Product specifications
AVIATION KEROSENE JET A-1

PROPERTY	UNITS	LIMITS		TEST METHODS (1)	
				ASTM STANDARDS	IP STANDARDS
Appearance		Clear, bright and visually free from solid matter and undissolved water at ambient temperature.		Visual	
Saybolt color (2)		report		D 156 D 6045	
Particulate contamination (3) or	mg/l	maximum 1,0		D 5452	IP 423
Particles per channel (4)	Particles per channel & ISO code	Channel counts	ISO Code		IP 565 IP 577
≥ 4 µm(c)		report	maximum 19		
≥ 6 µm(c)		report	maximum 17		
≥ 14 µm(c)		report	maximum 14		
≥ 21 µm(c)		report	report		
≥ 25 µm(c)		report	report		
≥ 30 µm(c)		report	maximum 13		
Total acidity	mg KOH/g	maximum 0,015		D 3242	IP 354
Aromatic hydrocarbon types: (5 y 6)					
Aromatics or	% V/V	maximum 25,0		D 1319	IP 156
Total Aromatics	% V/V	maximum 26,5		D 6379	IP 436
Sulfur, Total	% m/m	maximum 0,30			IP 336
Sulfur, Mercaptan (7) or	% m/m	maximum 0,0030		D 3227	IP 342
Doctor Test		Doctor Negative			IP 30
Refining components, at point of manufacture (8):					
Non-hydroprocessed components	% V/V	report			
Severely hydroprocessed components	% V/V	report			
Synthetic components (9)	% V/V	report			
Distillation (10):				D 86	IP 123
Initial Boiling point	°C	report			
10 % V/V recovery	°C	maximum 205.0			
50 % V/V recovery	°C	report			
90 % V/V recovery	°C	report			
End Point	°C	maximum 300.0			
Residue	% V/V	maximum 1,5			
Loss	% V/V	maximum 1,5			
Flash point	°C	minimum 38.0			IP 170
Density at 15 °C	kg/m³	775,0 a 840,0		D 4052	IP 365
Freezing point (11)	°C	maximum -47.0		D 2386	IP 16
Viscosity at -20 °C	mm²/s	maximum 8,000		D 445	IP 71
Smoke point (12) or	mm	minimum 25,0		D 1322	IP 598
Smoke point (12) and	mm	minimum 18,0		D 1322	IP 598
Naphthalenes	% V/V	maximum 3,00		D 1840	
Specific energy	MJ/kg	minimum 42,80		(13)	
Copper corrosion (14)	Class	maximum 1b		D 130	IP 154

PROPERTY	UNITS	LIMITS	TEST METHODS (1)	
			ASTM STANDARDS	IP STANDARDS
Thermal stability (JFTOT) (15): Test temperature tube rating Tube evaluation, one of the following requirements shall be met (16) (17): 1) VTR or 2) ITR or ETR, average over area of 2.5 mm^2 Pressure differential	 °C nm mm Hg	 minimum 260 maximum <3. No peacock (P) or abnormal deposits (A) maximum 85 maximum 25	D 3241	IP 323
Existent Gum	mg/100 ml	maximum 7		IP 540
Water separation characteristics at point of manufacture (refinery): (18) Microseparometer (MSEP) without SDA or Microseparometer (MSEP) with SDA		 minimum 85 minimum 70	D 3948	
Water separation characteristics downstream of the point of manufacture (refinery): (18) Microseparometer (MSEP) Microseparometer (MSEP)		 minimum 85 minimum 88	 D 7224 D 8073	 IP 624
Electrical conductivity (19) (20)	pS/m	50 a 600	D 2624	IP 274
Lubricity (21)	mm	maximum 0,85	D 5001	
FAME content (22) (23)	mg/kg	Less than 5.0		IP 585 IP 590 IP 599
DRA content (23) (24)	µg/l	nil	D 7872	
Additives (25)		(25)		

EDITION: 14	09/01/2023
SEE NOTES ON THE NEXT PAGE	

NOTES:

(0) If no assurance can be given that the product shall be shipped exclusively as Jet A-1 (civil aviation fuel) the specifications that apply to it shall be the most restrictive of the latest edition of DEF STAN 91-091 and NME 3004.

Following is a table of the properties and their most restrictive limits for compliance as JP8:

PROPERTY	UNITS	LIMITS	TEST METHODS (1)	
			ASTM STANDARDS	IP STANDARDS
Sulfur, Mercaptan or Doctor Test (*I*)	% m/m	maximum 0,0020 Doctor Negative	D 3227 (*I*) D 4952	IP 342
Hydrogen content (*II*)	% m/m	minimum 13,4	D 3343 D 3701 D 5291 D 7171	
Calculated cetane index		report	D 976 D 4737	
Filtration time (*III*)	min	maximum 15	(*III*)	
Components and additives (*IV*)		(18)		

(*I*) If the Doctor Test gives a "failure" (positive result) the determination of mercaptan sulfur shall be done by the reference method ASTM D 3227.

(*II*) The referee test method is ASTM D 7171.

(*III*) A minimum sample volume of 3,785 l is filtered. The filtration time is determined according to Appendix A of the MIL-DTL-83133K2 standard.

(*IV*) Antioxidants:

Immediately after processing and before the product is exposed to the atmosphere (such as during rundown into feed/batch tankage), could be added an approved antioxidant formulation or combination of approved antioxidant formulations to prevent the formation of gums and peroxides after manufacture. The concentration of antioxidant to be added shall be maximum 24.0 mg/l active component

Components:

The finished fuel could contain up to 5% of co-hydroprocessed esters and fatty acids or Fischer-Tropsch Hydrocarbons. For compliance as Jet A-1, according to DEF STAN 91-091 Issue 14, table 2 follows with the additional properties and their limits as given in Annex B.4 of that specification:

Table 2: Additional requirements for fuels incorporating co-hydroprocessed fatty acids and fatty acid esters.

CHARACTERISTICS (a)(b)	UNITS	LIMITS	TEST METHODS	
			ASTM STANDARDS	IP STANDARDS
Thermal stability (JFTOT): Test temperature (c) Tube assessment, one of the following requirements has to be fulfilled (d): 1) VTR or 2) RTI or RTE, average over 2.5 mm2 area Differential pressure	 °C standard scale nm mm Hg	 minimum 280 maximum <3. No peacock (P) or abnormal deposits (A) maximum 85 maximum 25	D 3241	IP 323
Freezing point	°C	maximum -47.0	D 5972 (e) D 7153 D 7154	IP 435 (e) IP529 IP 528

Viscosity at -40 ºC (f)	mm²/s	maximum 12,0	D 445 (g) D 7945	IP 71 (g)
Unconverted fatty acids and esters	mg/kg	maximum 15	D 7797 (h)	IP 583 (h)

(a) Applies only at the point of manufacture.

(b) Applies to the finished batch of aviation fuel.

(c) A temperature of 280°C has been selected in IP323/ASTM D 3241 methods to ensure that reactive components introduced in the co-processing of fatty acids and fatty acid esters and fatty acids are limited. Metal deactivator (MDA), as described in Annex A of DEF STAN 91-091 Issue 14, cannot be used to meet this requirement.

(d) Visual assessment of the tube using the VTR or measurement of the thickness of the deposits using the ETR or ITR shall be performed within 120 minutes of the completion of the test.

(e) IP 435/ASTM D 5972 are the reference methods.

(f) The upper limit of 12.0 mm2/s at -40°C mitigates the potential risk of viscosity increase due to increased n-paraffins. Compared to conventional hydrocarbons, the processed co-hydro stream of esters and fatty acids may contain a higher concentration of n-paraffins.

(g) IP 71/ASTM D 445 allow viscosity measurements down to -40°C, however, the accuracy values were established down to -20°C. Their determination is in progress.

(h) The ability of IP 583 / D7797 to identify carbonyl containing compounds in addition to FAME is recognised. The reported value may be corrected with a bias specific to the analysis of a conventional fuel sample to detect traces of carbonyl species inherent to conventional fuels (according to paragraph 4 of DEF STAN 91-091 Issue 14). The corrected values shall be identified as such.

(1) The test methods to be applied shall be those corresponding to the last published version.

Other acceptable methods are referenced in DEF STAN 91-091 Issue 14:

Table 1: Specified limits.

Annex E: Table 5: Alternative test methods.

(2) The determination of Saybolt color in the refinery allows to quantify the evolution of color in the distribution chain. Atypical or unusual colors should also be noted. For further information, see Annex F.4 of DEF STAN 91-091 Issue 14.

(3) These limits apply only in refineries. Refer to the information on particulate contamination at Annex F.1 of DEF STAN 91-091 Issue 14.

(4) This requirement is applicable only in the refinery. If Channel Counts / ISO code exceed the limits stated, Annex B of IP 565 or Annex B of IP 577 may be applied to eliminate trace free water, and cleanliness re-determined. In such cases, results before and after application of Annex B shall be reported. To meet the requirements of this standard the limits of either test particulate contamination or particles per channel shall be met. For JP-8 gravimetric particulate contamination shall be the referee according to MIL-DTL-83133K.

(5) The ASTM D 1319/IP 156 test methods are the required methods for measuring aromatics content. In addition, recently delivered supplies of the product gel containing the dye with lot numbers 3000000975, 3000000976, 3000000977, 3000000978, 3000000979 and 3000000980 were produced with a substitute dye that is unfortunately not suitable and will not provide accurate measurements of aromatic concentration if utilized.

When the aromatic level is needed to be determined, Jet A-1 fuel will only meet the aviation fuel operating limitations of aircraft certificated to operate on Jet A-1 fuel and the requirements of Def Stan 91-091Issue 14 if:

1) the fuel has been tested for aromatics concentration in accordance with ASTM D1319/IP156 with a dye other than from lot numbers 3000000975 through 3000000982, the lot number of the gel used shall be reported on the test certificate

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.

(6) Interlaboratory tests have shown the existence of a correlation between the total aromatic content measured by IP 156/ASTM D1319 and IP 436/ASTM D6379. Bias between both methods necessitates different equivalence limits as shown. In case of dispute IP 156 will be the referee method.

(7) The Doctor's test is an alternative to the mercaptan sulfur determination. In the event of conflict between Sulfur Mercaptan and Doctor Test, the Sulfur Mercaptan shall prevail.

(8) Refinery components used in the make-up of the batch shall be reported on the Refinery Certificate of Quality as a percentage by volume of the total fuel in the batch.

(9) 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.

(10) In methods IP 123 and ASTM D86 all fuels certified to this specification shall be classed as group 4 with a condenser temperature of 0 ºC to 4 ºC.

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

(12) IP 598/ASTM D1322 includes the manual and automatic method. The automatic method is the referee method.

(13) Specific Energy by one of the calculation methods listed in Annex E is acceptable.

(14) The sample shall be tested in a pressure vessel at 100 ± 1 ºC for 2 hours ± 5 min.

(15) Thermal Stability is a critical aviation fuel test and while competition among equipment manufacturers/suppliers is to be encouraged, aircraft safety must remain paramount. It is known that there are heater tubes being supplied by sources other than the original equipment manufacturer (OEM). Until the alternative manufacturers' tubes have been demonstrated to be equivalent to the OEM's test pieces, to the satisfaction of the AFC, they shall not be used. A list of manufacturers whose heater tubes have been found to be technically suitable is as follows: a) PAC – Alcor b) Falex.

(16) The evaluation of the deposits shall be measured according to the methods indicated in Table 1 (ASTM D3241 and IP 323) described in the corresponding annexes of these methods. Deposit assessment shall be measured by the interferometric (ITR) or ellipsometric (ETR) method when available. If the ITR equipment reports the result as "N/A" the analysis will be failed and reported as >85 nm. If the ITR or ETR values are reported the VTR value is not required. In case of conflict between the results of the visual method (VTR) and the metrological methods (ITR/ETR) the metrological method shall be considered the referee.

(17) Examination of the heater tube to determine the Visual Tube Rating using the Visual Tube Rater or deposit thickness by ETR or ITR shall be carried out within 120 minutes of completion of the test.

(18) Where SDA is added at point of manufacture the MSEP limit of 70 shall apply. No precision data are available for fuels containing SDA; if water separation property testing is carried out during downstream distribution no specification limits apply and the results are not to be used as the sole reason for rejection of a fuel. A protocol giving guidelines on water separation property testing can be found in the Joint Inspection Group's Bulletin Number 121. Where SDA is added downstream of point of manufacture, it is acknowledged that MSEP results using ASTM D3948 may be less than 70.

(19) The conductivity limits are mandatory for product to meet this Standard. However, it is acknowledged that in some manufacturing and distribution systems it is more practical to inject SDA further downstream. In such cases the Certificate of Quality for the batch should be annotated thus: “Product meets requirements of Defence Standard 91-091 Issue 14 except for electrical conductivity”. See Annex F.2 for more information.

(20) In deliveries to the EXOLUM System, SDA shall not be incorporated into the kerosene and therefore shall not have to comply with this specification. In these cases, two liters of SDA per thousand cubic meters of kerosene shall be given by refineries (or plants).

(21) The requirement to determine lubricity applies only to fuels whose composition is made up of a) less than 5% non hydroprocessed components and at least 20% severely hydroprocessed components (see Note 8) or b) includes synthesised fuel components. The limit applies only at the point of manufacture (see Note 9).

(22) Test method IP 585 shall be the referee method.

(23) A risk assessment shall be done 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.

(24) 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 detection limit. Where the level of DRA is otherwise unknown a result at or below 72 µg/l would support an assumption of nil addition.

(25) **Additives:**

Some additives, as qualified, include a hydrocarbon diluent as a solvent and the amount to be added is calculated based on the additive as received. These include Static Dissipator Additive and Lubricity Improver Additive.

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

The list of permitted additives is contained in Annex A of DEF STAN 91-091 Issue 14

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.

Anti-oxidants:

Anti-oxidants can be used to prevent the formation of peroxides and gums during storage.

Allowable antioxidants are detailed in A.2.4 of DEF STAN 91-091 Issue 14.

Annex B.2 of DEF STAN 91-091 Issue 14 contains requirements for anti-oxidants for fuels produced according to ASTM D7566.

The concentrations in which the qualified materials shall be used are as follows:

- Synthetic fuel: refer to the appropriate Annex in ASTM D7566.
- Aviation fuels: the total concentration of active material(s) in the final batch shall not exceed 24.0 mg/l.

The concentration of anti-oxidant added to the fuel shall be reported in the refinery quality certificate in the two ways indicated below:

a) firstly expressed as a proportion of the total hydro-processed and synthetic material, in order to ensure the minimum effective amount is used; and
b) secondly as a total proportion of the final blended fuel batch of all components, in order to ensure that the maximum overall concentration has not been exceeded.

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

Metal Deactivator Additive (MDA):

The permitted MDAs are detailed in A.3.3 of DEF STAN 91-091 Issue 14.

MDA may be added to aviation fuel under the following conditions:

- At Point of Manufacture
    a) No more than 5 % of the jet fuel batches produced in a 12 month period may be treated with MDA to meet Table 1 thermal oxidative stability requirements (260 °C test temperature).
    b) The batch of fuel shall pass Table 1 thermal oxidative stability requirements at a test temperature of 245 °C prior to any MDA addition.
    c) 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.
    d) The thermal oxidative stability test result at 245 °C prior to MDA addition, the original test result at 260 °C and the test result at 275 °C (post MDA addition) and the concentration of MDA added shall be reported on the Refinery Certificate of Quality.
- During Distribution
    a) MDA may be added to jet fuel in the distribution system to recover thermal oxidative stability performance lost during distribution (after refinery release). The Certificate of Analysis shall show the initial thermal oxidative stability test result, the result after the addition of the MDA and the concentration of MDA added.

The concentrations of MDA are as follows:

- First Addition of MDA maximum 2.0 mg/l
- MDA readjustment, cumulative concentration maximum 5.7 mg/l

Initial addition of more than 2 mg/l MDA, to aviation fuels that meet the requirements for thermal stability at oxidation (test temperature 260ºC) prior to MDA addition, is permitted when the fuel will be transported in supply chains where copper contamination can occur. The requirement for total accumulation of MDA applies also in these cases.

Static Dissipator Additive (SDA):

The permitted SDAs are detailed in A.4.2 of DEF STAN 91-091 Issue 14.

The concentrations of SDA are as follows:

- First SDA Addition maximum 3.0 mg/l
- SDA readjustment, cumulative concentration (including initial) maximum 5.0 mg/l

A suitable method for determining SDA content at the point of manufacture is IP 568/ASTM D7524.

In deliveries to the EXOLUM System this additive shall not be incorporated.

Lubricity Improver Additive (LIA):

The permitted LIAs and their concentration are detailed in A.5.4 of DEF STAN 91-0911 Issue 14.

The permitted additives and their concentrations are as follows:

• Hitec 580	minimum 15 mg/l	maximum 23 mg/l
• Octel DCI-4A	minimum 9 mg/l	maximum 23 mg/l
• Octel DCI-6A	minimum 9 mg/l	maximum 15 mg/l
• Nalco 5403	minimum 12 mg/l	maximum 23 mg/l
• Unicor J	minimum 9 mg/l	maximum 23 mg/l
• Nalco 5405	minimum 9 mg/l	maximum 23 mg/l
• Spec Aid 8Q22	minimum 9 mg/l	maximum 23 mg/l

Fuel System Icing Inhibitor (FSII):

FSII is not allowed if no agreement is reached between purchaser and supplier. Concentrations of less than 0.02% V/V are considered negligible and do not require agreement or notification.

For more information see Annex A.6 of DEF STAN 91-0911 Issue 14.

Leak Detection Additive (Tracer A):

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.

Permitted leak detection additives are detailed in A.8.2 of DEF STAN 91-091 Issue 14

The concentrations are as follows:

Tracer A (LDTA-A)	maximum 1.0 mg/kg

The Refinery Certificate of Quality CoQ (RCQ) shall contain all information concerning additives incorporated into kerosene, both the type and concentration of each. In the refinery batch test certificate, shall also note the names and codes of the additives listed in Annex A of DEF STAN 91-091 Issue 14.

IF THERE IS A MODIFICATION OF THE OFFICIAL SPECIFICATIONS IN FORCE IN SPAIN, THIS TABLE WILL BE REVISED IN ORDER TO ADAPT IT TO THE NEW SITUATION.