c. The covers can withstand the test of AC 20-135, Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards, and Criteria, issued 2/9/90, or ISO 2685-1992(E), Aircraft - Environment conditions and test procedures for airborne equipment - Resistance to fire in designated fire zones, for a period of 5 minutes. The test cover should be installed in a test fixture representative of actual installation in the aeroplane. Credit may be allowed for fuel as a heat sink if covers will be protected by fuel during all likely conditions. The maximum amount of fuel that should be allowed during this test is the amount associated with reserve fuel. Also, the static fuel pressure head should be accounted for during the burn test. There should be no burn-through or distortion that would lead to fuel leakage at the end of the tests; although damage to the cover and seal is permissible.

[Amdt 25/3]
[Amdt 25/14]

AMC 25.963(g) Fuel tanks: General

ED Decision 2007/010/R

(Revoked)

[Amdt 25/3]

CS 25.965 Fuel tank tests

ED Decision 2003/2/RM

(a) It must be shown by tests that the fuel tanks, as mounted in the aeroplane can withstand, without failure or leakage, the more critical of the pressures resulting from the conditions specified in sub-paragraphs (a)(1) and (2) of this paragraph. In addition it must be shown by either analysis or tests, (see AMC 25.965(a)) that tank surfaces subjected to more critical pressures resulting from the conditions of sub-paragraphs (a)(3) and (4) of this paragraph, are able to withstand the following pressures:

(1) An internal pressure of 24 kPa (3·5 psi).

(2) 125% of the maximum air pressure developed in the tank from ram effect.

(3) Fluid pressures developed during maximum limit accelerations, and deflections, of the aeroplane with a full tank.

(4) Fluid pressures developed during the most adverse combination of aeroplane roll and fuel load.

(b) Each metallic tank with large unsupported or unstiffened flat surfaces, whose failure or deformation could cause fuel leakage, must be able to withstand the following test, or its equivalent, without leakage or excessive deformation of the tank walls:

(1) Each complete tank assembly and its supports must be vibration tested while mounted to simulate the actual installation.

(2) Except as specified in sub-paragraph (b)(4) of this paragraph, the tank assembly must be vibrated for 25 hours at an amplitude of not less than 0.8 mm (1/32 of an inch) (unless another amplitude is substantiated) while two-thirds filled with water or other suitable test fluid.

(3) The test frequency of vibration must be as follows:

(i) If no frequency of vibration resulting from any rpm within the normal operating range of engine speeds is critical, the test frequency of vibration must be 2 000 cycles per minute.

(ii) If only one frequency of vibration resulting from any rpm within the normal operating range of engine speeds is critical, that frequency of vibration must be the test frequency.

(iii) If more than one frequency of vibration resulting from any rpm within the normal operating range of engine speeds is critical, the most critical of these frequencies must be the test frequency.

(4) Under sub-paragraph (b)(3)(ii) and (iii) of this paragraph, the time of test must be adjusted to accomplish the same number of vibration cycles that would be accomplished in 25 hours at the frequency specified in sub-paragraph (b)(3)(i) of this paragraph.

(5) During the test, the tank assembly must be rocked at the rate of 16 to 20 complete cycles per minute, through an angle of 15° on both sides of the horizontal (30° total), about the most critical axis, for 25 hours. If motion about more than one axis is likely to be critical, the tank must be rocked about each critical axis for 12·5 hours.

(c) Except where satisfactory operating experience with a similar tank in a similar installation is shown, non-metallic tanks must withstand the test specified in sub-paragraph (b)(5) of this paragraph, with fuel at a temperature of 43.3°C (110°F). During this test, a representative specimen of the tank must be installed in a supporting structure simulating the installation in the aeroplane.

(d) For pressurised fuel tanks, it must be shown by analysis or tests that the fuel tanks can withstand the maximum pressure likely to occur on the ground or in flight.

AMC 25.965(a) Fuel tank tests

ED Decision 2003/2/RM

The analysis or tests should be performed on each complete tank in the configuration ready and capable of flight. Each complete tank means any tank fully equipped which is isolated from other tanks by tank walls or which may be isolated by valves under some flight configurations.

CS 25.967 Fuel tank installations

ED Decision 2016/010/R

(See AMC 25.967)

(a) Each fuel tank must be supported so that tank loads (resulting from the weight of the fuel in the tanks) are not concentrated on unsupported tank surfaces. In addition –

(1) There must be pads, if necessary, to prevent chafing between the tank and its supports;

(2) Padding must be non-absorbent or treated to prevent the absorption of fluids;

(3) If a flexible tank liner is used, it must be supported so that it is not required to withstand fluid loads (see AMC 25.967(a)(3)); and

(4) Each interior surface of the tank compartment must be smooth and free of projections that could cause wear of the liner unless –

(i) Provisions are made for protection of the liner at these points; or

(ii) That construction of the liner itself provides that protection.

(b) Spaces adjacent to tank surfaces must be ventilated to avoid fume accumulation due to minor leakage. If the tank is in a sealed compartment, ventilation may be limited to drain holes large enough to prevent excessive pressure resulting from altitude changes.

(c) The location of each tank must meet the requirements of CS 25.1185(a).

(d) No engine nacelle skin immediately behind a major air outlet from the engine compartment may act as the wall of an integral tank.

(e) Each fuel tank must be isolated from personnel compartments by a fumeproof and fuelproof enclosure.

[Amdt 25/18]

AMC 25.967(a)(3) Fuel tank installation

ED Decision 2003/2/RM

The installation of a flexible tank and its venting, according to CS 25.975(a)(3) should be such that the tank liner will not be deformed in such a way as to significantly affect the fuel quantity indication.

CS 25.969 Fuel tank expansion space

ED Decision 2003/2/RM

Each fuel tank must have an expansion space of not less than 2% of the tank capacity. It must be impossible to fill the expansion space inadvertently with the aeroplane in the normal ground attitude. For pressure fuelling systems, compliance with this paragraph may be shown with the means provided to comply with CS 25.979(b).

CS 25.971 Fuel tank sump

ED Decision 2003/2/RM

(a) Each fuel tank must have a sump with an effective capacity, in the normal ground attitude, of not less than the greater of 0·10% of the tank capacity or one-quarter of a litre unless operating limitations are established to ensure that the accumulation of water in service will not exceed the sump capacity.

(b) Each fuel tank must allow drainage of any hazardous quantity of water from any part of the tank to its sump with the aeroplane in the ground attitude.

(c) Each fuel tank sump must have an accessible drain that –

(1) Allows complete drainage of the sump on the ground;

(2) Discharges clear of each part of the aeroplane; and

(3) Has manual or automatic means for positive locking in the closed position.

CS 25.973 Fuel tank filler connection

ED Decision 2003/2/RM

Each fuel tank filler connection must prevent the entrance of fuel into any part of the aeroplane other than the tank itself. In addition –

(a) Reserved

(b) Each recessed filler connection that can retain any appreciable quantity of fuel must have a drain that discharges clear of each part of the aeroplane;

(c) Each filler cap must provide a fuel-tight seal; and

(d) Each fuel filling point must have a provision for electrically bonding the aeroplane to ground fuelling equipment.

CS 25.975 Fuel tank vents

ED Decision 2018/005/R

(a) *Fuel tank vents*. Each fuel tank must be vented from the top part of the expansion space so that venting is effective under any normal flight condition. In addition –

(1) Each vent must be arranged to avoid stoppage by dirt or ice formation;

(2) The vent arrangement must prevent siphoning of fuel during normal operation;

(3) The venting capacity and vent pressure levels must maintain acceptable differences of pressure between the interior and exterior of the tank, during –

(i) Normal flight operation;

(ii) Maximum rate of ascent and descent; and

(iii) Refuelling and defuelling (where applicable);

(4) Airspaces of tanks with interconnected outlets must be interconnected;

(5) There may be no point in any vent line where moisture can accumulate with the aeroplane in the ground attitude or the level flight attitude, unless drainage is provided;

(6) No vent or drainage provision may end at any point:

(i) Where the discharge of fuel from the vent outlet would constitute a fire hazard; or

(ii) From which fumes could enter personnel compartments; and

(7) Each fuel tank vent system must prevent explosions, for a minimum of 2 minutes and 30 seconds, caused by the propagation of flames from outside the tank through the fuel tank vents into the fuel tank vapour spaces when any fuel tank vent is continuously exposed to flames. (See AMC 25.975(a)(7))

[Amdt 25/21]

AMC 25.975(a)(7) Fuel tank vent fire protection

ED Decision 2018/005/R

1. Purpose

This AMC provides guidance and acceptable means of compliance with CS 25.975(a)(7) and the related specifications for the prevention of fuel tank explosions caused by the ignition of vapours outside fuel tank vents.

2. References

2.1. Related certification specifications:

— CS 25.863 Flammable fluid fire protection

— CS 25.867 Fire protection: other components

— CS 25.901 Installation (paragraphs (b)(2) and (c))

— CS 25.954 Fuel system lightning protection

— CS 25.963 Fuel tanks: general (paragraphs (d) and (e)(2))

— CS 25.981 Fuel tank ignition prevention.

2.2. Technical publications

— Hill, Richard and George R. Johnson, Investigation of Aircraft Fuel Tank Explosions and Nitrogen Inerting Requirements During Ground Fires, FAA Technical Report No. FAA-RD-75-119. Washington, D.C.: U.S. Department of Transportation, 1975

— FAA Technical Report ADS-18, National Technical Information Service (NTIS), Lightning Protection Measures for Aircraft Fuel Systems. Springfield, VA: U.S. Department of Commerce, 1964

— Military Standard, Environmental Engineering Considerations and Laboratory Test Methods, MIL-STD-810G w/Change1, Method 511.6 Procedure II. Philadelphia, PA: U.S. Department of Defense, 2014

— RTCA, Inc., Environmental Conditions and Test Procedures for Airborne Equipment, RTCA/DO-160G. Washington DC: RTCA, Inc., 2010

— Coordinating Research Council, Inc., Handbook of Aviation Fuel Properties. Atlanta, GA: CRC, Inc., 2004

— Kuchta, Joseph M., Summary of Ignition Properties of Jet Fuels and Other Aircraft Combustible Fluids, Technical Report AFAPL-TR-75-70. Springfield, VA: U.S. Department of Commerce, 1975

3. Definitions

— **Autogenous Ignition (Auto-Ignition) Temperature (AIT).** The minimum temperature at which an optimised flammable vapour and air mixture will spontaneously ignite when heated to a uniform temperature in a normal atmosphere without an external source of ignition, such as a flame or spark.

— **Flammability Limit**. The highest and lowest concentration of fuel-in-air-by-volume per cent that will sustain combustion. A fuel-to-air mixture below the lower limit is too lean to burn, while a mixture above the upper limit is too rich to burn. The flammability limit varies with altitude and temperature and is typically presented on a temperature-versus-altitude plot.

— **Flash Point**. The minimum temperature at which a flammable liquid will produce flammable vapour at sea level ambient pressure.

— **Flame Holding**. The ability of a flame arrestor to halt the propagation of a flame front through a passage.

— **Ignition Source**. A source of sufficient energy to initiate combustion of a fuel-air mixture. Hot surfaces that can exceed the auto-ignition temperature of the flammable vapour under consideration are considered to be ignition sources. Electrical arcs, electrical sparks, and friction sparks are also considered to be ignition sources if sufficient energy is released to initiate combustion.

— **Stoichiometric Ratio**. The ratio of fuel to air corresponding to the condition in which the available amounts of fuel and oxygen completely react with each other, thereby resulting in combustion products that contain neither fuel nor oxygen.

4. Acceptable means of compliance

Acceptable means of compliance with CS 25.975(a)(7) include:

— flame arrestors in the fuel tank vents that prevent flame propagation into the fuel tank (see paragraph 5 of this AMC);

— fuel tank inerting systems that exceed the basic requirements of CS 25.981 and prevent fuel tank explosions* (see paragraph 7.1 of this AMC);

— fuel tank pressurisation systems or features of the system that result in a closed vent system and that are effective in preventing a fuel tank explosion during all operating conditions (e.g. taxiing, take-off, landing, refuelling, etc.) and post-crash fire conditions (see paragraph 7.2 of this AMC); and

— fuel tank or vent system fire suppression systems that prevent a fuel tank explosion with a fire present at the fuel tank vent outlet for the required 2 minutes and 30 seconds (see paragraph 7.3 of this AMC).

* Fuel tank inerting systems that meet CS 25.981 would not necessarily be adequate for demonstrating compliance with CS 25.975 because CS 25.981 does not require the fuel tank ullage to be fully inert at all times. If inerting is used as the means of compliance with CS 25.975, the inerting system must be effective in preventing flame that is present at the vent outlet from propagating to the fuel tank. The applicant should show this during normal operating conditions, all foreseeable ground fire conditions (e.g. from refuelling, refuelling overflow, etc.), and post-crash ground fire conditions.

5. Flame arrestors

5.1. This paragraph describes the use of flame arrestors as a means of meeting the 2-minute and 30-second time requirements defined in CS 25.975(a)(7). The guidance is based on evaluating the flame arrestor performance during critical case conditions anticipated to occur when fire is adjacent to the fuel tank vent outlet. The flame arrestor should meet the performance described in this AMC during post-crash ground fires or other fire scenarios such as those resulting from fuel leakage due to fuel tank damage or fuel spilled during refuelling mishaps.

5.2. Flame arrestors that meet the standards defined in this AMC may not be effective in preventing the propagation of fires that may occur following lightning strikes near the fuel tank vent outlet. The ignition of fuel vapours near the vent outlet caused by lightning results in a high-speed pressure wave that can travel through the flame arrestor without sufficient time for the heat transfer necessary for the flame arrestor to quench the flame front. Instead, fuel tank vent lightning protection may be addressed as discussed in AMC 25.954 'Fuel System Lightning Protection', which is based on locating vents outside the lightning strike zones of the aeroplane. While aeroplane manufacturers have used flame arrestors to address lightning protection in several instances, they needed dedicated testing that addressed the unique design features to demonstrate the effectiveness of the installation. The guidance in this AMC is intended to address compliance with CS 25.975(a)(7) and is not intended to be used as guidance for showing compliance with the lightning protection requirements in CS 25.954.

5.3. The installation of flame arrestors in the aeroplane fuel vent system will affect the performance of the fuel tank vent system. The applicant should account for factors such as the introduction of a flow restriction and the associated increase in the pressure drop during refuelling system failure conditions, as well as the impact of environmental conditions such as icing and lightning, when requesting approval of the fuel tank installation. Means of compliance for these considerations are not addressed in this AMC. General fuel system guidance is provided in AMC 25.963 and AMC 25.981.

5.4. Previous results from flame arrestor performance tests indicated that the critical condition for evaluating the effectiveness of the flame arrestor occurs when the flame front contacts the surface of the flame arrestor, which results in heating of the flame arrestor. As the flame arrestor is heated, the ability of the flame arrestor to absorb energy may be reduced, resulting in its inability to quench the flame. Once this occurs, the flame will then pass through the flame arrestor, resulting in flashback. It is important to realise that flashback through heated flame arrestor channels, which normally quench flames, should not be confused with auto-ignition or hot surface ignition. Flashback will occur when the rate of heat loss to the channel wall is insufficient to quench the flame. In this case, the wall acts as an inadequate heat sink and not as an ignition source. The flame retains sufficient heat energy to pass to the upstream side of the flame arrestor.

5.5. Flame propagation past the flame arrestor may also occur due to the ignition of flammable vapours by hot surfaces. The time it takes for the assembly surfaces on the internal side of the flame arrestor, including the line and housing, to be heated to a temperature higher than the AIT of the flammable vapour mixture could be the limiting factor in establishing the effectiveness of the flame arrestor assembly. The ignition of combustible mixtures by hot surfaces (auto-ignition) involves different phenomena from the phenomena involved in flashback as discussed in paragraph 5.4 of this AMC. For auto-ignition to occur, a portion of the combustible gas must dwell near a hot surface long enough for the amount of chemical heat produced to become greater than the heat dissipated to the surroundings. The maximum dwell time (commonly termed the ‘ignition lag’) is a function of the heat transfer characteristics of the gas and the heat source, as well as the kinetics of the combustion process. For this reason, the surface area and the shape of the hot surface, and the flow field around the heat source, are critical factors in determining whether ignition will occur.

5.6. The test conditions defined in this AMC are intended to evaluate the effectiveness of flame arrestors during two conditions. The first condition is the ignition, by an external source, of flammable vapours at the fuel tank vent outlet. The flame arrestor should be effective in stopping the initial propagation of flames. The second condition is a continuous flow of vapour exiting the fuel vent. The flame arrestor should hold the flames without passing the flames to the upstream portion of the vent system. The applicant should determine the critical test conditions following a review and analysis of the particular flame arrestor installation and its characteristics.

5.7. The conditions under which the flame arrestor should be effective include those where flammable fluid vapours are exiting the fuel tank at flow rates that vary from no flow, which typically occurs during normal ground operations, to high-flow conditions, which typically occur during refuelling or when the fuel tank is heated due to a ground fire following an accident.

5.8. The applicant should conduct an analysis to determine the pass/fail criteria for the aeroplane-specific flame arrestor installation. The analysis should include consideration of hot surface ignition when determining whether the flame arrestor assembly meets the explosion prevention requirement of 2 minutes and 30 seconds. The maximum surface temperatures of the flame arrestor installation and the flame arrestor should be established when meeting the requirement. The applicant should consider the velocity of the flammable fluid vapour on the surface of the flame arrestor and the duct sidewall upstream (tank) side of the flame arrestor. Provided that a uniform vapour velocity is present (i.e. there are no areas of stagnation), a heat source whose temperature exceeds the AITs quoted for static conditions (typically 230 °C/450 °F) will not cause ignition in the flame arrestor installation. Data in the Handbook of Aviation Fuels Properties (see Chapter 2.2 of this AMC) show the relationships between vapour velocities and AITs. Test results from developmental testing of flame arrestors installed in fuel vent lines have shown that ignition will not occur if the temperature of the centre of the flame arrestor remains below 370 °C/700 °F. However, this temperature limit may not be appropriate for other surfaces in the flame arrestor installation where a uniform flammable vapour flow is not present. The applicant should analyse the flame arrestor design to determine the critical locations and fuel vapour flow conditions that result in the highest surface temperatures, and run an adequate number of test conditions to validate the analysis.

6. Demonstrating compliance using flame arrestors

6.1. The performance of a flame arrestor is influenced by installation effects that may cause variations in critical parameters such as the speed of the flame front and the temperatures of the surfaces. The applicant should account for such installation effects in demonstrating compliance. The applicant may choose to show compliance with CS 25.975(a)(7) by testing a complete, conformed production installation of the flame arrestor (including the upstream and downstream ducting). Alternatively, the applicant may request EASA approval to use other tests and analysis of the flame arrestor and the installation as a means of compliance.

6.2. The applicant may propose to use flame arrestor elements from a supplier. The supplier may have previously qualified an element to flame propagation requirements without consideration of the design of the aeroplane into which the flame arrestor will be installed. The applicant should conduct tests to show that they have accounted for any effects of the installation, including flame front speeds and duct sidewall temperatures. The fuel types for these tests differ, and should be established as discussed in paragraph 6.3.1.3 of this AMC prior to conducting any testing.

6.3. Flame arrestor installation test.

6.3.1. Test Set-up.

Figure A-1 shows a schematic of the test set-up. The test set-up involves mounting the flame arrestor element in a tube configuration that is representative of the aeroplane installation. The speed of the flame front that travels down the fuel vent system tubing toward the flame arrestor is a critical factor in the performance of the flame arrestor in preventing flame propagation. The flame front will accelerate down the tubing, so higher velocities will occur if the flame arrestor is located farther away from the fuel tank vent outlet. Therefore, the shape and diameter of the tubing and its length from the fuel tank vent inlet to the flame arrestor should be representative of the production configuration, unless the flame arrestor element was previously found to comply in an installation in which the speed of the flame reaching the flame arrestor was higher. In addition, the orientation of the flame arrestor in the fixture is a critical parameter for the compliance demonstration. For instance, a flame arrestor installation that faces downward, so a ground fire impinges on its face, will have a shorter duration flame-holding capability than a flame arrestor that is mounted horizontally.

6.3.1.1. Test fixture features.

The applicant should consider the following features in designing the flame arrestor test fixture:

1. Orient the element to simulate the actual aeroplane installation.
2. Cut viewing sections into the pipe upstream and downstream of the flame arrestor element and cover them with transparent material to provide visual access to the element.
3. Locate igniters upstream and downstream of the element.
4. Locate thermocouples in the duct to measure the incoming flammable mixture temperature and the vapour temperatures downstream of the flame arrestor element.
5. Install thermocouples on the surface of the centre of the flame arrestor element's upstream face and on the surface of the upstream side of the duct.
6. Incorporate a pressure-relief feature in the upstream portion of the system to relieve explosive pressures when ignition of the upstream flammable fluid vapour occurs.
7. Mix air that is at a temperature higher than the boiling point of the fuel being used (see paragraph 6.3.1.3 of this AMC) with fuel, and introduce it at the inlet of the tube.
8. Vary fuel–air ratios by adjusting the respective fuel-vapour and air-supply rates.

6.3.1.2. Test equipment.

The test equipment should include:

1. The test article, including the flame arrestor and the downstream section of the vent system assembly that meets production specifications.
2. A section of ducting that is representative of the production flame arrestor installation.
3. A means of generating a supply of fuel vapour at preselected fuel-to-vapour air ratios and various flow rates.
4. A window for observing upstream and downstream conditions during the test. This should allow to determine the location of the flame front relative to the flame arrestor.
5. A means to measure temperatures on the upstream duct surfaces and the flame arrestor.

6. A means to measure fuel vapour mixture temperatures both upstream and downstream of the flame arrestor.

7. A means to relieve explosive pressure upstream of the flame arrestor.

8. Ignition sources for igniting the explosive mixture upstream and downstream of the flame arrestor.

6.3.1.3. Fuel type.

6.3.1.3.1. The applicant should establish the critical fuel type for the test based on a review of the approved fuels for the aeroplane model. The applicant should use fuels in the test that have representative characteristics of the critical fuel approved for use in the aeroplane. The use of hexane as a representative fuel for kerosene fuels such as Jet A and TS-1 has been found to be acceptable. Hexane (C_6H_{14}) is readily available and easily manipulated in the gaseous state, so it is typically a fuel of choice. The AIT for hexane of 223°C/433°F closely simulates that of Jet A kerosene fuel, which has an AIT of 224°C/ 435°F, and JP-4 which has an AIT of 229°C/445°F.

Note: The applicant should not use fuels with higher AITs than these, such as propane, for the flame arrestor element test because ignition on the back side of the flame arrestor would not be adequately evaluated.

6.3.1.3.2. Table A-1 summarises the properties of hexane and provides an example of the method for calculating the stoichiometric relationship of hexane needed for the test.

6.3.1.3.3. The applicant may use propane for testing of a flame arrestor installation if the AIT is not a critical parameter for the test. For example, testing of a simulated production flame arrestor installation to validate that temperatures of portions of the installation within the fuel tank remain below the maximum permitted fuel tank surface temperature (typically 200 °C/400 °F) would be acceptable, provided that the applicant or supplier has previously shown that the flame arrestor element meets the flame-holding requirements.

6.3.1.3.4. Table A-3 summarises the properties of propane as provided in FAA Technical Report ADS-18, Lightning Protection Measures for Aircraft Fuel Systems (see Chapter 2.2 of this AMC), and provides an example of the method for calculating the stoichiometric ratio of propane.

6.3.1.4. Thermocouples.

The applicant should use bare junction 1/16- to 1/8-inch metal-sheathed, ceramic-packed, chromel-alumel thermocouples with nominal 22 to 30 AWG (American wire gage) size conductors or equivalent. The applicant should not use air-aspirated, shielded thermocouples. Experience has shown that 1/16-inch thermocouples may provide more accurate calibration than 1/8-inch thermocouples; the 1/16-inch thermocouples are therefore recommended.