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CAN/CGSB-3.23-2023

Supersedes Corrigendum No. 1, January 2021 and CAN/CGSB-3.23-2020

Aviation turbine fuel (Grades JET A and JET A-1)

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NATIONAL STANDARD OF CANADA

CAN/CGSB-3.23-2023

Supersedes Corrigendum No. 1, January 2021
and CAN/CGSB-3.23-2020

Aviation turbine fuel (Grades JET A and JET A-1)

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Preface

This National Standard of Canada CAN/CGSB-3.23-2023 supersedes the 2020 edition and Corrigendum No. 1 published in January 2021.

Changes since the previous edition

- Test method CAN/CGSB 3.0 No. 28.8 has been added for visual haze in section 2.1.
- Paragraph 5.2.1 has been revised for clarification.
- Section 5.3 on co-processing of non-conventional feedstocks has been added to replace paragraphs 5.2.2 to 5.2.5 which were removed.
- Section 5.4 has an improved definition using the common industry terms for visual rating.
- Table 1 Fuel Properties – footnote n has been revised and footnote p has been added.
- Paragraphs 6.2, 6.2.1 and 6.2.2 have been revised to reflect changes in 5.2 and 5.3.
- A new paragraph, 6.10.1, has been added to the 'Contaminants' section of the Fuel Properties Table listing test methods cited in section 5.4 and simplifying reference to Purchaser's storage.
- An additional alternate test method, ASTM D7153, has been added for freezing point (6.6.1).
- An additional test method, ASTM D4176, has been added for visual appearance (6.10).
- Particulate matter limit was revised and re-numbered (reordered) 6.10.2 in Table 1.
- Existent gum was re-numbered 6.10.3.
- A new paragraph – 6.14 Extended requirements for fuels containing co-hydroprocessed synthetic kerosene – has replaced *old 6.15* and is re-numbered. Corresponding 'old Table 2' has been deleted as the information given is covered under paragraph 5.2.1 (revised). New Table 2 (*old Table 3*) is renumbered accordingly.
- A new paragraph – 10.8 Cleanliness information statement – has been added to the 'Precautions' section.
- A new paragraph – 10.9 Storage and distribution information statement – has been added to the 'Precautions' section.

The following definitions apply in understanding how to implement this National Standard of Canada:

- "shall" indicates a **requirement**;
- "should" indicates a **recommendation**;
- "may" is used to indicate that something is **permitted**;
- "can" is used to indicate that something is **possible**, for example, that an organization is able to do something.

Notes accompanying clauses do not include requirements or alternative requirements. The purpose of a note accompanying a clause is to separate explanatory or informative material from the text. Annexes are designated normative (mandatory) or informative (non-mandatory) to define their application.

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Tables

Aviation turbine fuel (Grades JET A and JET A-1)

1 Scope

This National Standard of Canada applies to two grades of kerosene-type aviation turbine fuel (grades JET A and JET A-1), consisting of conventional hydrocarbons, synthetic hydrocarbons, naturally occurring non-hydrocarbons and additives as specified herein.

The fuels are normally used in civil aviation operations. The two grades differ only in freezing point. Grade JET A has a maximum freezing point of -40 °C and Grade JET A-1 has a maximum freezing point of -47 °C. Kerosene-type aviation turbine fuels are distillates with a minimum flash point of 38 °C.

Limitations for use – Aircraft operators should consult their aircraft manuals for the type of fuel, fuel additives and any temperature-related or other limitations.

Temperature limitations – When temperatures are close to the fuel freezing point, fuel operability problems can be experienced. JET A, with a specification freezing point of -40 °C, is not intended for use during extremely cold weather conditions or when the ambient temperature is close to or below -40 °C. It also requires more restrictive use than JET A-1. For more information concerning temperature limitations, see Transport Canada's Airworthiness Notice No. B021 (par. 2.2) and 10.3 in this standard.

The testing and evaluation of a product against this standard may require the use of materials and/or equipment that could be hazardous. This document does not purport to address all the safety aspects associated with its use. Anyone using this standard has the responsibility to consult the appropriate authorities and to establish appropriate health and safety practices in conjunction with any applicable regulatory requirements prior to its use.

Units of measurement – Quantities and dimensions in this standard are provided in metric units from the International System of Units (SI units). This standard expresses the industry standard nominal units of measurement in North America of "% by mass" and "% by volume". The SI equivalent expressions for these units are "% m/m" and "% V/V" respectively.

2 Normative references

The following normative documents contain provisions that, through reference in this text, constitute provisions of this National Standard of Canada. The referenced documents may be obtained from the sources noted below.

Note: The contact information provided below was valid at the date of publication of this standard.

An undated reference is to the latest edition or revision of the reference or document in question, unless otherwise specified by the authority applying this standard. A dated reference is to the specified revision or edition of the reference or document in question.

2.1 Canadian General Standards Board

CAN/CGSB-3.0 — *Methods of testing petroleum and associated products:*

No. 28.8 — Visual haze rating of liquid fuels

CAN/CGSB-3.524 — *Biodiesel (B100) for blending in middle distillate fuels*

2.1.1 Contact information

The above may be obtained from the Canadian General Standards Board. Telephone: 1-800-665-2472. E-mail: ncr.cgsb-ongc@tpsgc-pwgsc.gc.ca. Web site: www.tpsgc-pwgsc.gc.ca/ongc-cgsb/index-eng.html.

2.2 Transport Canada

Airworthiness Notice No. B021 – *Low Temperature Operations with JET A Fuel*

2.2.1 Contact information

The above may be obtained from Transport Canada at www.tc.gc.ca.

2.3 ASTM International

Annual Book of ASTM Standards (see Annex A)

2.3.1 Contact information

The above may be obtained from ASTM International. Telephone: 610-832-9585. Web site: www.astm.org. They can also be obtained from Standards Store by Accuris. Telephone: 1-800-267-8220. Web site: https://global.ihs.com.

2.4 Energy Institute

IP 323 – *Determination of thermal oxidation stability of gas turbine fuels*

IP 540 – *Determination of the existent gum content of aviation turbine fuel – Jet evaporation method*

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*

IP 585 – *Determination of fatty acid methyl esters (FAME), derived from bio-diesel fuel, in aviation turbine fuel – GC-MS with selective ion monitoring/scan detection method*

IP 590 – *Determination of fatty acid methyl esters (FAME) in aviation turbine fuel – HPLC evaporative light scattering detector method*

IP 599 – *Determination of fatty acid methyl esters (FAME) in aviation turbine fuel – Gas Chromatography using heart-cut and refocusing*

2.4.1 Contact information

The above may be obtained from the Energy Institute. Telephone: +44 (0)20-7467-7100. E-mail: pubs@energyinst.org.uk, Web site: www.energyinst.org.uk.

2.5 European Committee for Standardization

EN 14214 — *Liquid petroleum products — Fatty acid methyl esters (FAME) for use in diesel engines and heating applications — Requirements and test methods*

2.5.1 Contact information

The above may be obtained from BSI Shop at http://www.bsigroup.com/.

2.6 U.S. Department of Defense

MIL-PRF-25017 – *Inhibitor, Corrosion/Lubricity Improver, Fuel Soluble*

QPL-25017 – *Qualified Products List of Products Qualified Under Performance Specification MIL-PRF-25017 Inhibitor, Corrosion/Lubricity Improver, Fuel Soluble*

2.6.1 Contact information

The above may be obtained from Document Automation and Production Service. Web site: https://quicksearch.dla.mil/qsSearch.aspx.

3 Terms and definitions

batch
an identifiable quantity of aviation turbine fuel with a single set of physical and chemical characteristics.

4 Classification

4.1 The kerosene-type aviation turbine fuel shall be classified in the following grades (see 9.1).

4.1.1 Grades

JET A;

JET A-1.

5 General fuel requirements

5.1 Conventional hydrocarbons shall be predominantly petroleum-derived from natural gas liquid condensates, crude oil and heavy oil, including bitumen from oil sands.

5.2 Synthetic hydrocarbons shall consist predominantly of hydrocarbons derived from non-conventional sources such as biomass, natural gas, coal, fats, and oils by processes such as gasification, Fischer-Tropsch synthesis, hydroprocessing or hydrocracking.

5.2.1 Synthetic hydrocarbons are only permitted in jet fuel in a blend with conventional hydrocarbons in accordance with ASTM D7566. Once the synthetic component has been confirmed to meet all requirements of the relevant Annex of ASTM D7566, it shall be blended with conventional blending components or jet fuel conforming to this standard. Once certified, any subsequent testing of the finished batch of fuel shall be done solely against the requirements of CAN/CGSB-3.23.

5.3 Co-processing of non-conventional feedstocks as defined in a) or b) below is recognized as being acceptable for production of co-hydroprocessed synthetic kerosene as controlled by this standard.

a) Mono-, di- and tri-glycerides, free fatty acids and fatty acid esters.

b) Hydrocarbons derived from synthesis gas via the Fischer-Tropsch process using iron or cobalt catalysts.

Only one co-processing feedstock as defined in a) or b) above shall be used for production of a single batch of fuel.

The process streams used for jet fuel production in co-processing refinery units shall not exceed 5 % by volume of either a) or b) above with the balance (≥ 95 % by volume) being conventionally sourced hydrocarbons as described in 5.1. The final jet fuel product is limited to a maximum 5 % by volume hydrocarbons derived from either a) or b) above in any jet fuel batch.

5.3.1 Co-processing of mono-, di- and tri-glycerides, free fatty acids and fatty acid esters shall include hydrocracking or hydrotreating and fractionation. Processing may include other conventional refinery processing. Supporting data is available from ASTM International in Research Report RR:D02-1886.

5.3.2 Co-processing of hydrocarbons derived from synthesis gas shall include hydrocracking and fractionation. Processing may include other conventional refinery processing. Supporting data is available from ASTM International in Research Report RR:D02-1929.

5.3.3 Additional requirements apply for co-hydroprocessed synthetic kerosene. Once a batch of aviation turbine fuel containing co-hydroprocessed synthesized kerosene is manufactured, it shall be tested against the requirements of Table 1 (6.4 to 6.13) and the extended requirements in 6.14. Once certified, any subsequent testing of the finished batch of fuel shall be done solely against the requirements of Table 1 (6.4 to 6.13).

5.4 The fuel shall be visually clear and free from undissolved water and particulate matter at point, time and temperature of custody transfer, commonly referred to as “Clear and Bright” or “Clean and Bright” (see 10.4).

If the initial sample fails, then resample and refer to 10.8 for additional guidance.

If there is a dispute regarding the presence of visible particulate matter, the dispute may be resolved by the measurement of particulate matter according to ASTM D5452 being less than the limit specified in 6.10.2 (see 10.8). A sample that continues to be hazy or has free water is not acceptable.

5.5 The odour of the fuel should not be nauseating or irritating.

6 Detailed requirements

6.1 The detailed requirements shall apply to the fuel unless otherwise specified.

6.2 The fuel shall comply with the detailed requirements specified in 6.4 to 6.13, using the test methods indicated. The specified limiting values shall not be changed. This precludes any allowances for the test method precision and adding or subtracting digits.

6.2.1 A batch of fuel which includes synthetic hydrocarbons defined in 5.2 shall also comply with the extended requirements specified in ASTM D7566 Table 1, Part 2 the first time it is tested for compliance with this standard.

6.2.2 A batch of fuel that includes co-hydroprocessed synthetic kerosene defined in 5.3 shall also comply with 6.14 the first time it is tested for compliance with this standard. The following additional requirements apply.

a) 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 ongoing commercial operation include, but are not limited to, feedstock (for example, selection, composition, pre-treatment), and hydroprocessing severity (for example, hydrogen partial pressure, residence time, temperature, catalyst conversion capability). 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 to hydrocarbon or Fischer-Tropsch hydrocarbons to synthetic kerosene when added to any jet batch. Refer to the Research Reports noted in 5.3.1 and 5.3.2 for additional considerations for MOC.

b) The initial batch certificate shall include wording to reflect that the batch may contain up to 5 % by volume co-hydroprocessed synthetic kerosene.

6.3 To determine conformance with the specified limiting values, an observed value or a calculated value shall be rounded off “to the nearest unit” in the last right-hand digit used in expressing the specified limiting values, in accordance with the rounding-off method of ASTM E29. Zeroes trailing the last nonzero digit for numbers represented with a decimal point are significant digits, in accordance with ASTM E29. There are two exceptions (see 6.5.1 and 6.5.4 depending on the method used) that shall be reported to the nearest 0.5 °C.

6.3.1 Where test values differ between two parties, a resolution shall be in accordance with ASTM D3244 in order to determine conformance with the specified limiting values, with the criticality of the limits set as $P = 0.5$.

Table 1 – Fuel properties

	Property	Specified limiting values		
		JET A or JET A-1		Test method
		Min.	Max.	ASTM
6.4	Composition	—		
6.4.1	Acidity, total, mg KOH/g	—	0.10	D3242
6.4.2	Aromatics, % by volume	—	25	D1319[a, b] or D8267
		—	26.5	D6379
6.4.3	Sulphur, total, % by mass (see 6.15)	—	0.30	D2622, D4294[a], D5453 or D7039
6.4.4	Sulphur, mercaptan[c], a) or b)	—		
	a) % by mass	—	0.003	D3227
	b) Doctor test	negative		D4952
6.5	Volatility	—		
6.5.1	Distillation temperature, °C, all	—		D86[a], D2887[d] or D7345[e]
	a) Initial boiling point	Report		
	b) 10% recovered (T10)	—	205	
	c) 50% recovered (T50)	Report		
	d) 90% recovered (T90)	Report		
	e) Final boiling point	—	300.	
6.5.2	Residue[f], % by volume	—	1.5	D86[a], D2887[d] or D7345[e]
6.5.3	Loss[f], % by volume	—	1.5	D86[a], D2887[d] or D7345[e]
6.5.4	Flash point, °C	38	—	D56[a] or D3828[g]
6.5.5	Density at 15 °C, kg/m^3	775	840.	D1298[a] or D4052
6.6	Fluidity	—		
6.6.1	Freezing point, °C (see 10.3)	—	-40. (JET A) -47 (JET A-1)	D2386[h], D5972[a] or D7153

	Property	Specified limiting values		
		JET A or JET A-1		Test method
		Min.	Max.	ASTM
6.6.2	Kinematic viscosity at -20 °C, mm^2/s[i] (see 10.3)	—	8.0	D445[a], D7042[j] or D7945
6.7	Combustion	—		
6.7.1	Combustion measurement, a) or b)	—		
	a) Smoke point, mm, or	25	—	D1322
	b) Smoke point, mm and	18	—	D1322
	Naphthalenes, % by volume	—	3.0	D1840
6.7.2	Net heat of combustion, MJ/kg	42.8	—	D3338[k], D4529[k] or D4809[a]
6.8	Corrosion (see 7.6 and 10.6)	—		
6.8.1	Copper strip corrosion, 2 h at 100 °C	—	No. 1	D130
6.9	Thermal stability[l] (see 10.2.2)	—	—	—
6.9.1	Filter pressure drop, mm Hg	—	25	D3241[a] or Energy Institute IP 323
6.9.2	Tube deposit, a), b) or c)	—		
	a) Tube deposit (visual)	Less than 3		D3241[a] or Energy Institute IP 323
	Visual examination, on the heater tube, darkest deposits	No peacock (rainbow) or abnormal colour deposits		
	b) Tube deposit (ITR), nm average over area of 2.5 mm^2	—	85	D3241 Annex A2
	c) Tube deposit (ETR), nm average over area of 2.5 mm^2	—	85	D3241 Annex A3
6.10	Contaminants (see 10.7)	—		
6.10.1	Appearance, at point, time and temperature of custody transfer (see 5.4, 10.4 and 10.8)	—	Clear & Bright	D4176 or CAN/CGSB-3.0 No. 28.8[a]
6.10.2	Particulate matter, mg/L at time of delivery to Purchaser's storage[p]	—	1.0	D2276 or D5452[m]

	Property	Specified limiting values		
		JET A or JET A-1		Test method
		Min.	Max.	ASTM
6.10.3	Existent gum, mg/100 mL	—	7	D381[a] (steam jet) or Energy Institute IP 540 (air or steam jet)
6.11	Water separation characteristics after addition of static dissipator additive (see 7.2 and 10.5)[n], a), b) or c)	—		
	a) Micro-separometer rating (MSEP)	85	—	D7224[a]
	b) Micro-separometer rating (MSEP)	70.	—	D3948
	c) Water separation index (WSI)	88	—	D8073
6.12	Electrical conductivity	—		
6.12.1	At point, time and temperature of use[o], pS/m (see 7.2)	50.	600.	D2624
6.13	Additives (see 10.6)	—		
6.13.1	Static dissipator additive (see 7.2), mg/L	—		
	a) Original addition	—	3	—
	b) Cumulative	—	5	—
6.13.2	Antioxidant additive (see 7.3), mg/L, Optional	—	24	—
6.13.3	Metal deactivator additive (see 7.4), mg/L, Optional	—	5.7	—
6.13.4	Fuel system icing inhibitor (see 7.5), % by volume, Optional	0.10	0.15	D5006
6.13.5	Corrosion inhibitor/lubricity improver (see 7.6), Optional	—	—	—
6.13.6	Leak detection additive (see 7.7), mg/kg, Optional	—	1	—

Property	Specified limiting values		
	JET A or JET A-1		Test method
	Min.	Max.	ASTM

[a] In the event of a dispute, this method shall be the referee method.

[b] Ensure the validity of dye when using this method.

[c] The mercaptan sulphur determination may be waived if the fuel is considered “sweet”, and received a negative result by the doctor test described in ASTM D4952.

[d] When testing in accordance with ASTM D2887, apply the relevant Annex to convert distillation temperature results to estimates of ASTM D86 results.

[e] Only bias-corrected values from ASTM D7345 shall be used as an alternate to ASTM D86.

[f] If ASTM D2887 is used to determine distillation temperature (see 6.5.1), then residue and loss requirements shall not apply because no residue or loss results from the application of ASTM D2887.

[g] The results obtained by ASTM D3828 can be up to 2 °C lower than those obtained by ASTM D56, which is the referee method.

[h] CAUTION: Results from two extensive round-robin tests reported in ASTM Research Reports 1536 and 1572 demonstrated that the manual freezing point test ASTM D2386 could only detect heavy material contamination (e.g. diesel fuel) in JET A-1 fuel in less than half of the cases tested, whereas the automatic freezing point test ASTM D5972 was effective at detecting such contamination in all cases tested.

[i] The SI unit for kinematic viscosity is the square metre per second. The preferred multiple for fluids in this viscosity range is the square millimetre per second, which is equivalent to a centiStokes (i.e., 1 mm^2/s = 1 cSt).

[j] Only bias-corrected values from ASTM D7042 shall be used as an alternate to ASTM D445.

[k] Calculate and report the net heat of combustion corrected for the sulphur content when using these empirical test methods.

[l] Thermal stability shall be determined using the thermal oxidation stability test instrument at a minimum heater-tube-controlled temperature of 260 °C. The SI unit equivalent for the pressure differential is 3.3 kPa. However, the thermal oxidation stability test instrument gives the results in mm Hg, and 25 mm Hg is the exact maximum.

[m] ASTM D2276 and D5452 refer to different sampling procedures. In some situations, it may not be practical to sample according to D2276; however, when results are obtained by both methods, D2276 shall be considered the referee method.

[n] MSEP by ASTM D7224 and WSI by D8073 can both be useful in determining the water separation characteristics of a batch of jet fuel even when additized with static dissipator additive and certain other additives that do not actually degrade water separation performance in coalescing separators. When a fuel system icing inhibitor (see 7.5) or a corrosion inhibitor/lubricity improver (see 7.6) is added, the water separation characteristic limits apply before its addition. For clarity, water separation characteristic results shall be reported by test method (i.e. MSEP by ASTM D3948 or MSEP by ASTM D7224 or WSI by ASTM D8073). Test results failing to meet the stated specification limits for MSEP / WSI downstream of the point of manufacture may not be used as the sole reason for rejection of a batch of fuel and are cause for further investigation (see 6.3.1).

[o] Conductivity often drops during fuel distribution due to additive depletion and lower temperatures, so it is common practice to initially additize at the upper end of the conductivity range.

[p] In the event of dispute between 6.10.1, Appearance, and 6.10.2, Particulate matter, 6.10.2 Particulate matter shall be the referee test method.

6.14 Extended requirements for fuels containing co-hydroprocessed synthetic kerosene

For a finished batch of fuel containing co-hydroprocessed synthetic kerosene defined in 5.3, the following table shall apply the first time the fuel is tested for compliance with this standard. Once a batch is certified against Table 1 and Table 2, any subsequent testing does not need to include the requirements of Table 2.

Table 2 – Fuel properties of fuels containing co-hydroprocessed synthetic kerosene

	Property	Specified limiting values		
		JET A or JET A-1		Test method
		Min.	Max.	ASTM
6.14.1	Mono-, di-, and triglycerides, free fatty acids, and fatty acid esters or Fischer-Tropsch hydrocarbons in co-processed feedstock, % by volume[c]	—	5	—
6.14.2	Thermal Stability[d, e] (2.5 h at control temperature of 280 °C min) Filter pressure drop, mm Hg	—	25	D3241[a] or Energy Institute IP 323
6.14.3	Tube deposit, a), b) or c)	—		
	a) Tube deposit (visual)	Less than 3		D3241[a] or Energy Institute IP 323
	Visual examination, on the heater tube, darkest deposits	No peacock (rainbow) or abnormal colour deposits		
	b) Tube deposit (ITR), nm average over area of 2.5 mm^2	—	85	D3241 Annex A2
	c) Tube deposit (ETR), nm average over area of 2.5 mm^2	—	85	D3241 Annex A3
6.14.4	Viscosity at -40 °C, mm^2/s[f]	—	12.0	D445 Section 1[a], D7042[b] or D7945
6.14.5	Unconverted esters and fatty acids, mg/kg	—	15	D7797[a, g] or Energy Institute IP 583

[a] In the event of a dispute, this method shall be the referee method.

[b] Only bias-corrected values from ASTM D7042 shall be used as an alternate to ASTM D445.

[c] The volume of mono-, di-, and triglycerides, free fatty acids, and fatty acid esters or Fischer-Tropsch hydrocarbons in the feedstock to the co-processing refinery units where process rundown streams are used for jet production shall be calculated from metered (measured) volumes.

[d] A D3241 test temperature of 280 °C has been selected to help ensure that reactive compounds introduced through co-hydroprocessed of esters and fatty acids are limited. Research is ongoing on the actual requirement for a more restrictive thermal stability limit.

[e] Metal deactivator additive (MDA) shall not be used to meet this requirement.

[f] The kinematic viscosity specification of 12.0 mm^2/s at -40 °C maximum mitigates the potential risk of increased viscosity due to n-paraffin enrichment. Compared to conventional hydrocarbons, a co-hydroprocessed esters and fatty acids stream may contain a higher concentration of n-paraffins.

[g] The ability for D7797 to identify carbonyl containing compounds in addition to FAME 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. Corrected values shall be identified as such.

6.15 Sulphur

The accuracy of ASTM D7039 for the sulphur content of jet fuel beyond 2822 mg/kg sulphur has not been validated. Users are cautioned to conduct their own validation when using this test method for jet fuel containing more than 2822 mg/kg sulphur.

7 Additive requirements

7.1 Only the additives listed in 7.2 to 7.7 may be added to the fuel. Refer to 6.13 for specified limiting values and test method for each property. The supplier shall record the amount and names of each additive.

7.1.1 The amount of each additive used in the fuel shall be determined by the test method (see 6.13 and 10.6) or by volume reconciliation. Procedures for volume reconciliation should include recording the volume of additive introduced to the fuel and the volume of fuel additized in appropriate units.

7.2 Static dissipator additive

7.2.1 Static dissipator additive (SDA) AvGuard™ SDA[1] or STADIS® 450[2] shall be added to the fuel to meet the electrical conductivity requirements specified in 6.12.1. The original concentration of the SDA shall not exceed 3 mg/L.

7.2.2 When additive depletion is evident by a conductivity loss, further addition of the SDA is permitted as follows:

a) if the original concentration of the SDA is not known, then an original addition of 3 mg/L is assumed and further addition of SDA shall not exceed 2 mg/L;

b) the cumulative concentration of the SDA shall not exceed 5 mg/L.

7.2.3 Electrical conductivity varies with temperature. A typical relationship follows:

$$\log\ k_t = a\left(t - t_1\right) + \log k_{t_1}$$

where:

k_t = electrical conductivity at temperature t, °C;

k_{t_1} = electrical conductivity at temperature t_1, °C;

a = a temperature-conductivity factor that depends on fuel composition but normally is within the range 0.013 to 0.018 for kerosene-type aviation turbine fuels.

7.2.3.1 The temperature-conductivity factor, *a*, increases at or below an approximate temperature of -10 °C. For conductivity at very low temperatures, it is recommended that a separate factor be determined based on actual measurements at the lowest expected temperatures that will be encountered. For more information on how low temperature affects conductivity, see the relevant Appendix of ASTM D2624.

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[1] AvGuard™ SDA, a registered trademark of Afton Chemical Corporation, 500 Spring Street, Richmond, VA 23219, is manufactured in the United States and distributed globally by Afton Chemical Corporation.

[2] STADIS® 450, a registered trademark of Innospec Fuel Specialties LLC, is manufactured in the United States and distributed globally by Innospec Fuel Specialties LLC.

7.3 Antioxidant additives

Only the following antioxidants may be added separately or in combination to the fuel. The total concentration (not including mass of solvent) shall not exceed 24 mg/L:

a) 2,6-di-*tert*-butylphenol;

b) 2,6-di-*tert*-butyl-4-methylphenol;

c) 2-*tert*-butyl-4,6-dimethylphenol (2,4-dimethyl-6-tertiary butylphenol);

d) 75% minimum, 2,6-di-*tert*-butylphenol, 25% maximum mixture of *tert*- and tri-*tert*-butylphenols;

e) 55% minimum, 2-*tert*-butyl- 4, 6-dimethylphenol (2,4-dimethyl-6-tertiary butylphenol), 15% minimum, 2,6-di-*tert*-butyl-4-methylphenol, remainder as methyl and dimethyl *tert*-butylphenols;

f) 72% minimum 2-*tert*-butyl- 4,6-dimethylphenol (2,4-dimethyl-6-tertiary butylphenol), 28% maximum, methyl and dimethyl *tert*-butylphenols.

Note: The names of the antioxidants conform to the International Union of Pure and Applied Chemistry (IUPAC) naming convention. In some cases, the common name of the antioxidant has been included in brackets after the IUPAC name.

7.4 Metal deactivator additive

Only *N,N'*-disalicylidene-1,2-propane-diamine may be added as a metal deactivator at a concentration not exceeding 2.0 mg/L (not including mass of solvent) on the initial fuel manufactured at the refinery. Higher concentrations are permitted in circumstances where copper contamination is suspected to occur during distribution. Cumulative concentration of metal deactivator when re-treating the fuel shall not exceed 5.7 mg/L (see 10.2).

7.5 Fuel system icing inhibitor

When specified [see 9.2 a)] and agreed by the supplier and the purchaser, a fuel system icing inhibitor conforming to ASTM D4171 (Type III [DIEGME]) shall be added to the fuel (see 6.13.4).

7.6 Corrosion inhibitors/lubricity improvers

When specified [see 9.2 b)] and agreed by the supplier and the purchaser, a corrosion inhibitor/lubricity improver qualified to U.S. Military Specification MIL-PRF-25017 and listed in the associated qualified product list (QPL) 25017 shall be added to the fuel (see 10.1). The concentration of the additive in the fuel shall be as specified in the QPL, and its introduction into the fuel shall be separate from the addition of other additives.

7.7 Leak detection additive[3]

Only Tracer A (LDTA-A®)[4] may be added as a leak detection additive. The maximum concentration is 1 mg/kg.

8 Inspection

Samples for testing shall be obtained in accordance with ASTM D4057. For automatic sampling, ASTM D4177 shall be used. Sample volume should be consistent with the requirement of the testing laboratory, the authority having jurisdiction or both.

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[3] The Tracer Tight® methodology to detect and locate leaks in ground-based fuel storage, delivery and dispensing systems does not form part of this standard. Refer to the additive supplier for this information. Linde plc can be contacted at 10 Riverview Drive, Danbury, CT 06810; telephone 1-844-445-4633; Web site: www.lindeus.com.

[4] Tracer A (LDTA-A®) is a registered trademark of Linde plc.

9 Options

9.1 The following option shall be specified in the application of this standard:

a) grade JET A or JET A-1 (see 4.1).

9.2 The following options may be specified in the application of this standard, if required:

a) fuel system icing inhibitor (see 7.5);

b) corrosion inhibitor/lubricity improver (see 7.6).

10 Precautions

10.1 Lubricity information statement

10.1.1 Lubricity, which is the ability of jet fuel to act as a lubricant for certain aircraft fuel-wetted components, can vary considerably. It depends on the design, materials used and the intrinsic lubricity of the fuel. There have been a number of cases of engine hardware failures directly attributed to poor-lubricity fuel.

10.1.2 ASTM D5001 may be used to determine the lubricity quality of the fuel. Hydrogen-processing[5] usually produces fuels with poor lubricity. Blending or commingling with non-hydrogen-processed fuels will improve lubricity, and the use of corrosion inhibitor/lubricity improver additives may offer a solution (see 7.6).

10.1.3 Problems are more likely to occur when aircraft operations are confined to a single refinery source where fuel is severely hydrogen-processed and where there is no commingling with fuels from other sources during distribution between refinery and the aircraft.

10.2 Copper information statement

10.2.1 The contamination of jet fuel can occur during manufacture or during distribution in marine vessels with copper coils, and from the copper-alloy components and fittings in sampling points.

10.2.2 Trace levels of copper, in the parts per billion range, can be sufficient to degrade the ASTM D3241 thermal oxidation stability test instrument test result. Where the possibility of copper pickup is suspected, an approved metal deactivator as specified in 7.4 may be added to preserve or restore the thermal stability of the fuel, or both.

Note: ASTM D6732 can be used to measure the level of copper in jet fuel.

10.3 Freezing point information statement for JET A

10.3.1 JET A, with a specification freezing point of -40 °C, is not intended for use during extremely cold weather conditions or when the ambient temperature is close to, or below, -40 °C. Operational experience shows that aircraft fuel tank temperatures can approach that of the ambient conditions in a time as short as 3 h for a business jet and 6 h for a large transport aircraft. Although lower flying, slower commuter aircraft are not exposed to the same ambient extremes for the same length of time, they could still encounter similar temperatures during flight, particularly if they have loaded cold fuel.

[5] Hydrogen-processing (also called hydroprocessing) is any petroleum refining process that uses hydrogen in the presence of a catalyst.

10.3.2 The consequences of low-ambient temperatures are an increase in viscosity and the eventual formation of wax crystals. The increased viscosity could result in adverse changes to the engine fuel regime while an excessive wax accumulation could cause filter blockage, fuel-pump-performance degradation or difficulty with transfer between tanks. See Annex B for further information. Additionally, Transport Canada has issued guidance and recommendations when operating on JET A fuel in the Airworthiness Notice No. B021 (see 2.2).

10.4 Colour information statement

While this standard does not have a colour requirement, colour may be a useful indicator of fuel quality or contamination. Normally fuel colour ranges from water white (colourless) to a pale straw yellow. Other fuel colours can be the result of crude oil characteristics or refining processes. Darkening of fuel or a change in fuel colour can be the result of product contamination and can indicate that the fuel is off-specification, which could render it unfit and not acceptable for aircraft or engine use, or both. Fuel having various shades of colour, that is, pink, red, green, blue, or a change in colour from the supply source should be investigated to determine the cause of the colour change to ensure suitability for aircraft or engine use, or both.

10.5 Water separation characteristic information statement

The ease of coalescence of water from fuels as influenced by surface-active agents (surfactants) may be assessed by ASTM D7224, D3948 or D8073. A high water separation characteristic rating suggests a fuel free of surfactants, whereas a low rating indicates the presence of surfactants. Surfactants can disarm coalescers, thus allowing water to pass through coalescer filters and remain in the fuel. Surfactants can be introduced into the fuel downstream from a refinery distribution system, in storage facilities or deliberately introduced through the addition of specific approved additives. In light of the factors that can degrade water separation characteristics, options such as supplying higher water separation characteristics than the minimum specification should be considered at the point of origin depending upon the means of distribution.

Due to the impact water can have on storage facilities and aircraft, and the resources associated with correcting off-specification fuel, it is recommended that test methods with the best precision, reflecting current filter media and ease of operator use, be adopted.

10.6 Refinery processing additive information statement

Additives used in refinery processes, such as corrosion inhibitors, can be carried over in trace quantities into aviation fuel. In a few isolated cases this has resulted in operational problems in aircraft fuel systems. Moreover, the tests and requirements specified in this standard may not be sufficient for detecting trace levels of refinery processing additives. It is therefore recommended that adequate quality assurance and management of change procedures, such as formal risk assessments, be in place to ensure that any relevant refinery processing additive use is well defined and controlled in order to maintain the quality of the finished product.

10.7 Contaminants – Incidental materials – Biodiesel information statement

Biodiesel (fatty acid methyl esters or FAME) is not an approved component in aviation turbine fuels. The use of FAME in other fuels has raised concern about contamination of aviation turbine fuels, particularly in non-dedicated distribution systems such as multi-product pipelines, marine vessels, railcars and tanker trucks.

The amount of incidental FAME (as defined by ASTM D6751, CAN/CGSB-3.524 or EN 14214) shall not exceed 50 mg/kg. Producers, distributors and users need to take appropriate precautions to avoid contamination. The supplier shall establish the need to test for FAME based on various risk factors that can lead to FAME contamination. Suitable test methods for determining the concentration of FAME in aviation turbine fuels are ASTM D7797, IP 583, IP 585, IP 590 and IP 599. IP 585 shall be the referee method in case of dispute.

10.8 Cleanliness information statement

Fuel cleanliness changes during the storage and distribution of fuel. Cleanliness is maintained by allowing time for fuel to settle in storage and the use of filtration that removes both particulate matter and undissolved water. Visual appearance of fuel is an indicator of contamination by particulate matter and undissolved water. However, interpretation of this requirement is subjective. Procedures such as ASTM D4176 Procedure 1 and CAN/CGSB-3.0 No. 28.8 can be used to evaluate fuel cleanliness rapidly. Note that it is essential that a representative fuel sample is obtained. Quantitative limits for particulate matter are given under paragraph 6.10.2.

10.9 Storage and distribution information statement

This standard applies to fuel as it is supplied to an aircraft. However, it is normally applied at the point of manufacture and at points of custody transfer. Some of the specified properties can change during storage and distribution so appropriate quality assurance testing and handling procedures should be followed. Standards, recommended practices and other guidelines for appropriate testing and handling procedures are available from the Energy Institute (EI), the American Petroleum Institute (API), the Joint Inspection Group (JIG), the International Air Transport Association (IATA), the International Civil Aviation Organization (ICAO), Airlines for America (A4A) and the CSA Group (CSA). Changes in how fuel is handled during storage and distribution should be subject to a Management of change (MOC) study.

Annex A
(normative)

Referenced ASTM International publications (see 2.3)

A.1 Annual Book of ASTM Standards

ASTM D56 – Standard Test Method for Flash Point by Tag Closed Cup Tester

ASTM D86 – Standard Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure

ASTM D130 – Standard Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test

ASTM D381 – Standard Test Method for Gum Content in Fuels by Jet Evaporation

ASTM D445 – Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity)

ASTM D1298 – Standard Test Method for Density, Relative Density or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method

ASTM D1319 – Standard Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption

ASTM D1322 – Standard Test Method for Smoke Point of Kerosene and Aviation Turbine Fuel

ASTM D1840 – Standard Test Method for Naphthalene Hydrocarbons in Aviation Turbine Fuels by Ultraviolet Spectrophotometry

ASTM D2276 – Standard Test Method for Particulate Contaminant in Aviation Fuel by Line Sampling

ASTM D2386 – Standard Test Method for Freezing Point of Aviation Fuels

ASTM D2622 – Standard Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry

ASTM D2624 – Standard Test Methods for Electrical Conductivity of Aviation and Distillate Fuels

ASTM D2887 – Standard Test Method for Boiling Range Distribution of Petroleum Fractions by Gas Chromatography

ASTM D3227 – Standard Test Method for (Thiol Mercaptan) Sulfur in Gasoline, Kerosine, Aviation Turbine, and Distillate Fuels (Potentiometric Method)

ASTM D3241 – Standard Test Method for Thermal Oxidation Stability of Aviation Turbine Fuels

ASTM D3242 – Standard Test Method for Acidity in Aviation Turbine Fuel

ASTM D3244 – Standard Practice for Utilization of Test Data to Determine Conformance with Specifications

ASTM D3338 – Standard Test Method for Estimation of Net Heat of Combustion of Aviation Fuels

ASTM D3828 – Standard Test Methods for Flash Point by Small Scale Closed Cup Tester

ASTM D3948 – Standard Test Method for Determining Water Separation Characteristics of Aviation Turbine Fuels by Portable Separometer

ASTM D4052 – Standard Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter

ASTM D4057 – Standard Practice for Manual Sampling of Petroleum and Petroleum Products

ASTM D4171 – Standard Specification for Fuel System Icing Inhibitors

ASTM D4176 – Standard Test Method for Free Water and Particulate Contamination in Distillate Fuels (Visual Inspection Procedures)

ASTM D4177 – Standard Practice for Automatic Sampling of Petroleum and Petroleum Products

ASTM D4294 – Standard Test Method for Sulfur in Petroleum and Petroleum Products by Energy Dispersive X-ray Fluorescence Spectroscopy

ASTM D4529 – Standard Test Method for Estimation of Net Heat of Combustion of Aviation Fuels

ASTM D4809 – Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method)

ASTM D4952 – Standard Test Method for Qualitative Analysis for Active Sulfur Species in Fuels and Solvents (Doctor Test)

ASTM D5001 – Standard Test Method for Measurement of Lubricity of Aviation Turbine Fuels by the Ball-on-Cylinder Lubricity Evaluator (BOCLE)

ASTM D5006 – Standard Test Method for Measurement of Fuel System Icing Inhibitors (Ether Type) in Aviation Fuels

ASTM D5452 – Standard Test Method for Particulate Contamination in Aviation Fuels by Laboratory Filtration

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

ASTM D5972 – Standard Test Method for Freezing Point of Aviation Fuels (Automatic Phase Transition Method)

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

ASTM D6732 – Standard Test Method for Determination of Copper in Jet Fuels by Graphite Furnace Atomic Absorption Spectrometry

ASTM D6751 – Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels

ASTM D7039 – Standard Test Method for Sulfur in Gasoline, Diesel Fuel, Jet Fuel, Kerosine, Biodiesel, Biodiesel Blends, and Gasoline-Ethanol Blends by Monochromatic Wavelength Dispersive X-ray Fluorescence Spectrometry

ASTM D7042 – Standard Test Method for Dynamic Viscosity and Density of Liquids by Stabinger Viscometer (and the Calculation of Kinematic Viscosity)

ASTM D7153 – Standard Test Method for Freezing Point of Aviation Fuels (Automatic Laser Method)

ASTM D7224 – Standard Test Method for Determining Water Separation Characteristics of Kerosine-Type Aviation Turbine Fuels Containing Additives by Portable Separometer

ASTM D7345 – Standard Test Method for Distillation of Petroleum Products and Liquid Fuels at Atmospheric Pressure (Micro Distillation Method)

ASTM D7566 – Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons

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

ASTM D7945 – Standard Test Method for Determination of Dynamic Viscosity and Derived Kinematic Viscosity of Liquids by Constant Pressure Viscometer

ASTM D8073 – Standard Test Method for Determination of Water Separation Characteristics of Aviation Turbine Fuel by Small Scale Water Separation Instrument

ASTM D8267 – Standard Test Method for Determination of Total Aromatic, Monoaromatic and Diaromatic Content of Aviation Turbine Fuels Using Gas Chromatography with Vacuum Ultraviolet Absorption Spectroscopy Detection (GC-VUV)

ASTM E29 – Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications

Annex B
(informative)

Significance of viscosity requirements for aviation fuels

B.1 Some engine and auxiliary power unit (APU) manufacturers specify a maximum viscosity of 12 mm^2/s to ensure satisfactory low temperature operation. Aviation turbine fuel viscosity can exceed 12 mm^2/s as the fuel temperature approaches the specification freeze point maximum when the viscosity at -20 °C exceeds 5.5 mm^2/s for Jet A (-40 °C freeze point) or 4.5 mm^2/s for Jet A-1 (-47 °C freeze point).

B.2 The atomization characteristics of fuel nozzles used in propulsion engines and APUs is such that successful cold engine starts may not be achieved at fuel viscosities above 12 mm^2/s (12 cSt). This can potentially impact certain aircraft operation such as limiting the low temperature start envelope, which could impact extended twin operations. While there are no known field problems at this time, there needs to be further discussion on the need for all the fuel being delivered to these engines to have a 12 mm^2/s (12 cSt) maximum viscosity and on how this could be accomplished (for example, through fuel specification changes, airframe or APU design changes, or operational changes).

Note: With permission, aligns with ASTM D7945, *Standard Test Method for Determination of Dynamic Viscosity and Derived Kinematic Viscosity of Liquids by Constant Pressure Viscometer*, copyright ASTM International, 100 Barr Harbor Drive, West Conshohocken, PA 19428. A copy of the complete standard may be obtained from ASTM International at www.astm.org.