

**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 7 Amendment 1, 16 December, 2011 for Turbine Fuel, Kerosene Type, Jet A-1, NATO Code F-35, Joint Service Designation: AVTUR.
- (b) ASTM Standard Specification D 1655-11b 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 that follow the table. The Notes highlight some of the main issues concerning the specification parameters.

Conformance to AFQRJOS requires conformance to the detail of both specifications listed above, not just the following table. See Note 22 for guidance on statements declaring conformance to these specifications.

Also, it should be specifically noted that DEF STAN 91-91/7 Amendment 1 requires traceability of product to point of manufacture and requirements applicable to fuels containing synthetic or renewable components. See Annexes J and D of DEFSTAN 91-91/7 Amendment 1 for more information.

**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 7, Amendment 1, dated 16 December 2011, Jet A-1.  
(b) ASTM D 1655 – 11b, Jet A-1.

PROPERTY	LIMITS	TEST METHOD		REMARKS
		IP	ASTM	
<b>APPEARANCE</b> Visual appearance	Clear, bright and visually free from solid matter and un-dissolved water at ambient fuel temperature			
Colour	Report		D 156 or D 6045	See Note 1
Particulate contamination mg/L max	1.0	423	D 5452	See Note 2
Particulate, cumulative channel particle counts, ISO Code & Individual Channel Counts		564 or 565 or 577		See Note 3
≥ 4 µm(c)	Report			
≥ 6 µm(c)	Report			
≥ 14 µm(c)	Report			
≥ 21 µm(c)	Report			
≥ 25 µm(c)	Report			
≥ 30 µm(c)	Report			
<b>COMPOSITION</b>				See Note 4 and 5
Total Acidity, mg KOH/g max	0.015	354	D 3242	
Aromatics, % v/v max	25.0	156	D 1319	
OR Total Aromatics, % v/v max	26.5	436	D 6379	See Note 6
Sulphur, Total, % m/m max	0.30	336	D 1266 or D 2622	or D 4294 or D 5453
Sulphur, Mercaptan, % m/m max	0.0030	342	D 3227	
OR Doctor Test	Negative	30	D 4952	See Note 7
<b>Refinery Components at point of manufacture:</b>				See Note 8
Non Hydroprocessed Components, %v/v	Report (incl. 'nil' or '100%')			
Mildly Hydroprocessed Components, % v/v	Report (incl. 'nil' or '100%')			
Severely Hydroprocessed Components, % v/v	Report (incl. 'nil' or '100%')			
Synthetic Components, %v/v	Report (incl. 'nil' or '50%')			See Note 4 for limits for synthetic components
<b>VOLATILITY</b>				
Distillation		123	D 86	See Note 9
Initial Boiling Point, °C	Report			Or IP 406 or D 2887, see Note 10
Fuel Recovered				
10% v/v at °C max	205.0			
50% v/v at °C	Report			
90% v/v at °C	Report			
End Point, °C max	300.0			
Residue, % v/v max	1.5			
Loss, % v/v max	1.5			
Flash Point, °C min	38.0	170 or 523	D 56 or D 3828	See Note 11
Density at 15°C, kg/m³	775.0 min to 840.0 max	160 or 365	D 1298 or D 4052	
<b>FLUIDITY</b>				
Freezing Point, °C max	- 47.0	16 or 435 or 528 or 529	D 2386 or D 5972 or D 7153 or D 7154	See Note 12
Viscosity at -20°C, mm <sup>2</sup> /s(cSt) max	8.000	71	D 445	
<b>COMBUSTION</b>				
Specific Energy, net, MJ/kg min	42.80	12 or 355	D 3338 or D 4809	See Note 13
Smoke Point, mm min	25.0	57	D 1322	
OR				
Smoke Point, mm min	19.0	57	D 1322	
AND Naphthalenes, % vol. max	3.00		D 1840	
<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)		323	D 3241	See Note 14
Control temperature, °C min	260			
Filter Pressure Differential, mm Hg max	25			
Tube Deposit Rating (Visual)	Less than 3, no 'Peacock' or 'Abnormal' colour deposits			

<b>CONTAMINANTS</b>					
Existent Gum, mg/100ml	max	7	540	D 381	See Note 15
Microseparometer (MSEP), rating Fuel with Static Dissipator Additive	min	70		D 3948	
<b>OR</b> Fuel without Static Dissipator Additive	min	85			
<b>CONDUCTIVITY</b>					
Electrical Conductivity, pS/m		50 min to 600 max	274	D 2624	See Note 16
<b>LUBRICITY</b>					
BOCLE wear scar diameter, mm	max	0.85		D 5001	See Note 17
<b>ADDITIVES</b> (Names and approval code from DEF-STAN 91-91/7 should be quoted on quality certificates).					
<b>Antioxidant, mg/l</b> in hydroprocessed & synthetic fuels (Mandatory) in non-hydroprocessed fuels (Optional)	max	17.0 min to 24.0 max 24.0			See Note 18
<b>Metal Deactivator, mg/l (Optional) *</b> First Doping Cumulative concentration after field re-doping	max	2.0 5.7			See Note 19
<b>Static Dissipator, mg/l *</b> First Doping Cumulative concentration after field re-doping	max	3.0 5.0			
<p>Antioxidants are mandatory in hydroprocessed fuels and synthetic fuels and <b>must</b> 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</p> <p>Fuel System Icing Inhibitor is not permitted unless agreed by all the participants in a joint system (see also Note 20).</p> <p>Corrosion Inhibitor/Lubricity Improver (CI/LI) additive may be added to the fuel without prior consent of the joint system participants (see also Note 17)</p>				<p>The types and concentrations of <b>all</b> additives used are to be shown on the original Certificates of Quality and on all other quality documents when they are added downstream of the point of manufacture. When additives are diluted (with hydrocarbon solvent only) to improve handling properties prior to addition, it is the concentration of active ingredient that shall be reported. See Annex A of DEF STAN 91-91/7 Amendment 1 for detailed advice.</p> <p>See Note 21 about requirements for management of change in refineries.</p> <p>* When the original dosage of additives is unknown, it has to be assumed that first doping was applied at maximum dose rate.</p>	

## 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 91-91/7 Amendment 1.
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 Issue 7 Amendment 1. For guidance on contamination limits for into-plane fuelling refer to 5<sup>th</sup> Edition IATA Guidance Material (Part III).
3. This requirement shall apply at point of manufacture only. Both the number of particles and the number of particles as a scale number as defined by Table 1 of ISO 4406:1999 shall be reported. It is the Specification Authority's intention to replace the gravimetric Millipore test with Particle Counting at the earliest opportunity.
4. Attention is drawn to DEF STAN 91-91 Issue 7 Amendment 1, which approves both Semi-Synthetic and Fully Synthetic Jet Fuel produced by SASOL. It also approves two generic components, a) up to 50% of Synthetic Paraffinic Kerosine certified as meeting the

requirements of ASTM D7566 Annex A1 and b) up to 50% Hydrogenated Esters and Fatty Acids certified as meeting the requirements of ASTM D 7566 Annex A2. For these fuels, additional testing requirements apply and reference should be made to DEF STAN 91-91/7 Amendment 1 Annex D. These particular semi- and fully synthetic fuels can be certified against this Issue of Check List. The volume percentage of each synthetic blending component shall be recorded along with its corresponding release Specification and Annex number, product originator and originator's Certificate of Quality number. From the point of manufacture to the point of blending to meet this specification, the synthetic component shall be handled, transported and documented in the same manner as finished jet fuel in order to maintain product integrity. Special care shall be taken to ensure homogeneity when blending semi-synthetic jet fuel, particularly where the component densities are significantly different. See also Note 10 in DEF STAN 91/91/7 Amendment 1 on minimum aromatic content.

5. Concentrations of FAME (Fatty Acid Methyl Ester) greater than or equal to 5.0 mg/kg are not acceptable. See section 5.6 and Annex G of DEFSTAN 91-91/7 Amendment 1 for details
6. 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 D 1319 will be the referee method. It is the intention of the DEF STAN 91/91 Technical Authority to change the referee method to IP 436 at a later date.
7. 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.
8. The need to report the %v/v of non hydroprocessed, mildly hydroprocessed, severely hydroprocessed and synthetic components (including "nil", "50%" or "100%" as appropriate) on refinery Certificates of Quality for Jet A-1 to Check List derives from DEF STAN 91-91/7 Amendment 1.

Each refinery component 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. **Mildly hydroprocessed** components are defined as those petroleum derived hydrocarbons that have been subjected to a hydrogen partial pressure of **less than** 7000 kPa (70 bar or 1015 psi) during manufacture. **Severely hydroprocessed** components are defined as those petroleum derived hydrocarbons that have been subjected to a hydrogen partial pressure of **greater than** 7000 kPa (70 bar or 1015 psi) during manufacture. The total of non-hydroprocessed plus mildly hydroprocessed plus severely hydroprocessed plus synthetic components shall equal 100%.

9. 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.
10. If IP 406 or ASTM D 2887 are used to produce IP123 equivalent or ASTM D 86 correlated data, there is no requirement to report residue or loss.
11. Subject to a minimum of 40°C, results obtained by method ASTM D 56 (Tag) may be accepted. The referee test method is IP 170.
12. These automatic methods are permitted; IP 16/ASTM D 2386 remains the referee method.

13. ASTM D 4529/IP 381 may be used where local regulations permit.
14. 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 Method that should be reported. Attention is drawn to Note 15 in DEF STAN 91-91/7 Amendment 1, which stresses that only approved heater tubes shall be used and lists heater tubes from PAC-Alcor and Falex as being technically suitable.
15. Attention is drawn to Note 17 of DEF STAN 91-91/7 Amendment 1 that states "Where SDA is added at point of manufacture the MSEP limit of 70 shall apply. No precision data are available for fuels containing SDA; if MSEP testing is carried out during downstream distribution, no specification limits apply and the results are not to be used as the sole reason for rejection of a fuel. A protocol giving guidelines on possible actions to be taken following failed MSEP testing can be found in the Joint Inspection Group's Bulletin Number 14, MSEP Protocol at [www.jointinspectiongroup.org](http://www.jointinspectiongroup.org) under "Fuel Quality". Where SDA is added downstream of point of manufacture, it is acknowledged that MSEP results may be less than 70.
16. Due to the requirements of DEF STAN 91-91/7 Amendment 1, 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 26 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 DEFSTAN 91-91/7 Amendment 1"
17. This requirement comes from DEF STAN 91-91/7 Amendment 1. The requirement to determine lubricity applies only to fuels whose composition is made up of a) at least 20% of severely hydroprocessed components and less than 5% of non-hydroprocessed components or b) includes synthesised fuel 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 91-91/7 Amendment 1. CI/LI additive (also known as LIA) may be used to improve lubricity; only those additives listed in Table 2 of ASTM D1655-11b/ Annex A of DEFSTAN 91-91/7 Amendment 1 are permitted. Note that two additional additives have been added to the list in DEF STAN 91-91/7 Amendment 1. Refer also to Appendix A.5 of DEF STAN 91-91/7 Amendment 1 for advice on point of addition. When injecting CI/LI downstream of point of manufacture, care must be taken to ensure that maximum dose rates are not exceeded.
18. Approved antioxidant additives are listed in Annex A.2.4 of DEF STAN 91-91/7 Amendment 1, 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 C of Q.
19. The approved Metal Deactivator Additive (MDA), RDE/A/650 appears in Annex A.3 of DEF STAN 91-91/7 Amendment 1. 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 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 permit the continuous addition of FSII at these low concentrations. Attention is drawn to the new note in Annex A.6 in DEF STAN 91-91/7 Amendment 1 highlighting that filter monitors cannot be used with fuel containing FSII.
21. Attention is drawn to the guidance in DEF STAN 91-91/7 Amendment 1 and ASTM D 1655-11b 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 a primary specification. The following statements are recommended.

“It is certified that the samples have been tested using the Test Methods stated and that the Batch represented by the samples conforms with DEF STAN 91-91 Issue 7 Amendment 1 and AFQRJOS Checklist Issue 26”.

Or

“It is certified that the samples have been tested using the Test Methods stated and that the Batch represented by the samples conforms with ASTM D 1655-11b and AFQRJOS Checklist Issue 26”.

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