown, or for which the CAA is the certificating agency.

2 Warning

The Ministry of Defence (MOD), like its contractors, is subject to both United Kingdom and European laws regarding Health and Safety at Work. Many Defence Standards set out processes and procedures that could be injurious to health if adequate precautions are not taken. Adherence to those processes and procedures in no way absolves users from complying with legal requirements relating to Health and Safety at Work.

3 Normative References

3.1 The documents and publications shown in Annex K are referred to in the text of this standard. Publications are grouped and listed in alpha-numeric order.

3.2 Reference in this Standard to any normative references means in any Invitation to Tender or contract the edition and all amendments current at the date of such tender or contract unless a specific edition is indicated. For some standards the most recent editions shall always apply due to safety and regulatory requirements. Examples of these are Statutory Instruments (SI's).

3.3 In consideration of clause 3.2 above, users shall be fully aware of the issue, amendment status and application of all normative references, particularly when forming part of an Invitation to Tender or contract. Responsibility for the correct application of standards rests with users.

3.4 Where conflict exists between this specification and references cited herein, the text of this document takes precedence.

3.5 DStan can advise regarding where to obtain normative referenced documents. Requests for such information can be made to the DStan Helpdesk. Details of how to contact the helpdesk are shown on the outside rear cover of Defence Standards.

4 Materials

4.1 Jet fuel is a complex mixture of hydrocarbons that varies depending on crude source and manufacturing process. Consequently, it is impossible to define the exact composition of jet fuel. This specification has therefore evolved primarily as a performance specification rather than a compositional specification. It is acknowledged that this largely relies on accumulated experience, therefore the specification limits jet fuels to those made from conventional sources or specifically approved synthetic processes.

4.1.1 Jet fuel, except as otherwise specified in this specification, shall consist predominantly 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 Annex A. The use of jet fuel blends containing components from other sources is permitted only in accordance with Annex D.

4.1.2 Fuels containing synthetic components derived from non-petroleum sources are only permitted provided that they meet the requirements of Annex D**,** in addition to those defined in clause 5, Quality Assurance.

4.2 Only additives qualified by and on behalf of the MOD's Aviation Fuels Committee shall be permitted. Details of qualified additives are given in Annex A.

4.3 Additives shall be identified by the appropriate RDE/A/XXX number as shown in Annex A. The amount, including NIL additions, of all additive additions shall be reported to the purchaser on batch quality certificates or as otherwise directed by the purchaser and/or contract.

4.4 Additional information on jet fuel lubricity can be found in Annex B.

4.5 The Ministry of Defence and/or its appointed agent(s) reserves the right to require that the material and any components used are subject to toxicological and physiological tests to ascertain their suitability for use.

5 Quality Assurance

5.1 Aviation fuel quality assurance is based on two key concepts: batches and traceability. A batch of fuel is defined as a distinct quantity of jet fuel that can be characterised by one set of test results. It is essential that refineries ensure batches are homogenous so that test results are representative of the product supplied. Homogenous is defined as the density not varying by more than 3.0 kg/m³ across the batch. Special care shall be taken to ensure homogeneity when blending semi synthetic jet fuel particularly where the component densities are significantly different.

5.2 At point of manufacture, the refinery shall issue a Certificate of Quality (see Annex J) to certify that the batch of fuel complies with all of the requirements of this standard. The certificate shall cover not only the quantitative Table 1 limits but also all other requirements set out in the main sections and annexes of this standard.

5.3 To certify compliance with Table 1 limits, representative samples shall be drawn using appropriate procedures such as those outlined in IP 475 and ASTM D4057. Each homogeneous batch of the finished product shall be tested against the requirements of Table 1**.** Results shall be reported on the appropriate batch certificate of quality. This requirement is not satisfied by averaging on-line analysis results.

5.4 The minimum requirements for information to be shown on the fuel's batch test certificate of quality at point of manufacture are given at Annex J**.** Documentation shall be provided by the supplier to the purchaser to show that the fuel meets the requirements of this standard and demonstrates traceability (see Annex J) to point of manufacture. Upon request the technical authority or end user shall be provided with the documentation.

5.5 Jet fuel can come into contact with incidental materials during manufacture and distribution. In a refinery, processing materials might be carried over in trace quantities into aviation fuels and some have been known to cause operational problems in aircraft fuel systems. In distribution, bulk jet fuel is typically handled in non-dedicated systems such as multiproduct pipelines and marine vessels where contact with incidental materials is unavoidable. Appropriate management of change measures shall be used at manufacturing locations, distribution, and storage facilities to maintain product integrity (see Annex G).

5.6 The recent mandatory introduction of biodiesel has resulted in the potential for trace amounts of FAME (Fatty Acid Methyl Ester) in jet fuel. Following studies conducted by the Energy Institute and with harmonization alignment with ASTM D1655, Jet fuel containing a maximum permitted level of 50 mg/kg of FAME that meets the requirements of EN 14214 or ASTM D6751 (as used in diesel fuels) as determined using the appropriate test methods is acceptable for use. See Table 1 test 12.

6 Testing

6.1 Properties of the product shall not exceed the maximum nor be less than the minimum values set out in Table 1 when tested by the methods referred to therein or Annex C.

Note. The IP 367 procedure, which covers the use of precision data, may be used for the interpretation of test results in cases of dispute between purchaser and supplier.

6.2 Methods quoted in Table 1 are referee methods. In cases of dispute the referee methods shall be used. Approved alternative methods are listed in Annex C. A list of ISO methods which were technically equivalent to the IP test methods at the time of issue of the specification can be found at Annex I.

6.3 For synthetic blends referee methods shall be used. Use of alternative technically equivalent methods may be used following the approval by the Technical Authority

7 Containers and Marking of Containers

7.1 The product shall be supplied in sound, clean and dry containers, suitable for the product and in accordance with the requirements of the contract or order.

7.2 Coatings and paint finishes shall comply with the requirements of the contract or order. Markings shall be in accordance with the requirements of Def Stan 05-52 (Part 1). The product identification shall be specified in the contract or order.

7.3 It shall be the responsibility of the contractor to comply with any legal requirements for the marking of containers.

Table 1 - Test Requirements

Test	Property	Units	Limits		Method
1	Appearance				
1.1	Visual Appearance		Clear, bright and visually free from solid matter and undissolved water at ambient fuel temperature		Visual (see Annex F)
1.2	Colour		Report		ASTM D156 or ASTM D6045 (see Note 1)
1.3	Particulate Contamination, at point of manufacture	mg/l	Max 1.0		IP423/ ASTM D5452 (see Note 2)
1.4	Particulate, at point of manufacture, cumulative channel particle counts	Individual channel counts & ISO Code	Channel Counts	ISO Code (see Note 3)	IP 564, IP 565 or IP 577 (see Note 4)
1.4.1	≥ 4 µm(c)		Report	Report	
1.4.2	≥6 µm(c)		Report	Report	
1.4.3	≥14 µm(c)		Report	Report	
1.4.4	≥21 µm(c)		Report	Report	
1.4.5	≥25 µm(c)		Report	Report	
1.4.6	≥30 µm(c)		Report	Report	
2	Composition				
2.1	Total Acidity	mg KOH/g	Max 0.015		IP 354/ ASTM D3242
2.2	Aromatic Hydrocarbon Types				
2.2.1 or	Aromatics	% v/v	Max 25.0		IP 156/ ASTM D1319
2.2.2	Total Aromatics	% v/v	Max 26.5		IP 436/ ASTM D6379 (see Note 5)
2.3	Sulfur, Total	% m/m	Max 0.30		IP 336
2.4 or	Sulfur, Mercaptan	% m/m	Max 0.0030		IP 342/ ASTM D3227 (see Note 6)
2.5	Doctor Test		Doctor Negative		IP 30

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Table 1: Test Requirements (continued)

2.6	Refining Components, at point of manufacture			(see Note 7)
2.6.1	Non Hydroprocessed Components	% v/v	Report	
2.6.2	Mildly Hydroprocessed Components	% v/v	Report	
2.6.3	Severely Hydroprocessed Components	% v/v	Report	
2.6.4	Synthetic Components	% v/v	Report For limits see Annex D	(See Note 8 and Note 9)
3	Volatility:			
3.1	Distillation:			IP 123/ ASTM D86 (see Note 10)
3.1.1	Initial Boiling Point	°C	Report	
3.1.2	10% Recovery	°C	Max 205.0	
3.1.3	50% Recovery	°C	Report	
3.1.4	90% Recovery	°C	Report	
3.1.5	End Point	°C	Max 300.0	
3.1.6	Residue	% v/v	Max 1.5	
3.1.7	Loss	% v/v	Max 1.5	
3.2	Flash Point	°C	Min 38.0	IP 170
3.3	Density at 15 °C	kg/m^3	Min 775.0 Max 840.0	IP 365/ ASTM D4052
4	Fluidity:			
4.1	Freezing Point	°C	Max minus 47.0	IP 16/ ASTM D2386
4.2	Viscosity at minus 20 °C	mm^2/s	Max 8.000	IP 71/ ASTM D445
5	Combustion:			
5.1	Smoke Point	mm	Min 25.0	IP 598 / ASTM D1322 (see Note 11)
or				
5.2	Smoke Point and	mm	Min 19.0	IP 598 / ASTM D1322
	Naphthalenes	% v/v	Max 3.00	ASTM D1840
5.3	Specific Energy	MJ/kg	Min 42.80	(see Note 12)
6	Corrosion:			
6.1	Copper Strip	Class	Max 1	IP 154/ ASTM D130 (see Note 13)

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Table 1: Test Requirements (continued)

Test	Property	Units	Limits	Method
7	Thermal Stability, JFTOT			IP 323 /ASTM D3241 (See Note 14)
7.1	Test Temperature	°C	Min 260	
7.2	Tube Rating Visual		Less than 3. No Peacock (P) or Abnormal (A)	(See Note 15)
7.3	Pressure Differential	mm Hg	Max 25	
8	Contaminants:			
8.1	Existent Gum	mg/100ml	Max 7	IP 540
9	Water Separation Characteristics			
9.1	Microseparometer, at Point of Manufacture:			ASTM D3948 (See Note 16)
9.1.1	MSEP Without SDA	Rating	Min 85	
9.1.2	MSEP With SDA	Rating	Min 70	
10	Conductivity:			
10.1	Electrical Conductivity	pS/m	Min 50 Max 600	IP 274/ ASTM D2624 (See Note 17)
11	Lubricity: Wear Scar Diameter	mm	Max 0.85	ASTM D5001 (See Note 18)
12	Identified Incidental Materials			(See Note 19)
12.1	Fatty Acid Methyl Ester	mg/kg	Max 50	IP 585 (See Note 20)

Note 1: The requirement to report Saybolt Colour shall apply at point of manufacture, thus enabling a colour change during distribution to be quantified. Where the colour of the fuel precludes the use of the Saybolt Colour test method, then the visual colour shall be reported. Unusual or atypical colours should also be noted. For further information on the significance of colour see Annex E.

Note 2: Refer to the information on Particulate Contamination at Annex F.

Note 3: 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.

Note 4: It is the Specification Authority's intention to replace Test 1.3 with Test 1.4 at the earliest opportunity.

Note 5: Round robin testing has demonstrated the correlation between total aromatics content measured by IP 156/ASTM D1319 and IP 436/ASTM D6379. Bias between the two methods necessitates different equivalence limits as shown. Testing laboratories are encouraged to measure and report total aromatics content by the two methods to assist verification of the correlation. In cases of dispute IP 156 will be the referee method. It is the intention of the Technical Authority to change the referee method to IP 436 at a later date.

Note 6: The alternative requirement 2.5 is a secondary requirement to 2.4. In the event of a conflict between Sulfur Mercaptan (2.4) and Doctor Test (2.5) results, requirement 2.4 shall prevail.

Note 7: Each refinery component used in the make-up of the batch shall be reported on the Refinery Certificate of Quality as a percentage by volume of the total fuel in the batch. Mildly hydroprocessed components are defined as those petroleum derived hydrocarbons that have been subjected to a hydrogen partial pressure of less than 7000 kPa (70 bar or 1015 psi) during manufacture. Severely hydroprocessed components are defined as those petroleum derived hydrocarbons that have been

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Table 1: Test Requirements (concluded)

subjected to a hydrogen partial pressure of greater than 7000 kPa (70 bar or 1015 psi) during manufacture. The total of non-hydroprocessed plus mildly hydroprocessed plus severely hydroprocessed plus synthetic components shall equal 100%.

Note 8: The volume percentage of each synthetic blending component type shall be recorded along with its corresponding release Specification and Annex number, product originator and originator's Certificate of Quality number.

Note 9: The aromatic content of the finished semi-synthetic Aviation Turbine Fuel shall not be less than 8.0% nor greater than 25.0% by volume when using method IP156, or not less than 8.4% nor greater than 26.5% by volume when using method IP436. Further, the boiling point distribution of the semi-synthetic Aviation Turbine Fuel shall have a minimum distillation slope as defined by the T50-T10 of ≥ 15°C and a T90-T10 of ≥ 40°C.

Note 10: In methods IP 123 and ASTM D86 all fuels certified to this specification shall be classed as group 4, with a condenser temperature of zero to 4°C.

Note 11: Alternative test requirements identified in Table 1; Test Requirements 5.1 or 5.2 are equal primary requirements. IP 598 includes both a manual and an automated method. The manual method in IP 598 is the referee method. It is the intention of the Specification Authority to make the automated method in IP 598 the referee method in January 2014.

Note 12: Specific Energy by one of the calculation methods listed at Annex C is acceptable. Where a measurement of Specific Energy is deemed necessary, the method to be used shall be agreed between the Purchaser and Supplier.

Note 13: The sample shall be tested in a pressure vessel at 100±1°C for 2 hours ± 5 minutes.

Note 14: Thermal Stability is a critical aviation fuel test and while competition among equipment manufacturers/suppliers is to be encouraged, aircraft safety must remain paramount. It is known that there are heater tubes being supplied by sources other than the original equipment manufacturer (OEM). Until the alternative manufacturers' tubes have been demonstrated to be equivalent to the OEM's test pieces, to the satisfaction of the AFC, they shall not be used. A list of manufacturers whose heater tubes have been found to be technically suitable is as follows: a) PAC – Alcor b) Falex

Note 15: Examination of the heater tube to determine the Visual Tube Rating using the Visual Tube Rator shall be carried out within 120 minutes of completion of the test.

Note 16: Where SDA is added at point of manufacture the MSEP limit of 70 shall apply. No precision data are available for fuels containing SDA; if MSEP testing is carried out during downstream distribution no specification limits apply and the results are not to be used as the sole reason for rejection of a fuel. A protocol giving guidelines on possible actions to be taken following failed MSEP testing can be found in the Joint Inspection Group's Bulletin Number 14, MSEP Protocol at 'www.jigonline.com' under 'fuel quality'. Where SDA is added downstream of point of manufacture, it is acknowledged that MSEP results may be less than 70.

Note 17: The 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 requirements of Defence Standard 91-91 except for electrical conductivity". The Specification Authority is also aware of situations where conductivity can decrease rapidly and the fuel can fail to respond to additional dosing of Stadis 450 (see Annex H for more information).

Note 18: The requirement to determine lubricity applies only to fuels whose composition is made up of a) less than 5% non hydroprocessed components **and** at least 20% severely hydroprocessed components (see Note 8) or b) includes synthesised fuel components. The limit applies only at the point of manufacture.

Note 19: See Clause 5.5 and 5.6 for additional information on identified incidental materials and FAME.

Note 20: Post manufacture a risk assessment shall be undertaken to quantify the potential risk of FAME carryover in all supply chains. 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 FAME carryover exists and it is not possible to control with additional quality assurance procedures, testing shall be instigated. Further guidance on how to verify compliance with this requirement is contained in Annex G.

Annex A

List of Qualified Additives

A.1 General Information on hydrocarbon diluents and additives

A.1.1 Some additives, as qualified, include a hydrocarbon diluent as a solvent and the amount to be added is calculated based on the additive as received. These include Static Dissipator Additive and Lubricity Improver Additive.

A.1.2 Other additives are qualified based on the active ingredient content as listed. These include Antioxidant, Metal Deactivator Additive, Fuel System Icing Inhibitor (FSII), and Leak Detection Additive.

A.1.3 Where it is necessary to dilute an additive for handling purposes any solvent used shall be hydrocarbon derived from the sources detailed in Clause 4 Materials. In this case the vendor/manufacturer shall provide directions for calculating dosage. This information shall be placed on the certificate of analysis or additive quality documentation.

A.2 Antioxidants

A.2.1 Antioxidants or mixtures of antioxidants, of a type detailed in **A.2.4** and at a concentration detailed in **A.2.5**, shall be added to a fuel (or component) which has been hydroprocessed (i.e. manufactured using a catalytic hydrogen process such as hydrotreating, hydrofining, hydrocracking, etc) or has been synthesised as defined in Annex D**.** This must be done immediately after hydroprocessing or synthesising and prior to the product or component being passed into storage to prevent peroxidation and gum formation after manufacture.

A.2.2 Where a finished fuel comprises a blend of several different components, the requirement for mandatory addition of antioxidant applies only to the portion of the blend that has been hydroprocessed. In such cases, the proportion of the blend which has been hydroprocessed shall be reported.

A.2.3 For fuel (or fuel component) which has not been hydroprocessed/synthesised, such addition is optional.

A.2.4 The following antioxidant formulations are qualified:

Formulation	Qualification Reference
(a) 2,6-ditertiary-butyl-phenol	RDE/A/606
(b) 2,6 ditertiary-butyl-4-methyl-phenol	RDE/A/607
(c) 2,4-dimethyl-6-tertiary-butyl-phenol	RDE/A/608
(d) 75 percent minimum, 2,6-ditertiary-butyl-phenol 25 percent maximum, tertiary and tritertiary-butyl-phenols	RDE/A/609
(e) 55 percent minimum, 2,4-dimethyl-6-tertiary-butyl-phenol 15 percent minimum, 4 methyl-2,6-ditertiary-butyl-phenol Remainder, 30 percent maximum, as a mixture of monomethyl and dimethyl-tertiary-butyl-phenols	RDE/A/610
(f) 72 percent minimum, 2,4-dimethyl-6-tertiary-butyl-phenol 28 percent maximum, mixture of tertiary-butyl-methyl-phenols and tertiary-butyl dimethyl phenols	RDE/A/611

A.2.5 The concentrations in which the qualified materials shall be used are as follows:

A.2.5.1 Hydroprocessed fuels or fuel components and synthesised fuels: the total concentration of active material(s) in fuel or that proportion of the fuel blend that has been hydroprocessed and/or synthesised shall not be less than 17.0 mg/l. The total concentration of active material in the final batch shall not exceed 24.0 mg/l.

A.2.5.2 Fuels which have not been hydroprocessed: the total concentration of active material(s) shall not exceed 24.0 mg/l and shall be reported on the certificate of quality.

A.2.6 The concentration of antioxidant added to the fuel should be reported as follows:

A.2.6.1 Where a fuel, or a blend component of the fuel, has been hydroprocessed, severely hydroprocessed and/or synthesised, the concentration of active material added to these portions of the blend shall be reported on the certificate of quality. If antioxidant has also been added to the non-hydroprocessed portion of the fuel, the concentration of active material added to this portion should be reported on a separate line on the certificate of quality.

A.2.6.2 The active material concentration of any antioxidant added to a fuel that has not been hydroprocessed shall be reported on the certificate of quality.

A.3 Metal Deactivator Additive (MDA)

A.3.1 An MDA, of a type detailed in **A.3.2** and at a concentration detailed in **A.3.3,** may be added to fuel to counteract the effects of metals known to be deleterious to thermal stability, such as Copper, Cadmium, Iron, Cobalt and Zinc, provided that the nature of the contamination is reported. Where metallic contamination is unproven, an MDA may be used to recover thermal stability provided that the JFTOT Test (in accordance with Table 1, Test 7) is determined before and after MDA addition and reported on the test certificate.

A.3.2 The following material is qualified:

Product	Qualification Reference
N,N'-disalicylidene 1,2-propanediamine.	RDE/A/650

A.3.3 The concentration of active material used on initial doping of the fuel shall not exceed 2.0 mg/l. Cumulative addition of MDA when redoping the fuel shall not exceed 5.7 mg/l. The requirements of **A.3.1** shall be met when doping or redoping.

A.4 Static Dissipator Additive (SDA)

A.4.1 Where necessary an SDA, of a type detailed in **A.4.2** and at a concentration detailed in **A.4.3,** shall be added to the fuel to impart electrical conductivity in accordance with Table 1, Test 10.1.

A.4.2 The following material is qualified:

Product	Manufacturer	Qualification Reference
Stadis® 450	Innospec LLC	RDE/A/621

A.4.3 Concentration and redoping limits:

A.4.3.1 The concentration of SDA to be used in newly manufactured, or on first doping of fuel, is 3.0 mg/l maximum.

A.4.3.2 The cumulative concentration of SDA allowed when redoping fuel to maintain conductivity is 5.0 mg/l maximum.

A.4.3.3 A suitable method for the determination of Stadis 450 at the point of manufacture is IP 568 or ASTM D7524.

A.5 Lubricity Improver Additive (LIA): previously cited as corrosion inhibitor/lubricity improver additive

A.5.1 An LIA, of a type and at a concentration as detailed at **A.5.4** may be added to impart improved lubricity to the fuel. Further information on Aviation Turbine Fuel Lubricity is available at Annex B.

A.5.2 Because LIA exists in equilibrium with the metal surfaces of fuel distribution systems as well as those of an aircraft, correct delivery to aircraft can be assured only by equilibration of the supply system downstream of the LIA addition or by additive injection at the point of entry to the aircraft.

A.5.3 Qualified materials, their respective qualification references, quality assurance requirements and the concentration limits applicable at the time of delivery to the purchaser, are listed in QPL 68-251, which is the authoritative document. Those additives qualified at the time of publication of this Defence Standard together with their qualification references and concentration limits are also listed below. In civil use other additives may be used provided that they have been adequately qualified in accordance with the certifying authorities and the appropriate aircraft and engine manufacturer.

A.5.4 The following materials are qualified at the specified concentrations:

Product	Manufacturer	Qualification Reference	Minimum mg/l	Maximum mg/l
Hitec 580	Afton Chemical Ltd.	RDE/A/661	15	23
Octel DCI-4A	Innospec LLC	RDE/A/662	9	23
Octel DCI-6A	Innospec LLC	RDE/A/663	9	15
Nalco 5403	Nalco Chemical Co.	RDE/A/664	12	23
Tolad 4410	Baker Petrolite	RDE/A/665	9	23
Tolad 351	Baker Petrolite	RDE/A/666	9	23
Unicor J	Dorf Ketal Chemicals	RDE/A/667	9	23
Nalco 5405	Nalco Chemical Co.	RDE/A/668	11	23
Spec Aid 8Q22	GE Betz	RDE/A/669	9	23

A.6 Fuel System Icing Inhibitor (FSII)

A.6.1 An FSII, of a type detailed in **A.6.3** and at a concentration as detailed at **A.6.4** may be added to the fuel by agreement between purchaser and supplier.

Note: Concentrations of less than 0.02% by volume can 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. **Under no circumstances is this background level allowed in fuel that is to be delivered through a filter monitor**. This does not permit the continuous addition of FSII at these low concentrations.

A.6.2 Under no circumstances shall fuels containing FSII be delivered through a filter monitor.

A.6.3 The following material is qualified and must comply with Def Stan 68-252:

Product	Qualification Reference
Diethylene Glycol Monomethyl Ether	RDE/A/630

A.6.4 The material shall be added, where mandated, at a concentration of not less than 0.10% and not more than 0.15% by volume at the time of delivery to the purchaser. Suitable methods for determining the additive concentration are IP 424 and ASTM D 5006.

A.7 Additive Mixtures

A.7.1 When LIA (clause **A.5)** and FSII (clause **A.6**) are to be used together it may be possible to add the LIA in a mixture with FSII.

A.7.2 The combined additive concentrate for this purpose is Joint Service Designation AL-48 controlled by Defence Standard 68-150. Whatever blending procedure is adopted, the supplier shall satisfy the purchaser that the correct concentration of additives has been incorporated homogeneously. It is known that AL-48 mixtures can be problematic, information on this can be found in Defence Standard 68-150.

A.7.3 Under no circumstances shall fuels containing FSII be delivered through a filter monitor

A.8 Leak Detection Additive

A.8.1 Where necessary a leak detection additive may be added to the fuel to assist in detecting and locating leaks in ground based fuel storage, delivery and dispensing systems. It should be recognized that other leak detection techniques may have less environmental impact than Tracer A. The additive should only be used when other options have been considered.

A.8.2 The following material is qualified:

Product	Manufacturer	Qualification Reference
Tracer A(LDTA-A)	Tracer Research Corporation	RDE/A/640

A.8.3 The concentration of Tracer A shall not exceed 1.0 mg/kg.

A.9 Contamination by Processing Additives

A.9.1 This section has been moved to Annex G, Product Integrity Management.

Annex B

Information Statement on Aviation Turbine Fuel Lubricity

B.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 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.

B.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 which tend to have a lower lubricity than straight-run or wet-treated fuels. Lubricity improver additives are widely used in military jet 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-based filtration systems and on fuel/water separation characteristics.

B.3 Some modern aircraft fuel system components have been and are being designed to operate on poor lubricity fuel. With the participation of the international aviation industry the SAE AE-5B group has revised the procedure for the Low Lubricity Endurance Test for aircraft engine fuel pumps, ARP 1797. The procedure now specifies that the test fluid used shall produce a wear scar diameter (wsd) between 0.85 and 0.96 mm as measured by ASTM D5001. The introduction of a lubricity requirement maximum of 0.85 mm wsd is to provide a limit to the fuel lubricity which attempts to ensure that future equipment proven against ARP 1797 procedure does not suffer lubricity related problems in use. The requirement only applies to fuels containing more than 95% hydroprocessed material and where at least 20% is severely hydroprocessed and to those fuels that contain a proportion of synthesised material as permitted by this standard. All the fuels which have caused problems have been in this category. It has been noted that not all fuels containing severely hydroprocessed components produce a wsd greater than 0.85 mm and this has been taken into account in setting the requirement.

B.4 There are older fuel system components still in use which are more sensitive to fuel lubricity. In these cases the aircraft operator should consult with the equipment manufacturer and fuel supplier to determine the best course of action which may include the use of a qualified lubricity additive to enhance the lubricity of a particular fuel, a measure which is already permitted by this standard.

Annex C

Alternative Test Methods for use with Table 1 Test Requirements

Table 2: Alternative Test Methods

Table 1 Test Number	Property	Alternative
1	Appearance	ASTM D4176 Procedure 1
2.3	Total Sulfur	IP 107 IP 243 IP 373 IP 447 ASTM D1266 ASTM D2622 ASTM D4294 ASTM D5453
2.5	Doctor Test	ASTM D4952
3.1	Distillation	IP 406 (Note 1)/ASTM D2887
3.2	Flash Point	IP 523 ASTM D56 (NOTE 2) ASTM D3828
3.3	Density at 15 °C	IP 160/ ASTM D1298
4.1	Freezing Point	IP 435/ ASTM D5972 IP 528 IP 529/ ASTM D7153 ASTM D7154
5.3	Specific Energy	IP 12 IP 355 ASTM D3338 ASTM D4809
8.1	Existent Gum	ASTM D381
12.1	Fatty Acid Methyl Ester	IP 583/ ASTM D7797 IP 590 IP 599

Note 1: The calculation of IP 123 estimated distillation data given in Annex G of IP 406 must be used to extrapolate results to IP 123. The requirement to report loss and residue is waived if IP 406 is used.
IP 123 estimated data may also be used for the calculation of Specific Energy.

Note 2: Subject to a minimum result of 40 °C being obtained using ASTM D56 (Tag method) the result(s) may be accepted.

Annex D

Additional Requirements Applicable to Fuels Containing Synthetic Components

D.1 Background

D.1.1 Previously this Standard has only permitted those fuels solely derived from petroleum sources. However, it must now be recognised that there is an emerging requirement for this Standard to encompass and control the use of fuels containing hydrocarbons synthesised from non-petroleum sources. The use of synthesised hydrocarbons represents a departure from experience and also from some of the key assumptions on which the requirements of this Standard have so far been based. As such, it had been deemed necessary to approve Jet fuels derived from alternative sources on a case by case basis dependent on the initial raw material and production process. These specific approvals are listed at **D.4**. Today, this principle still holds for fuels derived from alternative sources unless it is demonstrated that the alternative fuel type conforms to ASTM D7566 Annex A1 or Annex A2 (see **D.3**). Applications for the approval of synthetic fuels or for semi synthetic blends not covered by ASTM D7566 Annex A1or Annex A2 should still be made to the Technical Authority.

D.2 Investigation for Approval

D.2.1 Following the initial approval of the Sasol semi synthetic Jet fuel in this standard, and subsequent work conducted by others, it became clear that there was a need for a documented process in which both aviation turbine fuels from non conventional sources and aviation fuel additives should be assessed. In recognition of this, a standard practice has been developed that provides a framework for the qualification and approval of new fuels and new fuel additives for use in military and commercial aviation gas turbine engines. The practice as represented in the standard ASTM D4054 has been developed as a guide by the aviation gas-turbine engine & airframe Original Equipment Manufacturers (OEMs) who actively participate in the AFC and ASTM. The following paragraphs are intended to give guidance on the basis upon which individual synthetic, semi-synthetic blends and new fuel additives will be approved. Additional testing in line with the standard ASTM D4054 may also be required to demonstrate satisfactory operational performance. The requirement and scope of such testing shall be defined in agreement with the Technical Authority in conjunction with the appropriate certifying authority, aircraft and engine manufacturers.

D.3 Generic Synthetic Paraffinic Kerosine

D.3.1 The ASTM Standard Specification D7566 for Aviation Turbine Fuel Containing Synthesised Hydrocarbons defines in both Annex A1 and A2 the requirements for Hydroprocessed Synthesised Paraffinic Kerosine for use as a blending component in Aviation Turbine Fuels.

D.3.1.1 Synthetic Paraffinic Kerosine certified as meeting either the requirements of D7566 Annex A1 or A2 may be used, either individually or in combination, as blending components in Aviation Turbine Fuels meeting the requirements of this standard at up to a total combined 50% synthetic components by volume. The originator's Certificate of Quality must be available for each synthetic blend component and be quoted as part of the reporting requirements in Table 1 of this standard.

D.3.1.2 From the point of manufacture to the point of blending to meet this specification, all synthetic blend components shall be handled and transported in the same manner as finished jet fuel in order to maintain product integrity. In particular the restrictions of Clause 5.5 and Annex G, paragraphs G3 and G4 must be observed.

D.3.1.3 The location at which a semi-synthetic Aviation Turbine Fuel meeting this specification is blended need not be a refinery, but it shall be upstream of the airport fuel storage depot. The point of blending shall be considered as the point of manufacture of the jet fuel for the purposes of this specification. Therefore the appropriate requirements of this specification apply at that point: in

particular, but not limited to, those of Clause 5 and Annex J and include the requirement for the production of a Certificate of Analysis as defined in Annex J. In the case of blending synthetic components, the CoA shall include a listing of the quality documents relating to the conventional and synthetic batches in the blend **and** their respective volumes to show compliance with the 50% blending limit.

D.4 Specific Manufacturer Approvals

D.4.1 Individually approved synthetic and semi-synthetic fuel blends as identified in **D4.2** and **D4.3** must be manufactured according to declared procedures defined during the manufacture of prototype batches which have been submitted for examination and approval. Prototype batches must be shown to comply with all the requirements defined in **clause 6**. Changes to declared production procedures may only be undertaken following agreement with the Technical Authority. Such change may require additional testing, as in **D.2**, to be carried out before approval is given.

D.4.2 Sasol semi-synthetic Jet fuel blends

D.4.2.1 Sasol semi‑synthetic Aviation Turbine Fuel, containing synthetic Iso‑Paraffinic Kerosine (IPK), see clause D.4.2.3 by itself or as combined with SASOL heavy naphtha #1 (HN1), see clause D.4.2.4 blended with kerosine from conventional sources, see clause D.4.2.5 with a maximum of 50% synthetic product are currently the only specific manufacturer's semi‑synthetic blends which have been approved for use, see approval reference FS(Air)/ssjet/1.

D.4.2.2 The aromatic content of the Sasol semi-synthetic Jet fuels shall not be less than 8.0% nor greater than 25.0% by volume when using method IP156, or not less than 8.4% nor greater than 26.5% by volume when using method IP436. The fuels shall exhibit a maximum wear scar diameter of 0.85 mm when tested by ASTM D5001. Analysis for these properties shall be made at point of manufacture. These results shall be included on the batch certificate for the fuel. The amount of synthetic fuel in the final blend shall be included on the batch certificate for the fuel and shall not exceed 50% by volume.

D.4.2.3 Sasol synthetic Iso‑Paraffinic Kerosine is defined as that material manufactured at the Secunda plant by the Fischer ‑ Tropsch process as described in the Southwest Research Institute (SwRI) report number 8531. The synthetic component shall be derived solely from products of the Fischer – Tropsch process which have been polymerized and subsequently hydrogenated. The use of synthetic aromatic compounds is not permitted except as defined in clause D.4.2.1, D.4.2.4, and D.4.2.5. If used in combination with the Sasol HN1 (see clause D.4.2.4), the final synthetic blend shall contain at least 25% IPK by volume.

D.4.2.4 Sasol heavy naphtha #1 (HN1) is defined as that material manufactured at the Secunda plant by the Fischer – Tropsch process as described in the Southwest Research Institute (SwRI) report number 08-04438. HN1 shall be derived from products of the Fisher – Tropsch process by fractionation and hydrogenation. HN1 may be used in combination with IPK providing the final synthetic blend contains at least 25% IPK by volume. As a minimum, the HN1/IPK blend shall meet the requirements of Table 3.

D.4.2.5 The blending kerosine from conventional sources shall contain no more than 50% severely hydroprocessed material as defined in Note 8 of Table 1.

Table 3: Batch Requirements for HN1/IPK Blend

Test	Property	Units	Limits	Method
1	Thermal Stability, JFTOT			IP 323 /ASTM D3241 (see Note 1)
1.1	Test Temperature	°C	Min 325	
1.2	Tube Rating Visual		Less than 3. No Peacock (P) or Abnormal (A)	(see Note 2)
1.3	Pressure Differential	mm Hg	Max 25	
2	Fluidity			
2.1	Freezing Point	°C	Max minus 40.0	IP 16/ASTM D2386
3	Combustion			
3.1	Specific Energy	MJ/kg	Min 42.80	(see Note 3)
4	Composition			
4.1	Aromatics	% v/v	Max 7.0	IP 156/ASTM D1319
or 4.2	Total Aromatics	% v/v	Max 7.4	IP 436/ASTM D6379 (see Note 4)

Note 1: Thermal Stability is a critical aviation fuel test and while competition among equipment manufacturers/suppliers is to be encouraged, aircraft safety must remain paramount. It is known that there are heater tubes being supplied by sources other than the original equipment manufacturer (OEM). Until the alternative manufacturers' tubes have been demonstrated to be equivalent to the OEM's test pieces, to the satisfaction of the AFC, they shall not be used. A list of manufacturers whose heater tubes have been found to be technically suitable is as follows: a) PAC – Alcor b) Falex

Note 2: Examination of the heater tube to determine the Visual Tube Rating using the Visual Tube Rator shall be carried out within 120 minutes of completion of the test.

Note 3: Specific Energy by one of the calculation methods listed at Annex C will be acceptable. Where a measurement of Specific Energy is deemed necessary, the method to be used shall be agreed between the Purchaser and Supplier.

Note 4: Round robin testing has demonstrated the correlation between total aromatics content measured by IP 156/ASTM D1319 and IP 436/ASTM D6379. Bias between the two methods necessitates different equivalence limits as shown. Testing laboratories are encouraged to measure and report total aromatics content by the two methods to assist verification of the correlation. In cases of dispute IP 156 will be the referee method. It is the intention of the Technical Authority to change the referee method to IP 436 at a later date.

D.4.3 Sasol Fully Synthetic Jet Fuel

D.4.3.1 Sasol synthetic kerosine, see clause **D.4.3.4**, is currently the only fully synthetic jet fuel which has been approved for use.

D.4.3.2 The aromatic content of Sasol fully synthetic fuel shall not be less than 8.0% nor greater than 25.0% by volume when using method IP 156, or less than 8.4% nor greater than 26.5% by volume when using method IP 436. The fuel shall exhibit a maximum wear scar diameter of 0.85 mm when tested by ASTM D5001. Analysis for these properties shall be made at the point of manufacture. These results shall be included on the batch certificate for the fuel.

D.4.3.3 The flash point shall be no greater than 50°C. The boiling point distribution shall have a minimum slope defined by T50-T10 ≥ 10°C and T90-T10 ≥ 40°C when measured by IP 123 / ASTM D 86.

D.4.3.4 Sasol fully synthetic kerosine is defined as that material blended from light distillate, heavy naphtha and iso-paraffinic kerosine streams manufactured at the Secunda plant as described in the SwRI reports number 08-04438 and 08-04438-2. The batch certificate for the fuel shall state that the fuel contains 100% synthetic components.

Annex E

Information on Saybolt Colour

E.1 Colour can be a useful indicator of fuel quality. Darkening of fuel, a change in fuel colour, or an unusual colour may be the result of product contamination or instability.

E.2 Changes in Saybolt Colour from the original Certificate of Quality for the batch would usually be cause for investigation as follows:-

Initial Saybolt Colour at Point of Manufacture	Significant Change
>25	>8
≤25, but ≥15	>5
<15	>3

E.3 Normally fuel colour ranges from water white (colourless) to a straw/pale yellow. Other fuel colours may be the result of crude oil characteristics or refining processes. If unusual colours are produced at the point of manufacture, this should be noted on the batch certificate to provide information to downstream users. Unusual colours such as pink, red, green or blue that do not significantly impact the Saybolt Colour number should also be investigated to determine the cause.

Annex F

Information on Sampling and Particulate Contamination

F.1 The visual appearance of the product is a good indication of contamination and remains a key requirement for fuel throughout the distribution system. However, interpretation of the Appearance requirement can lead to problems due to the subjective nature of the visual assessment. Therefore, a quantitative limit has been established for particulate contamination. A maximum particulate contamination of 1.0 mg/l, when tested to IP 423/ASTM D5452, shall apply at point of manufacture only.

F.2 Fuels containing visual particulate or with particulate levels greater than 1.0 mg/l will require additional handling procedures, such as extended settling and/or filtration.

F.3 Where fuel is being delivered into aircraft, the IATA Guidance Material for Aviation Turbine Fuels Part III – Cleanliness and Handling, shall be referred to for appropriate information on contamination limits.

F.4 It is the intent of the Technical Authority to extend particulate contamination limits throughout the distribution system at a later date.

F.5 It is well known that free water can precipitate from jet fuel on cooling, therefore it can be important to assess the visual appearance of the fuel at the ambient temperature of the fuel at the time of sampling. Samples transported within a location, e.g. refinery tanks to a refinery laboratory should be assessed for visual appearance without delay to avoid any temperature variations between the laboratory and the tank. Thermostatically controlled oil or water baths can be used to maintain samples at the tank temperature, where delay in assessing visual appearance is unavoidable. If the samples are cooled significantly during transport from the tank to the certifying laboratory, typically occurring during air freight, there is a significant potential for water precipitation. This would in principle, constitute a failure of the visual appearance requirement. In such cases, it is permissible for the tank to be released by a competent person based on the tank side visual appearance of representative samples fully meeting the requirements this specification. The tank release note should be annotated with the comment **"Tank side sample visual appearance clear, bright and visually free from solid matter and undissolved water. Appearance of undissolved water in laboratory samples attributed to cooling during transport."** This exception is only valid where samples sent to the laboratory fail solely on the appearance of free water.

Annex G

Product integrity management

G.1 Background

G1.1 Clause 4, Materials limits the materials that can be present in jet fuel. However, it is acknowledged that trace levels of incidental materials have always been present in jet fuels meeting this standard. Defining a zero level for these materials is not straightforward; particularly given that:

a) Advances in analytical techniques continue to reduce the threshold detection levels of chemical species.

b) There could be a wide range of incidental materials involved.

c) In most cases there are no data on their effects in aircraft systems to define a no-harm level.

G1.2 It is therefore not possible for this standard to require detailed chemical analysis of each batch of aviation fuel beyond the requirements listed in this standard. Instead, manufacturing and distribution locations shall ensure that they have adequate quality assurance and management of change procedures in place to maintain product integrity.

G.2 Manufacturing

G.2.1 Experience has shown that refinery processing additives, such as corrosion inhibitors, might be carried over in trace quantities into aviation fuel during refinery production. In some cases, this has resulted in operational problems in aircraft fuel systems. Moreover, these additives can cause problems at levels which may not be detected by the standard specification testing detailed in Table 1. Changes in additive composition/manufacturing source or refinery processing conditions shall be subject to a formal risk assessment to ensure maintenance of finished product quality.

G.3 Distribution

G.3.1 Upstream of airport storage, bulk jet fuel is typically handled in non-dedicated systems such as multiproduct pipelines and marine vessels. As a result, jet fuel will come into contact with non-jet fuel materials. Product integrity is assured by the application of documented QA procedures as set out in various industry standards such as EI HM 50, API 1543 and Joint Inspection Group (JIG) Standards. Any changes in the fuel handling systems should be subject to a formal risk assessment and management of change to ensure product quality is maintained.

G.3.2 Specific information on FAME is given in **G.4** below.

G.4 Information Statement on the Carryover of FAME (Fatty Acid Methyl Ester) In Trace Quantities During Transportation in non-dedicated systems

G.4.1 When biodiesel containing FAME (Fatty Acid Methyl Ester) was first introduced into Multi Product Pipelines (MPPs) co-transporting jet fuel in 1995, trials conducted using the best available analytical methods at that time indicated no detectable trail back of the FAME component into following jet fuel batches. Pipeline sequencing operations were not altered based on these data. However, with significant advances in experimental analytical techniques, some evidence of very low level FAME was detected in interface samples in 2006 prompting both refinement of the analytical methods and a further controlled pipeline trial in 2007. This controlled trial demonstrated that low level trail back of the FAME component from biodiesel into a following jet fuel batch can occur at detectable levels. In the absence of reliable data on historical trace level FAME carryover in MPPs, the initial fuel supply industry advice required revision of the sequencing of batches of biodiesel and jet fuel by employing a non-aviation buffer material between the products.

G.4.2 The widespread mandated introduction of biodiesel has significantly increased the potential for trace amounts of FAME in jet fuel. This has presented a major challenge to the operators of fuel supply and distribution systems.

G.4.3 Comprehensive background and advice for managing the risks of FAME and jet fuel in non-dedicated distribution systems are available in a number of JIG Bulletins, Bulletin Number 61 is the current document on FAME update. Bulletin Numbers 15, 16, 20, 21 and 26 are not current but available for background/reference material only. These bulletins may be downloaded from 'www.jigonline.com'.

G.4.4 The maximum permitted level of 50 mg/kg of FAME is introduced as a result of the recommendation of the EI study "Joint Industry Project: Seeking Original Equipment Manufacturer Approvals for 100 mg/kg Fatty Acid methyl Ester (FAME) in Aviation Turbine Fuel" and the ASTM D4054-09 extensive testing programme. The aviation petroleum industry is working towards an approval of 100 mg/kg FAME in jet fuel under the guidance of the engine and airframe OEMs.. FAME has been added to table 1, test 12, as an incidental material in order that producers/suppliers shall monitor FAME levels to provide a level of confidence before consideration can be given to 100 mg/kg FAME level.

Annex H

Electrical Conductivity

The Specification Authority is aware of situations where conductivity can decrease rapidly and the fuel can fail to respond to additional dosing of Stadis 450. An industry investigation revisited the early work on conductivity which demonstrated that the static hazard was mitigated once conductivity was >20 pS/m (see JIG PQ Committee Report). The current minimum 50 pS/m therefore represents a cautious doubling of the 20 pS/m minimum. On this basis, and as an emergency provision when low conductivity occurs at airports, the Technical Authority will accept conductivities down to a minimum of 25 pS/m. The fuel should be fully tested according to the specification and the Tank Release Note annotated with the explanation “Product released below 50 pS/m due to conductivity loss as per Annex H in Defence Standard 91-91”.

Annex I

Technically Equivalent ISO Methods for Table 1 and Table 2 Test Methods

Table 4: Technically Equivalent ISO Methods

IP / ASTM Test Methods	ISO Methods
IP 71 / ASTM D445	ISO 3104
IP 123	ISO 3405
IP 154 / ASTM D130	ISO 2160
IP160 / ASTM D1298	ISO 3675
IP 170	ISO 13736
IP 243	ISO 4260
IP 336	ISO 8754
IP 342 / ASTM D3227	ISO 3012
IP 365 / ASTM D4052	ISO 12185
IP 367	ISO 4259
IP 447	ISO 14596
IP 523	ISO 3679

The methods listed above were technically equivalent at the date of issue of the specification.

Annex J

Product Certification and Traceability

J.1 Product Certification Documentation

J1.1 Aviation fuel quality assurance is based on certification at point of manufacture and procedures to verify that the quality of the aviation fuel concerned remains within the specification limits and has not changed significantly during distribution and delivery to aircraft. Proper documentation is an essential part of this process. Valid product certificates are:

a) Refinery Certificate of Quality (RCQ)

b) Certificate of Analysis (CoA)

c) Release Certificate (RC)

d) Recertification Test (RT) (as defined in JIG Standards)

J.1.2 Refinery Certificate of Quality (RCQ)

J.1.2.1 The RCQ is produced at the point of manufacture and is the definitive original document describing the quality of a batch of aviation fuel. It contains the results of measurements, made by the product originator's laboratory, of all the properties listed in Table 1 as well as those additional testing requirements detailed in Annex D for fuels containing synthesised components where appropriate. It also provides information regarding the addition of additives, including both type and amount of any such additives as permitted at Annex A.

The minimum information requirements to be included on the fuel's Refinery Certificate of Quality are given below:

a) Specification name, issue and any amendment number;
b) Name and address of testing laboratory;
c) Batch number or unique identifier;
d) Quantity of fuel in the batch;
e) Properties tested including specification limit, test method and result of test;
f) Additives, including qualification reference and quantity added;
g) Name and position of authorised test certificate signatory or electronic signature;
h) Date of certification

The RCQ can be produced by independent laboratories working on behalf of refineries but the certificate shall state the manufacturing source refinery. In the case of fuels containing synthesised components, the point of manufacture (blending) of the finished fuel shall be stated, along with the original source location and certification references for the blend components used if the points of manufacture are different.

J.1.3 Certificate of Analysis (CoA)

J.1.3.1 A CoA is issued by independent inspectors and/or laboratories and contains the results of measurements made of all the Table 1 properties but does not necessarily contain or provide information regarding those identified as being required at point of manufacture or the type and amount of any additives or percentage of synthetic or hydro-processed components. It shall be dated and signed by an authorized signatory. Typically CoAs are produced downstream of refineries in intermediate supply terminals or intermediate storage locations but may also be produced at refineries where finished product is imported.

Note: A Certificate of Analysis shall not be treated as a Refinery Certificate of Quality.

J.1.4 Release Certificates (RC)

J.1.4.1 The Release Certificate supports any transfer of aviation fuel, confirming compliance with this Standard and contains as a minimum the following information:

a) Reference to Batch number or other unique identifier (e.g. Tank number , date and time)
b) Test report number (last full certification (RCQ, CoA or RT on this batch.)
c) Date and time of release
d) Certified batch density
e) Quantity of fuel (this may be added subsequently for pipeline transfers)
f) Fully complies with the visual appearance requirement of Table 1 (and conductivity if SDA is present)
g) Grade of fuel and specification
h) Signature of releasing authority.

The RC need not duplicate existing information but **shall** be part of the consignment notes.

J.1.5 Documentation Requirements for Supply to Airports

J.1.5.1 For supply into airports, product shall be supported by a valid test certificate, as defined within **J.1.1**, which is less than 180 days old. Where the RCQ, CoA or RT is more than 180 days old, a new COA shall be issued. Should there have been subsequent changes to the specification during this period; any additional testing required by the current specification at the time of re-testing shall be conducted.

Note: drum stocks are an exception to this requirement. Here the certification is valid for 12 months from filling date or last re-test date for the batch of drums.

J.2 Traceability

J.2.1 General

Traceability for aviation turbine fuel is defined as the ability to track distinct batches of fuel through the distribution system back to the original point of manufacture. This requires batch volume and quality documentation with information on additive concentration, hydro-processed content and synthetic components (if present, see Annex D) to be maintained.

J.2.2 Minimum documentation requirements

J.2.2.1 To avoid the need to view excessive documentation at each point in the supply chain, traceability shall be fulfilled by listing the component batches RCQs/COAs/RTs that make up the new batch on the new certification document. By listing the component batches, the certifying authority (for example, depot or laboratory manager or subcontracted laboratory manager) is confirming that it has the documents for each of the component batches in their possession and that each document meets the requirements stated in Defence Standard 91-91.

J.2.2.2 A new batch may be stated as composing of CoA ‘A’, CoA ‘B’ and RCQ ‘X’ and each of these documents shall be visible to the signatory of the new batch. Both CoA ‘A’ and CoA ‘B’ may themselves be composed of other batches and these components will only need to be visible to the respective signatories of CoA ‘A’ and CoA ‘B’. The RCQs/CoAs/RT of the component batches do not need to be attached to the resultant CoA.

The resultant product certification document shall state:

a) Table 1 test results (excluding the items required only at point of manufacture)

b) Individual batch numbers with jet grade and point of last certification. If necessary (for example, because of limitations on space or logistics), listing the individual batch on a cross-referenced document attached to the certification document is acceptable.
c) RCQs, CoAs, RT meet the requirements of DEF STAN 91-91 and certify that the batch certificates are in the possession of the supplier (or certifying laboratory).

J.2.3. Fungible distribution systems

It is acknowledged that in some fungible pipeline systems traceability and documentation of specific batches as described above cannot be maintained because batches are added and subtracted during transportation along the pipeline. In such cases, the following requirements shall apply.

a) All batches entering the fungible pipeline system shall have full documentation (RCQ, CoA or RT) showing compliance with this Defence Standard.
b) When a batch is extracted from the system, the new CoA shall state compliance with this Defence Standard and contain sufficient information to allow the pipeline operator to trace back to the original documentation of all batches that comprised the batch.

J.3 Distribution System Blending

J.3.1 General

When certifying a mixture of batches as Jet A-1 meeting Defence Standard 91-91 downstream of the original manufacturing site, the guiding principle is that the batches should have been originally manufactured as jet fuel and subsequently handled and stored as jet fuel. Specifically, this means that the following options are permitted:

a) **Where all of the batches were originally certified as meeting Defence Standard 91-91.** The resultant CoA shall follow the requirements set out in J.2. In particular, it shall list the main table test results, individual batch numbers and certify that the batch certificates (RCQs or CoAs) are in the possession of the supplier (or certifying laboratory) and that they meet the current requirements of Defence Standard 91-91.

b) **Non-Defence Standard 91-91 batches.** These are allowed provided they were originally certified as meeting one of the other major international jet fuel specifications (as listed in the IATA Guidance Material for Aviation Turbine Fuels). For these non-Defence Standard 91-91 batches, there is an added requirement that the original RCQs or CoAs shall state explicitly that the Defence Standard 91-91 Issue 7 Amd 2 restrictions on composition (Clause 4 Materials and Notes 8 and 19 of Table 1) and additives (Annex A) are satisfied.

c) **Alternative fuel components.** As defined in Annexes 1 and 2 of ASTM D7566. These components may be blended with Jet A-1 meeting Defence Standard 91-91 downstream of the original manufacturing site (see Annex D for details). The alternative fuel component shall have a Certificate of Quality certifying compliance with the relevant Annex of D7566 and the component shall have been handled as though it was a certified jet fuel (Clause 5 Quality Assurance).

J.3.2 Residual Tank Heel

Provided that the batch in the tank has been certified, the residual heel in the tank (less than 3% of tank volume) need not be supported by all the RCQ/COA/RT documentation referred to above.

Annex K

Normative References

Designation	Title
Def Stan 05-52 (Part 1)	Markings for the Identification of Fuels, Lubricants and Associated Products: Containers Holding 216.5 Litres or Less
Def Stan 68-150	Mixture of Fuel System Icing Inhibitor and Lubricity Improving Additive JSD: AL-48
Def Stan 68-251	Fuel Soluble Lubricity Improving Additives for Aviation Turbine Fuels JSD: AL-61
Def Stan 68-252	Fuel System Icing Inhibitor JSD: AL-41
QPL 68-251	Qualified Products List of Aircraft Materials to Def Stan 68-251
IP 12	Determination of Specific Energy
IP 16	Petroleum Products – Determination of the Freezing Point of Aviation Fuels
IP 30	Detection of Mercaptans, Hydrogen Sulfide, Elemental Sulfur and Peroxides – Doctor Test Method
IP 71	Petroleum Products – Transparent and Opaque Liquids – Determination of Kinematic Viscosity and Calculation of Dynamic Viscosity
IP 107	Determination of Sulfur – Lamp Combustion Method
IP 123	Petroleum Products – Determination of Distillation Characteristics at Atmospheric Pressure
IP 154	Petroleum Products – Corrosiveness to Copper – Copper Strip Test
IP 156	Determination of Hydrocarbon Types in Petroleum Products – Fluorescent Indicator Adsorption Method
IP 160	Crude Petroleum and Liquid Petroleum Products – Laboratory Determination of Density – Hydrometer Method
IP 170	Petroleum Products and other Liquids– Determination of Flash Point – Abel Closed Cup Method
IP 243	Petroleum Products and Hydrocarbons – Determination of Sulfur Content – Wickbold Combustion Method
IP 274	Petroleum Products – Aviation and Distillate Fuels - Determination of Electrical Conductivity
IP 323	Petroleum Products - Determination of Thermal Oxidation Stability of Gas Turbine Fuels
IP 336	Petroleum Products – Determination of Sulfur Content – Energy-Dispersive - X-Ray Fluorescence Method
IP 342	Petroleum Products – Determination of Thiol (Mercaptan) Sulfur in Light and Middle Distillate Fuels – Potentiometric Method

IP 354	Determination of the Acid Number of Aviation Turbine Fuels – Colour-Indicator Titration Method
IP 355	Estimation of Net Specific Energy of Aviation Turbine Fuels, using Hydrogen Content Data
IP 365	Crude Petroleum and Petroleum Products – Determination of Density – Oscillating U-tube Method
IP 367	Petroleum Products – Determination and Application of Precision Data in Relation to Methods of Test
IP 373	Determination of Sulfur Content of Light and Middle Distillates by Oxidative Microcoulometry
IP 406	Petroleum Products – Determination of Boiling Range Distribution by Gas Chromatography
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EN 14214 :2008+A1:2009	Automotive Fuels. Fatty Acid Methyl Esters (FAME) for Diesel Engines. Requirements and Test Methods
ISO 4406:1999	Hydraulic fluid power – Fluids – Method for coding the level of contamination by solid particles.
EI HM 50	Guidelines for the cleaning of tanks and lines for marine tank vessels carrying petroleum and refined products
API 1543	Documentation, Monitoring and Laboratory Testing of Aviation Fuel During Shipment from Refinery to Airport
SAE ARP 1797	Aircraft and Aircraft Engine Fuel Pump Low Lubricity Fluid Endurance Test
SwRI – 8531	Qualification of Sasol Semi-Synthetic JET A-1 as Commercial Jet Fuel
SwRI 08-04438	Evaluation of Sasol Synthetic Kerosene for Suitability as Jet Fuel
SwRI 08-04438-2	Evaluation of Sasol Synthetic Kerosene for Suitability as Jet Fuel. Phase II, Engine and Combustion Tests.
SwRI 08-04438.04	Evaluation of Heavy Naphtha Stream from SASOL Fully Synthetic Jet Fuel to Produce Semi-Synthetic Jet Fuel
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