

**AVIATION FUEL QUALITY REQUIREMENTS FOR  
JOINTLY OPERATED SYSTEMS  
(AFQRJOS)**

This document has the agreement of: BP, Chevron, ENI, ExxonMobil, Kuwait Petroleum, Shell, Statoil, and Total. It defines the fuel quality requirements for supply into Jointly Operated Fuelling Systems.

The Aviation Fuel Quality Requirements for Jointly Operated Systems (AFQRJOS) for Jet A-1 embodies the most stringent requirements of the following two specifications:

- (a) British Ministry of Defence Standard DEF STAN 91-91/Issue 6, Amendment 1 of 25 August, 2008 for Turbine Fuel, Aviation Kerosene Type, Jet A-1, NATO Code F-35, Joint Service Designation AVTUR.
- (b) ASTM Standard Specification D 1655-08a for Aviation Turbine Fuels "Jet A-1".

Jet fuel that meets the AFQRJOS is usually referred to as "Jet A-1 to Check List", or "Check List Jet A-1" and, by definition, generally, meets the requirements of both of the above specifications.

The main table requirements in IATA Guidance Material for Aviation Turbine Fuels Specifications (GM) are no longer part of the Check List because Part I of the IATA GM is now a guide to specifications rather than a specification itself. However, the water and dirt limits for fuel at the point of delivery into aircraft, which are embodied in Part III of the IATA GM, remain part of Check List.

The Aviation Fuel Quality Requirements for Jointly Operated Systems for Jet A-1 are defined in the following table, which should be read in conjunction with the Notes on pages 3 to 5 of this document. The Notes highlight some of the main issues concerning the specification parameters.

In principle, conformance to AFQRJOS requires conformance to the detail of both specifications listed above, not just the following table. However, the JIG Product Quality Committee that publishes the Check List has decided to allow inclusion of some test methods that are not common to both parent specifications.

The reasons are that (1) there are some significant differences between the allowed test methods in DEF STAN 91/91 and ASTM D 1655, (2) there are variations in the availability of test equipment in different parts of the world and, (3) there is a desire to promote the adoption of more modern test methods.

**Therefore product tested using the test methods listed here meets the requirements for aviation fuel supply into Jointly Operated Systems. It does not necessarily meet the detailed test method requirements of both parent specifications. See Note 22 for guidance on statements declaring conformance to these specifications.**

Also, it should be specifically noted that DEF STAN 91-91/6 Am1 requires traceability of product to point of manufacture.

# JOINT FUELLING SYSTEM CHECK LIST FOR JET A-1

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Embodying the most stringent requirements in the following specifications for the grade shown:  
(a) British MoD DEF STAN 91-91/Issue 6, Amendment 1, dated 25 August 2008, Jet A-1.  
(b) ASTM D 1655-08a, Jet A-1.

PROPERTY	LIMITS	TEST METHOD		REMARKS
		IP	ASTM	
<b>APPEARANCE</b> Visual  Colour Particulate contamination, mg/l max Particulate, at point of manufacture, cumulative channel particle counts ISO Code ≥ 4 µm(c) ≥ 6 µm(c) ≥ 14 µm(c) ≥ 21 µm(c) ≥ 25 µm(c) ≥ 30 µm(c)	Clear, bright and visually free from solid matter and undissolved water at ambient temperature Report 1.0  Report Report Report Report Report	423  564 or 565	D 156 or D 6045 D 5452	See Note 1 See Note 2  See Note 2  See Notes 3 and 4
<b>COMPOSITION</b> Total Acidity, mg KOH/g max Aromatics, % vol. max OR Total Aromatics, % vol max Sulphur, Total, % mass max Sulphur, Mercaptan, % mass max OR Doctor Test Hydroprocessed components in batch, % vol. Severely hydroprocessed components in batch, % vol	0.015 25.0 26.5 0.30 0.0030 Negative Report (incl. 'nil' or '100%') Report (incl. 'nil' or '100%')	354 156 436 336 342 30	D 3242 D 1319 D 6379 D 1266 or D 2622 D 3227 D 4952	See Note 5 or D 4294 or D 5453  See Note 6 See Note 7 See Note 7
<b>VOLATILITY</b> Distillation Initial Boiling Point, °C Fuel Recovered 10% vol. at °C max 50% vol. at °C 90% vol. at °C End Point, °C max Residue, % vol. max Loss, % vol. max Flash Point, °C min Density at 15°C, kg/m³	Report  205.0 Report Report 300.0 1.5 1.5 38.0 775.0 min to 840.0 max	123        170 or 523 160 or 365	D 86        D 56 or D 3828 D 1298 or D 4052	See Note 8 Or IP 406 or D 2087, see Note 9        See Note 10
<b>FLUIDITY</b> Freezing Point, °C max  Viscosity at -20°C, cSt (mm²/s) max	- 47.0  8.000	16 or 435 or 528 or 529 71	D 2386 or D 5972 or D 7153 or D 7154 D 445	See Note 11
<b>COMBUSTION</b> Specific Energy, net, MJ/kg min Smoke Point, mm min OR Smoke Point, mm min AND Naphthalenes, % vol. max	42.80 25.0  19.0 3.00	57  57	D 3338 or D 4809 D 1322  D 1322 D 1840	See Note 12.
<b>CORROSION</b> Corrosion, Copper strip, classification (2 hours +/- 5 min. at 100 °C +/- 1°C) max	1	154	D 130	
<b>STABILITY</b> Thermal Stability (JFTOT) Control temperature, °C min Filter Pressure Differential, mm Hg max Tube Deposit Rating (Visual)	260 25.0 Less than 3, no 'Peacock' or 'Abnormal' colour deposits	323	D 3241	See Note 13
<b>CONTAMINANTS</b> Existent Gum, mg/100ml max  Microseparator (MSEP), rating Fuel with Static Dissipator Additive min OR Fuel without Static Dissipator Additive min	7  70 85	540  	D 381  D 3948	See Note 14
<b>CONDUCTIVITY</b> Electrical Conductivity, pS/m	50 min to 600 max	274	D 2624	See Note 15
<b>LUBRICITY</b> BOCLE wear scar diameter, mm max	0.85		D 5001	See Note 16
<b>ADDITIVES</b> (Names and approval codes from DEF-STAN 91-91/6 Am1 should be quoted on quality certificates). Antioxidant, mg/l in hydroprocessed & synthetic fuels (Mandatory) in non-hydroprocessed fuels (Optional) max Metal Deactivator, mg/l (Optional) max Static Dissipator, mg/l First Doping Re-doping  Antioxidants are mandatory in hydroprocessed fuels and synthetic fuels and must be added immediately after hydroprocessing or synthesising and prior to the product or component being passed into storage in order to prevent peroxidation and gum formation after manufacture. Fuel System Icing Inhibitor is not permitted unless agreed by all the participants in a joint system (see also Note 20). Corrosion Inhibitor/Lubricity Improver (C/LI) additive may be added to the fuel without prior consent of the joint system participants (see also Note 16).	17.0 min to 24.0 max 24.0 5.7  3.0			See Note 17  See Note 18  See Note 19  The types and concentrations of all additives used are to be shown on refinery Certificates of Quality and other quality documents. When additives are diluted (with hydrocarbon solvent only) to improve handling properties prior to addition, it is the concentration of the additive itself (prior to dilution) that shall be reported. See Annex A of DEF STAN 91-91/6 Am1 for detailed advice.  See Note 21 about requirements for management of change in refineries.

## Main Table Notes

- 1) The requirement to report Saybolt Colour shall apply at point of manufacture, thus enabling a colour change in 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 and investigated. For further information on the significance of colour see Annex E in DEF STAN 91-91/6 Amendment1.
- 2) This limit shall apply at point of manufacture only. For more information on particulate contamination refer to Annex F of DEF STAN 91-91/6 Am1. For guidance on contamination limits for into-plane fuelling refer to 6<sup>th</sup> Edition IATA Guidance Material (Part III). The implementation date for particle counting is 30th June 2009, but where possible, to help the data collection process, the results should be reported before that date. (To aid statistical analysis, reported results should include the measured cumulative counts as well as the ISO number). It is the Specification Authority's intention to replace the gravimetric membrane filtration test with Particle Counting at the earliest opportunity.
- 3) DEF STAN 91-91 and ASTM D1655 approve the Semi-Synthetic Jet Fuel (SSJF) produced by SASOL under approval reference FS(Air)ssjet/1. For SSJF, additional testing requirements apply and reference should be made to Annex D.4.1 of DEF STAN 91-91/6 Am1. This particular semi-synthetic fuel can be certified against this Issue of Check List. (Although Issue 6 Am1 of DEF STAN 91-91 also approves SASOL fully synthetic jet fuel, until it is approved also in ASTM D1655, it cannot be cited in this issue of the Checklist).
- 4) Concentrations of FAME (Fatty Acid Methyl Ester) greater than or equal to 5.0mg/kg are not acceptable. This does not require mandatory testing of every batch provided appropriate management controls are in place - see Section 5.5 and ANNEX G of DEF STAN 91-91/6 Am1 for details.
- 5) Round robin testing has demonstrated the correlation between total aromatics content measured by IP 156/ASTM D 1319 and IP 436/ASTM D 6379. 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/ASTM D1319 will be the referee method.
- 6) The Doctor Test is an alternative requirement to the Sulphur Mercaptan Content. In the event of conflict between the Sulphur Mercaptan and Doctor Test results, the Sulphur Mercaptan result shall prevail.
- 7) The need to report the %vol of hydroprocessed and severely hydroprocessed components (including "nil" or "100%" as appropriate) on refinery Certificates of Quality for Jet A-1 to Check List derives from DEF STAN 91-91/6 Am1. It relates to:
  - a) Antioxidant additives - additive dose rate cannot be interpreted unless the proportion of hydroprocessed fuel is known and therefore recipients of Jet A-1 cannot check or demonstrate that fuel complies with Check List if this information is omitted from refinery Certificates of Quality.
  - b) The requirement to report the volume % of severely hydroprocessed components as part of the lubricity requirement in DEF STAN 91-91/6 Am1. Note that "hydroprocessed" includes hydrotreated, hydrofined and hydrocracked. Severely hydroprocessed components are defined as petroleum derived hydrocarbons that have been subjected to hydrogen partial pressure of greater than 7000 kPa (70 bar or 1015 psi) during manufacture. The severely hydroprocessed components shall be reported on the certificate of quality as a percentage by volume of the total fuel in the batch.
- 8) In methods IP 123 and ASTM D 86 all fuels certified to this specification shall be classed as group 4, with a condenser temperature of zero to 4°C.

- 9) There are different requirements for the use of IP 406 or D 2887 as an alternate method between ASTM D 1655-08a and DEF STAN 91-91/6 Am1. ASTM allows the use of simulated distillation results directly with different limits, while DEF STAN requires a conversion of simulated distillation results to estimated IP 123 results using Annex G of IP 406. These different approaches were taken because of operational considerations rather than technical considerations; there is no intent that one approach is more restrictive than the other. If IP 406 is the method used to generate IP123 extrapolated data, there is no requirement to report residue or loss. IP 123 extrapolated data may also be used for the calculation of Specific Energy using ASTM D 3338.
- 10) Subject to a minimum of 40°C, results obtained by method ASTM D 56 (Tag) may be accepted.
- 11) These automatic methods are permitted; IP 16/ASTM D 2386 remains the referee method.
- 12) ASTM D 4529/IP 381 may be used where local regulations permit.
- 13) Examination of the heater tube to determine the Visual Tube Rating using the Visual Tuberator shall be carried out within 120 minutes of completion of the test. It is the Visual Tube Rating that should be reported. Attention is drawn to Note 13 in DEF STAN 91-91/6 Am1, which stresses that only approved heater tubes shall be used and lists JFTOT tubes from PAC-Alcor as being technically suitable.
- 14) Attention is drawn to Note 15 of DEF STAN 91-91/6 Am1 that states "No precision data are available for fuels containing SDA; if MSEP testing is carried out during downstream distribution, no specification limits apply and the results are not to be used as the sole reason for rejection of a fuel". A protocol giving guidelines on possible actions to be taken following failed MSEP testing can be found in the Joint Inspection Group's Bulletin Number 14, MSEP Protocol at [www.jointinspectiongroup.org](http://www.jointinspectiongroup.org) under 'fuel quality'.
- 15) Due to the requirements of DEF STAN 91-91/6 Am1, Conductivity limits are mandatory for product to meet this specification. However it is acknowledged that in some manufacturing and distribution systems it is more practical to inject SDA further downstream. In such cases, the Certificate of Quality for the batch should be annotated thus: "Product meets the requirements of AFQRJOS Check List 24 except for electrical conductivity". In some situations, the conductivity can decrease rapidly and the fuel can fail to respond to additional dosing with Stadis 450. In such cases, fuel may be released with conductivity down to a minimum of 25pS/m provided that the fuel is fully tested against the specification and the Tank Release Note is annotated with the explanation "Product released below 50pS/m due to conductivity loss as per Annex H of DEF STAN 91-91/6 Am 1".
- 16) This requirement comes from DEF STAN 91-91/6 Am1. The requirement to determine lubricity applies only to fuels containing more than 95% hydroprocessed material and where at least 20% of the total fuel volume is severely hydroprocessed (see Note 6 above) and for all fuels containing synthetic components. The limit applies only at the point of manufacture. For important advisory information on the lubricity of aviation turbine fuels see Annex B of DEF STAN 91-91/6 Am1.  
CI/LI additive (also known as LIA) may be used to improve lubricity; only those additives listed in Table 2 of ASTM D1655-08a are permitted. Refer also to Annex A.5 of DEF STAN 91-91/6 Am1 for advice on point of addition. When injecting CI/LI (LIA) downstream of point of manufacture, care must be taken to ensure that maximum dose rates are not exceeded.
- 17) Approved antioxidant additives are listed in Annex A.2.4 of DEF STAN 91-91/6 Am1, together with the appropriate RDE/A/XXX- Qualification Reference for quoting on refinery Certificates of Quality. Refer also to Annex A.2.6 for requirements for reporting additions on the CoQ.
- 18) The approved Metal Deactivator Additive (MDA), RDE/A/650 appears in Annex A.3 of DEF STAN 91-91/6 Am1. See also Annex A.3.1 about the need to report thermal stability before and after using when contamination of Jet A-1 by any of the trace metals listed in this Annex is unproven. Note also in A.3.3 that maximum doping at the point of manufacture or on initial doping is limited to 2mg/l.



19) Re-doping limits for Static Dissipator additive are:

Cumulative concentration                      Stadis® 450 (RDE/A/621)      5.0 mg/l

Original dosage not known:

Additional concentration                      Stadis® 450 (RDE/A/621)      2.0 mg/l

20) Concentrations of Fuel System Icing Inhibitor (FSII) 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. This does not allow the continuous FSII addition at these low concentrations.

21) Attention is drawn to the guidance in DEF STAN 91-91/6 Am1 and ASTM D 1655-08a concerning the need for appropriate management of change measures in refineries manufacturing jet fuel. The implications of any changes to feedstock, processing conditions or process additives on finished product quality and performance need to be considered (for example, experience has shown that some process additives might be carried over in trace quantities into aviation fuels).

22) It is normal to certify conformance to specifications with statements like "It is certified that the samples have been tested using the Test Methods stated and that the Batch represented by the samples conforms to AFQRJOS Checklist Issue 24". Where applicable, Batch Certificates may also confirm, specifically, compliance with DEF STAN 91-91 (latest issue) and/or ASTM D 1655 (latest issue).

The minimum requirements for information to be included on the fuel's refinery batch test certificate are given below:

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

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