NOTICE OF PROPOSED AMENDMENT (NPA) NO 2008-19

DRAFT DECISION OF THE EXECUTIVE DIRECTOR OF THE EUROPEAN AVIATION SAFETY AGENCY

AMENDING
DECISION NO 2003/2/RM of the Executive Director of the Agency of 17 October 2003 on certification specifications, including airworthiness code and acceptable means of compliance, for large aeroplanes (« CS-25 »)

AND
Decision No 2003/1/RM of the Executive Director of the Agency of 17 October 2003 on acceptable means of compliance and guidance material for the airworthiness and environmental certification of aircraft and related products, parts and appliances, as well as for the certification of design and production organisations ("AMC and GM to Part 21")

"Fuel tank flammability reduction"

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A. Explanatory Note

I. General

1. The purpose of this Notice of Proposed Amendment (NPA) is to envisage amending decision no 2003/2/RM of the Executive Director of the Agency of 17 October 2003 on certification specifications, including airworthiness code and acceptable means of compliance, for large aeroplanes (CS-25). The scope of this rulemaking activity is outlined in Terms of Reference (ToR) for task 25.056 (b) and is described in more detail below.

2. The European Aviation Safety Agency (the Agency) is directly involved in the rule-shaping process. It assists the Commission in its executive tasks by preparing draft regulations, and amendments thereof, for the implementation of the Basic Regulation[1] which are adopted as "Opinions" (Article 14(1)). It also adopts Certification Specifications, including Airworthiness Codes and Acceptable Means of Compliance (AMC) and Guidance Material (GM) to be used in the certification process (Article 14(2)).

3. When developing rules, the Agency is bound to following a structured process as required by Article 43(1) of the Basic Regulation. Such process has been adopted by the Agency's Management Board and is referred to as "The Rulemaking Procedure[2]".

4. This rulemaking activity is included in the Agency's rulemaking programme for 2008. It implements the rulemaking task 25.056(b) "fuel tank flammability reduction".

5. The text of this NPA has been developed by the Agency. It is submitted for consultation of all interested parties in accordance with Article 52 of the Basic Regulation and Articles 5(3) and 6 of the Rulemaking Procedure.

II. Consultation

6. To achieve optimal consultation, the Agency is publishing the draft decision of the Executive Director on its internet site. Comments should be provided within 3 months in accordance with Article 6(4) of the Rulemaking Procedure. Comments on this proposal should be submitted by one of the following methods:

CRT: Send your comments using the Comment-Response Tool (CRT) available at **http://hub.easa.europa.eu/crt/**

E-mail: Only in case the use of CRT is prevented by technical problems these should be reported to the CRT webmaster and comments sent by email to NPA@easa.europa.eu.

Correspondence: If you do not have access to internet or e-mail you can send your comment by mail to:
Process Support
Rulemaking Directorate
EASA
Postfach 10 12 53
D-50452 Cologne
Germany

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[1] Regulation (EC) No 216/2008 of the European Parliament and of the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC (OJ L 79, 19.03.2008, p.1).

[2] Management Board decision concerning the procedure to be applied by the Agency for the issuing of opinions, certification specifications and guidance material ("Rulemaking Procedure"), EASA MB 08-2007, 13.6.2007.

Comments should be received by the Agency before 18 October 2008. If received after this deadline they might not be taken into account.

III. Comment response document

7. All comments received in time will be responded to and incorporated in a comment response document (CRD). The CRD will be available on the Agency's website and in the Comment-Response Tool (CRT).

IV. Content of the draft decision

1. Introduction

This NPA is aimed at introducing new CS-25 specifications addressing fuel tank flammability exposure, and the eventual introduction of Flammability Reduction Means (FRM) to mitigate high flammability exposure.

The flammability exposure requirement are in line with the current Agency (and before the Agency, JAA) policy for adding special conditions to the certification basis of new products and for the review of existing designs as imposed on TC/STC holders. It is primarily intended to prevent high flammability exposure tanks. The criteria to delineate high and low flammability exposure tanks are based upon a maximum temperature rise in any part of the tank under the most critical conditions during a 4 hours ground operation and the FAA proposed Monte Carlo statistical analysis.

If a fuel tank still displays high flammability exposure despite the minimisation of heat and energy transfers, the specification then requires the introduction of FRM. The NPA is based upon FRM using a IGGS (Inert Gas Generating System), or Nitrogen Generating System (NGS), to reduce the flammability exposure of fuel tanks by utilisation of nitrogen enriched air (NEA). The FRM certification criteria are similar to special conditions issued by the Agency on several projects, including the Boeing 737, 747, 787, the Sukhoï SuperJet and the Airbus A350. It is largely harmonized with FAA material (e.g. Special Condition no. 25-285-SC for the Nitrogen Generating System installed on Boeing 747 aircraft models).

A list of acronyms specific to this NPA can be found hereafter:

- ASM: Air Separation Module
- CWT: Centre Wing Tank
- FRM: Flammability Reduction Means
- IGSS: Inert Gas Generating System
- NEA: Nitrogen Enriched Air
- NGS: Nitrogen Generating System
- OEA: Oxygen Enriched Air
- SFAR: Special Federal Aviation Regulation

2. Background

2.1. Accident history

The accident to a Boeing 747-100 aeroplane in 1996 has led to the influences on fuel tank safety being widely discussed in recent years to establish means by which fuel tank explosions can be prevented in the future. The National Transportation Safety Board (NTSB) investigation into this accident determined that the probable cause of the accident was an explosion of the centre wing fuel tank, resulting from ignition of the flammable fuel/air mixture in the tank. However the exact ignition source was never determined.

Additional accidents that have occurred since the B747-100 accident as a result of ignition from an unknown source have highlighted the difficulty in preventing ignition from occurring within fuel tanks. Previously, on 11 May 1990 a centre fuel tank explosion occurred on a

Boeing 737-300 series aeroplane while the aeroplane was on the ground at Nimoy Aquino International Airport, Manila, Philippines. Accident investigators focused on a wiring fault or fuel pumps as a likely cause for this accident but a definitive ignition source was never confirmed. More recently on 3 March 2001 there was an explosion aboard a Boeing 737-400 aeroplane that resulted in one fatality. The accident is still under investigation but it was determined that the centre fuel tank exploded. All of these three accidents involved operation in high ambient temperatures. A further explosion occurred in May 2006 on a Boeing 727 in India.

A table listing the civil fuel tank explosion accidents (non-maintenance related) over the period 1960 to 2007 is presented below:

Accident Number	Date	Aircraft	Flight Phase	Possible ignition sources
1	08 December 1963	B-707-121	Descent/Holding	Lightning induced ignition of the fuel/air mixture in the No.1 reserve fuel tank with resulting explosive disintegration of the left outer wing and loss of airplane control.
2	05 July 1970	DC-8	Go-around	Fire from leaking fuel that may have been ignited by dangling wires following engine separation caused some explosions.
3	11 May 1990	B-737-300	Push-back	The vapors ignited probably due to damaged wiring [possibly float switch wiring from the float switches to the refuelling panel], because no bomb, incendiary device or detonator has been found.
4	17 July 1996	B-747	Climb	The source of ignition energy for the explosion could not be determined with certainty, but, of the sources evaluated by the investigation, the most likely was a short circuit outside of the CWT that allowed excessive voltage to enter it through electrical wiring associated with the fuel quantity indication system.
5	03 March 2001	B-737-400	Parked	The source of the ignition energy for the explosion could not be determined with certainty, but the most likely source was an explosion originating at the centre wing tank pump as a result of running the pump in the presence of metal shavings and a fuel/air mixture.

2.2. Existing Design Principles

Contributing factors to these accidents were the design and certification concept that fuel tank explosions could be prevented solely by precluding all ignition sources. This is important in relation to the design of aircraft that have heat sources underneath the centre tanks. These features result in the tank ullage (the volume within the fuel tank not occupied by liquid fuel) being flammable to the extent that very small energy levels can ignite fuel vapours and to the extent that the overall risk is increased because the tank ullage remains in the flammable range for a significant proportion of the aircraft operational time. Eliminating all ignition sources from tanks that have a high flammability exposure may not be practically achievable.

The NTSB recommendations did include making improvements to and maintaining the safety of fuel tank designs. This could be achieved by reducing the probability of creating an ignition source within fuel tanks and also minimizing the development of flammable vapours in heated centre tanks.

Commercial transport aeroplane fuel tank safety requirements have remained relatively unchanged throughout the evolution of piston-powered aircraft and later into the jet age. The fundamental premise for ensuring protection from fuel tank explosions has involved establishing that the design did not develop a condition that would result in an ignition within the fuel tank ullage space (i.e. ignition prevention) as well as result in a heated surface that would cause auto-ignition of the fuel vapour. A basic assumption in this approach has been that the fuel tank could contain flammable vapours under a wide range of conditions even though it was recognized that there were periods of time in which the vapour space would either be too lean or too rich to support combustion. The use of Jet A/A-1 and Jet B fuels and mixtures of both fuels in early jet operations made it difficult to predict when and where the tanks would be flammable. An accident involving a lighting strike to the wing of a Boeing 707 in the early 1960's which resulted in catastrophic wing failure underscored the importance of protecting the fuel system from the direct (e.g. stroke penetration) and indirect (e.g. electrically induced) effects of lightning. This accident resulted in additional fuel system lightning protection/fuel system requirements being added to FAR part 25 in the mid 1960's. The focus remained on prevention of the ignition of vapour by preventing the lightning caused spark from occurring.

The reliance on spark or hot surface prevention as the principal safety strategy has been largely a consequence of the state-of-the-art in fuel tank and aviation system technology. Previous attempts to develop commercially viable systems or features which would reduce or eliminate either aspects of the "fire triangle" (i.e. fuel, oxygen, ignition) such as fuel tank inerting or ullage space vapour "scrubbing" (i.e. vapour sweeping in order to prevent the accumulation of sufficient concentrations of fuel vapour to become flammable) proved to be unrealistic due to the weight of the systems, poor reliability, or undesirable secondary effects such as unacceptable atmospheric pollution.

2.3. Developments and research into flammability reduction

Following the B747-100 accident the FAA began research in the areas of tank flammability and exploring concepts for reducing or eliminating flammable vapours. Prior to this, most scientific information regarding the physics of fuel vapour ignition was generated through research done by or for the military in order to develop fuel systems, which would be protected in a combat environment. The focus of this FAA research was specifically directed at better understanding of the ignition process of commercial aviation fuel vapours and exploring new concepts for reducing or eliminating the presence of flammable vapours within tanks. One of the concepts developed and tested involved generating NEA by using air separation modules (ASM) and directing this NEA at appropriate nitrogen concentrations into the ullage space of fuel tank configurations. Researchers involved in these efforts were aware of the earlier systems shortcomings in the areas of weight, reliability, cost, and performance and targeted their studies accordingly. The purpose of this research was to further the understanding of fuel vapour ignition and to develop a feasible technology that could be adapted to commercial aviation in order to further improve the safety of fuel systems.

In addition to these research efforts an Aviation Rulemaking Advisory Committee (ARAC) working group was established in 1998 and tasked with gathering additional information to address NTSB recommendations regarding fuel tank safety in support of future rulemaking.

The FAA's research and development efforts in the area of fuel system inerting over the past few years has demonstrated the feasibility of substantially reducing the fuel system vapour space flammability by applying available technology. This research has developed a system that uses available bleed air which through the combination of increasing the allowable oxygen level in the tank from 10% (achieved in military applications) to 12-14.5 % and using different flows in climb, cruise and descent, has resulted in a variable flow rate inerting system that can maintain the tank inert throughout flight except for very unusual high descent rates.

2.4. Existing Requirements

In October 2000 the JAA issued an interim policy (INT/POL/25/12) on the subject of fuel tank safety. The Agency is notifying via special conditions this interim policy to new certification projects. It requires that a safety assessment must be made of the ignition source probability using the assessment methods of JAR 25.901(c) and JAR 25.1309. These special conditions do not address flammability. Subsequent CS-25 specifications and acceptable means of compliance were developed to address ignition (refer to EASA NPA-10-2004) with the intention to align with the intent of FAR 25.981(c). These specifications and AMC were included in CS-25 Amendment 1 as published on 12 December 2005.

In June 2001, the FAA regulations known as SFAR (Special FAR) 88 related to fuel tank ignition prevention came into force. This requirement package includes fuel tank safety design requirements and of relevance here is FAR 25.981(c) and associated AC 25.981-2, fuel tank flammability minimization. The intent of the regulation is to require that the exposure to formation or presence of flammable vapours is equivalent to that of an unheated aluminium wing tank in the aeroplane being evaluated. This may require incorporating design features to minimize the formation of flammable vapours, or means to mitigate the hazards, assuming that ignition does occur in fuel tanks.

3. The Agency policy regarding flammability

The Agency current policy regarding fuel tank flammability is recalled hereafter. It consists of a three steps approach:

(1) Limit heat and energy transfer;
(2) Assess the flammability exposure;
(3) Mitigating flammability.

The above policy has been consistently applied on recent certification projects (new designs). CS 25.981(c), as modified by Amendment 1, features flammability considerations. The experience of enforcing this requirement on several projects has however shown the need for some further explanation.

3.1. Limiting heat transfer

As expressed in the current 25.981 and its associated AMC 25.981(c), the Agency's prime concern is linked to (unnecessary) heat transfer into the tank. Therefore, applicants should limit the heat inputs to the maximum extent. Heat sources can be other systems, but also include environmental conditions such as solar radiation. The following design features have been found acceptable:

- Heat insulation between a fuel tank and a adjacent heat source (typically, Environmental Control System (ECS) packs);
- Forced ventilation around a fuel tank;
- Fuel transfer logic leaving sufficient fuel in transfer tanks exposed to solar radiations on the ground in order to limit their effects;
- Solar reflecting paints to limit the heat input by solar radiation.

The Agency has not set any hard figure to evaluate heat transfer. In some cases, a 20 °C limit has been found acceptable. 20 °C is the maximum allowed temperature rise in any part of the tank under the most critical conditions during a 4 hour ground operation. Any physical phenomenon, including environmental conditions such as solar radiation, should be taken into account. For tanks fitted with Flammability Reduction Means (FRM), no temperature limit is set; for tanks not fitted with FRM, a 20 °C is found acceptable. This 20 °C limitation applies if dispatch with inoperative is requested. In any case, the temperature increase should be quantified.

3.2. Assessing the flammability exposure

For assessing flammability the FAA (sponsored) Monte Carlo method can be used[3]. The 7 % limit retained by FAA to delineate between high and low flammability exposure tanks has not yet been introduced into CS-25. For harmonisation purposes this limitation could be retained. This limit was first established by the ARAC Fuel tank Harmonization Working Group in 1998, as being the exposure of typical wing tanks which have a satisfactory in-service experience. Since, some data have suggested that the actual flammability exposure of normal wing tanks could be a couple of points lower. The data also shows a clear separation between high flammability exposure tanks (with an exposure time ranging from 10 to 25 %) and low flammability exposure tanks (below 5 %, with a few rare exceptions around 6-7 %). Hence, the 7 % threshold is considered adequate for the purpose of the proposed rule as it allows an adequate distinction between high and low flammability exposure tanks.

The initial EASA proposal featured a 7 % flammability exposure to differentiate between high and low flammability exposure tanks. The EASA assumes that the FAA final rule will include a 3 % limit and for that reason this number has been retained. This will avoid adopting a less stringent standard in Europe when all manufacturers will have to comply with the FAA requirements if they wish to obtain a US TC. This change may have significant consequences such as preventing the certification without FRM of any fuel tank within the fuselage contour, heated or unheated. There is only a limited amount of data scientific or in-service experience supporting this limit of 3 %. The FAA Regulatory Evaluation does not seem to have taken into account the effects of this shift from 7 % to 3 %.

3.3. Mitigating flammability

If, despite heat transfer limitations, a tank still displays a high flammability exposure, the flammability exposure should be addressed and should be limited through specific design features. Active flammability reduction systems, such as membrane-based IGGS/NGS (Inert Gas Generating System/Nitrogen Generating System) have been certified by the Agency through special conditions harmonised with FAA. Such systems are simplex systems, they can be dispatched inoperative under MMEL and are therefore not acceptable as a sole means of compliance to CS 25.981.

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[3] The method is called after the city in the Monaco principality, because of a roulette, a simple random number generator. The name and the systematic development of Monte Carlo methods dates from about 1944. The real use of Monte Carlo methods as a research tool stems from work on the atomic bomb during the Second World War. This work involved a direct simulation of the probabilistic problems concerned with random neutron diffusion in fissile material; but even at an early stage of these investigations, von Neumann and Ulam refined this particular ''Russian roulette'' and ''splitting'' methods. However, the systematic development of these ideas had to await the work of Harris and Herman Kahn in 1948. About 1948 Fermi, Metropolis, and Ulam obtained Monte Carlo estimates for the Eigen values of Schrodinger equation. In about 1970, the newly developing theory of computational complexity began to provide a more Monte Carlo method. The theory identified a class of problems for which the time to evaluate the exact solution to a problem within the class grows at least exponentially with M. The question to be resolved was whether or not the Monte Carlo method could estimate the solution to a problem in this intractable class to within a specified statistical accuracy in time bounded above by a polynomial in M. Numerous examples now support this contention. Karp (1985) shows this property for estimating reliability in a planar multiterminal network with randomly failing edges. Dyer (1989) establishes it for estimating the volume of a convex body in M-dimensional Euclidean space. Broder (1986) and Jerrum and Sinclair (1988) establish the property for estimating the permanent of a matrix or, equivalently, the number of perfect matchings in a bipartite graph. Discussion derived from *History of the Monte Carlo Method*, Sabri Pllana, http://geocities.com/College Park/Quad/2435/index.html.

3.4. Summary

The Agency's approach to fuel tank safety can be summarised as a 3-step approach:

- limit heat and energy input to the maximum extent possible;
- Assess the flammability;
- If required and in addition to heat transfer limitations, mitigate flammability through the introduction of other systems.

The proposed rule follows this philosophy. Attachment 1 provides a summary of the proposed new specification in CS-25.

4. Flammability Reduction Means (FRM) requirement

The FAA has proposed the outline of a Flammability Reduction Means that utilises a Nitrogen Generating System (NGS). Several manufacturers have already applied for certification of such system, for retrofit of in-service aircraft, production on new airframes, or for new designs. Typically, the generation part of the system will be located in wing-to-fuselage fairing. Compressed cabin outflow air will flow through the system to generate Nitrogen Enriched Air (NEA) that will be supplied to the tanks.. The Oxygen Enriched Air (OEA) from the Air Separation Membrane (ASM) will be exhausted overboard. The FRM will also include a fuel vent system which prevents dilution of the nitrogen enriched ullage in the centre tank due to cross-venting characteristics of typical existing tank vent designs.

The typical system is a simplex system with no redundancy. This has the advantage of achieving an affordable system but the effects of failures and the demands of aircraft dispatch availability will need particular consideration. In order to minimise the weight of the system the inerting performance covers the majority, but not all flight conditions. The certification approach agreed in principle by the Agency and FAA is that the 'Monte Carlo' statistical methods previously developed in ARAC working groups will be used to assess operational mean risk for periods when tank inerting may not be fully available both due to performance limits, and periods when the system has failed and operating under the MMEL. This fact supports the Agency requirements to minimise by design the heat and energy transfers into the fuel tanks.

The IGGS/NGS is intended to reduce the fleet average flammability exposure of a tank to a level equal to or less than that of an unheated aluminium wing tank. The IGGS/NGS is intended to minimise the development of flammable vapours in order to allow showing compliance with the proposed CS 25.981(b)(2). The IGGS represents technology and fuel tank inerting principles not previously used on this class of aircraft, and the associated certification criteria are given in the proposed Appendix K, which sets safety and performance standards for the design and installation of such systems.

5. EASA related actions

The approach to fuel tank safety relies on actions on two of the segments of the fire triangle: ignition and flammability.

The Agency has already taken a considerable amount of actions including a modification to CS-25 (Amendment 1 resulting from NPA 10/2004) and Airworthiness Directives to address the issue of ignition and has now turned its efforts to address flammability. It is also worth mentioning that NPA 2007-01 relative to electrical wiring systems should also contribute to reduce the risk of fuel tank explosions.

Concerning flammability, the Agency is working on three issues right now:

1. This NPA to modify CS-25.

2. An envisaged production cut-in to address new aeroplanes on the production line. The Agency is at the time being defining the affected aircraft and the possible date for such production cut-in.
3. Last but not least, the Agency is considering the issue of retrofit to the existing fleet. In 2004 a Regulatory Impact Assessment was produced that concluded that actions 1 and 2 were necessary but left the issue of retrofit open. The Agency has commissioned a study to evaluate the issue of retrofit and this study together with the comments made on the FAA NPRM have been passed to a rulemaking group that should provide its recommendations relative to a possible retrofit in June of this year.

V. Regulatory Impact Assessment

1. Purpose and Intended Effect

   a. Issue which the NPA is intended to address:

   This NPA will require aeroplanes (new designs) to minimize heat and energy transfer into the fuel tanks. For tanks still featuring high flammability exposure characteristics after this assessment, an active Flammability Reduction Means must be installed. It is believed that these provisions will incite manufacturers to minimise flammability exposure rather than introduce an additional system; nevertheless it offers an option in cases where acceptable flammability levels are not achievable.

   It should be pointed out that the FAA is in the process of issuing a rule affecting a much larger portion of the fleet. This will involve retrofitting a significant proportion of the in-service fleet. In contrast, the Agency is only evaluating the need for a production cut-in on newly manufactured aircraft. The proposed amendment in this NPA is applicable only to new designs or a major change/STC in accordance with the change product rule. Current certification projects such as the Boeing Model 787 or the Airbus A350 feature Flammability Reduction System as baseline, primarily to meet FAA (and to a lesser degree the Agency) requirements introduced through Special Conditions. This NPA is effectively introducing those special conditions into CS-25.

   b. Scale of the issue (quantified if possible):

   This will affect all future large aeroplanes for which an application for TC is filed after CS-25 is amended and major changes/STC to existing large aeroplanes in accordance with the change product rule.

   c. Brief statement of the objectives of the NPA:

   This NPA will reduce the risk of fuel tank explosion on large aeroplanes mentioned above

2. Options

   The options identified are:

   - Option O: doing nothing;
   - Option 1: modifying CS-25 as proposed in this NPA

3. Sectors concerned

   The affected sectors of the aviation community within the Agency scope are:

   - Manufacturers,
   - Operators,
   - Maintenance organisations,
   - Leasing companies,
   - STC companies.

4. Impacts

   a. All identified impacts

      i. Safety

Note: the numbers quoted in this paragraph are based upon statistical data and not actual accident rates, and is intended to quantify the future risk based on past history and forecasting (A list of accidents has been provided in paragraph 2.1.)

The embodiment of a Flammability Reduction Means is introducing an additional and independent layer of protection in the fuel tank explosion protection scheme. Its net safety effect therefore largely depends upon the robustness of the ignition prevention exercise: the more effective the ignition prevention is, the less safety benefits can be expected from an FRM. However, predicting the efficiency of the ignition prevention exercises has proven to be a very difficult task. According to the Regulatory Impact Assessment issued in 2004, dealing with fuel tank safety, the introduction of the flammability reduction system will prevent between 1.5 and 5 accidents until 2030, depending on the effectiveness of the ignition prevention measures. Those figures are based upon a production cut-in and the effect of this NPA (which involves only new designs) is only a subset of this FRM introduction.

It should be noted that Flammability Reduction Means might introduce new potentially hazardous or catastrophic failure conditions (for example: over pressurising the fuel tank, contaminating the passenger and crew compartments with nitrogen-enriched air). The manufacturers will be required to show that the probability of such failure conditions is extremely remote or extremely improbable, respectively, but an accident caused by an FRS failure or an installation error during the major retrofit cannot be entirely ruled out.

The potential hazards to maintenance personnel associated with FRS must also be recognised. At least one fatal accident has occurred in the military as a result of inadvertent entry into nitrogen-enriched atmospheres without appropriate protective equipment. Fuel tank entry safety procedure, equipment and training in place today will need to be further developed once inerting systems are installed on aeroplanes.

      ii. Economic

Considering that other regulatory initiatives, including the one led by FAA, have a much larger impact on the large transport aeroplane fleet, no detailed quantitative economic assessment is provided in this NPA. The FAA NPRM[4] provides information on the cost associated to mandating FRM systems for future TC, aircraft in production and retrofit to the existing fleet. In a similar manner the EASA RIA[5] produced in 2004 provides comparable information. However the data included into this RIA needs to be updated. Concerning future TC, the following estimates can be provided:

Development costs (non-recurring): 70 millions Euros per aircraft manufacturer.
Cost of production: 85 000 to 220 000 Euros for aeroplane ranging from a typical single aisle aeroplane to a typical twin aisle aeroplane.

[4] See: http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgNPRM.nsf/0/BC0DF3960AE59183862570FF005235BA?OpenDocument&Highlight=flammability%20reduction

[5] See: http://www.easa.europa.eu/ws_prod/g/doc/Events/fueltanksafety_24062005/easa_fueltanksafety_24062005_ria_issue_1.pdf

Ownership costs: 13 500 to 38 500 Euros per year for aeroplanes ranging from small to large.

iii. Environmental

The Nitrogen-Enriched Air supplied to the centre fuel tanks of affected aircraft will displace fuel vapour into the atmosphere. The quantity of fuel vapour displaced into the atmosphere by the airflow into the tank is complex and dependant on many factors. It is clear that additional fuel vapour will be vented into the atmosphere as a result of the introduction of FRM but we have no evidence that this would have adverse effects.

The increase in fuel burn due to the introduction of FRM is approximately 0.1%. After maintenance involving fuel tank entry it is likely that some increase in APU or engine running time may be necessary to ensure the FRM is fully recharged before operating the aeroplane. Noise issues are increasingly sensitive at many European airports, but the FRM overall effect should be negligible in that respect.

Manufacturing by-products of the FRS should not have any significant impacts. Therefore, it can be concluded that the environmental effects are small.

iv. Social

No significant social impact is associated with the introduction of FRM on new designs.

v. Other aviation requirements outside the Agency scope:

- Appendix M and N are based upon FAA material; the proposed CS 25.981 slightly differs from the FAA proposal (as proposed in the NPRM published in November 2005). The most important difference with FAA the emphasis put by the Agency on minimising unnecessary heat transfer.

Compared to the FAA proposal, the Agency's NPA features a requirement imposing a boundary on heat transfer. This is based upon a review of the in-service experience, which clearly shows that the events occurred on the models featuring the highest heat transfer. The only figure provided in the AMC (20 °C temperature increase) concerns tanks not fitted with FRM able to meet the hot day criteria of Appendix M (K25.1(b)(1)). The 20 °C limits is however applicable if dispatch with the FRM inoperative is requested.

Despite those differences, FRM systems should be able to meet both FAA and the Agency's requirements through a single compliance exercise. Considering some regulations mandating the introduction of FRM for production aircraft or even retrofit would already be in place, this NPA should have a minimal impact.

The FAR 25 reporting requirement is not incorporated in CS-25, which is supported to have only technical requirement; an AMC to part 21 has been created for that purpose.

The initial EASA proposal featured a 7 % flammability exposure to differentiate between high and low flammability exposure tanks. The EASA assumes that the FAA final rule will include a 3 % limit and for that reason this number has been retained. This will avoid adopting a less stringent standard in Europe when all manufacturers will have to comply with the FAA requirements if they wish to obtain a US TC. This change may have significant consequences such as preventing the certification without FRM of any fuel tank within the fuselage contour, heated or unheated. There is only a limited amount of data scientific or in-service experience supporting this limit of 3 %. The FAA Regulatory

Evaluation does not seem to have taken into account the effects of this shift from 7 % to 3 %.

b. Equity and fairness in terms of distribution of positive and negative impacts among concerned sectors:

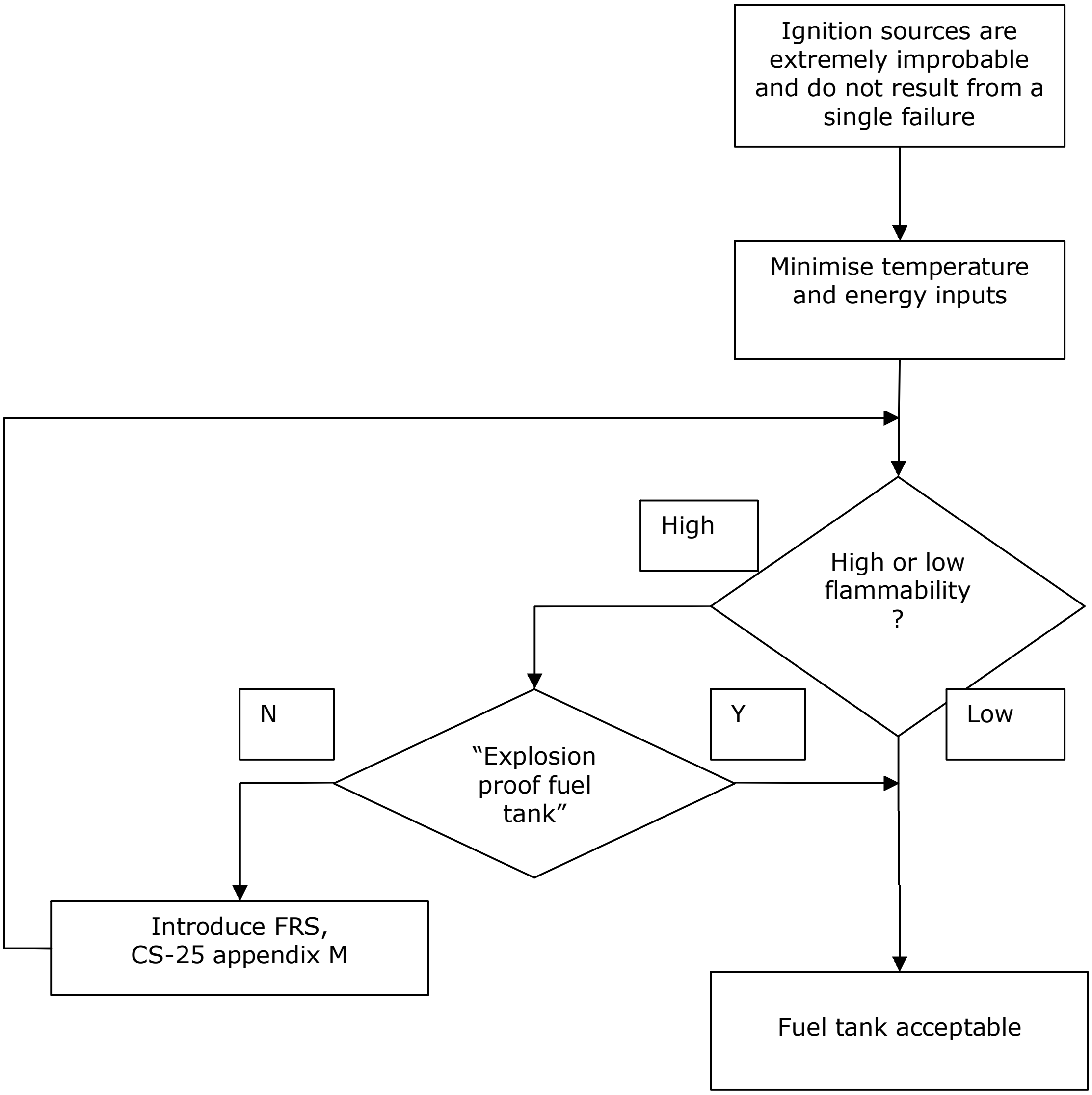
None identified at this stage.

5. Summary and Final Assessment:

Based on the above elements, the Agency believes that option 1 (Modifying CS-25 as proposed by this NPA) should be followed.

Attachment 1

The following is a summary for a given tank, of the proposed new specification in CS-25:



B. DRAFT DECISION

The text of the amendment is arranged to show deleted text, new text or new paragraph as shown below:

- deleted text is shown with a strike through: ~~deleted~~
- new text is highlighted with grey shading: new
- ….

  indicates that remaining text is unchanged in front of or following the reflected amendment.

I Draft Decision amending CS-25

CS-25 Book 1

25.981 Fuel tank ignition prevention.

Replace paragraph 25.981 (b) reserved by

(b) Fuel tank flammability

(1) To the extent practicable, design precautions must be taken to prevent the likelihood of flammable vapours within the fuel tanks by limiting heat and energy transfer (See AMC 25.981(b)(1)).

(2) Except as provided in sub-paragraph (4) of this paragraph, no fuel tank Fleet Average Flammability Exposure level may exceed:

(i) three percent, or

(ii) the exposure achieved in a fuel tank within the wing of the aeroplane model being evaluated. If the wing is not a conventional unheated aluminium wing, the analysis must be based on an assumed Equivalent Conventional Unheated Aluminium Wing (see AMC 25.981(b)(2).

The Fleet Average Flammability Exposure is determined in accordance with appendix N of CS-25.

(3) Any active Flammability Reduction means introduced to allow compliance with sub-paragraph (2) must meet appendix M of CS-25.

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(4) Sub-Paragraph (2) does not apply to a fuel tank if following an ignition of fuel vapours within that fuel tank the aeroplane remains capable of continued safe flight and landing.

CS-25 Book 1

Add a new appendix M to read:

Appendix M – Fuel Tank Flammability Reduction Means (FRM)

M25.1 Fuel tank flammability exposure requirements.

(a) The Fleet Average Flammability Exposure level of each fuel tank, as determined in accordance with Appendix N of CS-25, must not exceed 3 percent of the Flammability Exposure Evaluation Time (FEET), as defined in Appendix N of CS-25. If flammability reduction means (FRM) are used, neither time periods when any FRM is operational but the fuel tank is not inert, nor time periods when any FRM is inoperative may contribute more than 1.8 percent to the 3 percent average fleet flammability exposure of a tank.

(b) The Fleet Average Flammability Exposure, as defined in Appendix N of this part, of each fuel tank for ground, takeoff and climb phases of flight during warm days must not exceed 3 percent of FEET in each of these phases. The analysis must consider the following conditions.

(1) The analysis must use the subset of flights starting with a sea level ground ambient temperature of 26,7°C [80° F] (standard day plus 10°C (21° F) atmosphere) or more, from the flammability exposure analysis done for overall performance.

(2) For the ground, takeoff, and climb phases of flight, the average flammability exposure must be calculated by dividing the time during the specific flight phase the fuel tank is flammable by the total time of the specific flight phase.

(3) Compliance with this paragraph may be shown using only those flights for which the airplane is dispatched with the flammability reduction means operational.

M25.2 Showing compliance.

(a) The applicant must provide data from analysis, ground testing, and flight testing, or any combination of these, that:

(1) validate the parameters used in the analysis required by paragraph K25.1;

(2) substantiate that the FRM is effective at limiting flammability exposure in all compartments of each tank for which the FRM is used to show compliance with paragraph M25.1; and

(3) describe the circumstances under which the FRM would not be operated during each phase of flight.

(b) The FRM must meet the requirements of paragraph M25.1 with any combination of engine model, engine thrust rating, fuel type, and relevant pneumatic system configuration for which approval is sought.

(c) Any FRM failures or failures that could affect the FRM, with potential catastrophic consequences shall not result from a single failure or a combination of failures not shown to be extremely improbable.

(1) It must be shown that the fuel tank pressures will remain within limits during normal operating conditions and failure conditions.

(2) Identify critical features of the fuel tank system to prevent an auxiliary fuel tank installation from increasing the flammability exposure of main tanks above that permitted under paragraphs 1.3(a)(1), (2) and (b) of this appendix and to prevent degradation of the performance and reliability of the NGS.

(d) Oxygen-enriched air produced by the NGS must not create a hazard during normal operating conditions.

M25.3 Reliability indications and maintenance access

(a) Reliability indications must be provided to identify latent failures of the FRM.

(b) Sufficient accessibility to FRM reliability indications must be provided for maintenance personnel or the flight crew.

(c) The access doors and panels to the fuel tanks with FRMs (including any tanks that communicate with a tank via a vent system), and to any other confined spaces or enclosed areas that could contain hazardous atmosphere under normal conditions or failure conditions must be permanently stencilled, marked, or placarded to warn maintenance personnel of the possible presence of a potentially hazardous atmosphere.

M25.4 Airworthiness limitations and procedures.

The FRM shall be subject to analysis using conventional processes and methodology to ensure that the minimum scheduled maintenance tasks required for securing the continuing airworthiness of the system and installation are identified and published as part of the CS 25.1529 compliance. Maintenance tasks arising from either the Monte Carlo analysis or a CS 25.1309 safety assessment shall be dealt with in accordance with the principles laid down in AMC 25.19.

(a) If FRM is used to comply with paragraph M25.1, Airworthiness Limitations must be identified for all maintenance or inspection tasks required to identify failures of components within the FRM that are needed to meet paragraph M25.1.

(b) Maintenance procedures must be developed to identify any hazards to be considered during maintenance of the fuel system and of the FRM. These procedures must be included in the instructions for continued airworthiness (ICA).

CS-25 Book 1

Add a new Appendix N to read:

Appendix N – Fuel Tank Flammability Exposure

N25.1 General.

(a) This appendix specifies the requirements for conducting fuel tank fleet average flammability exposure analyses required to meet CS 25.981(b) and Appendix M. This appendix defines parameters affecting fuel tank flammability that must be used in performing the analysis. These include parameters that affect all aeroplanes within the fleet, such as a statistical distribution of ambient temperature, fuel flash point, flight lengths, and aeroplane descent rate. Demonstration of compliance also requires application of factors specific to the aeroplane model being evaluated. Factors that need to be included are maximum range, cruise mach number, typical altitude where the aeroplane begins initial cruise phase of flight, fuel temperature during both ground and flight times, and the performance of an FRM if installed (See AMC to appendix L25.1)

N25.2 Definitions.

(a) <u>Bulk Average Fuel Temperature</u> means the average fuel temperature within the fuel tank or different sections of the tank if the tank is subdivided by baffles or compartments.

(b) <u>Flammability Exposure Evaluation Time (FEET)</u>. The time from the start of preparing the aeroplane for flight, through the flight and landing, until all payload is unloaded, and all passengers and crew have disembarked. In the Monte Carlo program, the flight time is randomly selected from the Flight Length Distribution (Table 3), the pre-flight times are provided as a function of the flight time, and the post-flight time is a constant 30 minutes.

(c) <u>Flammable</u>. With respect to a fluid or gas, flammable means susceptible to igniting readily or to exploding (ref. CS-Definitions). A non-flammable ullage is one where the fuel-air vapour is too lean or too rich to burn or is inert as defined below. For the purposes of this appendix, a fuel tank that is not inert is considered flammable when the bulk average fuel temperature within the tank is within the flammable range for the fuel type being used. For any fuel tank that is subdivided into sections by baffles or compartments, the tank is considered flammable when the bulk average fuel temperature within any section of the tank, that is not inert, is within the flammable range for the fuel type being used.

(d) Flash Point. The flash point of a flammable fluid means the lowest temperature at which the application of a flame to a heated sample causes the vapour to ignite momentarily, or "flash." Table 1 of this appendix provides the flash point for the standard fuel to be used in the analysis.

(e) Fleet average flammability exposure is the percentage of the flammability exposure evaluation time (FEET) the fuel tank ullage is flammable for a fleet of an aeroplane type operating over the range of flight lengths in a world-wide range of environmental conditions and fuel properties as defined in this appendix.

(f) Gaussian Distribution is another name for the normal distribution, a symmetrical frequency distribution having a precise mathematical formula relating the mean and standard deviation of the samples. Gaussian distributions yield bell shaped frequency curves having a preponderance of values around the mean with progressively fewer observations as the curve extends outward.

(g) Hazardous atmosphere. An atmosphere that may expose maintenance personnel, passengers or flight crew to the risk of death, incapacitation, impairment of ability to self-rescue (that is, escape unaided from a confined space), injury, or acute illness.

(h) Inert. For the purpose of this appendix, the tank is considered inert when the bulk average oxygen concentration within each compartment of the tank is 12 percent or less from sea level up to 10,000 feet altitude, then linearly increasing from 12 percent at 10,000 feet to 14.5 percent at 40,000 feet altitude, and extrapolated linearly above that altitude.

(i) Inerting. A process where a non-combustible gas is introduced into the ullage of a fuel tank so that the ullage becomes non-flammable.

(j) Monte Carlo Analysis. The analytical method that is specified in this appendix as the compliance means for assessing the fleet average flammability exposure time for a fuel tank.

(k) Standard deviation is a statistical measure of the dispersion or variation in a distribution, equal to the square root of the arithmetic mean of the squares of the deviations from the arithmetic means.

(l) Transport Effects. For purposes of this appendix, transport effects are the change in fuel vapour concentration in a fuel tank caused by low fuel conditions and fuel condensation and vaporization.

(m) Ullage. The volume within the fuel tank not occupied by liquid fuel.

N25.3 Fuel tank flammability exposure analysis

(a) A flammability exposure analysis must be conducted for the fuel tank under evaluation to determine fleet average flammability exposure for the aeroplane and fuel types under evaluation. For fuel tanks that are subdivided by baffles or compartments, an analysis must be performed either for each section of the tank, or for the section of the tank having the highest flammability exposure. Consideration of transport effects is not allowed in the analysis. (See AMC to appendix N25.3 (a))

(b) The following parameters are defined in the Monte Carlo analysis and provided in paragraph N25.4:

(1) Cruise Ambient Temperature – as defined in this appendix.

(2) Ground Temperature – as defined in this appendix.

(3) Fuel Flash Point – as defined in this appendix.

(4) Flight length Distribution –that must be used is defined in Table 2 of this appendix.

(5) Aeroplane Climb and Descent Profiles – the applicant must use the climb and descent profiles defined in the users' manual.

(c) Parameters that are specific to the particular aeroplane model under evaluation that must be provided as inputs to the Monte Carlo analysis are:

(1) Aeroplane Cruise Altitude

(2) Fuel Tank quantities. If fuel quantity affects fuel tank flammability, inputs to the Monte Carlo analysis must be provided that represent the actual fuel quantity within the fuel tank or compartment of the fuel tank throughout each of the flights being evaluated. Input values for this data must be obtained from ground and flight test data or the approved FAA fuel management procedures.

(3) Aeroplane cruise Mach Number.

(4) Aeroplane maximum Range

(5) Fuel Tank Thermal Characteristics. If fuel temperature affects fuel tank flammability, inputs to the Monte Carlo analysis must be provided that represent the actual bulk average fuel temperature within the fuel tank throughout each of the flights being evaluated. For fuel tanks that are subdivided by baffles or compartments, bulk average fuel temperature inputs must be provided either for each section of the tank or for the section of the tank having the highest flammability exposure. Input values for these data must be obtained from ground and flight test data or a thermal model of the tank that has been validated by ground and flight test data.

(6) Maximum aeroplane operating temperature limit as defined by any limitations in the aeroplane flight manual.

(d) Fuel Tank FRM Model. If FRM is used, an Agency approved Monte Carlo program must be used to show compliance with the flammability requirements of CS 25.981 and Appendix M of this part. The program must determine the time periods during each flight phase when the fuel tank or compartment with the FRM would be flammable. The following factors must be considered in establishing these time periods:

(1) Any time periods throughout the flammability exposure evaluation time and under the full range of expected operating conditions, when the FRM is operating properly but fails to maintain a non-flammable fuel tank because of the effects of the fuel tank vent system or other causes,

(2) If dispatch with the system inoperative under the Master Minimum Equipment List (MMEL) is requested, the time period assumed in the reliability analysis, (60 flight hours must be used for a 10-day MMEL dispatch limit unless an alternative period has been approved,

(3) Frequency and duration of time periods of FRM inoperability, substantiated by test or analysis, caused by latent or known failures, including aeroplane system shut-downs and failures that could cause the FRM to shut down or become inoperative,

(4) Effects of failures of the FRM that could increase the flammability exposure of the fuel tank,

(5) Oxygen Evolution: If an FRM is used that is affected by oxygen concentrations in the fuel tank, the time periods when oxygen evolution from the fuel results in the fuel tank or compartment exceeding the inert level. The applicant must include any times when oxygen evolution from the fuel in the tank or compartment under evaluation would result in a flammable fuel tank. The oxygen evolution rate that must be used is defined in the users' manual.

(6) If an inerting system FRM is used, the effects of any air that may enter the fuel tank following the last flight of the day due to changes in ambient temperature, as defined in Table 4, during a 12-hour overnight period.

N25.4 Variables and data tables.

The following data must be used when conducting a flammability exposure analysis to determine the fleet average flammability exposure. Variables used to calculate fleet flammability exposure must include atmospheric ambient temperatures, flight length, flammability exposure evaluation time, fuel flash point, thermal characteristics of the fuel tank, overnight temperature drop, and oxygen evolution from the fuel into the ullage.

(a) Atmospheric Ambient Temperatures and Fuel Properties.

(1) In order to predict flammability exposure during a given flight, the variation of ground ambient temperatures, cruise ambient temperatures, and a method to compute the transition from ground to cruise and back again must be used. The variation of the ground and cruise ambient temperatures and the flash point of the fuel is defined by a Gaussian curve, given by the 50 percent value and a ± 1-standard deviation value.

(2) Ambient Temperature: Under the program, the ground and cruise ambient temperatures are linked by a set of assumptions on the atmosphere. The temperature varies with altitude following the International Standard Atmosphere (ISA) rate of change from the ground ambient temperature until the cruise temperature for the flight is reached. Above this altitude, the ambient temperature is fixed at the cruise ambient temperature. This results in a variation in the upper atmospheric temperature. For cold days, an inversion is applied up to 10,000 feet, and then the ISA rate of change is used.

(3) Fuel properties:

(a) For Jet A fuel, the variation of flash point of the fuel is defined by a Gaussian curve, given by the 50 percent value and a ± 1-standard deviation, as shown in Table 1.

(b) The flammability envelope of the fuel that must be used for the flammability exposure analysis is a function of the flash point of the fuel selected by the Monte Carlo for a given flight. The flammability envelope for the fuel is defined by the upper flammability limit (UFL) and lower flammability limit (LFL) as follows:

(i) LFL at sea level = flash point temperature of the fuel at sea level minus 5.5°C (10° F). LFL decreases from sea level value with increasing altitude at a rate of 0.55 °C (1º F) per 808 feet.

(ii) UFL at sea level = flash point temperature of the fuel at sea level plus 19.5°C (63.5º degrees F). UFL decreases from the sea level value with increasing altitude at a rate of 0.55°C (1º F) per 512 feet.

(4) For each flight analyzed, a separate random number must be generated for each of the three parameters (ground ambient temperature, cruise ambient temperature, and fuel flash point) using the Gaussian distribution defined in Table 1.

Table 1. Gaussian Distribution for Ground Ambient Temperature, Cruise Ambient Temperature, and Fuel Flash Point

	Temperature in Deg C/Deg F		
Parameter	Ground Ambient Temperature.	Cruise ambient Temperature.	Fuel Flash Point (FP)
Mean Temp	15.36/59.95	_ -73.3/ -70	48.8/ 120
Neg 1 std dev	11.18/ 20.14	4.4/ 8	4.4/ 8
Pos 1 std dev	9.6/ 17.28	4.4/ 8	4.4/8

(a) The Flight Length Distribution defined in Table 2 must be used in the Monte Carlo analysis.

Table 2. Flight Length Distribution

		Aeroplane Maximum Range – Nautical Miles (NM)									
		1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
Flight Length (NM)		Distribution of flight lengths (Percentage of total)									
From	To										
0	200	11.7	7.5	6.2	5.5	4.7	4.0	3.4	3.0	2.6	2.3
200	400	27.3	19.9	17.0	15.2	13.2	11.4	9.7	8.5	7.5	6.7
400	600	46.3	40.0	35.7	32.6	28.5	24.9	21.2	18.7	16.4	14.8
600	800	10.3	11.6	11.0	10.2	9.1	8.0	6.9	6.1	5.4	4.8
800	1000	4.4	8.5	8.6	8.2	7.4	6.6	5.7	5.0	4.5	4.0
1000	1200	0.0	4.8	5.3	5.3	4.8	4.3	3.8	3.3	3.0	2.7
1200	1400	0.0	3.6	4.4	4.5	4.2	3.8	3.3	3.0	2.7	2.4
1400	1600	0.0	2.2	3.3	3.5	3.3	3.1	2.7	2.4	2.2	2.0
1600	1800	0.0	1.2	2.3	2.6	2.5	2.4	2.1	1.9	1.7	1.6
1800	2000	0.0	0.7	2.2	2.6	2.6	2.5	2.2	2.0	1.8	1.7
2000	2200	0.0	0.0	1.6	2.1	2.2	2.1	1.9	1.7	1.6	1.4
2200	2400	0.0	0.0	1.1	1.6	1.7	1.7	1.6	1.4	1.3	1.2
2400	2600	0.0	0.0	0.7	1.2	1.4	1.4	1.3	1.2	1.1	1.0
2600	2800	0.0	0.0	0.4	0.9	1.0	1.1	1.0	0.9	0.9	0.8
2800	3000	0.0	0.0	0.2	0.6	0.7	0.8	0.7	0.7	0.6	0.6
3000	3200	0.0	0.0	0.0	0.6	0.8	0.8	0.8	0.8	0.7	0.7
3200	3400	0.0	0.0	0.0	0.7	1.1	1.2	1.2	1.1	1.1	1.0
3400	3600	0.0	0.0	0.0	0.7	1.3	1.6	1.6	1.5	1.5	1.4
3600	3800	0.0	0.0	0.0	0.9	2.2	2.7	2.8	2.7	2.6	2.5
3800	4000	0.0	0.0	0.0	0.5	2.0	2.6	2.8	2.8	2.7	2.6
4000	4200	0.0	0.0	0.0	0.0	2.1	3.0	3.2	3.3	3.2	3.1
4200	4400	0.0	0.0	0.0	0.0	1.4	2.2	2.5	2.6	2.6	2.5
4400	4600	0.0	0.0	0.0	0.0	1.0	2.0	2.3	2.5	2.5	2.4
4600	4800	0.0	0.0	0.0	0.0	0.6	1.5	1.8	2.0	2.0	2.0
4800	5000	0.0	0.0	0.0	0.0	0.2	1.0	1.4	1.5	1.6	1.5
5000	5200	0.0	0.0	0.0	0.0	0.0	0.8	1.1	1.3	1.3	1.3
5200	5400	0.0	0.0	0.0	0.0	0.0	0.8	1.2	1.5	1.6	1.6
5400	5600	0.0	0.0	0.0	0.0	0.0	0.9	1.7	2.1	2.2	2.3
5600	5800	0.0	0.0	0.0	0.0	0.0	0.6	1.6	2.2	2.4	2.5
5800	6000	0.0	0.0	0.0	0.0	0.0	0.2	1.8	2.4	2.8	2.9
6000	6200	0.0	0.0	0.0	0.0	0.0	0.0	1.7	2.6	3.1	3.3

6200	6400	0.0	0.0	0.0	0.0	0.0	0.0	1.4	2.4	2.9	3.1
6400	6600	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.8	2.2	2.5
6600	6800	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.2	1.6	1.9
6800	7000	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.8	1.1	1.3
7000	7200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.7	0.8
7200	7400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.5	0.7
7400	7600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.5	0.6
7600	7800	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.5	0.7
7800	8000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6	0.8
8000	8200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.8
8200	8400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.0
8400	8600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.3
8600	8800	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	1.1
8800	9000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.8
9000	9200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
9200	9400	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
9400	9600	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
9600	9800	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
9800	10000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1

(c) Overnight Temperature Drop. For aeroplanes on which FRM is installed, the overnight temperature drop for this appendix is defined using:

(1) A temperature at the beginning of the overnight period that equals the landing temperature of the previous flight that is a random value based on a Gaussian distribution; and

(2) An overnight temperature drop that is a random value based on a Gaussian distribution.

(3) For any flight that will end with an overnight ground period (one flight per day out of an average of number of flights per day, depending on utilization of the particular aeroplane model being evaluated), the landing outside air temperature (OAT) is to be chosen as a random value from the following Gaussian curve:

Table 3. Landing Outside Air Temperature

Parameter	Landing Outside Air Temperature °C/ °F
Mean Temperature	14.82/ 58.68
negative 1 std dev	11.41/ 20.55
positive 1 std dev	7.3/ 13.21

(4) The outside ambient air temperature (OAT) overnight temperature drop is to be chosen as a random value from the following Gaussian curve:

Table 4. Outside Air Temperature (OAT) Drop

Parameter		OAT Drop Temperature °C/ °F
Mean Temp		-11.11/ 12.0
1 std dev		3.3/ 6.0

(d) Number of Simulated Flights Required in Analysis. In order for the Monte Carlo analysis to be valid for showing compliance with the fleet average and warm day flammability exposure requirements, the applicant must run the analysis for a minimum number of flights to ensure that the fleet average and warm day flammability exposure for the fuel tank under evaluation meets the applicable flammability limits defined in Table 5.

Table 5. Flammability Exposure Limit

Minimum Number of Flights in Monte Carlo Analysis	Maximum Acceptable Monte Carlo Average Fuel Tank Flammability Exposure (%) to meet 3% requirements	Maximum Acceptable Monte Carlo Average Fuel Tank Flammability Exposure (%) to meet 7% requirements
10,000	2.91	6.79
100,000	2.98	6.96
1,000,000	3.00	7.00

CS-25 Book 2

Add a new AMC 25.981 (b) (1) to read:

AMC 25.981(b)(1)

The intention of this requirement is to introduce design precautions, to avoid unnecessary increases in fuel tank flammability. These precautions should ensure :

(i) no large net heat sources going into the tank,
(ii) no unnecessary spraying, sloshing or creation of fuel mist,
(iii) minimization of any other energy transfer such as HIRF;

Applicants should limit the heat inputs to the maximum extent. Heat sources can be other systems, but also include environmental conditions such as solar radiation. The following design features have been found acceptable:

- heat insulation between a fuel tank and a adjacent heat source (typically, ECS packs),
- forced ventilation around a fuel tank,
- fuel transfer logic leaving sufficient fuel in transfer tanks exposed to solar radiations on the ground in order to limit their effects
- heat rejecting paintings or solar energy reflecting paints to limit the heat input by solar radiation.

A critical parameter is the maximum temperature rise in any part of the tank under the most critical conditions during a 4 hour ground operation). Any physical phenomenon, including environmental conditions such as solar radiation, should be taken into account. A temperature increase in the order of 20°C limit has been found acceptable for tanks not fitted for with an active Flammability Reduction Means and therefore unable to meet the exposure criteria as defined in M25.1(b)(1).
Note 1: for tanks fitted with Flammability Reduction Means, applicants should limit heat and energy transfers to the maximum extent. No maximum temperature increase limit is defined; however the 20 °C limit is applicable in case of dispatch with the active Flammability Reduction Means inoperative.
Note 2: the maximum temperature increase under the conditions described above should be quantified whether or not the affected tank is fitted with a Flammability Reduction Means.

Add a new AMC 25.981 (b) (2) to read:

AMC 25.981(b)(2)

Equivalent Conventional Unheated Aluminium Wing is a semi-monocoque aluminium wing of a subsonic aeroplane that is equivalent in aerodynamic performance, structural capability, fuel tank capacity and tank configuration to the designed wing.

Fleet Average Flammability Exposure is defined in Appendix Nand means the percentage of time the fuel tank ullage is flammable for a fleet of an aeroplane type operating over the range of flight lengths.

CS-25 Book 2:

Add an new AMC to Appendix N to read:

AMC to Appendix N- **Fuel Tank Flammability Exposure**

AMC to Appendix N25.1 General:

The FAA program defined in FAA document, Fuel Tank Flammability Assessment Method Users Manual DOT/FAA/AR-05/8 dated May 2008, is an acceptable means of compliance with § 25.981(b) and Appendix M. A copy may be obtained from the Office of the Federal Register, 800 North Capitol Street, N.W., Suite 700, Washington, D.C. The following definitions, input variables, and data tables that are used in the program to determine fleet average flammability exposure for a specific aeroplane model are the ones included into paragraph N25.2 definitions and N25.4 variables and data tables.

AMC to Appendix N25.3 Fuel tank flammability exposure analysis:

The Monte Carlo program contained in FAA document, Fuel Tank Flammability Assessment Method Users Manual DOT/FAA/AR-05/8 dated May 2008 is an acceptable means of compliance to Appendix N25.3 (b). The parameters specified in sections N25.3 (b) and (c) are the ones to be used in the fuel tank flammability exposure "Monte Carlo" analysis.

II Draft decision amending AMC and GM to Part-21

Introduce a new subparagraph as follows:

AMC 21A.3 (a) Collection, investigation and analysis of data related to FRM reliability:

Holders of a type-certificate, restricted type certificate, supplemental type certificate and of any other relevant approval deemed to have been issued under part-21 and which have include FRM in their design should assess on an on-going basis the effects of airplane component failures on FRM reliability. This should be part of the system for collection, investigation and analysis of data required by 21A.3 (a). The applicant/holder should do the following:

(a) Demonstrate effective means to ensure collection of FRM reliability data. The means should provide data affecting FRM reliability, such as component failures.

(b) Unless alternative reporting procedures are approved by the Agency, provide a report to the Agency every six months for the first five years after service introduction. After that period, continued reporting every six months may be replaced with other reliability tracking methods found acceptable to the Agency or eliminated if it is established that the reliability of the FRM meets, and will continue to meet, the exposure specifications of paragraph M25.1 of appendix M to CS-25

(c) Develop service instructions or revise the applicable airplane manual, according to a schedule approved by the Agency, to correct any failures of the FRM that occur in service that could increase any fuel tank's Fleet Average Flammability Exposure to more than that specified by paragraph M25.1.