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

Section 1

Foreword

Defence Standard Structure

Section 1

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- Historical Record
- Warning
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Section 2 (Technical information provided by Subject Matter Expert)

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REVISION NOTE

This issue has been updated to provide clarity on single tank batch certification requirements; make particle counting to IP 565 the referee method for fuel cleanliness at point of manufacture in Table 1 and provide advanced notice that gravimetric testing will be removed from Def Stan 91-091 in 2028. Leak detection additive has been moved to the incidental materials annex, and further guidance on the testing requirements for Def Stan 91-091 certification of fuel produced from an approved pathway in ASTM D7566. ASTM D8615 has been added to Table 5 as an alternative method for Freezing Point. Clause A.5.4 has been added to detail the reporting requirements for lubricity testing post manufacture certification if LIA has been subsequently blended. Notes 6 and 7 within Table 1 have been edited to clarify the reporting requirements for blend components, lubricity and LIA details where LIA is blended downstream of initial certification.

Full details of the changes made can be found in Section 3 “Changes Since Last Revision”.

HISTORICAL RECORD

This standard supersedes the following:

Def Stan 91-091 Issue 18

WARNING

The Ministry of Defence (MOD), like its contractors, is subject both to United Kingdom law and any EU-derived law that has been retained under the European Union (Withdrawal) Act 2018 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

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 Operational Energy Authority (OEA).

Note. The Technical Authority is the Operational Energy Authority, Cedar 3A MP #3360, 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 blending 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**, 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 airframe 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 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 from a single tank. Manufacturing locations shall 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. At point of manufacture, initial batching of fuel shall be limited to the contents of a single storage tank only. Where multiple storage tanks are filled from a single movement of fuel at a point of manufacture and/or at all points in the supply chain, except marine vessels, then each tank shall be individually tested and allocated a discrete batch identity.

5.2 At point of manufacture (point of batch origin), the operator shall issue a Certificate of Quality (CoQ) (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 CoQ 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. At the point of manufacture, 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 may cause the fuel to be not fit for purpose despite the fuel meeting all the specification test requirements. Some specific incidental materials in this category have been identified and 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 Standards EI/JIG 1530 and EI 1533, if a synthetic-containing jet fuel is involved.

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, IP 367 Part 2: Petroleum and related products – Precision of measurement methods and results – Part 2: Interpretation and application of precision data in relation to methods of test, 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 Where the product is required in drums or cans, it 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 EI 1542 or Def Stan 05-052 (Part 1).

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(1)
	1.3	Particulate at point of manufacture				
		Cumulative channel particle counts	Individual channel counts & ISO code	Channel Counts	ISO Code	IP 565 (2,3)
		≥ 4 µm(c)	-	Report	Max 19	
		≥ 6 µm(c)	-	Report	Max 17	
		≥ 14 µm(c)	-	Report	Max 14	
		≥ 21 µm(c)	-	Report	Report	
		≥ 25 µm(c)	-	Report	Report	
		≥ 30 µm(c)	-	Report	Max 13	
2	Composition					
	2.1	Total Acidity	mg KOH/g	Max 0.015		IP 354 / ASTM D3242
	2.2	Aromatic Hydrocarbon Types (one of the following requirements shall be met)				
	2.2.1 or	Aromatics	% v/v	Max 25.0		IP 156 / ASTM D1319
	2.2.2	Total Aromatics	% v/v	Max 26.5		IP 436 / ASTM D6379(4)
	2.3	Sulfur, Total	% m/m	Max 0.30		IP 336
	2.4	Mercaptans (one of the following requirements shall be met)				
	2.4.1 or	Sulfur, Mercaptan	% m/m	Max 0.0030		IP 342 / ASTM D3227(5)
	2.4.2	Doctor Test	-	Doctor Negative		IP 30
	2.5	Blending Components, at point of manufacture (6)				
	2.5.1	Non-Hydroprocessed Components	% v/v	Report		
	2.5.2	Severely Hydroprocessed Components	% v/v	Report		
	2.5.3	Synthetic Components	% v/v	Report, for limits see **Annex B**		(7) (see **Annex B**)
3	Volatility					
	3.1	Distillation				IP 123 / ASTM D86(8)
	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(9)
	4.2	Viscosity at minus 20°C	mm^2/s	Max 8.000		IP 71 Section 1 / ASTM D445
5	Combustion					
	5.1	Smoke Point (one of the following requirements shall be met)				

Table 1: Test Requirements

Test		Property	Units	Limits	Method
	5.1.1 or	Smoke Point	mm	Min 25.0	IP 598 / ASTM D1322[10]
	5.1.2	Smoke Point and	mm	Min 18.0	IP 598 / ASTM D1322
		Naphthalenes	% v/v	Max 3.00	ASTM D1840
	5.2	Specific Energy	MJ/kg	Min 42.80	[11]
6	Corrosion				
	6.1	Copper Strip	Class	Max 1	IP 154 / ASTM D130[12]
7	Thermal Stability				IP 323 / ASTM D3241[13]
	7.1	Test Temperature	°C	Min 260	
	7.2	Tube Rating (one of the following requirements shall be met)			[14]
	7.2.1 or	Annex B VTR	-	Less than 3. No Peacock (P) or Abnormal (A)	
	7.2.2	Annex C ITR, Annex D ETR or Annex E MWETR, 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 (one of the following requirements shall be met)			ASTM D3948[15]
	9.1.1 or	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[16]
11	Lubricity				
	11.1	Wear Scar Diameter	mm	Max 0.85	ASTM D5001[17]

Notes for Table 1:

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.**
2. This limit shall apply at point of manufacture only. To meet the requirements of this standard the limits of particle counts (**test 1.3**) or particulate contamination (See Table 5 alternative test methods) shall be met and it is only necessary to report whichever property is being used to support release of the fuel. It is the intention of the Technical Authority to withdraw the use of IP 423 / ASTM D5452 before the end of 2028. For more information on particulate contamination or particle counting refer to **Annex F**.
3. The number of particles and the number of particles as a scale number as defined by Table 1 of ISO 4406 shall be reported (see also **Note 2**). If limits are exceeded, Annex B of IP 565, may be applied to eliminate trace free water, and cleanliness re-determined. In such cases, results before and after application of the annex shall be reported.
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. 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.
5. Doctor Test (**test 2.4.2**) is an alternative requirement to Sulfur Mercaptan (**test 2.4.1**). If the Doctor Test result is Positive, the Sulfur Mercaptan Test shall be carried out and reported.
6. Blend components used in the make-up of the batch shall be reported on the Certificate of Quality as a percentage by volume of the total fuel in the batch to determine if lubricity testing is required (see **Note 17**). 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. Hydroprocessing severity of the conventional blend components may not be known, either with or without synthetic components present (See **Annex**

D.2.3.1 and **Annex D.3.1.1**). In these cases, "unknown" shall be reported and ASTM D5001 lubricity shall be determined.
Note that the sum of the reported composition may be less than 100% if the batch includes a mildly hydroprocessed component.

7. The semi-synthetic jet fuel CoQ at point of batch origination shall include a listing of the quality documents relating to the conventional and synthetic blend component (SBC) batches in the blend and their respective volumes to show compliance with the blending limits set out in the Annexes to ASTM D7566. The SBC producer's CoQ, CoA or RT certificate (see AnnexD) shall be available for each SBC at the point of batch origination including antioxidant concentration (as the concentration of active material reported on originator's CoQ) and corresponding formulation Qualification reference per **Annex A.2.4**.
8. 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.
9. 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°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 the alternative test methods listed in **Table 5**.
10. Alternative test requirements identified in **Table 1**; Test Requirements **5.1.1** or **5.1.2** are alternative primary requirements. IP 598 includes both a manual and an automated method. The automated method in IP 598 is the referee method.
11. Specific Energy by one of the 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.
12. The sample shall be tested in a pressure vessel at 100±1°C for 2 hours ± 5 minutes.
13. Heater tubes other than those supplied by the original equipment manufacturer (OEM) shall not be used.
    Technically suitable heater tubes are a) PAC - Alcor, or b) Falex.
14. 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), ellipsometric (ETR) or multi-wave ellipsometric (MWETR) method. Tube deposit ratings shall be measured by IP 323 Annex C ITR, Annex D ETR or Annex E MWETR, 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, Annex D ETR or Annex E MWETR deposit thickness measurements are reported. In case of dispute between results from visual and metrological methods, the metrological method (ITR / ETR / MWETR) shall be the referee.
15. Where SDA is added at point of manufacture the MSEP limit of 70 shall apply, except when using the alternative method (ASTM D8073 / IP 624) when the limits of **Table 5 note 6** apply. 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 latest bulletin in force, Bulletin Number 150 (at the time of this publication) – Testing Water Separation Properties of Jet Fuel (MSEP) at https://www.jig.org/. Where SDA is added downstream of point of manufacture, it is acknowledged that MSEP results using ASTM D3948 may be less than 70.
16. The conductivity limits are mandatory for product to meet this Standard at the point of delivery to aircraft. However, it is acknowledged that in some manufacturing and distribution systems it is more practical to inject SDA further downstream of the point of manufacture. In such cases the Certificate of Quality for the batch and any subsequent recertifications (CoA / RTC) shall 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).
17. 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 6**) or b) includes synthesised fuel components (see **Note 7**). The limit applies only at the point of manufacture. Where the lubricity result is greater than the 0.85 mm wear scar it may be more practical to inject LIA downstream of initial certification or blend the batch (downstream of point of manufacture) to bring the lubricity result within the required limit. In this case the batch at point of manufacture shall be annotated thus: "Product meets requirements of Defence Standard

	91-091 except for lubricity, either addition of a qualified LIA to this batch or blending with another batch of jet fuel is required. Either corrective action requires a subsequent ASTM D5001 lubricity evaluation to ensure maximum 0.85 mm wear scar (see Annex A.5.4 and Annex F.3)”.

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 shall be calculated based on the additive as received. These include Static Dissipator Additive and Lubricity Improver Additive.

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

A.1.3 The product owner at the point of additive dosing shall ensure that the additive dose is within the specification limits of this standard.

A.1.4 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 Antioxidant (AO)

A.2.1 AO may be used to prevent peroxidation and gum formation during storage.

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

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

A.2.4 The following AO formulations are qualified:

Formulation	Qualification Reference
2,6-ditertiary-butyl-phenol	RDE/A/606
2,6 ditertiary-butyl-4-methyl-phenol	RDE/A/607
2,4-dimethyl-6-tertiary-butyl-phenol	RDE/A/608
75% minimum, 2,6-ditertiary-butyl-phenol 25% maximum, tertiary and tritertiary-butyl-phenols	RDE/A/609
55% minimum, 2,4-dimethyl-6-tertiary-butyl-phenol 15% minimum, 4 methyl-2,6-ditertiary-butyl-phenol Remainder, 30% maximum, as a mixture of monomethyl and dimethyl-tertiary-butyl-phenols	RDE/A/610
72% minimum, 2,4-dimethyl-6-tertiary-butyl-phenol 28% 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 If AO is added to the fuel the AO concentration shall be reported as a total active material in mg/l in the final batched fuel volume.

Note: To account for residual tank heel concentrations of AO, where new batches do not contain AO, it is not required to report the concentration of active material in the final batch once the calculated dosage is <0.5 mg/l.

A.2.6.1 If AO 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
   1) No more than 5% of the jet fuel batches produced in a 12-month period shall be treated with MDA to meet **Table 1** thermal oxidative stability requirements (260°C test temperature).
   2) The batch of fuel shall pass **Table 1** thermal oxidative stability requirements at a test temperature of 245°C prior to any MDA addition.
   3) 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.
   4) The thermal oxidative stability test result at 245°C prior to MDA addition, the original test result at 260°C, the test result at 275°C (post MDA addition) and the concentration of MDA added shall be reported on the manufacturer's Certificate of Quality.

b) During Distribution
   1) MDA may be added to jet fuel in the distribution system to recover thermal oxidative stability performance lost during distribution (after release from point of manufacture). 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 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 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 If LIA is added post manufacture certification, report the LIA Qualification Reference and concentration used in the final batched fuel on the Certificate of Analysis and Release Certificate along with an ASTM D5001 lubricity test result after blending the LIA.

A.5.5 The following materials are qualified at the specified concentrations:

Product	Manufacturer	Qualification Reference	Minimum mg/l	Maximum mg/l
Innospec DCI-4A	Innospec LLC	RDE/A/662	9	23
Innospec DCI-6A	Innospec LLC	RDE/A/663	9	15
Nalco 5403	Nalco Chemical Co.	RDE/A/664	12	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 shall 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 D5006.

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.

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, new fuel component approvals are progressed via ASTM Task Forces with the components defined and approved as Annexes in ASTM D7566. ASTM D7566 is a fuel Standard created specifically for the purpose of listing and controlling these components.

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-processing approved feedstocks, 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.

B.2 Generic Synthetic Kerosene Approvals

B.2.1 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 **Clause 4** and **Annex C** of this standard or shall be a fuel defined as acceptable in this **Annex**.
d) The finished blended fuel shall pass all Table 1 properties of ASTM D7566 (This includes additional test property requirements currently including minimum aromatics (%v/v), distillation gradients, low temperature viscosity and lubricity), 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, but the more stringent requirements of Def Stan 91-091 shall apply.
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** shall be manufactured according to declared procedures defined during the manufacture of prototype batches that have been submitted for examination and approval. Prototype batches shall 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 IP 156, or not less than 8.4% nor greater than 26.5% by volume when using method IP 436. 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 6** of **Table 1**.

Table 2: Batch Requirements for HN1/IPK Blend

Test		Property	Units	Limits	Method
1	Thermal Stability				IP 323 / ASTM D3241(1)
	1.1	Test Temperature	°C	Min 325	
	1.2	Tube Rating (one of the following requirements shall be met):			
	1.2.1 or	Annex B VTR, VTR colour code	-	Less than 3. No Peacock (P) or Abnormal (A)	
	1.2.2	Annex C ITR, Annex D ETR or Annex E MWETR, nm average over area of 2.5 mm^2	nm	Max 85	
	1.3	Pressure Differential	mm Hg	Max 25	
2	Fluidity				
	2.1	Freezing Point	°C	Max minus 40.0	IP 16 / ASTM D2386
3	Combustion				
	3.1	Specific Energy	MJ/kg	Min 42.80	(2)
4	Composition (one of the following requirements shall be met):				
	4.1	Aromatics	% v/v	Max 7.0	IP 156 / ASTM D1319
	4.2	Total Aromatics	% v/v	Max 7.4	IP 436 / ASTM D6379(3)

Notes for Table 2:

1. Thermal Stability is a critical aviation fuel test and while competition among equipment manufacturers/suppliers is to be encouraged, aircraft safety shall 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.
2. Specific Energy by one of the calculation methods listed in **Annex E** 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.
3. 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 0.85mm 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 approved feedstocks producing co-processed semi-synthetic kerosene is recognized as being acceptable for jet fuel manufacture as controlled by this Standard. Approved feedstocks are:

a) mono-, di-, and triglycerides, free fatty acids and fatty acid esters.
b) hydrocarbons derived from synthesis gas via the Fischer-Tropsch process using Iron or Cobalt catalyst.
c) hydrocarbons from hydroprocessed mono-, di-, and triglycerides, free fatty acids and fatty acid esters.

Only one co-processing feedstock and only one co-processing route (as defined by B.4.1.1.1, B.4.1.1.2, B.4.1.2 and B.4.1.3) may be used for the production of any single jet fuel batch. Refer to **Annex F.5** for a discussion of bio-based carbon content and identification of an applicable test method.

B.4.1.1 Co-hydroprocessing of mono-, di-, and triglycerides, free fatty acids and fatty acid esters shall include hydrotreating or hydrocracking and fractionation. Processing may also include other conventional fuel manufacturing processes.

B.4.1.1.1 In the case of hydrotreating, the feed into the final hydrotreating unit, where process streams are used for jet production, shall not exceed 5% by volume in approved feedstock derived volume with the balance (≥ 95% by volume) being conventional sources as described in **Clause 4.1.1**. The final jet batch is limited to 5% by volume of co-hydroprocessed synthesized kerosene derived from co-hydrotreated mono-, di-, and triglycerides, free fatty acids and fatty acid esters.

B.4.1.1.2 In the case of hydrocracking, a hydrogen partial pressure of greater than 7000 kPa (70 bar or 1015 psi) shall be present. The feed into the final hydrocracking unit, where process streams are used for jet production, shall not exceed 30% by volume in approved feedstock with the balance (≥ 70% by volume) being conventional sources as described in **Clause 4.1.1**. The resultant stream shall:

a) not exceed 30 % by volume of co-hydroprocessed synthesized kerosene derived from mono-, di-, and triglycerides, free fatty acids, and fatty acid esters.
b) be blended at 50 % by volume maximum with conventional kerosene derived from sources as described in **Clause 4.1.1** when more than 5 % by volume of co-hydroprocessed synthesized kerosene derived from co-hydrocracked mono-, di-, and triglycerides, free fatty acids, and fatty acid ester feedstock is present, and in such cases, the finished blend shall include antioxidant of the type specified in **A.2.4** at a concentration of 17.0 to 24.0 mg/l.

The final jet batch is limited to 15% by volume of co-hydroprocessed synthesized kerosene derived from co-hydrocracked mono-, di-, and triglycerides, free fatty acids and fatty acid esters.

B.4.1.2 Co-hydroprocessing of Fischer-Tropsch hydrocarbons shall include hydrocracking or hydrotreating and fractionation. Processing may also include other conventional fuel manufacturing processes. The feed into the final hydrocracking or hydrotreating unit, where process streams are used for jet production, shall not exceed 5% by volume in approved feedstock with the balance (≥ 95% by volume) being conventional sources as described in **Clause 4.1.1**. The final jet batch is limited to 5% by volume of co-hydroprocessed synthesized kerosene derived from Fischer-Tropsch hydrocarbons.

B.4.1.3 Co-processing of hydrocarbons from hydroprocessed mono-, di-, and triglycerides, free fatty acids and fatty acid esters shall include fractionation. Processing may also include other conventional fuel manufacturing

processes. The feedstock shall be free of additives, except for the optional addition of an antioxidant of the type and concentration specified in **A.2**. Antioxidant should be added to the feedstock and in such a way to ensure adequate mixing if significant exposure to air is expected. The feed into the final fractionation unit, where process streams are used for jet production, shall not exceed 24% by volume of hydrocarbons derived from hydroprocessed mono-, di- and triglycerides, free fatty acids, or fatty acid esters with the balance (≥ 76% by volume) being conventional sources as described in **Clause 4.1.1**. The final jet batch is limited to 10% by volume of co-processed synthesized kerosene derived from hydroprocessed mono-, di-, and triglycerides, free fatty acids or fatty acid esters.

B.4.2 For semi-synthetic kerosene manufactured by co-processing mono-, di- and triglycerides, free fatty acids and fatty acid esters; Fischer-Tropsch hydrocarbons; or hydrocarbons from hydroprocessed mono-, di-, and triglycerides, free fatty acids and fatty acid esters, the following additional requirements and **Table 3** limits apply. For Annex B.4 co-processing the more stringent limits and test methods listed in Table 3 shall be applied at point of manufacture. Downstream from manufacture standard Table 1 limits and test methods apply.

B.4.2.1 An initial Management of Change (MOC) study shall be undertaken and documented for sites manufacturing semi-synthetic kerosene by co-processing. 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), hydroprocessing severity (e.g. hydrogen partial pressure, residence time, temperature, catalyst, conversion capability) and determination of biobased carbon content where appropriate. 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, Fischer-Tropsch hydrocarbons or hydrocarbons from hydroprocessed mono-, di-, and triglycerides, free fatty acids and fatty acid esters to synthetic kerosene when added to any jet batch. Refer to the research report (see **B.4.2.4**) for additional considerations for MOC.

B.4.2.2 For semi-synthetic kerosene manufactured by co-hydroprocessed mono-, di- and triglycerides, free fatty acids and fatty acid esters or co-processed hydrocarbons from hydroprocessed mono-, di-, and triglycerides, free fatty acids and fatty acid esters 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.4.2.3 The Certificate of Quality (CoQ) shall include wording to reflect that the batch may contain up to the maximum permitted co-processed synthesized kerosene as indicated in **B.4.1.1**, **B.4.1.2** or **B.4.1.3**. There is no requirement to list the percent 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 co-processing is not required to be determined on a batch basis.

B.4.2.4 Supporting data for co-hydroprocessing fatty acid esters and fatty acids at up to 5% volume with crude oil derived middle distillates have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1886. Supporting data for the co-hydroprocessing of hydrocarbons derived from hydrocracking esters and fatty acids in the concentration range of more than 5% to a maximum of 30% v/v feedstock with crude oil derived middle distillate have been filed at the Operational Energy Authority (OEA) and may be obtained by requesting Research Report OEA-001.Supporting data for hydrocarbons derived from synthesis gas via the Fischer-Tropsch process using Iron or Cobalt catalyst have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-1929. Supporting data for co-processing hydrocarbons from hydroprocessed mono-, di-, and triglycerides, free fatty acids and fatty acid esters has been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D02-2052.

Table 3: Extended Requirements of Aviation Turbine Fuels Containing Co-processed Synthesised Kerosene[1,2]

	Test	Property	Units	Limits	Method
1	Thermal Stability				IP 323 / ASTM D3241
	1.1	Test Temperature for 2.5 hr	°C	Min 280	[3]
	1.2	Tube Rating (one of the following requirements shall be met):			
	1.2.1 or	Annex B VTR	-	Less than 3. No Peacock (P) or Abnormal (A)	
	1.2.2	Annex C ITR, Annex D ETR or Annex E MWETR, average over area of 2.5 mm^2	nm	Max 85	
	1.3	Pressure differential	mm	Max 25	
2	Fluidity				
	2.1	Freezing Point	°C	Max minus 47.0	IP 435 / ASTM D5972[4] IP 529 / ASTM D7153 ASTM D7154 ASTM D8615
	2.2	Viscosity at minus 40°C[5]	mm^2/s	Max 12.0	IP 71 Section 1[4,6] or ASTM D445[6], ASTM D7042[7], ASTM D7945
3	Composition				
	3.1	Aromatics: One of the following requirements shall be met[8,9]			
	3.1.1 or	Aromatics	% v/v	Min 8	IP 156[4] or ASTM D1319, ASTM D8267, ASTM D8305[10]
	3.1.2	Aromatics	% v/v	Min 8.4	IP 436 / ASTM D6379
4	Volatility				
	4.1	Distillation[8]	°C		IP 123[4, 11] or ASTM D86[11], IP 406 or ASTM D2887[12], ASTM D7345[13]
	4.2	T50-T10		Min 15	
	4.3	T90-T10		Min 40	
5	Lubricity				
	5.1	Lubricity[8]	mm	Max 0.85	ASTM D5001
6	Process Control				
		Unconverted fatty acid esters and fatty acids	mg/kg	Max 15	IP 583 / ASTM D7797[14]
7	Additives				
		Antioxidant[15]	mg/l	Min 17.0 Max 24.0	

Notes for Table 3:

1. Applies at the point of manufacture only.
2. Applies for the finished batch of jet fuel as opposed to the product of the manufacturing location co-processing unit which is used to blend the finished batch of jet fuel.
3. An IP323/ASTM D3241 test temperature of 280°C has been selected to help ensure that reactive compounds introduced through co-hydroprocessing 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.
4. Referee method to be used in case of dispute.
5. The kinematic viscosity specification of 12.0 mm^2/s at minus 40°C maximum mitigates the potential risk of increased viscosity due to n-paraffin enrichment. Compared to conventional hydrocarbons, a co-processed esters and fatty acids stream may contain a higher concentration of n-paraffins. Research is ongoing on how n-paraffin enrichment from co-processed esters and fatty acids impacts low temperature viscosity. The results of that research will be used to confirm the necessity of and possible need for adjusting this requirement.
6. IP 71 Section 1 or ASTM D445 allows measuring the viscosity at minus 40°C, however, the precision values were determined down to minus 20°C. A revision to Test Method IP 71 Section 1 and ASTM D445 to specify measurement precision at minus 40°C is in process.
7. The temperature scanning procedure shall be used.
8. Applies to co-processing hydrocarbons from hydroprocessed esters and fatty acids or when hydrocarbons derived from hydrocracking esters and fatty acids in the concentration range of more than 5 to a maximum of 30% v/v feedstock have been blended into finished product.
9. Minimum aromatics contents are based on current experience with semi-synthetic fuels and those levels were established from what is typical for refined jet fuel. Research is ongoing on the actual need for aromatics.
10. Results from test method ASTM D8305 shall be bias-corrected using the bias-correction equation for total aromatics in Section 13 (Precision and Bias) of test method ASTM D8305.
11. In methods IP 123 and ASTM D86 all fuels certified to this Standards shall be classed as group 4, with a condenser temperature of zero to 4°C.
12. IP 406 and ASTM D2887 results shall be converted to estimated IP 123 or ASTM D86 results by application of the correlation in Annex G of IP 406 or Appendix X4 on Correlation for Jet and Diesel Fuel in test method ASTM D2887.
13. Results from test method ASTM D7345 shall be corrected for relative bias as described in the method.
14. Applies to co-processing esters and fatty acids or hydrocarbons from hydroprocessed esters and fatty acids. The ability of IP 583/ASTM 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.
15. For fuel approved in accordance with clause **B.4.1.1.2 b)** the finished blend shall include antioxidant of the type specified in **A.2.4** at a concentration of 17.0 to 24.0 mg/l

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 synthetic blend component has an originator's Certificate of Quality (ASTM D7566) available. This shall be quoted as part of the technical requirements in **Table 1** of this Standard. Note that the lubricity test (BOCLE) is mandatory at the point of manufacture.

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 to maintain product integrity. In particular the restrictions of Clause **5.5** and **Annexes C** and **F** shall 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 special case the blending may be done at the airport depot in a dedicated tank or dedicated fueller and handling of the synthetic blending component shall ensure that it is not possible to deliver this component to an aircraft.

B.5.4 The point of blending shall be considered as the point of manufacture of the semi-synthetic 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 Quality as defined in **Annex D**. After blending, the semi-synthetic jet fuel shall be quarantined until a Certificate of Quality is provided. The CoQ 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.

B.5.5 Residual volumes of synthetic or co-processed components contained in non-synthetic blend components from line clearance or tank heels that constitute less than 3% of a finished blend may be considered negligible for the purposes of reporting documentation and traceability. (See also D.3.2.)

B.5.6 Residual volumes of synthetic components from line clearance or tank heels that constitute less than 1% of a finished blend may be considered negligible for the purposes of reporting documentation, lubricity testing and traceability.

B.5.7 Further information on the handling of synthetic blending components and semi-synthetic jet fuel can be found in EI 1533 Quality assurance requirements for semi-synthetic jet fuel and synthetic blending components (SBC) – A supplement to EI/JIG Standard 1530.

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	Max permitted level	Detection Level	Test methods
Fatty acid methyl ester (FAME)[1,2,3,4]	50 mg/kg		D7797 / IP 583, IP 585[4], IP 590, IP 599
Pipeline Drag Reducing Additive (DRA)[1]	Nil	72 µg/L[5]	D7872

Notes for Table 4:

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 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.
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 distribution systems where contamination of jet fuel can occur.
3. On an emergency basis, up to 100 mg/kg FAME is permitted in jet fuel by the airframe and engine manufacturers when managed in compliance with airframe and engine requirements (see FAA SAIB NE-09-25R2 dated May 19, 2016 which provides corrective actions and procedures to be followed in the event of a contamination). 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.
4. Test method IP 585 shall be the referee method.
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 crude oil processing / distribution additives or point of manufacture processing additives, such as corrosion inhibitors, might be carried over in trace quantities into aviation fuel during manufacture. 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 (where known), manufacturing source or point of manufacture 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 1533, 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) and Drag Reducing Agent (DRA) In Trace Quantities during Transportation in non-dedicated systems

C.4.1 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 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.

C.4.2 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 106 is the current document on FAME update. This bulletin may be downloaded from https://www.jig.org/.

C.4.3 There is no need to report the DRA level at the point of manufacture. However, DRA content testing is required as part of a Risk Assessment where DRA is known to be present or is to be added into other products in a multiproduct pipeline system which is also transporting jet fuel**.**

C.5 Leak Detection Additive

C.5.1 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.

C.5.2 The following material is qualified:

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

C.5.3 The concentration of Tracer A shall not exceed 1.0 mg/kg.

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) Certificate of Quality (CoQ)
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 Certificate of Quality (CoQ)

D.1.2.1 The CoQ 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**. Certificates of Quality shall always be dated and signed by an authorised signatory and shall state that the fuel meets all aspects of this Standard. This is different from a CoA in that the CoA is limited to a declaration of the testing results of the fuel.

D.1.2.2 The minimum information requirements to be included on the fuel's 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) Tank number.
e) Quantity of fuel in the batch.
f) Properties tested including specification limit, test method and result of test.
g) Additives, including qualification reference and quantity added.
h) Name and position of authorised test certificate signatory or electronic signature.
i) Date of certification.

D.1.2.3 A CoQ either originates from a Refinery (in which case it may be entitled "Refinery Certificate of Quality" (RCQ) or from a midstream terminal that manufactures a Sustainable Aviation Fuel (SAF) blend and issues its Certificate of Quality. An independent laboratory working on behalf of a manufacturing location can produce the CoQ, but the certificate shall state the name and address of the manufacturing source. 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 hydroprocessed 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 Certificate of Quality.

D.1.4 Release Certificates (RC)

D.1.4.1 The RC 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 (CoQ, 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) Sample from water drain 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, that are transported in conventional distribution systems such as multiproduct pipelines. 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 CoQ or CoA) that are particularly sensitive to contamination. The test results shall be checked to confirm that the specification limits are met, and no significant changes have occurred in any of the properties. To help identify change, the Recertification Test results on flash point, freezing point, distillation and density shall be compared with the linear calculation of expected results from a weighted average of the most recent analysis made on each fuel batch used to form the new batch (e.g. CoQ, COA or RT Certificate, whichever applies – note only a maximum of three new batches and the tank heel are permitted for recertification testing). Where test results have changed significantly from their expected values an investigation into possible contamination should seek to identify cause and may include but not necessarily be limited to CoA 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 three 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 CoQ, CoA or RT is more than 180 days old, a new CoA shall be issued following resampling and analysis. Where 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, hydroprocessed 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 a unique identifier of the appropriate quality document (CoQ, 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’, CoQ ‘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 CoQs / 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) CoQs, 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 Fungible distribution systems are those that transport jet fuel products comingled with other quantities of certified jet fuel, but from a different batch. The term is typically used in reference to pipelines, but may also be applied to other systems such as ship-to-ship transfers, multiple port loadings / discharges, and large marine cargoes. It is acknowledged that in some fungible distribution systems traceability and documentation of specific batches as described above cannot be fully maintained because batches may be added and subtracted during transportation within the fungible distribution system. In such cases, the following requirements shall apply.

a) All batches entering the fungible distribution system shall have full documentation (CoQ, 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 system operator to trace back to the original documentation of all batches that make up the new batch.
c) Where batches from a fungible system are used as conventional blending components, the composition requirements detailed in **Table 1 Tests 2.5.1** and **2.5.2** may not be known. See **Table 1 Note 6**. ("unknown" shall be reported and ASTM D5001 lubricity shall be determined.)

D.3 Distribution System Blending

D.3.1 General

D.3.1.1 Downstream of the original point of manufacture, when certifying a mixture of batches as Jet A-1 meeting Def Stan 91-091, the guiding principle is that all of the component batches shall have been originally manufactured as recognized international jet fuel and subsequently handled and stored as such. Specifically, this means that only 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 **Annex D.2**. In particular, it shall list the main **Table 1** test results, individual batch numbers and certify that the batch certificates (CoQs 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 as a blend component to produce a new batch, provided the following conditions have been met:
    i. they were originally certified as meeting a recognised international jet fuel specification and the batch certificates (CoQs or CoAs) are in the possession of the supplier (or certifying laboratory).
    ii. an ASTM D5001 BOCLE test demonstrates the product meets the test limits (See **Table 1 Note 6**).
    iii. any additives in the batch comply with the requirements detailed in **Annex A** of this Standard.
    iv. appropriate management of change (MOC) measures have been used at the distribution blending facility to maintain product integrity.

The resulting final blend meets the current requirements of Def Stan 91-091.For example, the above conditions could be met if the blend component had been originally certified as ASTM D1655 or CGSB 3.23.

c) Synthetic blend components (SBCs) that are defined in the Annexes of ASTM D7566. These SBCs may be blended with Jet A-1 meeting Def Stan 91-091 (regardless of its composition) downstream of the original manufacturing site (see **Annex B** of this Standard for details). The blending location is defined as the point of manufacture in this case and a new CoQ is required. The synthetic blend component shall have a Certificate of Quality certifying compliance with the relevant Annex of ASTM D7566 and the SBC shall have been handled as though it was a certified jet fuel (**Clause 5** Quality Assurance). The resultant CoQ shall follow the requirements set out in **B.5**.

D.3.2 Residual Tank Heel

D.3.2.1 Operational practice 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:

a) All components of the new batch, including residual volumes, meet the compositional requirements of this Standard as defined by **Clause 4**.
b) The total line clear / residual volume shall compose less than 3% of the new batch and need not be supported by all the CoQ / CoA / RT documentation referred to above.
c) 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
1.1	Appearance	ASTM D4176 Procedure 1 ASTM D6986 Procedure A, Section 8.1.1.1
1.3	Particulate, at point of manufacture	IP 423 / ASTM D5452(1)
1.3	Particulate, at point of manufacture, cumulative channel particle counts	IP 577(2) ASTM D7619 (2)
2.2.1	Aromatics	ASTM D8267 ASTM D8305
2.3	Total Sulfur	IP 243 IP 373 IP 447 ASTM D2622 ASTM D4294 ASTM D5453
2.4.2	Doctor Test	ASTM D4952
3.1	Distillation	IP 406 / ASTM D2887(3) ASTM D7345(4)
3.2	Flash Point(5)	IP 523 ASTM D56 ASTM D3828 IP 34 / ASTM D93 (Procedure A) IP 534 / ASTM D7236
3.3	Density at 15°C	IP 160 / ASTM D1298
4.1	Freezing Point	IP 435 / ASTM D5972 IP 529 / ASTM D7153 ASTM D7154 ASTM D8615
4.2	Viscosity	ASTM D7042(6) ASTM D7945
5.1.2	Naphthalenes	ASTM D8305
5.2	Specific Energy	IP 12 ASTM D3338 ASTM D4809
8.1	Existent Gum	ASTM D381
9	Water Separation Characteristics	ASTM D8073 / IP 624(7)

Notes for Table 5:

1. Particulate contamination by gravimetric determination with a limit of maximum 1.0 mg/l shall apply at point of manufacture only. It is the intention of the Technical Authority to withdraw this method by the end of 2028.
2. If Channel Counts / ISO code exceed the limits stated, either Annex B of IP 577, or Annex X2 of ASTM D7619 may be applied to eliminate trace free water, and cleanliness re-determined. In such cases, results before and after application of the appropriate Annex shall be reported.
3. IP 406 and ASTM D2887 results shall be converted to estimated IP 123 or D86 results by application of the correlation in Annex G of IP 406 or Appendix X4 on Correlation for Jet and Diesel Fuel in Test Method D2887. Distillation residue and loss limits provide control of the distillation process during the use of Test Method IP 123 / ASTM D86, and they do not apply to Test Method ASTM D2887 / IP 406. Distillation residue and loss shall be reported as “not applicable” (N/A) when reporting D2887 results. IP 123 / ASTM D86 estimated data may also be used for the calculation of Specific Energy.

4. Results from Test Method ASTM D7345 shall be corrected for relative bias as described in Test Method ASTM D7345.
5. A joint Energy Institute and ASTM International study of results from alternative flash point methods to IP 170 was published in 2019 and showed that the results obtained are comparable within the precision statement for the methods. EI report reference is ILS2019_MMS_1.
6. 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 minus 20°C as described in the precision and bias section.
7. A limit of 88 shall be applicable to Test Method ASTM D8073 / IP 624. This is a conservative limit, applicable to fuels with and without SDA, taking advantage of the D8073 / IP 624 use of 5th edition material and its low response to weak surfactants such as SDA and CI/LI. This limit has been established based on the evidence within the ASTM D02 committee report “Rationale for the Establishment of a Minimum Limit for Water Separation Characteristics by Test Method ASTM D8073 for Application to D1655” Work Item 54722.

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, quantitative limits have been established for particulate contamination.

F.1.2 It is acknowledged that, during their shipment within the distribution chain, fuels can accumulate elevated levels of particulate. If this occurs, or where the particulate levels are greater than 1.0 mg/l or particle counts are greater than the limits in **Table 1**, additional handling procedures such as extended settling and/or filtration will be required prior to the point of delivery to aircraft. This acknowledgement does not negate or alter the **Table 1, Test 1.1** requirements.

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. point of manufacture tanks to a point of manufacture 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 shall 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 to be supplied shall be fully tested according to the Standard and the Tank Release Note annotated with the explanation “Product released below 50pS/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 less than 5% non-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 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 A significant reduction in Saybolt Colour rating (darkening) 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 Reduction
>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 is 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(1)
IP 71 Section 1 / 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 406 / ASTM D2887	ISO 3924
IP 447	ISO 14596
IP 523	ISO 3679

Notes for Table 6:
1. 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 UK Defence Standardization Help Centre 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
05-052, Pt 02, Iss 02	Markings for the Identification of Fuels, Lubricants and Associated Products - Containers Holding over 216.5 Litres and Pipelines
68-150, Iss 03	Mixture of Fuel System Icing Inhibitor and Lubricity Improving Additive Joint Service Designation: AL-48
68-251, Iss 04	Fuel Soluble Lubricity Improving Additives for Aviation Turbine Fuels NATO Code: S-1747 Joint Service Designation: AL-61
68-252, Iss 04	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
BS / BS EN / BS ISO Standards	BS EN ISO 12185:2024: Crude petroleum, petroleum products and related products — Determination of density — Laboratory density meter with an oscillating U-tube sensor
BS / BS EN / BS ISO Standards	BS EN ISO 2160:1998: Petroleum products. Corrosiveness to copper. Copper strip test

BS / BS EN / BS ISO Standards	BS EN ISO 3104: Methods of test for petroleum and its products. Petroleum products. Transparent and opaque liquids. Determination of kinematic viscosity and calculation of dynamic viscosity.
BS / BS EN / BS ISO Standards	BS EN ISO 3679:2022: Determination of flash no flash and flashpoint. Rapid equilibrium closed cup method
BS / BS EN / BS ISO Standards	BS ISO 4406:2021: Hydraulic fluid power — Fluids — Method for coding the level of contamination by solid particles
BS / BS EN / BS ISO Standards	BS EN 14214:2012+A2:2019: Liquid petroleum products. Fatty acid methyl esters (FAME) for use in diesel engines and heating applications. Requirements and test methods
BS / BS EN / BS ISO Standards	BS EN 24260:1994: Methods of test for petroleum and its products. Petroleum products and hydrocarbons. Determination of sulfur content. Wickbold combustion method
BS / BS EN / BS ISO Standards	ISO 3012:1999: Petroleum products. Determination of thiol (mercaptan) sulfur in light and middle distillate fuels. Potentiometric method
BS / BS EN / BS ISO Standards	ISO 3405:2019; Petroleum and related products from natural or synthetic sources — Determination of distillation characteristics at atmospheric pressure
BS / BS EN / BS ISO Standards	ISO 3675:1998: Crude petroleum and liquid petroleum products — Laboratory determination of density — Hydrometer method
BS / BS EN / BS ISO Standards	ISO 4259-2:2017 Amd 1:2019: Petroleum and related products — Precision of measurement methods and results — Part 2: Interpretation and application of precision data in relation to methods of test — Amendment 1
BS / BS EN / BS ISO Standards	ISO 8754:2003: Petroleum products — Determination of sulfur content — Energy-dispersive X-ray fluorescence spectrometry
BS / BS EN / BS ISO Standards	ISO 13736:2021 + Amd 1:2022: Determination of flash point — Abel closed-cup method
BS / BS EN / BS ISO Standards	ISO 14596:2007: Petroleum products — Determination of sulfur content — Wavelength-dispersive X-ray fluorescence spectrometry
Other Civilian/Industry Standards	API 1543 - Documentation, Monitoring and Laboratory Testing of Aviation Fuel During Shipment from Refinery to Airport
Other Civilian/Industry Standards	API 1595 - Design, Construction, Operation, Maintenance, and Inspection of Aviation Pre-Airfield Storage Terminals
Other Civilian/Industry Standards	ASTM D56 Standard Test Method for Flash Point by Tag Closed Cup Tester
Other Civilian/Industry Standards	ASTM D86 - Standard Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure

Other Civilian/Industry Standards	ASTM D93 - Standard Test Methods for Flash Point by Pensky-Martens Closed Cup Tester
Other Civilian/Industry Standards	ASTM D130 - Standard Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test
Other Civilian/Industry Standards	ASTM D156 - Standard Test Method for Saybolt Color of Petroleum Products (Saybolt Chromometer Method)
Other Civilian/Industry Standards	ASTM D381 - Standard Test Method for Gum Content in Fuels by Jet Evaporation
Other Civilian/Industry Standards	ASTM D445 - Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)
Other Civilian/Industry Standards	ASTM D1298 - Standard Test Method for Density, Relative Density, or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method
Other Civilian/Industry Standards	ASTM D1319 - Standard Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption
Other Civilian/Industry Standards	ASTM D1322 - Standard Test Method for Smoke Point of Kerosene and Aviation Turbine Fuel
Other Civilian/Industry Standards	ASTM D1655 - Standard Specification for Aviation Turbine Fuels
Other Civilian/Industry Standards	ASTM D1840 - Standard Test Method for Naphthalene Hydrocarbons in Aviation Turbine Fuels by Ultraviolet Spectrophotometry
Other Civilian/Industry Standards	ASTM D2386 - Standard Test Method for Freezing Point of Aviation Fuels
Other Civilian/Industry Standards	ASTM D2622 - Standard Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-Ray Fluorescence Spectrophotometry
Other Civilian/Industry Standards	ASTM D2624 - Standard Test Methods for Electrical Conductivity of Aviation and Distillate Fuels
Other Civilian/Industry Standards	ASTM D2887 - Standard Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography

Other Civilian/Industry Standards	ASTM D3227 - Standard Test Method for (Thiol Mercaptan) Sulfur in Gasoline, Kerosene, Aviation Turbine, and Distillate Fuels (Potentiometric Method)
Other Civilian/Industry Standards	ASTM D3241 - Standard Test Method for Thermal Oxidation Stability of Aviation Turbine Fuels
Other Civilian/Industry Standards	ASTM D3242 - Standard Test Method for Acidity in Aviation Turbine Fuel
Other Civilian/Industry Standards	ASTM D3338 - Standard Test Method for Estimation of Net Heat of Combustion of Aviation Fuels
Other Civilian/Industry Standards	ASTM D3828 - Standard Test Methods for Flash Point by Small Scale Closed Cup Tester
Other Civilian/Industry Standards	ASTM D3948 - Standard Test Method for Determining Water Separation Characteristics of Aviation Turbine Fuels by Portable Separometer
Other Civilian/Industry Standards	ASTM D4052 - Standard Test Method for Density, Relative Density and API Gravity of Liquids by Digital Density Meter
Other Civilian/Industry Standards	ASTM D4054 - Standard Practice for Qualification and Approval of New Aviation Turbine Fuels and Fuel Additives
Other Civilian/Industry Standards	ASTM D4057 - Standard Practice for Manual Sampling of Petroleum and Petroleum Products
Other Civilian/Industry Standards	ASTM D4176 - Standard Test Method for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures)
Other Civilian/Industry Standards	ASTM D4294 - Standard Test Method for Sulfur in Petroleum and Petroleum Products by Energy-Dispersive X- Ray Fluorescence Spectrometry
Other Civilian/Industry Standards	ASTM D4809 - Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)
Other Civilian/Industry Standards	ASTM D4952 - Standard Test Method for Qualitative Analysis for Active Sulfur Species in Fuels and Solvents (Doctor Test)
Other Civilian/Industry Standards	ASTM D5001 - Standard Test Method for Measurement of Lubricity of Aviation Turbine Fuels by the Ball-on-Cylinder Lubricity Evaluator (BOCLE)

Other Civilian/Industry Standards	ASTM D5006 - Standard Test Method for Measurement of Fuel System Icing Inhibitors (Ether Type) in Aviation Fuels
Other Civilian/Industry Standards	ASTM D5452 - Standard Test Method for Particulate Contamination in Aviation Fuels by Laboratory Filtration
Other Civilian/Industry Standards	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 Civilian/Industry Standards	ASTM D5972 - Standard Test Method for Freezing Point of Aviation Fuels (Automatic Phase Transition Method)
Other Civilian/Industry Standards	ASTM D6045 - Standard Test Method for Color of Petroleum Products by the Automatic Tristimulus Method
Other Civilian/Industry Standards	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 Civilian/Industry Standards	ASTM D6751 - Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels
Other Civilian/Industry Standards	ASTM D6866 - Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis
Other Civilian/Industry Standards	ASTM D6986 Standard Test Method for Free Water, Particulate and Other Contamination in Aviation Fuels (Visual Inspection Procedures)
Other Civilian/Industry Standards	ASTM D7042 - Standard Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic Viscosity)
Other Civilian/Industry Standards	ASTM D7153 - Standard Test Method for Freezing Point of Aviation Fuels (Automatic Laser Method)
Other Civilian/Industry Standards	ASTM D7154 - Standard Test Method for Freezing Point of Aviation Fuels (Automatic Fiber Optical Method)
Other Civilian/Industry Standards	ASTM D7236: Standard Test Method for Flash Point by Small Scale Closed Cup Tester (Ramp Method)
Other Civilian/Industry Standards	ASTM D7345 - Standard Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure (Micro Distillation Method)

Other Civilian/Industry Standards	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 Civilian/Industry Standards	ASTM D7566 - Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons
Other Civilian/Industry Standards	ASTM D7619 Standard Test Method for Sizing and Counting Particles in Light and Middle Distillate Fuels, by Automatic Particle Counter
Other Civilian/Industry Standards	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 Civilian/Industry Standards	ASTM D7872 - Standard Test Method for Determining the Concentration of Pipeline Drag Reducer Additive in Aviation Turbine Fuels
Other Civilian/Industry Standards	ASTM D7945 - Determination of Dynamic Viscosity and Derived Kinematic Viscosity of Liquids by Constant Pressure Viscometer
Other Civilian/Industry Standards	ASTM D8073: Standard Test Method for Determination of Water Separation Characteristics of Aviation Turbine Fuel by Small Scale Water Separation Instrument
Other Civilian/Industry Standards	ASTM D8267: Determination of Total Aromatic, Monoaromatic and Diaromatic Content of Aviation Turbine Fuels Using Gas Chromatography with Vacuum Ultraviolet Absorption Spectroscopy Detection (GC-VUV)
Other Civilian/Industry Standards	ASTM D8305: Std TM for The Determination of Total Aromatic Hydrocarbons & Total Polynuclear Aromatic Hydrocarbons in Avn Turbine Fuels & other Kerosene Range Fuels by Supercritical Fluid Chromatography
Other Civilian/Industry Standards	ASTM D8615: Standard Test Method for Freezing Point of Aviation Fuels (Automatic Coaxial Optical Fibers Method)
Other Civilian/Industry Standards	EI HM 50 - Guidelines for the cleaning of tanks and lines for marine tank vessels carrying petroleum and refined products
Other Civilian/Industry Standards	EI 1542 - Identification markings for dedicated aviation fuel manufacturing and distribution facilities, airport storage and mobile fuelling equipment
Other Civilian/Industry Standards	EI/JIG 1530 - Quality assurance requirements for the manufacture, storage and distribution of aviation fuels to airports
Other Civilian/Industry Standards	EI/JIG 1533 - Quality assurance requirements for semi-synthetic jet fuel and synthetic blending components (SBC)

Other Civilian/Industry Standards	IP 12 Determination of Specific Energy
Other Civilian/Industry Standards	IP 16 Petroleum Products – Determination of the Freezing Point of Aviation Fuels
Other Civilian/Industry Standards	IP 30 - Detection of Mercaptans, Hydrogen Sulfide, Elemental Sulfur and Peroxides – Doctor Test Method
Other Civilian/Industry Standards	IP 34 - Determination of Flash Point. Pensky-Martens Closed Cup Method
Other Civilian/Industry Standards	IP 71 - Petroleum Products – Transparent and Opaque Liquids – Determination of Kinematic Viscosity and Calculation of Dynamic Viscosity
Other Civilian/Industry Standards	IP 123 - Petroleum Products - Determination of Distillation Characteristics at Atmospheric Pressure
Other Civilian/Industry Standards	IP 154 - Corrosiveness to Copper - Copper Strip Test
Other Civilian/Industry Standards	IP 156 - Determination of Hydrocarbon Types in Petroleum Products – Fluorescent Indicator Adsorption Method
Other Civilian/Industry Standards	IP 160 - Crude Petroleum and Liquid Petroleum Products – Laboratory Determination of Density – Hydrometer Method
Other Civilian/Industry Standards	IP 170 - Petroleum Products and other Liquids– Determination of Flash Point – Abel Closed Cup Method
Other Civilian/Industry Standards	IP 243 - Petroleum Products and Hydrocarbons – etermination of Sulfur Content – Wickbold Combustion Method
Other Civilian/Industry Standards	IP 274 - Petroleum Products – Aviation and Distillate Fuels - Determination of Electrical Conductivity
Other Civilian/Industry Standards	IP 323 - Petroleum Products - Determination of Thermal Oxidation Stability of Gas Turbine Fuels
Other Civilian/Industry Standards	IP 336 - Petroleum Products – Determination of Sulfur Content – Energy-Dispersive - X-Ray Fluorescence Method

Other Civilian/Industry Standards	IP 342 - Petroleum Products – Determination of Thiol (Mercaptan) Sulfur in Light and Middle Distillate Fuels – Potentiometric Method
Other Civilian/Industry Standards	IP 354 - Determination of the Acid Number of Aviation Turbine Fuels – Colour-Indicator Titration Method
Other Civilian/Industry Standards	IP 365 - Crude Petroleum and Petroleum Products – Determination of Density – Oscillating U-tube Method
Other Civilian/Industry Standards	IP 367 - Part 2: Petroleum and related products – Precision of measurement methods and results – Part 2: Interpretation and application of precision data in relation to methods of test
Other Civilian/Industry Standards	IP 373 - Determination of Sulfur Content of Light and Middle Distillates by Oxidative Microcoulometry
Other Civilian/Industry Standards	IP 406 - Petroleum Products – Determination of Boiling Range Distribution by Gas Chromatography
Other Civilian/Industry Standards	IP 423 - Determination of Particulate Contaminant in Aviation Turbine Fuels by Laboratory Filtration
Other Civilian/Industry Standards	IP 424 - Determination of Fuel System Icing Inhibitor Content of Aviation Turbine Kerosenes by High Performance Liquid Chromatography
Other Civilian/Industry Standards	IP 435 - Determination of the Freezing Point of Aviation Turbine Fuels by the Automated Phase Transition Method
Other Civilian/Industry Standards	IP 436 - Determination of Aromatic Hydrocarbon Types in Aviation Fuels and Petroleum Distillates – High Performance Liquid Chromatography Method with Refractive Index Detection
Other Civilian/Industry Standards	IP 447 - Petroleum Products – Determination of Sulfur Content – Wavelength-Dispersive X- Ray Fluorescence Spectrometry
Other Civilian/Industry Standards	IP 475 - Petroleum Liquids – Manual Sampling (ISO 3170:2004)
Other Civilian/Industry Standards	IP 523 - Determination of Flash Point – Rapid Equilibrium Closed Cup Method
Other Civilian/Industry Standards	IP 528 - Determination of the Freezing Point of Aviation Turbine Fuels – Automated Fibre Optic Method

Other Civilian/Industry Standards	IP 529 - Determination of the Freezing Point of Aviation Fuels – Automatic Laser Method
Other Civilian/Industry Standards	IP 534: Determination of flash point - Small scale closed cup ramp method
Other Civilian/Industry Standards	IP 540 - Determination of the Existent Gum Content of Aviation Turbine Fuel – Jet Evaporation Method
Other Civilian/Industry Standards	IP 565 - Determination of the level of cleanliness of aviation turbine fuels - Portable automatic particle counter method
Other Civilian/Industry Standards	IP 568 - Determination of the static dissipater additives (SDA) in aviation turbine fuel and middle distillate fuels - HPLC Method
Other Civilian/Industry Standards	IP 577 - Determination of the level of cleanliness of aviation turbine fuel – Automatic particle counter method using light extinction
Other Civilian/Industry Standards	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 Civilian/Industry Standards	IP 598 - Determination of the smoke point of kerosene, manual and automated method
Other Civilian/Industry Standards	IP 624 – Determination of Water Separation Characteristics of Aviation Turbine Fuel by Small Scale Water Separation Instrument
Other Civilian/Industry Standards	JIG BULLETIN 150 - TESTING WATER SEPARATION PROPERTIES OF JET FUEL (REVISED MSEP PROTOCOL)
Other Civilian/Industry Standards	QPL 68-251 - Qualified Products List of Aircraft Materials to Def Stan 68-251
Other Civilian/Industry Standards	Rationale for The Establishment of a Minimum Limit for water separation characteristic by test method ASTM D8073 for Application to D1655
Other Civilian/Industry Standards	RR:D02-1886 Modification of ASTM D1655: Co-Processing of HEFA feedstocks with Petroleum Hydrocarbons for Jet Production using Hydrotreating & Hydrocracking
Other Civilian/Industry Standards	RR:D02-1929 Modification of ASTM D1655: Co-Processing of Fischer-Tropsch Feedstocks with Petroleum Hydrocarbons for Jet Production using Hydrotreating & Hydrocracking

Other Civilian/Industry Standards	RR:D02-2052 Modification of ASTM D1655: Co-Processing of Hydroprocessed Fatty Acids and Fatty Acid Esters with Petroleum Hydrocarbons for Jet Production
Other Civilian/Industry Standards	SAE ARP 1797A: Aircraft and Aircraft Engine Fuel Pump Low Lubricity Fluid Endurance Test
Other Civilian/Industry Standards	SAIB NE-09-25R2 Fuel - Jet Fuel Containing Fatty Acid Methyl Ester (FAME)
Other Civilian/Industry Standards	SwRI 08-04438 - Evaluation of Sasol Synthetic Kerosene for Suitability as Jet Fuel
Other Civilian/Industry Standards	SwRI 08-04438-2 - Evaluation of Sasol Synthetic Kerosene for Suitability as Jet Fuel. Phase II, Engine and Combustion Tests
Other Civilian/Industry Standards	SwRI 8531 - Qualification of Sasol Semi-Synthetic JET A-1 as Commercial Jet Fuel
Other Civilian/Industry Standards	OEA-001 – Defence Standard 91-091 Research Report: Co-Processing of HEFA Feedstocks with Petroleum Hydrocarbons for Jet Fuel Production using Hydrocracking

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 UK Defence Standardization Help Centre. Details of how to contact the Help Centre 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

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
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 Naphtha #1
HPLC	High Performance Liquid Chromatography
IATA	International Air Transport Association
IEC	International Electro-technical Commission
ILS	Inter-Laboratory Study
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
OEA	Operational Energy Authority
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
SAF	Synthetic Aviation Fuel
SASOL	Company trading name
SDA	Static Dissipator Additive
SwRI	Southwest Research Institute

UK	United Kingdom
VTR	Visual Tube Rating
WSD	Wear Scar Diameter

Changes Since Previous Issue

The changes incorporated in this issue are shown below. For more information, please contact DStan through the UK Defence Standardization Help Centre. Details of how to contact the Help Centre are shown on the outside rear cover of Defence Standards.

Clause	Page	Change	Change Reason
Section 2 Contents Tables	2-1	Replacement of "Fatty Acid Esters and Fatty Acids" by "Synthesized Kerosene".	Correction to align with title of Table 3 in Annex B.4 Page 2-17.
5.1	2-2	Addition of "from a single tank." To end of 1st sentence and additional sentences at the end.	Clarification. At the point of manufacture a representative sample can only be obtained from a single tank for the purposes of initial certification.
6.1 Note		Added: IP 367 Part 2: Petroleum and related products – Precision of measurement methods and results – Part 2: Interpretation and application of precision data in relation to methods of test.	IP 367 has been divided into parts, so the reference has been updated to reflect the relevant part.
Table 1 Tests 1.3	2-4	Particle counting becomes the referee method.	As indicated in Table 1 notes, this has been the intention of the Technical Authority for several years. Of the particle counting methods, IP 565 is chosen due to better precision. Alternate methods are listed in Annex E Table 5.
Table 1 Note 2	2-5	Note updated to reflect the change in referee method for particulate at the point of manufacture. Intention to withdraw IP 423 / ASTM D5452 by end 2028 stated.	IP 565 is now the referee method so references to other methods deleted and moved to Table 5. Due to poor precision method IP 423 / ASTM D5452 will be withdrawn by end 2028.
Table 1 Note 3	2-5	Note updated to reflect the change in referee method for particulate at the point of manufacture.	IP 565 is now the referee method so references to other methods deleted and moved to Table 5.
Table 1 Note 6		Text added: Hydroprocessing severity of the conventional blend components may not be known, either with or without synthetic components present (See **Annex D.2.3.1.** and **Annex D.3.1.1**) In these cases, "unknown" shall be reported and ASTM D5001 lubricity shall be determined.	To clarify the reporting requirements for blend components in relation to the requirement for lubricity testing.
Table 1 Note 17		Text added: Where the lubricity result is greater than the 0.85 mm wear scar it may be more practical to inject LIA downstream of initial certification or blend the batch (downstream of point of manufacture) to bring the lubricity result within the required limit. In this case the batch at point of manufacture shall be annotated thus: "Product meets requirements of	To clarify the reporting requirements where LIA has been blended downstream of initial certification.

		Defence Standard 91-091 except for lubricity, either addition of a qualified LIA to this batch or blending with another batch of jet fuel is required, Either corrective action requires a subsequent ASTM D5001 lubricity evaluation to ensure maximum 0.85 mm wear scar (see Annex A.5.4 and Annex F.3)".	
A.5.4		New clause.	To clarify the reporting requirements where LIA has been blended downstream of initial certification.
A.8	2-10	Use of Tracer A is not preferred. This section has been moved to Annex C.	Concern by the Airframe and Engine equipment manufacturers regarding the chemistry of Tracer A and its potential impact indicates that this additive is not preferred for use in leak detection and other methods should be used. Tracer A is still approved, but is now considered as an incidental material.
B.2.1 d)	2-11	Addition of "(This includes additional test property requirements currently including minimum aromatics (%v/v), distillation gradients, low temperature viscosity and lubricity),".	All requirements of ASTM D7566 Table 1 shall be met for fuels produced from non-conventional sources. In relation to aviation turbine fuel containing synthetic blending components approved in ASTM D7566 annexes, additional tests are mandated. The additional test requirements have been included to ensure full clarity in this Standard.
Table 3, Test 2.1		ASTM D8615 added.	New alternative freezing point method.
B.5.3 and B.5.4	2-19	Edited with additional details.	Guidance has been added to clarify the limitations for blending a semi-synthetic jet fuel.
B.5.5	2-19	Added "or co-processed" and "(See also D.3.2)".	Residual heels are covered for finished fuels in D.3.2 and it important to cross-reference this section to highlight that fuels produced from non-conventional sources can be designated as Defence Standard 91-091 Jet A-1.
C.4.3		Known to be present reinstated to sentence.	Correction of accidental deletion.
C5	2-21	This is a new clause, but is A.8 moved to Annex C.	Concern by the Airframe and Engine equipment manufacturers regarding the chemistry of Tracer A and its potential impact indicates that this additive is not preferred for use in leak detection and other methods should be used. Tracer A is still approved but is now considered as an incidental material.
D.1.5.2	2-23	(e.g. CoQ, COA or RT Certificate, whichever applies – note only a maximum of three new batches and the tank heel are permitted for recertification testing).	Correction of typographical error.

D.2.3.1b	2-25	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 system operator to trace back to the original documentation of all batches that make up the new batch.	Change to reflect the wider definition of fungible “systems”, as these are no longer restricted to pipelines.
D.3.1.1 b)	2-25	New ii) An ASTM D5001 BOCLE test demonstrates the product meets the test limits shown in Table 1. Note previous sub-bullet points ii), iii) and iv) become iii), iv) and v) respectively.	As non-Def Stan batches from other recognised international jet fuel specifications may contain non-conventional feedstocks that are not required to be listed on test reports, the mandatory requirement for a BOCLE test has been introduced to ensure the finished blend is fit for purpose.
E Table 5 1.3	2-27	IP 423 / ASTM D5452 and IP 577 moved from Table 1 to Table 5.	IP 565 has become the referee method, but these methods remain approved as alternative methods.
E Table 5 4.1		ASTM D8615 added.	New alternative Freezing Point method.
E Table 5 Note 1	2-27	New Note 1 Particulate contamination by gravimetric detemination with a limit of 1.0mg/l shall apply at point of manufacture only. It is the intention of the Technical Authority to withdraw this method by the end of 2028. Note that all existing notes have increased by one number to accommodate the new note 1.	As IP 423 / ASTM D5452 has been moved from Table 1 to Table 5 it is necessary to state the limit applicable to this method here. Due to poor precision, it is also the intention of the Technical Authority to withdraw the method by the end of 2028.

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File Reference

The DStan file reference relating to work on this standard is 00852/2026.

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