AVIATION FUEL QUALITY REQUIREMENTS FOR JOINTLY OPERATED SYSTEMS

(AFQRJOS): Issue 31 – NOV 2019 (supersedes Issue 30 – NOV 2018)

This document defines the fuel quality requirements for supply into Jointly Operated Fuelling Systems operated to JIG Standards. The Aviation Fuel Quality Requirements for Jointly Operated Systems (AFQRJOS) for Jet A-1 embodies the requirements of the following two specifications:

(a) British Ministry of Defence Standard DEF STAN 91-091/Issue 11 28th October 2019 for Turbine Fuel, Kerosene Type, Jet A-1, NATO Code F-35, Joint Service Designation: AVTUR.

(b) ASTM Standard Specification D1655 for Aviation Turbine Fuels "Jet A-1" (Latest issue).

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, allows custodians of the fuel to supply against either of these specifications.

AFQRJOS is normally revised and published annually but if urgent issues need to be addressed it may be revised more frequently.

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. Specifically of note, Issue 31 introduces the following changes:

- Information included on suitable Fluorescent Indicator Dyed Gel to be used when measuring Aromatic Content by ASTM D1319 or IP 156.
- The change of mandatory requirement for antioxidant in hydroprocessed fuels to an optional requirement in fuel manufactured from petroleum sources (refer to Clause 4 'Materials' in Defence Standard 91-091 and Section 6 'Materials and Manufacture' in ASTM D1655). The requirement to use an antioxidant in fuels produced to ASTM D7566 remains.
- Approval of co-processing of mono-, di-, and triglycerides, free fatty acids and fatty acid esters producing co-hydroprocessed hydrocarbon synthetic kerosene as an acceptable process for jet fuel manufacture as controlled by Defence Standard 91-091 and ASTM D1655.
- Clarification of the requirements for reporting DRA content and the use of fuels containing DRA
- Addition of Test Method D7945 - Standard Test Method for Determination of Dynamic Viscosity and Derived Kinematic Viscosity of Liquids by Constant Pressure Viscometer.

Clarification on the statements to be used when certifying fuel detailed in Note 27, Conformance to AFQRJOS requires conformance to the detail of both specifications listed above, not just the following table. See Notes 27 for further guidance on statements declaring conformance to these specifications. Airports operated to JIG Standards may supply jet fuel to either of the parent specifications listed above provided the participants agree.

It should be specifically noted that DEF STAN 91-091/11 requires traceability of product to point of manufacture and requirements applicable to fuels containing synthetic or renewable components. See Annexes D and B of DEFSTAN 91-091/11 for more information.

Note: Before fuel containing synthetic components may be delivered to a NATO aircraft it shall be ascertained that the appropriate clearance document(s) permitting its use have been obtained according to contract. This may restrict supply of fuel containing synthetic components in some pipeline systems with direct connections to NATO storage locations.

JOINT FUELLING SYSTEM CHECK LIST FOR JET A-1

Issue 31 – November 2019

Supersedes Issue 30 - November 2018

Embodying the requirements of the following specifications for the grade shown:

(a) British MoD DEF STAN 91-091/Issue 11, dated 28th October 2019, Jet A-1

(b) ASTM D1655 – Jet A-1 Latest Issue

PROPERTY		LIMITS	TEST METHOD		REMARKS
			IP	ASTM	
APPEARANCE					
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			
COMPOSITION					See Note 4,5
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
Refinery Components at point of manufacture:					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
INCIDENTAL MATERIALS					See Notes 9
VOLATILITY					
Distillation			123	D 86	or D7345., See Note 10
Initial Boiling Point, ºC		Report			
Fuel Recovered					See Note
10% v/v at ºC	max	205.0			Or IP 406 or D 2887,
50% v/v at ºC		Report			see Note 11
90% v/v at ºC		Report			
End Point, ºC	max	300.0			
Residue, % v/v	max	1.5			
Loss, % v/v	max	1.5			
Flash Point, ºC	min	38.0	170 or 523	D 56 or D 3828	
Density at 15ºC, kg/m³		775.0 min to 840.0 max	160 or 365	D 1298 or D 4052	12
FLUIDITY					
Freezing Point, ºC	max	- 47.0	16 or 435 or 528 or 529	D 2386 or D 5972 or D 7153 or D 7154	See Notes 13 and 14
Viscosity at -20ºC, mm^2/s(cSt)	max	8.000	71	D 445	D7945 or D7042, See Note 15
COMBUSTION					
Specific Energy, net, MJ/kg	min	42.80	12 or 355	D 3338 or D 4809	See Note 16
Smoke Point, mm	min	25.0	598	D 1322	See Note 17
OR					
Smoke Point, mm	min	18.0	598	D 1322	See Note 17
AND Naphthalenes, % vol.	max	3.00		D 1840	

CORROSION Corrosion, Copper strip, classification (2 hours +/- 5 min. at 100 ºC +/- 1ºC)	max	1	154	D 130	
STABILITY Thermal Stability (JFTOT) Control temperature, ºC Filter Pressure Differential, mm Hg One of the following requirements shall be met: (1) Annex B VTR (2) Annex C ITR or Annex D ETR, average over area of 2.5mm^2	 min max nm max	 260 25 Less than 3, no 'Peacock' or 'Abnormal' colour deposits 85	323	D 3241	See Note 18
CONTAMINANTS Existent Gum, mg/100ml Microseparometer (MSEP), rating Fuel with Static Dissipator Additive **OR** Fuel without Static Dissipator Additive	max min min	7 70 85	540	D 381 D 3948	 See Note 19
CONDUCTIVITY Electrical Conductivity, pS/m		50 min to 600 max	274	D 2624	See Note 20
LUBRICITY BOCLE wear scar diameter, mm	max	0.85		D 5001	See Note 21
ADDITIVES (Names and approval code from DEF STAN 91-091 should be quoted on quality certificates). **Antioxidant**, mg/l in final batch (Optional) **Metal Deactivator**, mg/l (Optional) * First Doping Cumulative concentration after field re-doping **Static Dissipator**, mg/l * First Doping Cumulative concentration after field re-doping	 max max max 	 24.0 2.0 5.7 3.0 5.0			 See Note 22 See Note 23 See Note 24

Antioxidants are still mandatory for synthetic fuels and **shall** be added prior to or during release from the designated manufacturing site of the ASTM D7566 component.

Fuel System Icing Inhibitor is not permitted unless agreed by all the participants in a joint system (see also Note 25).

Lubricity Improver Additive (LIA) additive may be added to the fuel without prior consent of the joint system participants (see also Note 21)

The types and concentrations of **all** additives used shall 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 91-091 for detailed advice.

See Note 26 about requirements for management of change in refineries.

* When the original dosage of additives is unknown, it has to be assumed that first doping was applied at maximum dose rate.

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 F in DEF STAN 91-091/11.
2. This limit shall apply at point of manufacture only. For more information on particulate contamination refer to Annex F of DEF STAN 91-091 Issue 11. For guidance on contamination limits for into-plane fuelling refer to 7th 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 91-091 Issue 11 which approves both Semi-Synthetic and Fully Synthetic Jet Fuel produced by SASOL. It also approves all the generic components listed in the Annexes of ASTM D7566. For these fuels, additional testing requirements apply, and reference should be made to DEF STAN 91-091/11 Annex B. These semi- and fully synthetic fuels may 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. DEF STAN 91-091/11 also states that blending of synthetic fuels shall take place upstream of airports.
5. The Coprocessing of mono-, di- and triglycerides, free fatty acids and fatty acid esters has been approved in Defence Standard 91-091 Issue 11 in alignment with ASTM D1655. The requirements for coprocessing are detailed in Annex B4 of Defence Standard 91-091 Issue 11 and Annex A1.1.2.2 of ASTM D1655.

   The Refinery Certificate of Quality (RCQ) shall include wording to reflect that the batch may contain up to 5 % by volume co-hydroprocessed synthesized kerosene.
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 shall be the referee method. It is the intention of the DEF STAN 91-091 Technical Authority to change the referee method to IP 436 at a later date.

   The proprietary dye necessary to conduct that IP156/ ASTM D1319 is no longer available. In addition, recently delivered supplies of the product gel containing the dye with lot numbers 3000000975 and above were produced with a substitute dye that is unfortunately not suitable and will not provide accurate measurements of aromatic concentration if utilised. Given the above, if IP 156 or ASTM D1319 is used for analysis of Aromatics, the lot number of the gel used shall be reported on the test certificate.

   When the aromatic level is needed to be determined, Jet A-1 fuel will only meet the aviation fuel operating limitations of airplanes certificated to operate on Jet A-1 fuel and the requirements of Def Stan 91-091 if:

1) the fuel has been tested for aromatics concentration in accordance with ASTM D1319/IP156 with a dye from lot number 3000000974 or lower

or

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

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

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 91-091/11. Each of the defined refinery 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. **Mildly hydroprocessed** components are defined as those petroleum derived hydrocarbons that have been subjected to a hydrogen partial pressure **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. Table 2 Incidental materials

Material	Maximum permitted level	Detection Level	Test methods
Fatty acid methyl ester (FAME)[a,b,c,]	50 mg/kg		D7797/IP583, IP585[d], IP590, IP599
Pipeline Drag Reducer (DRA)	Nil	72 µg/l[e,f]	D7872

a) Post manufacture each custodian shall undertake a risk assessment to quantify the potential risk of incidental material carry over. Where such assessments indicate that there could be a potential risk in jet fuel supplies, additional quality assurance procedures shall be introduced to increase control in order to mitigate the risk. Where the risk of incidental material carryover exists and it is not possible to control with additional quality assurance procedures, testing shall be instigated.

b) For the purposes of meeting this requirement, FAME is defined as material meeting the limits of EN14214 or ASTM D6751. Fatty acid methyl esters that fail to meet biodiesel standards are not permitted in jet fuel.1

c) On an emergency basis, up to 100 mg/kg FAME is permitted in jet fuel when authorised by the airframe and engine manufacturers and managed in compliance with airframe and engine requirements. For Military purposes an emergency basis can be defined as an unexpected and unforeseen situation that requires prompt action. For example, where FAME contamination has been introduced into part of an airport distribution system where it cannot be quickly segregated or isolated for remediation without halting airport refuelling operations. All such instances should be raised through the procurement Authority, Duty Holder or Aircraft Operator. For commercial operators

refer to SAIB NE-09-25R2 dated May 19, 2016, which provides corrective actions and procedures to be followed in the event of FAME contamination.

d) Test method IP585 shall be the referee method.

e) 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

f) 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 or is to be added into other products in a multiproduct pipeline system which is also transporting jet fuel.

10. 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. Where ASTM D 7345 is used, results shall be corrected for relative bias as described in the test method.

11. 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.

12. 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.

13. These automatic methods are permitted; IP 16/ASTM D 2386 remains the referee method.

14. During downstream distribution if the freezing point of the fuel is very low and cannot be reported when measured by IP 16 the limit is max -65 degrees C. If no crystals appear during cooling of the fuel and when the thermometer indicates a temperature of –65°C, the freezing point shall be recorded as below –65°C. This limit does not apply if the freezing point is measured by IP435/ASTM D5972, IP 529/ASTM D7153, IP528 or ASTM D7154.

15. Test method ASTM D 7042 results shall be converted to bias-corrected kinematic viscosity results as described in the precision and bias section of ASTM D7042.

16. ASTM D 4529/IP 381 may be used where local regulations permit.

17. The IP 598 test for smoke point includes both the standard manual method and an automatic method, with the automated method in IP 598 being the referee method.

18. The annexes referred to in the Table 1 and this note correspond to those in IP323. If the technically equivalent ASTM D3241 test method is used, the same protocol shall be followed using the appropriate annex that corresponds to the visual (VTR), interferometric (ITR) or ellipsometric (ETR) method. Tube deposit ratings shall be measured by IP323 Annex C ITR or Annex D ETR, when available. If the Annex C ITR device reports "N/A" for a tube's volume measurement, the test shall be a failure and the value reported as >85 nm. Visual rating of the heater tube shall be by the method in IP323 Annex B is not required when Annex C ITR or Annex D ETR deposit thickness measurements are reported. In case of dispute between results from visual and metrological methods, the metrological method shall be considered the referee.
Examination of the heater tube to determine the Visual Tube Rating using the Visual Tube Rater or deposit thickness by ETR or ITR shall be carried out within 120 minutes of completion of the test.

19. Note that neither of the primary Standards mandate the testing of water separation properties downstream of the point of manufacture. Water separation property testing by ASTM D3948 is a mandatory requirement only at point of manufacture. Where it is required by JIG Standards for the purposes of product quality management, the following methods and limits shall apply:

Test Method	Limits
ASTM D7224	85 min
ASTM D8073	88 min

Table 3. Water Separation Limits Downstream of Point of Manufacture

JIG intends that future versions of Checklist will permit only the methods listed in Table 3 for determining water separation downstream of manufacture. On an interim basis, JIG continues to permit the use of ASTM D3948. Where ASTM D3948 is used, it should be noted that this test method can be sensitive to weak surfactants, which can result in the reporting of results less than 70. When this occurs, it is acceptable to release the fuel if it meets one of the limits listed in Table 3 above.

This protocol is also referenced in Note 18 of Def Stan 91-091/11.

20. Due to the requirements of DEF STAN 91-091/11, 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 31 except for electrical conductivity". In some situations, the conductivity can decrease rapidly, and the fuel can fail to respond to additional dosing with Static Dissipator Additive(s). 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 F of DEFSTAN 91-091/11".

21. This requirement comes from DEF STAN 91-091/11. 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% non-hydroprocessed components or b) includes synthetic fuel components. The limit applies only at the point of manufacture. For important advisory information on the lubricity of aviation turbine fuels see Annex F of DEF STAN 91-091/11. LIA additive (also known as LIA) may be used to improve lubricity; only those additives listed in Table 2 of ASTM D1655 / Annex A of DEF STAN 91-091/11 are permitted. Refer also to Appendix A.5 of DEF STAN 91-091/11 for advice on point of addition. When injecting LIA downstream of point of manufacture, care shall be taken to ensure that maximum dose rates are not exceeded.

22. The use of anti-oxidant is optional.

23. If it is added the maximum limit is 24 mg/l. Approved antioxidant additives are listed in Annex A.2.5 of DEF STAN 91-091/11, together with the appropriate RDE/A/XXX- Qualification Reference for quoting on Refinery Certificates of Quality or Certificates of Analysis.

24. The approved Metal Deactivator Additive (MDA), RDE/A/650 appears in Annex A.3 of DEF STAN 91-091/11 Annex A3.1 of DEF STAN 91-091/11 contains restrictions on the use of MDA at the point of manufacture and directs the producer

to the reporting requirements when MDA is used at the point of manufacture. Note that routine use of MDA (>5% of batches) at the point of manufacture is not permitted. The use of MDA at the point of manufacture is limited to 2.0 mg/l, except when copper contamination within the supply chain is known. See also Annex A.3.1 for the use of MDA in the supply chain, which includes the need to report thermal stability before and after MDA use.

25. Concentrations of Fuel System Icing Inhibitor (FSII) less than 0.02% by volume may 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 note in Annex A.6 in DEF STAN 91-091/11 highlighting that filter monitors cannot be used with fuel containing FSII.

26. Attention is drawn to the guidance in DEF STAN 91-091/11 and ASTM D1655 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 shall be considered (for example, experience has shown that some process additives might be carried over in trace quantities into aviation fuels).

27. Test certificates shall state conformance to a primary specification. Checklist is not a specification and manufacturing locations shall not release fuel only to Checklist. If reference to Checklist is to be made the following statement should be used if the fuel meets the requirements of this bulletin.

"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 91-091 Issue 11 and AFQRJOS Checklist Issue 31".
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 D1655 and AFQRJOS Checklist Issue 31".

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

- Specification name, issue and any amendment number;
- Name, telephone number, fax number, email address and postal address of testing laboratory;
- Tank Number;
- 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.

Actions to Implement this Bulletin (See Table 2 for Action Type Codes)

Action Description	Action Type	Target Completion Date
In-scope Operations, testing laboratories and other entities using or referring to JIG AFQRJOS Checklist shall implement JIG AFQRJOS Issue 31, with an implementation date no later than 28th January 2020.	JS	28/01/2020

Table 2 Action Type Codes

Action Types	JIG Bulletin Action Type Definition
JS	Change to JIG Standard – to be adopted by JV and/or Operator to continue to meet the JIG Standard(s) (JIG 1, 2, 4, EI/JIG 1530 and the JIG HSSE Management System).
RA	Required Action to implement one off verification or checks outlined in the table of actions.
RP	JIG Recommended Practice which the JV should consider adopting as its own practice (**).
I	Issued for information purposes only.
Note (**) - If the JV agreements require any of the JIG Standards and/or any of the JIG Common Processes as the governing operational standard then adoption of changes to applicable JIG Standards and/or Common Processes should not be considered optional by the JV Board.	