Ministry of Defence

Defence Standard 91-091

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Turbine Fuel, Kerosene Type, Jet A-1; NATO Code: F-35; Joint Service Designation: AVTUR

Unless otherwise stated, the implementation date for this Standard is 3 months from date of publication

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REVISION NOTE

An annual up issue to ensure that the standard remains current and fit for use. Changes include insertion of a new co-processing clause; guidance on bio based carbon content; introduction of a table with the extended requirements of aviation turbine fuels containing co-hydroprocessed fatty acid esters and fatty acids. Additionally there have been grammatical and formatting changes throughout.

HISTORICAL RECORD

This standard supersedes the following:

Def Stan 91-091 Issue 10	dated 28 September 2018
Def Stan 91-091 Issue 9	dated 3 October 2016
Def Stan 91-091 Issue 8	dated 26 August 2016 (not implemented)
Def Stan 91-91 Issue 7	Amendment 3 dated 02 February 2015
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

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.

STANDARD CLAUSES

a) This standard has been published on behalf of the Ministry of Defence (MOD) by UK Defence Standardization (DStan).

b) This standard has been reached following broad consensus amongst 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.

c) Please address any enquiries regarding the use of this standard 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.

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

e) 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.

Section 2

Turbine Fuel, Kerosene Type, Jet A-1; NATO Code: F-35; Joint Service Designation: AVTUR

0 Introduction

Defence Standard 91-091 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 (DSFA).

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

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1 Scope

1.1 This Defence Standard specifies the requirements for one grade of kerosene type aviation turbine fuel intended for use in aircraft gas turbine engines. Fuel provided to this Standard 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

2.1 See Section 1 for warnings.

3 Normative References

3.1 The documents and publications shown in Section 3 are referred to in the text of this Standard. Publications are grouped and listed in alpha-numeric order.

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 Standard has therefore evolved primarily as a performance Standard rather than a compositional Standard. It is acknowledged that this largely relies on accumulated experience. Therefore this Standard 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 Standard, 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 B**.

4.1.2 Fuels containing synthetic components derived from non-petroleum sources are only permitted provided that they meet the requirements of **Annex B** (subject to **Annex B.1** Note), 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**. End users of fuel meeting this Standard should check with their OEMs to ensure that additives are approved for use in the equipment.

4.3 Additives shall be identified by the appropriate RDE/A/XXX or RDE/A/DSFA/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 F.3**.

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 Refinery Certificate of Quality (RCQ) (see **Annex D**) to certify that the batch of fuel complies with all 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 quality document. This requirement is not satisfied by averaging results from online analysis.

5.4 The minimum requirements for information to be shown on the fuel's RCQ at point of manufacture are given at **Annex D**. 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 D**) 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 C**).

5.6 Incidental materials have been identified where there is a risk of contamination. For these materials specific maximum limits are defined in **Table 4** of **Annex C**.

5.7 In addition to the test requirements, this Standard also contains requirements for how the fuel shall be handled and documented in the distribution chain. Further guidance on manufacture and distribution of jet fuel may be found in the industry Standard EI/JIG 1530.

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 E**.

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 E**. A list of ISO methods that were

technically equivalent to the IP test methods at the time of issue of this Standard can be found at **Annex G**.

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 05-052 (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)
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	Aromatics	% v/v	Max 25.0		IP 156 / ASTM D1319 (see Note 5)
or					
2.2.2	Total Aromatics	% v/v	Max 26.5		IP 436 / ASTM D6379 (see Note 6)
2.3	Sulfur, Total	% m/m	Max 0.30		IP336
2.4	Sulfur, Mercaptan	% m/m	Max 0.0030		IP 342 / ASTM D3227 (see Note 7)
or					
2.5	Doctor Test		Doctor Negative		IP 30
2.6	Refining Components, at point of manufacture				(see Note 8)
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 B		(See Note 9 and Annex B, Note in Annex B.1)

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Table 1 - Test Requirements (Continued)

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 (see Note 11)
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 12)
or				
5.2	Smoke Point and	mm	Min 18.0	IP 598 / ASTM D1322
	Naphthalenes	% v/v	Max 3.00	ASTM D1840
5.3	Specific Energy	MJ/kg	Min 42.80	(see Note 13)
6	Corrosion:			
6.1	Copper Strip	Class	Max 1	IP 154 / ASTM D130 (see Note 14)

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Table 1 - Test Requirements (Continued)

7	Thermal Stability, JFTOT			IP 323 /ASTM D3241 (See Note 15)
7.1	Test Temperature Tube Rating	°C	Min 260	
7.2	One of the following requirements shall be met:			(See Note 16) (See Note 17)
	(1) Annex B VTR		Less than 3. No Peacock (P) or Abnormal (A)	
	(2) Annex C ITR or Annex D ETR, average over area of 2.5 mm^2	nm	Max 85	
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 18)
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 19)
11	Lubricity:			
11.1	Wear Scar Diameter	mm	Max 0.85	ASTM D5001 (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 F.4**.

Note 2: Refer to the information on Particulate Contamination at **Annex F.1**.

Note 3: Both the number of particles and the number of particles as a scale number as defined by Table 1 of ISO 4406 shall be reported.

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

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Table 1 - Test Requirements (Continued)

Note 5: Typically, the ASTM international standard test method D1319 and Energy Institute test method IP156, "Standard Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption" is specified as the required test method for aromatics measurement. However, the proprietary dye necessary to conduct that test is no longer available. In addition, recently delivered supplies of the product gel containing the dye with lot numbers 3000000975 and above were produced with a substitute dye that is unfortunately not suitable and will not provide accurate measurements of aromatic concentration if utilised. Given the above, if ASTM D1319/IP156 is used for analysis of Aromatics, the lot number of the gel used shall be reported on the test certificate.

When the aromatic level is needed to be determined, Jet A-1 fuel will only meet the aviation fuel operating limitations of aircraft 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 ASTM D1319/IP156 with a dye from lot number 3000000974 or lower

or

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

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

Note 6: Inter laboratory studies have 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 7: 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 8: 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 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 9: The volume percentage of each synthetic blending component type shall be recorded along with its corresponding release specification and ASTM D7566 Annex number, product originator and originator's Certificate of Quality number.

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

Note 11: During downstream distribution if the freezing point of the fuel is very low and cannot be determined within the IP 16 lowest achievable temperature of minus 65 degrees C, if no crystals appear during cooling of the fuel and when the thermometer indicates a temperature of minus 65°C, the freezing point shall be recorded as below minus 65°C. This limit does not apply if the freezing point is measured by IP435/ASTM D5972, IP 529/ASTM D7153 or IP528/ASTM D7154.

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Table 1 - Test Requirements (Concluded)

Note 12: 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 automated method in IP 598 is the referee method**.**

Note 13: Specific Energy by one of the calculation methods listed in **Annex E** 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 14: The sample shall be tested in a pressure vessel at 100±1°C for 2 hours ± 5 minutes.

Note 15: 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 16: The annexes referred to in **Table 1** and this note correspond to those in IP 323. 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 IP 323 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 shall be by the method in IP 323.

IP 323 Annex B (VTR) 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.

Note 17: 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.

Note 18: 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 water separation property 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 water separation property testing can be found in the Joint Inspection Group's Bulletin Number 121 – Testing Water Separation Properties of Jet Fuel (Revised MSEP Protocol) at ‘www.jigonline.com’ under 'fuel quality'. Where SDA is added downstream of point of manufacture, it is acknowledged that MSEP results using ASTM D3948 may be less than 70.

Note 19: The conductivity limits are mandatory for product to meet this Standard. 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 91-091 except for electrical conductivity”. The Technical Authority is also aware of situations where conductivity can decrease rapidly and the fuel can fail to respond to additional dosing of SDA (see **Annex F.2** for more information).

Note 20: 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 (see **Note 9**).

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 Anti-oxidant, 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 Anti-oxidants

A.2.1 Anti-oxidants can be used to prevent peroxidation and gum formation during storage.

A.2.2 The use of anti-oxidants or mixtures of anti-oxidants is optional for fuels manufactured from petroleum sources (see **4.1.1**). Permitted anti-oxidants are detailed in **A.2.4** at concentrations specified in **A.2.5** may be added to prevent peroxidation and gum formation.

A.2.3 Refer to **Annex B.2** of this Standard for specific anti-oxidants requirements for fuels produced to ASTM D7566.

A.2.4 The following anti-oxidant 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 Synthesised fuels: refer to the appropriate Annex in ASTM D7566.

A.2.5.2 Petroleum fuels: the total concentration of active material(s) in the final batch shall not exceed 24.0 mg/l.

A.2.6 The concentration of anti-oxidant added to the fuel shall be reported on the RCQ in two ways: firstly expressed as a proportion of the total hydro-processed and synthetic material, in order to ensure the minimum effective amount is used; and secondly as a total proportion of the final blended fuel batch of all components, in order to ensure that the maximum overall concentration has not been exceeded.

A.2.6.1 If anti-oxidant is added post manufacture, report the total active material concentration in the final batched fuel on the Certificate of Analysis and the Release Certificate.

A.3 Metal Deactivator Additive (MDA)

A.3.1 An MDA, of a type detailed in **A.3.3** and at a concentration detailed in **A.3.4**, may be added to fuel under the following conditions:

a) At Point of Manufacture

   i) No more than 5 % of the jet fuel batches produced in a 12 month period may be treated with MDA to meet Table 1 thermal oxidative stability requirements (260 °C test temperature).
   ii) The batch of fuel shall pass Table 1 thermal oxidative stability requirements at a test temperature of 245 °C prior to any MDA addition.
   iii) The fuel batch after MDA addition (2.0 mg/L maximum MDA) shall pass Table 1 thermal oxidative stability requirements at a test temperature of 275 °C.
   iv) The thermal oxidative stability test result at 245 °C prior to MDA addition, the original test result at 260 °C and the test result at 275 °C (post MDA addition) and the concentration of MDA added shall be reported on the Refinery Certificate of Quality.

b) During Distribution

   i) MDA may be added to jet fuel in the distribution system to recover thermal oxidative stability performance lost during distribution (after refinery release). The Certificate of Analysis shall show the initial thermal oxidative stability test result, the result after the addition of the MDA and the concentration of MDA added.

A.3.2 Initial addition of more than 2.0 mg/L MDA to jet fuel that meets Table 1 thermal oxidative stability requirements (260 °C test temperature) prior to MDA addition is permitted when fuel will be transported in supply chains where copper contamination can occur: the maximum cumulative addition table still applies.

A.3.3 The following material is qualified:

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

A.3.4 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 to meet the conductivity requirements 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 materials are qualified:

Product	Manufacturer	Qualification Reference
Stadis® 450	Innospec LLC	RDE/A/621
AvGuard SDA	Afton Chemical Ltd	RDE/A/DSFA/001

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 It is permitted to add additional SDA downstream of the point of manufacture or first doping as referenced in **A.4.3.1**. In such circumstances the maximum total SDA concentration, including initial doping shall not exceed 5.0 mg/l.

A.4.3.3 A suitable method for the determination of SDA concentration 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 F**.

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	9	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 Def Stan 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 Def Stan 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)	Praxair	RDE/A/640

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

Annex B

Additional Requirements Applicable to Fuels from Non-Conventional Sources

B.1 Background

B.1.1 This Standard was originally developed on the basis that the fuel would be derived solely from petroleum sources and processed using conventional techniques. This changed in 1999 when, after exhaustive testing and peer review, jet fuel blending components manufactured from coal by SASOL were allowed in this Standard. Since then, interest in widening the range of both processes and feedstocks has increased dramatically, driven mainly by the aviation community's desire to produce renewable jet fuels. The process for approval is now well established and is set out in ASTM D4054.

B.1.2 Although, this Standard pioneered the introduction of unconventional feedstocks and processes, the industry has settled on ASTM Committee D02, Subcommittee J as the primary location for this synthetic fuels activity. Typically, approval of new fuel components are progressed via ASTM Task Forces and the approved components are defined and approved as Annexes in ASTM D7566. D7566 was a new fuel Standard created specifically for the purpose of listing and controlling these new components and the process has been shown to work well.

B.1.3 To avoid duplication and to assure harmonisation between Specifications/Standards for the new synthetic components, this Standard refers to ASTM D7566 and its associated Annexes. The original SASOL approvals granted by this Standard are set out in **B.3**. For fuels derived from co-hydroprocessed fatty acid esters and fatty acids see **B.4**. Importantly, fuel manufactured, certified and released to all the requirements of ASTM D7566 also meets all the requirements of ASTM D1655 and can be designated, handled and supplied to aircraft as ASTM D1655 Jet A or Jet A-1. This allowance is on the basis that during evaluation synthetic blends as defined in ASTM D7566 have been demonstrated to be technically equivalent to ASTM D1655 fuel.

Note: It is the intention of the Authority to be in a position to be able to use fuel with synthetic blending components in the future. As the Authority progresses towards achieving a complete OEM approval it has been decided to include fuel blending components in accordance with ASTM D1655 and ASTM D7566 Annexes for the benefit of other users, global and commercial, within this issue of the Standard. However, it should be noted that UK MoD are not in a position to accept such fuels until complete OEM approval has been obtained. The provision of such fuels to the UK MoD are currently restricted by contract clauses.

B.2 Generic Synthetic Kerosene Approvals

B.2.1 Individual synthetic blend components listed in ASTM D7566 are permitted to be present in jet fuel meeting this Standard, subject to the following conditions:

a) The synthetic blend component shall be limited to the maximum concentration permitted for that specific blend component as defined by ASTM D7566.

b) The synthetic blend component shall be subject to any and all additional testing requirement required by the Annex of ASTM D7566 pertaining to the proposed blend component.

c) The non-synthetic blend component shall either meet the requirements of Def Stan 91-091 or fuels as defined as acceptable in this Annex.

d) The finished blended fuel shall pass all Table 1 Part 2 properties of ASTM D7566 as well as those contained in **Table 1** of Def Stan 91-091. Duplicate testing is not necessary; the same data may be used for both D7566 and Def Stan 91-091 compliance.

e) The synthetic blend component shall be subject to the same additive requirements and limitations as defined by ASTM D7566, including antioxidants.

B.2.2 Any fuel containing a synthetic component meeting the above requirements shall be deemed to meet the requirements of Def Stan 91-091 and shall be accorded the same limitations and privileges of any fuel meeting this Standard. Specifically, the fuel can be designated as Def Stan 91-091 and handled and supplied to aircraft as such.

B.3 Specific Manufacturer Approvals

B.3.1 Individually approved synthetic and semi-synthetic fuel blends as identified in **B.3.2**, **B.3.3** and **B.4** must be manufactured according to declared procedures defined during the manufacture of prototype batches that 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 to be carried out before approval is given.

B.3.2 Sasol semi-synthetic Jet fuel blends

B.3.2.1 Sasol semi-synthetic Aviation Turbine Fuel, containing synthetic Iso-Paraffinic Kerosene (IPK), see Clause **B.3.2.3** by itself or as combined with SASOL heavy naphtha #1 (HN1), see Clause **B.3.2.4** blended with kerosene from conventional sources, see Clause **B.3.2.5** 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.

B.3.2.2 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.

B.3.2.3 Sasol synthetic Iso-Paraffinic Kerosene 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 that have been polymerized and subsequently hydrogenated. The use of synthetic aromatic compounds is not permitted except as defined in Clause **B.3.2.1**, **B.3.2.4**, and **B.3.2.5**. If used in combination with the Sasol HN1 (see Clause **B.3.2.4**), the final synthetic blend shall contain at least 25% IPK by volume.

B.3.2.4 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 2**.

B.3.2.5 The blending kerosene from conventional sources shall contain no more than 50% severely hydroprocessed material as defined in Note 8 of **Table 1**.

Table 2: 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	mmHg	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	IP156/ASTM D1319
or				
4.2	Total Aromatics	% v/v	Max 7.4	IP436/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 Rater shall be carried out within 120 minutes of completion of the test.

Note 3: Specific Energy by one of the calculation methods listed in **Annex G** 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: Inter laboratory studies have 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.

B.3.3 Sasol Fully Synthetic Jet Fuel

B.3.3.1 Sasol synthetic kerosene, see Clause **B.3.3.4**, is currently the only fully synthetic jet fuel that has been approved for use.

B.3.3.2 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.

B.3.3.3 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 D86.

B.3.3.4 Sasol fully synthetic kerosene is defined as that material blended from light distillate, heavy naphtha and iso-paraffinic kerosene 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.

B.4 Co-Processing

B.4.1 Co-processing of mono-, di-, and triglycerides, free fatty acids and fatty acid esters producing co-hydroprocessed hydrocarbon synthetic kerosene is recognized as being acceptable for jet fuel manufacture as controlled by this Standard. Other feedstocks are excluded from jet fuel co-processing. The co-processing refinery units where process streams are used for jet production shall not exceed 5 percent by volume of mono-, di-, and triglycerides, free fatty acids and fatty acid esters in feedstock volume with the balance (>= 95% by volume) being conventional sources as described in Clause **4.1.1**.

B.4.2 Co-processing of mono-, di-, and triglycerides, free fatty acids and fatty acid esters shall include hydrocracking or hydrotreating and fractionation. Processing may also include other conventional refinery processes. The final product is limited to 5 volume % of co-hydroprocessed synthesized kerosene in any jet batch. Refer to **Annex F.5** for a discussion of bio based carbon content and identification of the applicable test method.

B.4.3 For semi-synthetic kerosene manufactured by co-hydroprocessed fatty acid esters and fatty acids, the following additional requirements and **Table 3** limits apply.

B.4.3.1 An initial Management of Change (MOC) study shall be undertaken and documented for sites manufacturing semi-synthetic kerosene by coprocessing. Changes that impact the conversion process shall require an updated MOC. Specific changes that may have to be managed during initial and subsequent on-going commercial operation include, but are not limited to, feedstock (e.g. selection, composition, pre-treatment), and hydroprocessing severity (e.g. hydrogen partial pressure, residence time, temperature, catalyst, conversion capability). Each MOC shall ensure that the cumulative processing severity is evaluated to be sufficient to convert mono-, di-, and triglycerides, free fatty acids and fatty acid esters to hydrocarbon when added to any jet batch. Refer to the research report (see **B.4.3.4**) for additional considerations for MOC.

B.4.3.2 The extent of conversion shall be assessed via IP 583/ASTM D7797. In addition to the **Table 3** limit on the finished product, the preferred methodology for assessing conversion is

comparison of D7797/IP 583 results between process unit rundown jet line samples prior to and during co-processing.

B.4.3.3 The Refinery Certificate of Quality (RCQ) shall include wording to reflect that the batch may contain up to 5 % by volume co-hydroprocessed synthesized kerosene. There is no requirement to list the % volume as part of the reporting requirements in **Table 1** as a synthetic blend component has not been added to the fuel and the percentage introduced by coprocessing is not required to be determined on a batch basis.

B.4.3.4 An ASTM task force studied the impact of co-hydroprocessing fatty acid esters and fatty acids at up to 5% volume with crude oil derived middle distillates following ASTM D7566 Annex A2 approval. Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1886.

Table 3: Extended Requirements of Aviation Turbine Fuels Containing Co-hydroprocessed Fatty Acid Esters and Fatty Acids [1, 2]

Test	Property	Units	Limits	Method
1	Thermal Stability, JFTOT			IP 323 /ASTM D3241
1.1	Test Temperature for 2.5hr	°C	Min 280	(see Note 3)
1.2	Tube Rating: One of the following requirements shall be met:			(see Note 4)
	(1) Annex A1 VTR, VTR color code		Less than 3. No Peacock (P) or Abnormal (A)	
	(2) Annex A2 ITR or Annex A3 ETR, nm average over area of 2.5 mm^2	nm	Max 85	
1.3	Pressure Differential	mmHg	Max 25	
2	Fluidity:			
2.1	Freezing Point	°C	Max minus 47.0	IP 435 / ASTM D5972 (see Note 5) IP 529 / ASTM D7153 IP 528 / ASTM D7154
2.2	Viscosity at minus 40 °C (see Note 6)	mm^2/s	Max 12.0	IP 71 / ASTM D445, Section 1 (see Note 7), ASTM D7945
3	Unconverted fatty acid esters and fatty acids	mg/kg	Max 15	IP583 / ASTM D7797 (see Note 8)

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Table 3: Extended Requirements of Aviation Turbine Fuels Containing Co-hydroprocessed Fatty Acid Esters and Fatty Acids [1, 2] (Concluded)

Note 1: Applies at the point of manufacture only.

Note 2: Applies for the finished batch of jet fuel as opposed to the product of the refinery hydroprocessing unit which is used to blend the finished batch of jet fuel.

Note 3: An IP323/ ASTM D3241 test temperature of 280°C has been selected to help ensure that reactive compounds introduced through co-hydroprocessed of fatty acid esters and fatty acids are limited. Research is ongoing on the actual requirement for a more restrictive thermal stability limit. Metal Deactivator (MDA), as described in **Annex A**, may not be used to meet this requirement.

Note 4: 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.

Note 5: IP 435/D5972 is the referee method.

Note 6: The kinematic viscosity specification of 12.0 mm^2/s at -40°C maximum mitigates the potential risk of increased viscosity due to n-paraffin enrichment. Compared to conventional hydrocarbons, a co-hydroprocessed esters and fatty acids stream may contain a higher concentration of n-paraffins. Research is ongoing on how n-paraffin enrichment from co-hydroprocessed esters and fatty acids impact low temperature viscosity. The results of that research will be used to confirm the necessity of and possibly adjust this requirement.

Note 7: IP 71/ ASTM D445 Section 1 allows measuring the viscosity at –40 °C, however the precision values were determined down to –20 °C. A revision to Test Method IP 71 and ASTM D445 to specify measurement precision at –40 °C is in process.

Note 8: The ability for IP 583/D7797 to identify carbonyl containing compounds in addition to FAMEs is acknowledged. The reported value may be corrected for a local sample-specific bias related to trace carbonyl species inherent in aviation turbine fuel derived from conventional sources (as per **Clause 4**). Corrected values shall be identified as such.

B.5 Handling and documentation of synthetic kerosene components and blends

B.5.1 In addition to the requirements set out in **B.2** and **B.3**, this Standard requires that 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. Note that the lubricity test (BOCLE) is mandatory at the point of manufacture. Documentation shall follow the certified batch clearly stating the concentration of synthetic component. This is to ensure that the maximum limit on synthetic components is not exceeded by any blending downstream of the production of the semi-synthetic batch.

B.5.2 From the point of manufacture to the point of blending to meet this Standard, all synthetic blend components shall be handled and transported in the same manner as certified jet fuel in order to maintain product integrity. In particular the restrictions of Clause **5.5** and **Annexes C** and **F** must be observed.

B.5.3 The location at which a semi-synthetic Aviation Turbine Fuel meeting this Standard is blended shall be upstream of the airport fuel storage depot except in development phase where the volumes involved are small (no more than the capacity of one or two fuellers for example). In this case the blending could be done at the airport depot in a dedicated tank or dedicated fueller. In this

case the synthetic component shall be segregated to ensure that this product shall not be provided to an aircraft. After blending the fuel shall be quarantined until a Certificate of Analysis is provided according to all the requirements of **Table 1** of this Standard.

B.5.4 The point of blending shall be considered as the point of manufacture of the jet fuel for the purposes of this Standard. Therefore, the appropriate requirements of this Standard apply at that point: in particular, but not limited to, those of **Clause 5** and **Annex D** and include the requirement for the production of a Certificate of Analysis as defined in **Annex D**. 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 blending limits set out in the Annexes to ASTM D7566. This documentation is important to prevent blending with jet fuels that already contain synthetic components.

Annex C

Product Integrity Management

C.1 Background

C.1.1 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.

C.1.2 It is therefore not possible for this Standard to list maximum levels and test methods for all the possible materials that could be unintentionally present in jet fuel. In this Standard, the potential risk posed by incidental materials is managed in two ways. Firstly, there is a requirement that manufacturing and distribution locations shall ensure that they have adequate quality assurance and management of change procedures in place to maintain product integrity. Secondly, for identified materials where the requirements of this section cannot be assured, specific maximum limits are defined. Currently two such incidental materials are included in this category and their maximum limits are listed below in **Table 4**.

Table 4: Incidental Materials

Material	Maximum permitted level	Detection Level	Test methods
Fatty acid methyl ester (FAME)[1,2,3,4]	50 mg/kg		D7797/IP583, IP585[3], IP590, IP599
Pipeline Drag Reducing Additive (DRA)[1]	Nil	72 µg/L[5]	D7872

Note 1: 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.

Note 2: For the purposes of meeting this requirement, FAME is defined as material meeting the limits of EN14214 or ASTM D6751. Fatty acid methyl esters that fail to meet biodiesel standards are not permitted in jet fuel.

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Table 4: Incidental Materials (Concluded)

Note 3: On an emergency basis, up to 100 mg/kg FAME is permitted in jet fuel when authorised 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 refuelling operations. All such instances should be raised through the procurement Authority, Duty Holder or Aircraft Operator. For commercial operators refer to SAIB NE-09-25R2 dated May 19, 2016, which provides corrective actions and procedures to be followed in the event of FAME contamination

Note 4: Test method IP585 shall be the referee method.

Note 5: DRA is not an approved additive for jet fuel at any concentration. Dilution of fuels with known levels of DRA is not permitted, even to levels below the level stated in table 4. Where the level of DRA is otherwise unknown a result at or below the level in table 4 would support an assumption of nil addition.

C.2 Manufacturing

C.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 specified 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.

C.3 Distribution

C.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/JIG 1530, EI HM-50, API 1543, API 1595 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.

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

C.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.

C.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.

C.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 75 is the current document on FAME update. Bulletin Numbers 15, 16, 20, 21 and 26 and 61 are not current but available for background/reference material only. These bulletins may be downloaded from 'www.jigonline.com'.

C.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.

Annex D

Product Certification and Traceability

D.1 Product Certification Documentation

D.1.1 Key Documentation

D.1.1.1 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 defined limits of the Standard 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 EI JIG 1530. See **D.1.5**)

D.1.2 Refinery Certificate of Quality (RCQ)

D.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 B** 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**.

D.1.2.2 The minimum information requirements to be included on the fuel's Refinery Certificate of Quality are given below:

a) Standard/ 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

D.1.2.3 An independent laboratory working on behalf of a refinery can produce the RCQ, but the certificate shall state the name and address of 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.

D.1.3 Certificate of Analysis (CoA)

D.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. If additives have been added the quantity added and qualification reference shall be recorded. It shall be dated and signed by an authorised 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.

D.1.4 Release Certificates (RC)

D.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 Standard/ Specification
h) Additives, including qualification reference and quantity added during transfer;
i) Signature of releasing authority.

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

D.1.5 Recertification Test Certificates (RT Certificate)

D.1.5.1 The recertification test is a powerful tool for detecting some contaminants, such as diesel or gasoline, during distribution. Where there is a risk of trace contamination refer to **Annex C**. The recertification test is normally used when aviation fuels are transferred in multiproduct systems such as pipelines or ocean-going tankers.

D.1.5.2 Recertification testing comprises a reduced set of tests (compared with the full set in the RCQ or CoA) that are particularly sensitive to contamination. The testing not only checks that the parameters meet the limits defined by the Standard/ Specification but, crucially, they have not changed significantly from their initial values. The RT Certificate shall be dated and signed by an authorised representative of the laboratory carrying out the testing.

D.1.5.3 The comparison with the original values is a powerful means of detecting contamination but it becomes inappropriate when there are more than 3 new batches mixed together on top of an existing tank heel. In such cases, EI/JIG 1530 states that a full Standard/ Specification test shall be conducted to produce a CoA.

D.1.5.4 Note that the JIG Standards do not require comparison of the initial boiling point value as this parameter has an inherent variability that can exceed the 8°C limit. Flash point is a more effective indicator of contamination by low boiling point materials.

D.1.6 Documentation Requirements for Supply to Airports

D.1.6.1 For supply into airports, product shall be supported by a valid test certificate as defined in **D.1.1**. The certificate shall be 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 this Standard during this period; any additional testing required by the current Standard 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.

D.2 Traceability

D.2.1 General

D.2.1.1 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 using the correct documentation. This requires batch volume and quality documentation with information on additive concentration, hydro- processed content and synthetic components (if present, see **Annex B**) to be maintained.

D.2.2 Minimum documentation requirements

D.2.2.1 To avoid the need to view excessive documentation at each point in the supply chain, traceability shall be fulfilled by listing unique identifier of the appropriate quality document (RCQ, CoA or RT as defined in **D.1**) for each of the component batches that make up the new batch on the new certification document together with their respective volumes. 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 Def Stan 91-091.

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

D.2.2.3 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, volume 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. See **D.2.3** for situations where volume information is not available.

c) RCQs, CoAs, RT meet the requirements of Def Stan 91-091 and certify that the batch certificates are in the possession of the supplier (or certifying laboratory).

D.2.3 Fungible distribution systems

D.2.3.1 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 make up the new batch.

D.3 Distribution System Blending

D.3.1 General

D.3.1.1 When certifying a mixture of batches as Jet A-1 meeting Def Stan 91-091 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 Def Stan 91-091. The resultant CoA shall follow the requirements set out in **D.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 Def Stan 91-091.

b) Non-Def Stan 91-091 batches. These are allowed provided they were originally certified as meeting one of the other major international jet fuel Standards/ Specifications (as listed in the IATA Guidance Material for Aviation Turbine Fuels). For these non-Def Stan 91-091 batches, there is an added requirement that the original RCQs or CoAs shall state explicitly that the Def Stan 91-091 latest issue restrictions on composition (**Clause 4** Materials and **Notes 9** and **20** of **Table 1**) and additives (**Annex A**) are satisfied.

c) Synthetic fuel components. As defined in Annexes A1, A2, A3, A4 and A5 of ASTM D7566. These components may be blended with Jet A-1 meeting Def Stan 91-091 downstream of the original manufacturing site (see **Annex B** of this Standard for details). The synthetic 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).

D.3.2 Residual Tank Heel

D.3.2.1 Operational practise may result in line clear and residual tank volumes of kerosene distillates that may not be certified as Jet fuel to this Standard. This is permitted with the following controls:

1) All components of the new batch, including residual volumes, meet the compositional requirements of this Standard as defined by **Clause 4**.

2) The total line clear/residual volume shall compose less than 3% of the new batch and need not be supported by all the RCQ/CoA/RT documentation referred to above.

3) The new batch shall meet all other requirements of this Standard.

Annex E

Alternative Test Methods for use with Table 1 Test Requirements

Table 5: 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 ASTM D7345 (NOTE 2)
3.2	Flash Point	IP 523 ASTM D56 (NOTE 3) 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
4.2	Viscosity	ASTM D7042 (NOTE 4) ASTM D7945
5.3	Specific Energy	IP 12 ASTM D3338 ASTM D4809
8.1	Existent Gum	ASTM D381

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: Results from Test Method ASTM D7345 shall be corrected for relative bias as described in Test Method ASTM D7345.

Note 3: Subject to a minimum result of 40°C being obtained using ASTM D56 (Tag method) the result(s) may be accepted.

Note 4: Test Method ASTM D7042 results shall be converted to bias-corrected kinematic viscosity results by the application of the correction described in Test Method ASTM D7042 for jet fuel at -20°C as described in the precision and bias section.

Annex F

Additional Information on Fuel Properties

F.1 Information on Sampling and Particulate Contamination

F.1.1 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.1.2 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.1.3 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.1.4 It is the intent of the Technical Authority to extend particulate contamination limits throughout the distribution system at a later date.

F.1.5 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 airfreight, 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 Standard. 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.

F.2 Electrical Conductivity

F.2.1 The Technical Authority is aware of situations where conductivity can decrease rapidly and the fuel can fail to respond to additional dosing of SDA. 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: Report on the Investigation into the Sydney Low Conductivity Incident, August 2005). 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 Standard and the Tank Release Note

annotated with the explanation “Product released below 50 pS/m due to conductivity loss as per **Annex F.2** in Defence Standard 91-091”.

F.3 Information Statement on Aviation Turbine Fuel Lubricity

F.3.1 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.

F.3.2 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.

F.3.3 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 that 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.

F.3.4 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.

F.4 Information on Saybolt Colour

F.4.1 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.

F.4.2 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

F.4.3 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.

F.5 **Bio based Carbon Content** (for guidance only)

F.5.1 This Standard does not include a renewable content rating because this rating is a regulatory matter that involves other factors beyond the technical requirements of this Standard. The following is provided solely for information and may be of interest to parties attempting to determine the renewable content rating of a fuel. Radiocarbon (^{14}C) is an isotope of carbon which can be used for the determination of renewable content. Atmospheric carbon dioxide contains very low concentrations of ^{14}C compared to normal ^{12}C and this ratio if reflected in the carbon content of living biological matter. When animal or plants die, they cease to exchange carbon with the atmosphere and their ^{14}C content starts to decline due to radioactive decay. The half-life of ^{14}C is about 5000 years and by measuring the ^{14}C to ^{12}C ratio, the age of biological material can be calculated. After about 50,000 years the ^{14}C content is effectively zero. Fossil fuels have zero ^{14}C content and can therefore be differentiated from fuels manufactured from recently created biological material. Blends can also be quantified based on their ^{14}C concentration. The method for using radiocarbon to determine the bio-based content of a hydrocarbon is ASTM D6866.

Annex G

Technically Equivalent ISO Methods for Table 1 and Table 5 Test Methods

Table 6: 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 (now BS EN 24260)
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 this Standard.

Section 3

Normative References

1 The publications shown below are referred to in the text of this standard. Publications are grouped and listed in alpha-numeric order.

Note: Def Stan's can be downloaded free of charge from the DStan web site by visiting **<http://dstan.uwh.diif.r.mil.uk/>** for those with RLI access or **<https://www.dstan.mod.uk>** for all other users. All referenced standards were correct at the time of publication of this standard (see 2, 3 & 4 below for further guidance), if you are having difficulty obtaining any referenced standard please contact the DStan Helpdesk in the first instance.

Def Stans

Number	Title
05-052, Pt 01, Iss 03	Markings for the Identification of Fuels, Lubricants and Associated Products - Containers Holding 216.5 Litres or Less
68-150, Iss 02	Mixture of Fuel System Icing Inhibitor and Lubricity Improving Additive Joint Service Designation: AL-48
68-251, Iss 03	Fuel Soluble Lubricity Improving Additives for Aviation Turbine Fuels NATO Code: S-1747 Joint Service Designation: AL-61
68-252, Iss 03	Fuel System Icing Inhibitor NATO Code: S-1745 Joint service Designation: AL-41

STANAGs

Number	Title

Allied Publications

Number	Title

Other References

Standard Type	Standard Name
Other	API 1543 - Documentation, Monitoring and Laboratory Testing of Aviation Fuel During Shipment from Refinery to Airport
Other	API 1595 - Design, Construction, Operation, Maintenance, and Inspection of Aviation Pre-Airfield Storage Terminals

Other	ASTM D56 - Standard Test Method for Flash Point by Tag Closed Cup Tester
Other	ASTM D86 - Standard Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure
Other	ASTM D130 - Standard Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test
Other	ASTM D156 - Standard Test Method for Saybolt Color of Petroleum Products (Saybolt Chromometer Method)
Other	ASTM D381 - Standard Test Method for Gum Content in Fuels by Jet Evaporation
Other	ASTM D445 - Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and the Calculation of Dynamic Viscosity)
Other	ASTM D1266 - Standard Test Method for Sulfur in Petroleum Products (Lamp Method)
Other	ASTM D1298 - Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
Other	ASTM D1319 - Standard Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption
Other	ASTM D1322 - Standard Test Method for Smoke Point of Kerosene and Aviation Turbine Fuel
Other	ASTM D1655 - Standard Specification for Aviation Turbine Fuels
Other	ASTM D1840 - Standard Test Method for Naphthalene Hydrocarbons in Aviation Turbine Fuels by Ultraviolet Spectrophotometry
Other	ASTM D2386 - Standard Test Method for Freezing Point of Aviation Fuels
Other	ASTM D2622 - Standard Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-Ray Fluorescence Spectrophotometry
Other	ASTM D2624 - Standard Test Methods for Electrical Conductivity of Aviation and Distillate Fuels
Other	ASTM D2887 - Standard Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography
Other	ASTM D3227 - Standard Test Method for (Thiol Mercaptan) Sulfur in Gasoline, Kerosene, Aviation Turbine, and Distillate Fuels (Potentiometric Method)
Other	ASTM D3241 - Standard Test Method for Thermal Oxidation Stability of Aviation Turbine Fuels (JFTOT Procedure)
Other	ASTM D3242 - Standard Test Method for Acidity in Aviation Turbine Fuel

Other	ASTM D3338 - Standard Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
Other	ASTM D3828 - Standard Test Methods for Flash Point by Small Scale Closed Cup Tester
Other	ASTM D3948 - Standard Test Method for Determining Water Separation Characteristics of Aviation Turbine Fuels by Portable Separometer
Other	ASTM D4052 - Standard Test Method for Density, Relative Density and API Gravity of Liquids by Digital Density Meter
Other	ASTM D4054 - Standard Practice for Evaluation of New Aviation Turbine Fuels and Fuel Additives
Other	ASTM D4057 - Standard Practice for Manual Sampling of Petroleum and Petroleum Products
Other	ASTM D4176 - Standard Test Method for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures)
Other	ASTM D4294 - Standard Test Method for Sulfur in Petroleum and Petroleum Products by Energy-Dispersive X- Ray Fluorescence Spectrometry
Other	ASTM D4809 - Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)
Other	ASTM D4952 - Standard Test Method for Qualitative Analysis for Active Sulfur Species in Fuels and Solvents (Doctor Test)
Other	ASTM D5001 - Standard Test Method for Measurement of Lubricity of Aviation Turbine Fuels by the Ball-on-Cylinder Lubricity Evaluator (BOCLE)
Other	ASTM D5006 - Standard Test Method for Measurement of Fuel System Icing Inhibitors (Ether Type) in Aviation Fuels
Other	ASTM D5452 - Standard Test Method for Particulate Contamination in Aviation Fuels by Laboratory Filtration
Other	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
Other	ASTM D5972 - Standard Test Method for Freezing Point of Aviation Fuels (Automatic Phase Transition Method)
Other	ASTM D6045 - Standard Test Method for Color of Petroleum Products by the Automatic Tristimulus Method
Other	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

Other	ASTM D6751 - Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels
Other	ASTM D6866 - Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis
Other	ASTM D7042 - Standard Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic Viscosity)
Other	ASTM D7153 - Standard Test Method for Freezing Point of Aviation Fuels (Automatic Laser Method)
Other	ASTM D7154 - Standard Test Method for Freezing Point of Aviation Fuels (Automatic Fiber Optical Method)
Other	ASTM D7345 - Standard Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure (Micro Distillation Method)
Other	ASTM D7524 - Standard Test Method for Determination of Static Dissipater Additives (SDA) in Aviation Turbine Fuel and Middle Distillate Fuels—High Performance Liquid Chromatograph (HPLC) Method
Other	ASTM D7566 - Standard Specification for Aviation Turbine Fuel Containing Synthesised Hydrocarbons
Other	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
Other	ASTM D7872 - Standard Test Method for Determining the Concentration of Pipeline Drag Reducer Additive in Aviation Turbine Fuels
Other	ASTM D7945 - Determination of Dynamic Viscosity and Derived Kinematic Viscosity of Liquids by Constant Pressure Viscometer
Other	BS EN 14214 - Liquid petroleum products. Fatty acid methyl esters (FAME) for use in diesel engines and heating applications. Requirements and test methods.
Other	BS EN 24260 - Methods of test for petroleum and its products. Petroleum products and hydrocarbons. Determination of sulfur content. Wickbold combustion method
Other	EI HM 50 - Guidelines for the cleaning of tanks and lines for marine tank vessels carrying petroleum and refined products
Other	EI/JIG 1530 - Quality assurance requirements for the manufacture, storage and distribution of aviation fuels to airports
Other	IP 12 - Determination of Specific Energy
Other	IP 16 - Petroleum Products – Determination of the Freezing Point of Aviation Fuels

Other	IP 30 - Detection of Mercaptans, Hydrogen Sulfide, Elemental Sulfur and Peroxides – Doctor Test Method
Other	IP 71 - Petroleum Products – Transparent and Opaque Liquids – Determination of Kinematic Viscosity and Calculation of Dynamic Viscosity
Other	IP 107 - Determination of Sulfur – Lamp Combustion Method
Other	IP 123 - Petroleum Products – Determination of Distillation Characteristics at Atmospheric Pressure
Other	IP 154 - Petroleum Products – Corrosiveness to Copper – Copper Strip Test
Other	IP 156 - Determination of Hydrocarbon Types in Petroleum Products – Fluorescent Indicator Adsorption Method
Other	IP 160 - Crude Petroleum and Liquid Petroleum Products – Laboratory Determination of Density – Hydrometer Method
Other	IP 170 - Petroleum Products and other Liquids– Determination of Flash Point – Abel Closed Cup Method
Other	IP 243 - Petroleum Products and Hydrocarbons – Determination of Sulfur Content – Wickbold Combustion Method
Other	IP 274 - Petroleum Products – Aviation and Distillate Fuels - Determination of Electrical Conductivity
Other	IP 323 - Petroleum Products - Determination of Thermal Oxidation Stability of Gas Turbine Fuels
Other	IP 336 - Petroleum Products – Determination of Sulfur Content – Energy-Dispersive - X-Ray Fluorescence Method
Other	IP 342 - Petroleum Products – Determination of Thiol (Mercaptan) Sulfur in Light and Middle Distillate Fuels – Potentiometric Method
Other	IP 354 - Determination of the Acid Number of Aviation Turbine Fuels – Colour-Indicator Titration Method
Other	IP 365 - Crude Petroleum and Petroleum Products – Determination of Density – Oscillating U-tube Method
Other	IP 367 - Petroleum Products – Determination and Application of Precision Data in Relation to Methods of Test
Other	IP 373 - Determination of Sulfur Content of Light and Middle Distillates by Oxidative Microcoulometry
Other	IP 406 - Petroleum Products – Determination of Boiling Range Distribution by Gas Chromatography

Other	IP 423 - Determination of Particulate Contaminant in Aviation Turbine Fuels by Laboratory Filtration
Other	IP 424 - Determination of Fuel System Icing Inhibitor Content of Aviation Turbine Kerosenes by High Performance Liquid Chromatography
Other	IP 435 - Determination of the Freezing Point of Aviation Turbine Fuels by the Automated Phase Transition Method
Other	IP 436 - Determination of Aromatic Hydrocarbon Types in Aviation Fuels and Petroleum Distillates – High Performance Liquid Chromatography Method with Refractive Index Detection
Other	IP 447 - Petroleum Products – Determination of Sulfur Content – Wavelength-Dispersive X- Ray Fluorescence Spectrometry
Other	IP 475 - Petroleum Liquids – Manual Sampling (ISO 3170:2004)
Other	IP 523 - Determination of Flash Point – Rapid Equilibrium Closed Cup Method
Other	IP 528 - Determination of the Freezing Point of Aviation Turbine Fuels – Automated Fibre Optic Method
Other	IP 529 - Determination of the Freezing Point of Aviation Fuels – Automatic Laser Method
Other	IP 540 - Determination of the Existent Gum Content of Aviation Turbine Fuel – Jet Evaporation Method
Other	IP 564 - Determination Of The Level Of Cleanliness Of Aviation Turbine Fuel – Laboratory Automatic Particle Counter Method
Other	IP 565 - Determination of the level of cleanliness of aviation turbine fuels - Portable automatic particle counter method
Other	IP 568 - Determination of the static dissipater additives (SDA) in aviation turbine fuel and middle distillate fuels - HPLC Method
Other	IP 577 - Determination of the level of cleanliness of aviation turbine fuel – Automatic particle counter method using light extinction
Other	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
Other	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
Other	IP 590 - Determination of fatty acid methyl esters (FAME), derived from bio-diesel fuel, in aviation turbine fuel – HPLC evaporative light scattering detector method

Other	IP 598 - Determination of the smoke point of kerosene, manual and automated method
Other	IP 599 - Determination of Fatty Acid Methyl Esters (FAME) in Aviation Turbine Fuel by Gas Chromatography using Heart-cut and Refocusing
Other	ISO 2160 - Petroleum products -- Corrosiveness to copper -- Copper strip test
Other	ISO 3012 - Petroleum products -- Determination of thiol (mercaptan) sulfur in light and middle distillate fuels -- Potentiometric method
Other	ISO 3104 - Petroleum products -- Transparent and opaque liquids -- Determination of kinematic viscosity and calculation of dynamic viscosity
Other	ISO 3405 - Petroleum and related products from natural or synthetic sources -- Determination of distillation characteristics at atmospheric pressure
Other	ISO 3675 - Crude petroleum and liquid petroleum products -- Laboratory determination of density -- Hydrometer method
Other	ISO 3679 - Determination of flash no-flash and flash point -- Rapid equilibrium closed cup method
Other	ISO 4259 - Petroleum and related products -- Precision of measurement methods and results
Other	ISO 4406 - Hydraulic fluid power – Fluids – Method for coding the level of contamination by solid particles
Other	ISO 8754 - Petroleum products -- Determination of sulfur content -- Energy-dispersive X-ray fluorescence spectrometry
Other	ISO 12185 - Crude petroleum and petroleum products -- Determination of density -- Oscillating U-tube method
Other	ISO 13736 - Determination of flash point -- Abel closed-cup method
Other	ISO 14596 - Petroleum products -- Determination of sulfur content -- Wavelength-dispersive X-ray fluorescence spectrometry
Other	JIG Standards - www.jigonline.com
Other	QPL 68-251 - Qualified Products List of Aircraft Materials to Def Stan 68-251
Other	SAE ARP 1797 - Aircraft and Aircraft Engine Fuel Pump Low Lubricity Fluid Endurance Test
Other	SwRI 08-04438 - Evaluation of Sasol Synthetic Kerosene for Suitability as Jet Fuel
Other	SwRI 08-04438-2 - Evaluation of Sasol Synthetic Kerosene for Suitability as Jet Fuel. Phase II, Engine and Combustion Tests

Other	SwRI 8531 - Qualification of Sasol Semi-Synthetic JET A-1 as Commercial Jet Fuel

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. Care should be taken when referring out to specific portions of other standards to ensure that they remain easily identifiable where subsequent amendments and supersession's might be made. For some standards the most recent editions shall always apply due to safety and regulatory requirements.

3 In consideration of clause 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. Correct identification of standards is as defined in the ITT or contract.

4 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.

Definitions

For the purpose of this standard, ISO/IEC Guide 2 ‘Standardization and Related Activities – General Vocabulary’ and the definitions shown below apply.

Definition	Description
Air Traffic Management	Equipment used for the provision of ATM, including equipment used in the air defence environment. ATM equipment can be land based or part of an aircraft, ship or vehicular platform. (MAA 02)

Abbreviations

Abbreviation	Description
A	Abnormal (Thermal Stability Testing Visual Tube Rating result)
AE-5B	SAE Aircraft and Engine Fuel and Lubricant System Components Committee
AFC	Aviation Fuels Committee
API	American Petroleum Institute
ARP	Aerospace Recommended Practices
ASTM	American Society for Testing and Materials
ATM	Air Traffic Management
BOCLE	Ball-on-Cylinder Lubricity Evaluator
BS	British Standard
CAA	Civil Aviation Authority
CoA	Certificate of Analysis
Def Stan	Defence Standard
DRA	Drag Reducing Agent
DSFA	Defence Strategic Fuels Authority
DStan	UK Defence Standardization
EI	Energy Institute
EN	European Norm
ETR	Ellipsometric Tube Rating
FAME	Fatty Acid Methyl Esters
FSII	Fuel System Icing Inhibitor
GC-MS	Gas Chromatography – Mass Spectrometry
HN1	Heavy Naphth #1
HPLC	High Performance Liquid Chromatography
IATA	International Air Transport Association
IEC	International Electrotechnical Commission

IP	Institute Petroleum
IPK	Iso-Paraffinic Kerosene
ISO	International Organisation of Standardization
ITR	Interferometric Tube Rating
ITT	Invitation To Tender
JFTOT	Jet Fuel Thermal Oxidation Test
JIG	Joint Inspection Group
LIA	Lubricity Improver Additive
LLC	Limited Liability Company
MAA	Military Aviation Authority
MDA	Metal Deactivator Additive
MOC	Management of Change
MoD	Ministry of Defence
MPP	Multi Product Pipeline
MSEP	Microseparometer
OEM	Original Equipment Manufacturer
P	Peacock (Thermal Stability Testing Visual Tube Rating result)
PAC	company trading name
QA	Quality Assurance
QPL	Qualified Products List
RC	Release Certificate
RCQ	Refinery Certificate of Quality
RT	Recertification Test
SAE	Society of Automotive Engineers
SASOL	Company trading name
SDA	Static Dissipator Additive
SwRI	Southwest Research Institute

UK	United Kingdom
VTR	Visual Tube Rating
WSD	Wear Scar Diameter

Defence Standards are published by and obtainable from:

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File Reference

The DStan file reference relating to work on this standard is 91/91.

Contract Requirements

When Defence Standards are incorporated into contracts, users are responsible for their correct application and for complying with contractual and statutory requirements. Compliance with a Defence Standard does not in itself confer immunity from legal obligations.

Revision of Defence Standards

Defence Standards are revised as necessary by an up-issue or amendment. It is important that users of Defence Standards ensure that they are in possession of the latest issue or amendment. Information on all Defence Standards can be found on the DStan Websites https://www.dstan.mod.uk and http://dstan.uwh.diif.r.mil.uk/, updated weekly. Any person who, when making use of a Defence Standard, encounters an inaccuracy or ambiguity is encouraged to notify UK Defence Standardization (DStan) without delay in order that the matter may be investigated and appropriate action taken.

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