



U.S. Department
of Transportation
**Federal Aviation
Administration**

Advisory Circular

**Subject: FUEL TANK
FLAMMABILITY**

**Date: DRAFT
Initiated By: ANM-112**

**AC No: 25.981-2A
Change:**

1. **PURPOSE.** This advisory circular (AC) provides information and guidance on compliance with the airworthiness standards for transport category airplanes about limiting the time a fuel tank may be flammable or mitigation of hazards from flammable fuel air mixtures within fuel tanks. This guidance is applicable to certain transport category airplanes for which a new, amended, or supplemental type certificate is requested and affects existing design approval holders as stated in the proposed new §§ 25.1815, 25.1817, 25.1819 and 25.1821 contained in a new Subpart I to Title 14, Code of Federal Regulations (CFR) part 25, “Continued Airworthiness and Safety Improvements.” This AC also provides guidance on compliance with the associated requirements for operators of affected airplanes that must comply with requirements in 14 CFR parts 91, 121, 125 and 129 to incorporate flammability reduction or ignition mitigation means by specified dates.

2. **APPLICABILITY.**

a. This guidance is for design approval holders, airplane manufacturers, modifiers, operators, foreign regulatory authorities, and Federal Aviation Administration (FAA) transport category airplane type certification engineers and their designees. The Notice of Proposed Rulemaking (NPRM), Notice No. 05-14, would not apply the new requirements to transport category airplanes designed solely for cargo carriage. However, AC 25.981-2 remains applicable to these airplanes, which must comply with the current flammability standards contained in § 25.981(c) that would be moved to the proposed § 25.981(e). We will consider combining this guidance for all transport category airplanes into one AC when the final rule and AC are issued.

b. Like all AC material, this AC is not, in itself, mandatory, and does not constitute a regulation. It describes an acceptable means, but not the only means, for showing compliance with the requirements for transport category airplanes. The FAA will consider other methods of showing compliance that an applicant may elect to present. While these guidelines are not mandatory, we derived them from extensive FAA and industry experience in showing compliance with the relevant regulations. On the other hand, if we become aware of circumstances that convince us that following this AC would not

result in compliance with the applicable regulations, we will not be bound by the terms of this AC. We may require additional substantiation or design changes as a basis for finding compliance.

c. This material does not change, create any additional, authorize changes in, or permit deviations from, regulatory requirements.

d. Terms in this AC, such as “shall” or “must” are used only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance described herein is used. While these guidelines are not mandatory, they are derived from Federal Aviation Administration (FAA) and industry experience in determining compliance with the pertinent regulations.

3. CANCELLATION. None at this time.

4. RELATED DOCUMENTS.

a. Federal Aviation Regulations. The applicable sections of part 25 that prescribe the design requirements for the substantiation and certification about prevention of ignition sources within the fuel tanks of transport category airplanes include:

§ 25.863	Flammable fluid fire protection
§ 25.901	Installation
§ 25.954	Fuel system lightning protection
§ 25.981	Fuel tank ignition prevention

b. Advisory Circulars (AC). You can get the following FAA ACs from the U.S. Department of Transportation, Subsequent Distribution Office, M-30, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785.

- (1) AC 25-8 Auxiliary Fuel System Installations.
- (2) AC 20-53A Protection of Aircraft Fuel Systems Against Fuel Vapor Ignition Due to Lightning.
- (3) AC 25.981-1B Fuel Tank Ignition Source Prevention Guidelines.
- (4) AC 120-27 Aircraft Weight and Balance Control.

c. Society of Automotive Engineers (SAE) Documents. You can get the following documents from the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, Pennsylvania, 15096.

- (1) SAE AIR 5128, “Electrical Bonding of Aircraft Fuel System Plumbing Systems,” (January 1997).

(2) SAE AIR 4170A, “Reticulated Polyurethane Safety Foam Explosion Suppressant Material for Fuel Systems and Dry Bays,” (November 1998).

(3) SAE AIR 1903, “Fuel Tank Inerting Systems,” (future).

(4) SAE AIR 1662, “Minimization of Electrostatic Hazards in Aircraft Fuel Systems,” (October 1984).

d. Military Specifications (MIL).

(1) MIL-B-83054, Baffle and Inerting Material, Aircraft Fuel Tank (March 1984). (Note: this reference provides an extensive list of military specifications about the use of polyurethane foam.)

e. Other.

(1) FAA Document DOT/FAA/AR-98/26, "Review of the Flammability Hazard of Jet A Fuel Vapor in Civil Transport Aircraft Fuel Tanks" (June 1998). (You can get a copy of this report from the National Technical Information Service (NTIS), Springfield, Virginia 22161, or at the following web site address: <http://www.fire.tc.faa.gov/pdf/ar98-26.pdf>.)

(2) Aviation Rulemaking Advisory Committee (ARAC), Fuel Tank Harmonization Working Group, Final Report (July 1998). You can get a copy of this report online from the U.S. Department of Transportation (DOT) electronic docket, Docket No. FAA-1998-4183, at the following web site address: <http://www.fire.tc.faa.gov/systems/fueltank/papers.stm>.

(3) “Effects of Fuel Slosh and Vibration on the Flammability Hazards of Hydrocarbon Turbine Fuels Within Aircraft Fuel Tanks,” Technical Report AFAPL-TR-70-65 (November 1970), Edwin E. Ott. Contact the Air Force Aero Propulsion Laboratory, Airforce Systems Command, Wright-Patterson Air Force Base Ohio.

(4) FAA Document DOT/FAA/AR-99/65, "Mass Loading Effects on Fuel Vapor Concentrations in an Aircraft Fuel Tank Ullage." You can get a copy of this report from the National Technical Information Service (NTIS), Springfield, Virginia 22161, or at the following web site address: <http://www.fire.tc.faa.gov/pdf/tn99-65.pdf>.

(5) FAA Document DOT/FAA/AR-00/19, “The Cost of Implementing Ground-Based Fuel Tank Inerting in the Commercial Fleet.” DOT/FAA/AR-00/19 (May 2000). You can get a copy of this report from the National Technical Information Service (NTIS), Springfield, Virginia 22161, or at the following web site address: <http://www.fire.tc.faa.gov/pdf/00-19.pdf>.

(6) FAA Document DOT/FAA/AR-01/6, “Inerting of a Vented Aircraft Fuel Tank Test Article With Nitrogen Enriched Air” (December 2000). You can get copy of

this report from the National Technical Information Service (NTIS), Springfield, Virginia 22161, or at the following web site address: <http://www.fire.tc.faa.gov/pdf/01-6.pdf>.

(7) “The Effectiveness of Ullage Nitrogen-Inerting Systems against 30-mm High-Explosive Incendiary Projectiles,” China Lake Naval Weapons Center, J. Hardy Tyson and John F. Barnes, May 1991. You can get a copy of this report at the following web site address :<http://dms.dot.gov/>, by inserting the rulemaking docket number associated with this AC (FAA-2005-22997) into the docket search function.

(8) FAA Document DOT/FAA/AR-TN02/79, “Limiting Oxygen Concentrations Required to Inert Jet Fuel Vapors Existing at Reduced Fuel Tank Pressures” (April 2003). You can get a copy of this report from the National Technical Information Service (NTIS), Springfield, Virginia 22161, or at the following web site address: <http://www.fire.tc.faa.gov/pdf/TN02-79.pdf>.

(9) FAA Special Condition, “Boeing Model 747-100/200B/200F/200C/SR/SP/100B/300/100B SUD/400/400D/400F Airplanes; Flammability Reduction Means (Fuel Tank Inerting),” Docket No. NM270; Special Conditions No. 25-285-SC You can get a copy of these special conditions at the following web site address: <http://dms.dot.gov>, by inserting the rulemaking docket number associated with this AC (FAA-2005-22997), as shown on the first page of the NPRM as published in the Federal Register.

(10) FAA Document DOT/FAA/AR-TN0x/xx, “Transport Airplane Fuel Flash Point Survey,” August 2005. (This report is currently being developed. A copy of this report will be available through the National Technical Information Service (NTIS), Springfield, Virginia 22161, or at the following web site address when it is published: <http://www.fire.tc.faa.gov>.)

(11) FAA Document DOT/FAA/AR-TN02/79, “Fuel Tank Flammability Assessment Method Users Manual” (March 2005), web site address: <http://www.fire.tc.faa.gov/systems/fuel tank/FTFAM.stm>

(12) FAA Document DOT/FAA/AR-04/41, “Evaluation of Fuel Tank Flammability and the FAA Inerting System on the NASA 747 SCA” (December 2004), web site address: <http://www.fire.tc.faa.gov/pdf/04-41.pdf>.

5. DEFINITIONS.

a. Auxiliary Fuel Tank, as defined in § 25.1803, is “a normally emptied fuel tank that has been installed pursuant to a supplemental type certificate (STC) or field approval to make additional fuel available.” These fuel tanks are installed to make additional fuel available for increasing the flight range of that airplane. The term “auxiliary” means that the tank is secondary to the airplane’s main fuel tanks. The reference to “auxiliary tank” in this AC primarily refers to auxiliary body tanks typically located within the pressurized cabin.

b. Main Fuel Tank means a fuel tank that feeds fuel directly into one or more engines and holds required fuel reserves continually throughout each flight. The functions of the main tanks are immediately available and operate without immediate supervision by the flightcrew in the event of failure or inadvertent depletion of fuel in an auxiliary tank. Generally, main tanks are those dedicated to the feed of the engines during engine feed isolation.

c. Bulk Average Fuel Temperature is the average fuel temperature within the fuel tank, or different sections of the tank if the tank is subdivided by baffles or compartments.

d. Center Wing Tank (CWT) is a fuel tank located in the center of an airplane's wing box.

e. Flammable (with respect to a fluid or gas) means susceptible to igniting readily or to exploding (14 CFR part 1, Definitions). A non-flammable ullage is one where the fuel-air vapor is too lean or too rich to burn or is inert as defined below. For this AC, a fuel tank vapor space 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 is within the flammable range for the fuel type being used.

f. Fleet Average Flammability Exposure means the percentage of time the fuel tank ullage is flammable for a fleet of an airplane type operating over the range of flight lengths. This term is expressed as a percent of time that the tank is flammable during the flammability exposure evaluation time in question. Fleet average flammability exposure is the total time the tank is flammable divided by the total flammability exposure evaluation time.

g. Flammability Exposure Evaluation Time (FEET) is the time from the start of preparing the airplane 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 Mission Range Distribution defined in Appendix L of the proposed rule. The pre-flight times are provided as a function of the flight time, and the post-flight time is a constant 30 minutes.

h. Flammability Envelope is the pressure (i.e., altitude)/temperature domain where the fuel vapor/air mixture is flammable. This domain is dependent on the type of fuel used and is defined in Appendix L of the proposed rule for typical fuels used in transport category airplanes. Appendix L also defines the slope of the lower flammability limit (LFL) and upper flammability limit (UFL) as a function of altitude. The flammability envelope for the fuel is defined by the UFL and LFL as follows:

(1) LFL at sea level is the flash point temperature of the fuel at sea level minus 10 degrees F. LFL decreases from sea level value with increasing altitude at a rate of 1 degree F per 808 feet.

(2) UFL at sea level is the flash point temperature of the fuel at sea level plus 63.5 degrees F. UFL decreases from the sea level value with increasing altitude at a rate of 1 degree F per 512 feet.

i. Flammability Reduction Means (FRM) is any system intended and designed to reduce the flammability exposure of a fuel tank either by affecting oxygen levels or by affecting fuel vapor concentration levels.

j. Flash Point of a flammable fluid means the lowest temperature at which the application of a flame to a heated sample causes the vapor to ignite momentarily, or “flash.” Appendix L of the proposed rule, and the Monte Carlo Model defined in paragraph 4e(11) of this AC provides the flash point for the standard fuel to be used in the analysis.

k. Fuel Air Ratio (FAR) is the ratio of the weight of fuel vapor to the weight of air in the ullage. Specific FAR values are only applicable to conditions where the air is nominally 20.9 percent oxygen.

l. Fuel Types approved for use for a given airplane type are listed in the Airplane Flight Manual (AFM). Each fuel type has its own properties; those directly related to flammability are “flash point” and “distillation” characteristics. Property differences can occur in different batches of a given fuel type because of variations in the properties of the source crude oil and the refining process used to produce the fuel. The most widely used fuel types are JET-A/JET-A1, (with older airplanes approved for use of JET-B (JP-4)), per ASTM Specification D1655-99, “Standard Specification for Aviation Turbine Fuels.”

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

n. Ignition Energy is the minimum amount of energy required to ignite fuel vapors.

o. Inert is when the bulk average oxygen concentration within each compartment of the fuel 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.

p. Inerting is a process where a noncombustible gas is introduced into the ullage of a fuel tank so that the ullage becomes non-flammable.

q. Lean Fuel Vapor/Air Mixture is a fuel vapor/air mixture that contains a concentration of fuel molecules below that which will support combustion.

r. Upper and Lower Flammability Limits. The upper flammability limit (UFL) defines the temperature at a specific altitude, above which the fuel vapor/air mixture is too rich to ignite. The lower flammability limit (LFL) defines the temperature at a specific altitude below which the fuel vapor/air mixture is too lean to ignite.

s. Monte Carlo Analysis is the analytical method that is specified in this AC as the compliance means for assessing the fleet average flammability exposure time for a fuel tank.

t. Rich Fuel Vapor/Air Mixture is a fuel vapor/air mixture that contains a concentration of fuel molecules above that which will support combustion.

u. Warm Day Case is that portion of the flammability exposure for warm day (greater than 80 degrees F) ground operations or warm day climb operations.

v. 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.

w. Transport Effects are the changes in fuel vapor concentrations in a fuel tank caused by either low fuel conditions, i.e., “mass loading” paragraph 4(e)(4), fuel condensation or vaporization.

x. Ullage, or Ullage Space is the volume within the tank not occupied by liquid fuel.

y. Equivalent Conventional Unheated Aluminum Wing is defined in § 25.981 as a semi-monocoque aluminum wing of a subsonic airplane that is equivalent in aerodynamic performance, structural capability, fuel tank capacity and tank configuration to the designed wing.

6. REGULATORY BACKGROUND.

a. Amendment 25-11 to part 25 introduced the requirements of § 25.981 about limiting temperatures in fuel tanks to prevent ignition of fuel vapors in the fuel tanks from hot surfaces. Advisory Circular 25.981-1A, which was issued in 1972 (now canceled), provided guidance that included failure modes that should be considered when determining compliance with the fuel tank surface temperature requirements defined in § 25.981.

b. Other sections of part 25 require prevention of ignition sources from lightning (§ 25.954) and from failures in the fuel tank system (§§ 25.901 and 25.1309). Sections 25.901 and 25.1309 set forth the provisions to evaluate the fuel tank system and show that “no single failure or malfunction or probable combination of failures will jeopardize the safe operation of the airplane...” However, service history has shown that ignition sources have developed in airplane fuel tanks because of external ignition sources, and internal ignition sources resulting from unforeseen failure modes, manufacturing and maintenance errors or factors that were not considered at the time of original certification of the airplane.

c. Section 25.981, as amended by Amendment 25-102, was adopted to provide improved standards for preventing ignition sources within fuel tanks and minimizing the exposure to operation of transport category airplanes with flammable vapors in the fuel tanks. Under Amendment 25-102, the title of § 25.981 was revised to “Fuel tank ignition prevention,” and paragraphs (a) and (b) were revised to address the prevention of ignition sources within the fuel tanks. Guidance on these paragraphs is provided in AC 25.981-1B, Fuel Tank Ignition Source Prevention Guidelines. Amendment 25-102 also added a new paragraph (c), which requires minimization of the formation of flammable vapors in the fuel tanks, or mitigation of any hazards if ignition does occur. This provision was included in § 25.981(c), which was intended to require design practices that reduce exposure to operation with flammable vapors in transport category airplane fuel tanks to the lowest practical level.

7. CURRENT REQUIREMENTS.

a. This AC provides guidance for the proposed amendment to § 25.981 that applies to new type certification, the additional new requirements of Subpart I related to continued airworthiness requirements applicable to type design approval holders, and the operational requirements for affected operators of the affected airplane models. The following table summarizes the amendments and the applicability of each amendment.

Table 1. Summary of regulatory changes that relate to fuel tank flammability safety.

Summary of Rules		
14 CFR	Description of Proposed Requirement	Applies To
§ 25.981, Fuel Tank Flammability Hazards	Relocate flammability requirements to paragraph (b). Revise these requirements to specify limits on fuel tank flammability exposure for different fuel tank types. Add paragraph (c) to restate current option of using Ignition Mitigation Means (IMM). Add paragraph (d) to include airworthiness limitation items (ALI) for IMM or FRM.	Applicants for future TCs for passenger-carrying transport category airplanes and design changes to those certificates. ¹
Appendix 25 K, Fuel Tank System Flammability Reduction Means	Establishes performance, reliability and reporting requirements for FRM.	Applicants for approval of FRM.
Appendix 25 L, Fuel Tank Flammability Exposure and Reliability Analysis	Defines flammability analysis method and input parameters that must be used in the analysis.	Any person required to perform flammability analysis.
Continued Airworthiness and Safety Improvements		
§ 25.1 Applicability § 25.2 Special retroactive requirements	Expand applicability to current holders of TCs, STCs, and certain manufacturers. Amend § 25.2 to make reference to the subpart I.	Applicants for TCs, and changes to those TCs for transport category airplanes. Manufacturers of certain airplane models.
Subpart I § 25.1801, Purpose and scope	Defines the intent of the subpart.	TCs, and design changes to those TCs for transport category airplanes. Manufacturers of certain airplane models.
§ 25.1815, Holders of	Require flammability exposure analysis of all fuel tanks	TC holders.

¹ All-cargo airplanes are subject to the existing requirements of § 25.981(b) [redesignated as § 25.981(e)], which requires that fuel tank flammability be “minimized.” See AC 25.981-2.

<p>Type Certificates: Fuel tank safety</p>	<p>within 150 days after effective date of the rule. If below 7 percent no flammability reduction required. Compliance with § 25.981(e) to define ALI required. If above 7 percent and in fuselage and normally emptied, must develop service instructions to meet § 25.981(c), (d) and (e). If above 7 percent and other tank type, must develop service instructions to incorporate IMM (meet § 25.981(d)) or reduce flammability to 7 percent. Specific compliance dates for each Boeing and Airbus airplane model. Other models within 24 months.</p>	<p>Large transport category passenger-carrying airplanes, with passenger capacity of 30 or more or a payload of 7500 lbs. or more (original TC or later increase).</p>
<p>§ 25.1817, Changes to type certificates affecting fuel tank flammability</p>	<p>Require flammability exposure analysis of all fuel tanks installed under STC within 12 months after effective date of the rule. Require impact assessment of fuel tanks installed by STCs, and (for pending and future applicants) other STCs affecting fuel tank flammability, on IMM or FRM developed by TC holder under § 25.1815 to determine if any ALI has been violated 6 months after FAA approval of ALI submitted by TC holders under § 25.1815 or before certification, whichever is later. Require development of service instructions to correct designs that compromise ALI defined by TC holder under § 25.1815 within 24 months. Require within 24 months after TC holder compliance with § 25.1815 development of service instructions for a IMM or FRM for any tank with flammability above 7 percent, if located within the fuselage and normally emptied.</p>	<p>Auxiliary tank STC holders for large transport category passenger-carrying airplanes, with passenger capacity of 30 or more or a payload of 7500 lbs. or more (original TC or later increase).</p> <p>Applicants for future STCs or amendments to TCs that affect fuel tank system or IMM/FRM on passenger-carrying airplanes.</p>
<p>§ 25.1819, Pending type</p>	<p>Requires IMM or FRM for any fuel tank with a</p>	<p>Pending</p>

certification projects: Fuel tank flammability safety	flammability level that exceeds 7 percent. Fuel tanks located in the fuselage and normally emptied must meet § 25.981(c) level. Other fuel tanks must be reduced below 7 percent. Requires compliance with § 25.981(c).	certification projects for large transport category passenger-carrying airplanes. Pre-Amendment 102. Post-Amendment 102.
§ 25.1821, Newly produced airplanes: Fuel tank flammability safety	Requires any affected airplanes produced after a certain date to incorporate IMM or FRM.	Manufacturers of certain passenger carrying airplane models.
Operational Requirements		
§ 91.1509 § 121.917 § 125.509 § 129.117	Require installation of IMM or FRM into large airplanes with high flammability fuel tanks. Require large transport category airplanes manufactured after specific dates to have IMM or FRM in high flammability fuel tanks. Require incorporation of ALI into the maintenance program.	U.S. certificate holders and foreign persons operating U.S.-registered large transport category passenger-carrying airplanes.

b. Section 25.981 includes new flammability limits for fuel tanks that are normally emptied and located within the fuselage contour of 3 percent average and 3 percent warm day flammability exposure. The flammability exposure of other fuel tanks is limited to either 3 percent, or that of an unheated aluminum wing fuel tank. If a flammability reduction system, such as nitrogen inerting, is used, requirements are provided in a new Appendix K of the proposed rule for the FRM, and a new Appendix L of the proposed rule that includes the method for demonstrating the flammability exposure of fuel tanks need to show compliance. The regulation retains the option of using IMM to address fuel tank flammability safety in paragraph (c). It also extends the existing requirements for development of critical design configuration control limitations (CDCCL) for ignition prevention, that were formerly in paragraph (b), to any FRM or IMM and places the amended requirement in paragraph § 25.981(d). The revised § 25.981(b), (c) and (d) read as follows:

“(b) Except as provided in paragraph (c) of this section, no fuel tank Fleet Average Flammability Exposure level on an airplane other than one

designed solely for all-cargo operations may exceed three percent, or a fuel tank within the wing of the airplane model being evaluated. If the wing is not a conventional unheated aluminum wing, the analysis must be based on an assumed Equivalent Conventional Unheated Aluminum Wing.

(1) Fleet Average Flammability Exposure is determined in accordance with Appendix L of this part.

(2) Any fuel tank other than a main tank on an airplane other than one designed solely for all-cargo operations must meet the flammability exposure criteria of Appendix K to this part if any portion of the tank is located within the fuselage contour.

(3) As used in this paragraph,

(i) Equivalent Conventional Unheated Aluminum Wing is a semi-monocoque aluminum wing of a subsonic airplane that is equivalent in aerodynamic performance, structural capability, fuel tank capacity and tank configuration to the designed wing.

(ii) Fleet Average Flammability Exposure is defined in Appendix L to this part and means the percentage of time the fuel tank ullage is flammable for a fleet of an airplane type operating over the range of flight lengths.

(iii) Main Fuel Tank means a fuel tank that feeds fuel directly into one or more engines and holds required fuel reserves continually throughout each flight.

(c) Paragraph (b) and (e) of this section do not apply to a fuel tank if means are provided to mitigate the effects of an ignition of fuel vapors within that fuel tank such that no damage caused by an ignition will prevent continued safe flight and landing.

(d) Critical design configuration control limitations (CDCCL), inspections, or other procedures must be established, as necessary, to prevent development of ignition sources within the fuel tank system pursuant to paragraph (a) of this section, to prevent increasing the flammability exposure of the tanks above that permitted under paragraph (b) of this section, and to prevent degradation of the performance and reliability of any means provided according to paragraphs (a), (b) or (c) of this section. These CDCCL, inspections, and procedures must be included in the Airworthiness Limitations section of the instructions for continued airworthiness required by § 25.1529. Visible means of identifying critical features of the design must be placed in areas of the airplane where foreseeable maintenance actions, repairs, or alterations may compromise the critical design configuration limitations (e.g., color-coding of wire to identify separation limitation). These visible means must also be identified as CDCCL.

(e) For airplanes designed solely for all-cargo operations, except as provided in paragraph (c) of this section, the fuel tank installation must include means to minimize the development of flammable vapors in the fuel tanks (in the context of this rule, "minimize" means to incorporate practicable design methods to reduce the likelihood of flammable vapors)."

c. The amendment also includes continued airworthiness and safety improvement requirements that are contained in a new subpart I to part 25. The new sections include §§ 25.1815, 25.1817, 25.1819 and 25.1821. These sections specify different compliance

requirements for the affected type design approval holders (DAH). The affected DAH include those airplanes with a seating capacity of 30 passengers or more, or a payload of 7500 pounds or more. Appendix 5 of this AC provides a list of affected models. The intent of § 25.981(b) is to require that the exposure to the formation or presence of flammable vapors is limited to specific values for fuel tanks located within the wing and fuselage contour. The flammability limits for the specific tank type are summarized in the following table as follows:

Table 2. Summary of flammability limits for the specific tank type.

<u>Airplanes</u> <u>Affected</u> (* See Note)	Category of Action [Cert. Projects Include TCs, ATCs, & STCs]	<u>Applicable</u> <u>Regulations</u>	Fleet Flammability Exposure (Percent Exposure Time)	
			<u>Wing & Tail</u> <u>Tanks</u>	Fuselage Tanks Normally Emptied
All Part 25 Transports	Future Applications	§ 25.981(b)	3 Percent	Appendix K
Turbine powered Large Transports ↓ Max Pass ≥ 30 Or Max P/L ≥ 7500 Lb See Appendix 5 for list of airplane models	<u>Pending Cert Projects:</u> Pre-amendment 25-102 ▪ Applied <u>before</u> June 6, 2001.	§ 25.1817(d)(1)	or Equal to Conventional Aluminum Tank	(Flam ≤ 3% Plus 3% warm day limit)
	<u>Pending Cert Projects:</u> Amendment 25-102 ▪ Applied on or after June 6, 2001.	§ 25.1817(d)(2)	Flammability ≤ 7%	If Flam > 7%, Do Appendix K Reduce flammability to: ≤ 3% average and ≤ 3% warm day limit
	Production Cut-In	§ 25.1821 & Ops Rules		
	Fleet Retrofit	§ 25.1815(c) & Ops Rules		
	Other Existing Models	§ 25.1815(c) & Ops Rule		

* Applies to transport category, passenger carrying airplanes with a type certificate issued after January 1, 1958. Transport category airplane models not affected are listed in § 25.1815(j).

8. COMPLIANCE DEMONSTRATION.

a. Showing Compliance with § 25.981(b) or (c). Section 25.981 provides two options for addressing the hazards associated with fuel tank flammability:

- Controlling fuel tank flammability to specified levels, and
- Mitigating the hazards if ignition of the fuel vapors occurs.

(1) The first means, as provided in § 25.981(b), shows that the flammability of a fuel tank does not exceed the limits defined in the regulation. When this method of compliance is used, a flammability analysis is required to establish the flammability of the fuel tank, and incorporation of an FRM in any fuel tank to reduce the flammability of any tank that exceeds the applicable flammability limit. Guidance for determining the flammability of a fuel tank is provided in paragraph 10 of this AC. Guidance for incorporating an FRM, including pressurization of a fuel tank, temperature control of a fuel tank, limiting fuel properties and fuel tank inerting, are provided in paragraph 9 of this AC.

(2) Compliance with § 25.981(b) is not required if the hazards of ignition of fuel vapors are mitigated by use of an IMM meeting the requirements of § 25.981(c). Guidance for demonstrating compliance using IMM is provided in paragraph 12 of this AC. Ignition mitigation means include filling the tank with polyurethane foam, metallic foils, or explosion suppression systems. Since IMM mitigates the effects of ignition so that it is not hazardous, there is no requirement to determine the fuel tank flammability, if this method is used to demonstrate compliance.

b. Showing Compliance with § 25.981(d). Appendix 3 of this AC includes guidance for establishing CDCCL relating to FRM or IMM for the fuel tank system.

c. Showing Compliance with §§ 25.1815, 25.1817, 25.1819, 25.1821. Specific guidance for compliance with the continued operational safety requirements contained in subpart I is provided in Appendix 4 of this AC.

d. Showing Compliance with parts 91, 121, 125 and 129. Guidance for showing compliance with the operational requirements to incorporate flammability mitigation means by specified dates is provided in Appendix 6 of this AC.

9. GENERAL CONSIDERATIONS - FUEL TANK FLAMMABILITY.

a. Formation of Flammable Vapors. The critical considerations in controlling exposure to operation with flammable mixtures in the tank include the control of formation of flammable vapors and/or oxygen concentration. Factors influencing the formation of flammable vapors include fuel type and properties, fuel temperature, pressure in the tank, and any design feature that significantly increases the potential for fuel mists to be created. The time a fuel tank is flammable determined by the Monte Carlo analysis is based upon the assumption that design features needed to prevent spraying and misting of fuel in the tank have been incorporated into the design so these factors are not considered. Rather, the fuel properties and temperature and pressure in the fuel tank are used to determine when the fuel tank is flammable. General design practices that affect the overall flammability risk are described below. Airplane designs submitted for FAA evaluation will be evaluated against these practices.

b. Design Practices to Minimize Flammability Exposure.

(1) Misting and sloshing. The flammability of fuel vapors in a fuel tank can be dramatically influenced by agitation, sloshing, spraying, or misting of fuel. These processes increase the surface area of the fuel allowing more fuel vapors to evolve from the fuel, which results in a higher concentration of fuel molecules in the ullage space. Design practices that reduce the potential for fuel agitation, sloshing, spraying and misting should be incorporated into the design so that flammability is minimized. Examples of proven design practices include installation of sufficient baffling in the tanks to reduce sloshing, and returning any fuel used to cool fuel pumps to the bottom of the tank. Section 6 of SAE Document AIR 1662 describes recommended design practices for minimizing hazards associated with electrostatic charging in fuel tanks. Several of these practices relate to minimizing the formation of flammable vapors, including:

(a) Introducing fuel at low velocity near the bottom of fuel tanks so that the inlet is covered early in the refueling or fuel transfer process.

(b) Directing the fuel flow onto a grounded conducting surface to reduce electrostatic charge build-up.

(c) Using a balanced distribution system to make sure that all fuel tank bays are filled to equal levels to assist in reducing fuel velocity (this minimizes charge relaxation time and mist formation).

These practices greatly reduce the presence of fuel mist that will broaden the flammability range of the fuel at the lean end and cause flammable vapors at temperatures well below the flash point. The Monte Carlo flammability assessment methodology defined in paragraph 4e(11) of this AC defines the pressure and temperature envelope when the fuel tank is flammable that is based upon the assumption that design precautions described in this paragraph have been implemented.

(2) Fuel Temperature is one of the key factors that determines fuel tank flammability in unpressurized fuel tanks approved for use with common Jet A type fuels. The most effective methods for controlling fuel tank temperature may differ between different fuel tanks, according to their exposure to the risk. For instance, fuel tanks located in the wings of subsonic transport category airplanes, with little or no heat input from airplane systems or from other adjacent fuel tanks that have large surface areas that allow cooling of the fuel, have been analyzed and shown to meet the intent of the regulation. Fuel tanks located within the fuselage contours or other tanks located within the wing that do not cool, require more design attention. For example, auxiliary fuel tanks located in the cargo compartment or pressurized areas, tanks located in the center wing box, horizontal stabilizer tanks, tanks with small surface areas exposed to airflow, and tanks made from materials that act as insulators, may have less ability to reject heat to ambient air, both on the ground and in flight, and may be subject to heat sources from equipment located nearby in the fuselage such as the air conditioning packs that supply cool air to the cabin. For fuel tanks that, because of installation location and/or other factors, do not meet the applicable flammability limits, an FRM or IMM is needed to comply.

(3) Fuel Types. The approved fuels for an airplane type are submitted by the applicant for approval to the FAA, and once approved are shown in the AFM. The definitions of LFL and UFL define the fuel temperature at which a fuel tank can be expected to be flammable. From the definitions, it can easily be seen that fuel flash point is key. Currently, Jet-A and Jet-A1 are the predominant fuels used in commercial aviation. Because of this, wing tanks are commonly not flammable as the fuel temperature is typically below the LFL. However, the heat input to any tank can push tanks fueled with Jet-A/A1 into the flammable range. A fuel such as JP-4 has the reverse effect. The flash point is below normal ambient temperatures during ground operations, resulting in more flammability exposure for typical wing tanks and less for tanks that are insulated from outside air, such as **CWT**. The higher temperature tanks are less flammable because the fuel temperature is above the UFL more of the time, resulting in an over-rich condition.

(a) Appendix L to Part 25 defines a typical transport category airplane fuel based upon a survey of fuels drawn from operating airplanes as shown in paragraph 4e(10) of this AC. The fuels include Jet A/A1 flash point distribution and also lower flash point fuels commonly used in China and Russia. This distribution is also included in Appendix L to part 25 and the Monte Carlo analysis in the paragraph 4d11) of this AC. For consistency across applicants, and for simplicity, each applicant is required to apply the distribution defined in Appendix L unless the FAA finds that this distribution is not representative of the fuels that could be expected to be used on the particular airplane being evaluated.

(b) If the use of low flash point fuels, such as JP-4, is proposed as an approved fuel, the fuel properties defined in the Users Manual may not provide a representative flammability exposure analysis. Use of JP-4 type fuels on a typical

transport category airplane may significantly increase operational exposure to flammable vapors. Therefore, modification of the flammability analysis and incorporation of additional flammability reduction capability, such as improved FRM performance, may be required to mitigate the increased exposure created by continuous use of such fuels.

(4) Fuel Temperature. As discussed in paragraph (1) above, fuel flash point at a given temperature and pressure determines when the ullage in the tank is flammable. When the fuel temperature is in the range between the LFL and the UFL, the ullage is assumed to instantaneously become flammable. When using a Monte Carlo analysis, that transition is considered to occur instantaneously as pressure and temperature changes. The Monte Carlo Model is based on the assumption that any fuel being loaded during refuel is at ambient outside temperature when determining flammability exposure.

(5) Fuel Tank Ullage Sweeping is the introduction of air into a fuel tank and dumping the fuel vapor overboard to reduce the concentration of fuel vapors in the ullage. This means would result in significant emission of fuel vapors into the atmosphere and would likely not meet emissions standards, unless these vapors were removed prior to dumping the air into the atmosphere.

(6) Controlling Oxygen Concentration. The accepted level for tank inerting used by the military is to reduce the oxygen concentration in the tank ullage to less than 9 percent. This is the standard established in the 1950s for a zero flammability risk design because ignition sources (hostile munitions) are a likely event in military missions. The standard precludes “cool flame” ignition, where the pressure rise is relatively low. The actual oxygen concentration needed to prevent a catastrophic fuel tank rupture during an ignition event per FAA testing is higher. The higher the oxygen concentration, the higher the pressure that is developed in the fuel tank during a combustion event. Therefore, the applicant may establish the acceptable oxygen concentration based upon evaluation of the structural capability and maximum peak pressure of the fuel tank. The oxygen concentration defined in the definitions paragraph of this AC is an acceptable benchmark for transport category airplane fuel tanks inerted with nitrogen, without additional substantiation.

10. DETERMINING FUEL TANK FLAMMABILITY.

a. Acceptable Means of Determining the Flammability Exposure. There are two means of establishing the flammability of a fuel tank. The method that is acceptable depends upon the flammability level that the tank is required to meet. A qualitative method is acceptable for fuel tanks that are required to show equivalence to an unheated aluminum wing per § 25.981(c), and meet the criteria listed below. For all other fuel tanks, the Monte Carlo Model defined in paragraph 4e(11) of this AC must be used.

(1) Qualitative Flammability Assessment.

(a) Integral aluminum fuel tanks located in the wing, fueled with Jet-A type fuel, operated on typical flight profiles, not heated by airplane heat sources and having a

large surface area-to-volume ratio to allow cooling, have been shown to minimize the formation of flammable fuel vapors. For these tanks, a qualitative assessment showing equivalency to the unheated aluminum wing fuel tank is acceptable. As stated in the Users Manual, any subsonic transport category airplane with wing fuel tanks only that is designed in accordance with the design guidelines identified in paragraph 9 of this AC, would be considered to meet the intent of the proposed rule and the flammability assessment would consist of a qualitative description of the particular tank design including:

- 1 a description of the airplane configuration, (including subsonic, wing construction, etc.),
- 2 a listing of any heat sources in or adjacent to the fuel tank,
- 3 the type of fuel approved for the airplane,
- 4 the tank operating pressure relative to ambient static pressure,
- 5 the tank is uninsulated and made of aluminum, and
- 6 the tank has a large surface area exposed to outside air to transfer heat from the tank.

(b) Fuel tanks with an aerodynamic surface area to volume ratio greater than 1.0 have been shown to meet these criteria. Fuel tanks with a ratio less than 1 require development of a Monte Carlo Model flammability assessment model. The aerodynamic surface area includes the area of the integral aluminum wing fuel tank that is exposed to outside air. It does not include any portion of a fuel tank that is shielded from free stream airflow, such as the front and rear spar, or an area under a fairing or wing thermal blanket.

(c) Wing tanks that do not meet the criteria in this paragraph for use of the qualitative method must use the Monte Carlo method. For example, if a fuel tank were made of composites, the applicant would need to conduct an assessment of a simulated wing fuel tank meeting the criteria above, on the airplane type for which approval is sought. This would establish the maximum allowable flammability level for the wing fuel tank. By comparing the reference unheated aluminum wing tank to the tank in question, the applicant can demonstrate that adequate provisions have been included in the design to minimize flammability exposure.

(2) Monte Carlo Assessment. When the compliance demonstration requires demonstrating a fuel tank meets a specific fuel tank flammability or the tank does not meet the qualitative assessment criteria previously discussed, the flammability assessment must be conducted in accordance with the method that is incorporated by reference in the regulation as defined in the FAA document, “Fuel Tank Flammability

Assessment Method Users Manual,” dated March 2005. This document may be obtained from the following web site: (<http://www.fire.tc.faa.gov/systems/fuel tank/FTFAM.stm>)

(a) This analytical method is based upon predicting the average fleet exposure, and the warm day exposure as applicable, to operation with flammable fuel air vapors in the fuel tank. The average fuel tank flammability exposure for the tank being evaluated is calculated for the specific fleet of airplanes of interest for which approval is sought.

(b) The flammability exposure must be determined independently for each tank or compartment of each tank if partitions exist in the tank that prevent mixing of fuel vapors. Within each tank where barriers or walls prevent mixing of the fuel/air mixtures, separate volumes or compartments should be treated independently to determine the worst case flammability exposure for that tank because of temperature variations within different portions of the tank. If FRM based upon inerting is used, oxygen concentration in those compartments of the tank can differ significantly from other compartments in the tank (such as an airplane model that has a center wing box that extends out into the wing, or a compartment in a fuel tank where vent inlets may create differences in temperature or oxygen concentration (if an FRM based on inerting is used)). The applicant is allowed to perform a qualitative assessment of each compartment in the tank to determine the most critical compartment with the worst case flammability. The flammability exposure of the most critical compartment of the fuel tank would then be stated as the fuel tank flammability.

(c) It is possible for the critical compartment to change from one compartment of the tank to another compartment during different portions of the flight. In this case, the flammability of the individual compartments would need to be determined throughout the flight and the times when any compartment of the tank is flammable would be included in the overall average flammability calculation.

(d) If a fuel tank is determined to exceed the applicable flammability requirements, the holder may control fuel tank flammability by incorporation of an FRM or IMM. Guidance for FRM is provided in paragraph 11 of this AC

(3) Developing inputs to the Monte Carlo Model. The Monte Carlo simulation, which randomly generates values for uncertain variables over and over, is used to simulate a process where the variables are random within defined distributions. The results of a large number of cases can then be used to approximate the results of the real world conditions. Appendix L of the proposed rule provides standard distributions and values that must be used when determine fuel tank flammability. Figure 1 shows the parameters that are used by the Monte Carlo Model to determine fuel tank flammability.

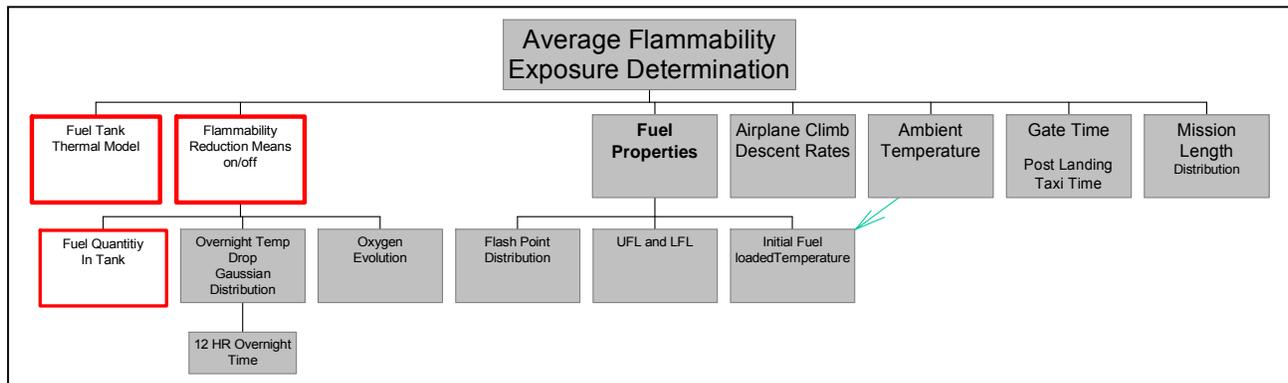


Figure 1. Monte Carlo Parameters to Determine Fuel Tank Flammability.

(4) The fuel tank thermal model, and fuel quantity in the fuel tank, are user inputs needed to determine the fuel tank flammability for a fuel tank without an FRM. The performance of an FRM must also be provided by the user if an FRM is installed. User inputs to the Monte Carlo include the following:

(a) Standardized parameters defined in Appendix L of the proposed rule used in the Monte Carlo Model:

- 1 cruise ambient temperature,
- 2 ground temperature,
- 3 fuel flash point,
- 4 flight length distribution,
- 5 airplane climb and descent profiles (the applicant must use the climb and descent profiles defined in the Users Manual or calculated values as defined in the Users Manual),
- 6 preflight gate time,
- 7 oxygen evolution rate (included in model when FRM used based upon Users Manual, section 4.3),
- 8 overnight temperature change (when FRM is added).

(b) Airplane specific inputs:

- 1 airplane cruise altitude.

2 Maximum airplane operating temperature limit as defined by any limitations in the AFM. This value is obtained from the flight manual for the specific airplane type.

3 Fuel tank quantities. As discussed in the Users Manual, the FAA Monte Carlo Model has a feature that allows the user to input times when the tank is full and empty so that the fuel quantity in the tank can be modeled. The model assumes a constant rate of fuel use between the specified tank full and empty times and does not account for unique fuel management techniques such as fuel transfer systems that may be incorporated for purposes such as center of gravity (C.G.) management. If fuel quantity affects fuel tank flammability, inputs to the Monte Carlo analysis may need to be modified by the user if the standard model does not provide a realistic representation of 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 FAA approved fuel management procedures in the AFM.

4 Airplane cruise mach number.

5 Airplane maximum range. This parameter should be determined assuming a payload equivalent to a load factor of 75 percent for a typical two class passenger configuration for the airplane model, using year-around average passenger weights and standard average baggage and carry-on weights per AC 120-27, "Aircraft Weight and Balance Control", standard day atmosphere, zero wind, long range cruise speed and domestic or international reserves as would apply to the typical operation of the airplane.

6 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 critical compartment of 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 should be developed for each section of the tank and the section temperature in the compartment that results in the highest flammability should be used in the tank flammability analysis or for the section of the tank having the highest flammability exposure if one compartment in the tank always has 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.

(aa) Fuel tank thermal model. A computer simulation, validated by flight test data, is one way to provide inputs for the model that simulates the thermal behavior of the tank throughout the airplane operating envelope. This model must be provided by the applicant based on the particular characteristics of the particular fuel tank that is being evaluated. The applicant may use the thermal modeling tool incorporated into the Monte Carlo Model if flight test data show that this modeling technique provides conservative prediction of fuel tank temperatures. The Monte Carlo Model includes a

feature to use exponential time constants to define the heating and cooling characteristics of a fuel tank. This feature has the capability to input 6 different constants for various conditions that may be present on typical aluminum fuel tanks. While this feature is one method of modeling the fuel tank thermal characteristics so that fuel tank temperatures can be predicted, it is not an acceptable method of modeling the fuel tank if it does not provide accurate results. It may be necessary for the applicant to develop a separate fuel tank temperature model that accurately predicts fuel tank temperatures. Appendix 1 of this AC provides further guidance regarding developing a validated fuel tank thermal model for use in showing compliance for fuel tanks. This guidance will be helpful for use in developing a thermal model for a fuel tank with an FRM.

(bb) Simplified fuel tank thermal model. To simplify the certification process and avoid the need to develop a fuel tank thermal model, if an applicant so chooses, it is acceptable to determine the flammability exposure of a tank with an inerting system added by assuming the fuel temperature is otherwise always between the LFL and UFL.

b. Fuel Tank FRM Model. If FRM is used, an FAA-approved Monte Carlo program must be used to show compliance with the flammability requirements of § 25.981 and Appendix K of part 25. 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) The effect of any inerting system may be included in this analysis. The applicant should present a description of the system including its control logic, and data to substantiate its performance at lowering the ullage oxygen content to below the inert level defined in Appendix L of the proposed rule to comply with the applicable average flammability level. Where the system does not provide continuous protection such as a ground based inerting system as described in paragraph 4e(5) of this AC, the degradation of the ullage inerting level with time, altitude, fuel out-gassing, air inhalation with fuel use or altitude reduction, and possible effects from vent system operation must be addressed.

c. Compliance Report. The results of the analysis described above, together with substantiation data for the assumptions used in the analysis, including test data validating the thermal analysis used, must be presented to the FAA. If the tank in question requires a demonstration of equivalence, an analysis of a real or hypothetical unheated wing tank on the same airplane must also be presented. The tank in question must be considered to have an acceptably low flammability exposure if it meets the applicable levels defined in the proposed rule.

d. Documentation and Validation of Monte Carlo Modifications. As discussed earlier in paragraph 10, modifications are limited to the additional features needed to model an FRM, tank thermal characteristics, and fuel management. All modifications to the model's code must be thoroughly documented and validated both through detailed analysis and flight test. The compliance report should include a summary section that lists all modifications.

11. **FLAMMABILITY REDUCTION MEANS.** The available methods of limiting exposure to operation with a flammable ullage space in the tank include preventing the formation of flammable vapors and/or controlling the oxygen concentration. Factors that directly influence the formation of flammable vapors include the fuel type properties, fuel temperature, pressure within the fuel tank, and any design feature that increases the potential for fuel mists to be created. Design precautions described earlier within this AC to limit misting or sloshing of fuel within a fuel tank should be taken.

Demonstrating compliance when an FRM is used requires modification to the Monte Carlo Model to include a simulation of the FRM performance. The simulation must determine the times during the flight when the FRM is effective at maintaining a non-flammable fuel tank. Factors that need to be considered when developing the simulation are discussed within this section.

a. Managing Heat Transfer to the Fuel Tank. In general, heat sources should not be located in or near fuel tanks, and heating from other sources, such as hydraulic heat exchangers or rejection of heat from engine systems, should be avoided unless features are incorporated to maintain fuel tank flammability equivalent to an unheated wing fuel tank. Locating heat-producing systems away from the tanks should be considered. If this is not a practical solution, installation of an FRM using thermal control may be another option. Possible technical solutions include the use of thermal insulation blankets, and/or providing ventilation and/or dedicated cooling to remove excess heat from areas adjacent to the tank.

b. Cooling/Ventilation of Fuel Tanks. If the fuel tank is located in an area of the airplane where little or no cooling occurs, such as the center wing box, horizontal stabilizer, or auxiliary fuel tanks located in the cargo compartment, ventilation or dedicated cooling may also be an effective means of demonstrating compliance. The cooling/ventilation means should be effective under all operating conditions, including ground and flight operation, considered necessary to achieve the desired goal of showing the tank flammability is equivalent to the unheated wing tanks. Adequate cooling/ventilation may be provided for certain airplane types by means such as installation of an air gap in spaces adjacent to fuel tanks and utilizing cold air source during ground operation to cool the tank, and the use of ram air inlets for in-flight operation to transfer heat from the tank. Other means (e.g., bleeding cool air from the ECS packs into the air gap) may also be effective at providing adequate cooling/ventilation of the tank.

c. Controlling Fuel Tank Pressure. The flammability of the fuel tank is affected by the pressure in the tank. Typical transport category airplane fuel tanks are vented to the atmosphere and operate at or slightly above local ambient pressure. Fuel tanks located within the wing typically operate with a pressure equal to the local static pressure unless features are incorporated to increase the fuel tank operating pressure. Manufacturers have incorporated NACA scoops on the vent outlets of some airplane fuel tank systems to enhance engine suction feed performance. The pressure recovery factor of these scoops varies but in general is in the range of .4 to .6. Therefore fuel tank pressure during flight may be between .5 to 1.25 psi above local static pressure. The increase in tank pressure results in a reduction in fuel tank flammability.

Many recently designed auxiliary fuel tanks incorporate structural features that allow utilization of pneumatic pressure to transfer fuel from the fuel tank to the airplane fuel tank system. These tanks typically are designed to operate at a pressure equivalent to roughly 8000 feet. This results in a significant reduction in fuel tank flammability. Controlling fuel tank pressure is one means of reducing fuel tank flammability. The Monte Carlo Model defined in paragraph 4e(11) of this AC has features that allow analysis of a fuel tank with fixed or variable pressure so that fuel tank flammability under these conditions can be evaluated.

d. Fuel Tank Ullage Sweeping. A positive ventilation system may be used to “sweep” the ullage of flammable fuel vapor/air mixtures at a rate that keeps the ullage lean when the fuel temperature and pressure in the tank would otherwise define the tank as being flammable. This method would not be an acceptable method of showing compliance without requesting a finding of equivalent safety. The rule requires that the fuel tank flammability be determined based upon the Monte Carlo Method, which does not provide for consideration of ullage sweeping. Demonstrating equivalency would require showing that the fuel vapor concentration is lean within each portion of the fuel tank such that the tank is not flammable, e.g., does not leave pockets of flammable fuel vapor-air mixtures within the tank. The applicant would also need to address any negative effects such as adverse environmental effects of sweeping unburned hydrocarbons into the atmosphere.

e. Higher Flash Point Fuels. One method of minimizing the exposure to operation with flammable fuel vapors is to restrict the fuel type specified in the AFM to higher flash point fuels (e.g., JP-5, 140 degrees F flash point). This method, in combination with other means, may be effective at reducing the exposure. However, as discussed in the ARAC Fuel Tank Harmonization Working Group Report in paragraph 4e(2) of this AC), this approach is not considered to be practical at this time. Compliance demonstration using this method would also require demonstrating equivalent safety to the requirements of the rule because the required method of determining fuel tank flammability defined in Appendix L of the proposed rule and the Users Manual is based upon fuel properties with a specified flash point. If this method were considered, the applicant would need to request FAA approval for use of a fuel type with a different flash point when conducting the flammability assessment.

f. Oxygen Concentration.

(1) Fuel Tank Inerting. Fuel tank inerting is a highly effective means of reducing or eliminating the flammability exposure within a given tank. This method eliminates flammable vapors by displacing oxygen from the ullage space of the tank with inert gas (reducing the oxygen concentration below the level that would support combustion of flammable vapors). The military has used this method to prevent fuel tank explosions of combat airplanes. While system requirements for commercial applications are different, paragraph 4(c)(3), SAE Document 1903, "Aircraft Inerting Systems," describes considerations for installation of inerting systems. The development of nitrogen gas separation technology has allowed the size and weight of nitrogen inerting systems to be significantly reduced.

(2) Recent technology developments have made it possible to develop inerting systems that use optimized air sources that are part of the initial airplane design. These systems are capable of inerting a fuel tank during normal airplane operating conditions. Older technology airplanes that have limited bleed air sources are less efficient and it may not be practical to provide an inerting system that inertes the tank throughout the flight envelope. On these airplanes a flammability assessment based upon the time the inerting system is effective, as well as consideration of the fuel tank flammability, may be part of the overall compliance demonstration.

(3) The applicant may show that inerting is only needed for certain missions, for example during warmer days when the fuel ullage would be flammable, or parts of a particular flight to lower the fuel tank vapor/air mixture average exposure to a level that meets the flammability limit. Inerting may be achieved by supplying inert gas from on-board storage bottles, holding either gas or liquid inerting agent, on board inert gas generation systems (OBIGGS), or from a ground storage system if the tank is inerted only on the ground. Nitrogen is currently the inert gas of choice for inerting fuel tanks and the requirements in the § 25.981 address the requirements for use of nitrogen based inerting systems. Use of other gases, such as carbon dioxide, to inert a fuel tank would include many of the same considerations for markings and maintenance procedures. However there may be other considerations that need to be addressed in the certification plan, such as gas absorbed by the fuel and the effect of the gas absorbed on the fuel system performance, such as suction feed performance.

(4) Flammability reduction means designs that reduce the oxygen concentration to very low levels during cruise and increase the flow of nitrogen enriched air (NEA) into the fuel tank during decent have been found to optimize the design. One nitrogen inerting system designed for retrofit into airplanes with limited air sources has a dual flow mode that takes into consideration the performance of the air separation modules (see paragraph 4e(12) of this AC)). During cruise the system operates at low flow mode where high nitrogen concentration NEA is introduced into the fuel tank to lower the oxygen concentration to very low levels. During decent the system is operated in high flow mode where the flow rate of NEA is increased. At high flow rates the nitrogen concentration NEA is lower.

(5) Oxygen Level. The accepted level for tank inerting used by the military is to reduce the oxygen concentration in the tank ullage to less than 9 percent. Data obtained from military testing that was conducted in 1991 (see paragraph 4e(7) of this AC), as well as FAA testing (see paragraph 4e(8) of this AC), show that 12 percent oxygen concentration at sea level, will provide sufficient protection for transport category airplanes. As stated in the definitions paragraph of this AC, a fuel tank is considered to be inert when the bulk average oxygen concentration within each compartment of the fuel 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.

g. Oxygen Evolution. Fuel loaded on the airplane from sources vented to the atmosphere contains dissolved oxygen. Systems added to inert fuel tanks must take into account the oxygen entrained in the fuel when loaded onto the airplane. The applicant can either design the system to allow and compensate for the evolution of the oxygen or include provisions to remove or “scrub” the oxygen from the fuel during refueling. The effect of oxygen that may rapidly evolve from the fuel during pressure reduction conditions, such as during climb, must be accounted for in the Monte Carlo Model. Section 4.3 of the Users Manual discusses how oxygen evolution should be treated in the Monte Carlo analysis when an FRM using inerting is developed. Note: An FAA ground and flight test program evaluated the effectiveness of inerting a center wing fuel tank with a ground based nitrogen enriched air supply without a closed vent system. The testing included measuring the effects of oxygen evolution. The results of the test program are contained in FAA Report, Ground and Flight Testing of a Boeing 737 Center Wing Fuel Tank Inerted with Nitrogen Enriched Air, Report # DOT/FAA/AR-01/63, (July 2001). The report is available on the internet at <http://www.fire.tc.faa.gov/pdf/01-63.pdf>.

h. Overnight Temperature Change. As the airplane sits overnight, the temperature will change accompanied by an associated density change of the fuel tank ullage. Usually, the change in temperature is downward from the last flight of the day to the first flight the next day. The result is that the fuel tank will breathe in additional air as the ullage density increases. The applicant must take this effect into consideration. The appendix defines the required distribution the applicant must use in a Monte Carlo analysis to determine the change in temperature. The starting temperature is the temperature of the ullage at the end of the last flight as determined by the validated thermal model. The ending temperature is the ambient outside temperature before the next flight after an overnight temperature change. The applicant must substantiate the number of flights per day for a particular airplane and apply the overnight temperature change effect once “per day” in the FRM module developed by the applicant for the Monte Carlo analysis.

i. Open Vent Systems and Descent. Airplanes with open vent systems will draw in air during descent. The FAA recognizes that the air drawn into the tank displaces the nitrogen providing the inert atmosphere and also dilutes the fuel vapor as well. For that

reason, the FAA has determined that the Monte Carlo analysis need not include any time determined to be flammable by fuel temperature analysis during descent as flammable time in the fleet wide flammability exposure results of the Monte Carlo analysis. Once the airplane has landed the analysis should assume the tank is flammable if the bulk fuel temperature is within the flammable region, and the oxygen concentration in any compartment of the tank is above the inert level.

j. Other Considerations Related to Oxygen. The applicant should consider any other environmental or airplane system that may have an effect on the oxygen concentration within the fuel tank in question. Some existing fuel tank vent systems are designed to vent to both wing tips. For a fuel tank that may be vented to both sides of the airplane, the applicant must consider the effects of pressure differences across the wing and the resulting cross flow through the tank. Differential pressures created during maneuvers, between the vents located near each wing tip result in significant flow of air through the fuel tank and can result in adverse effects on an FRM that is based upon limiting oxygen concentrations. Installation of check features, such as a lightly loaded check valve in the vent system, or limiting the venting to one vent outlet have been shown to limit cross-flow. Any changes to an existing airplane vent system must meet the associated regulations. For example, one factor that needs to be considered is possible increases in fuel tank bottom pressures during refueling conditions due to any additional pressure losses resulting from modifications to the vent system.

k. Compliance Demonstration. Flight test demonstration and analysis will be required to demonstrate the effectiveness of the inerting system. The demonstration should include critical conditions and demonstration that the inerting system reduces the oxygen concentration in the tank to an acceptable level, without leaving pockets of oxygen concentrations above the maximum level within the tank. Where the applicant uses inerting as one part of an overall method to reduce flammability, for example inerting in combination with tank temperature control, the applicant should demonstrate the effectiveness of each part of the method independently, as well as in normal operation.

(1) The amount of flight testing that would be acceptable for showing compliance is dependent upon the proposed method of compliance. For example, an applicant may choose to develop an FRM performance model and then substantiate by airplane testing that the model accurately predicts the system performance. An applicant may also choose to define the critical points in the airplane operating envelope and then conduct flight test conditions at the critical points to show compliance.

(2) For an inerting-based FRM that is effective at preventing fuel tank flammability during normal airplane operating conditions, the demonstration that would be needed may be limited to providing substantiation that the distribution system is effective at inerting all sections of the tank, that the system provides adequate flow, and that the reliability of the system meets the overall requirements.

(3) In addition, the applicant must substantiate that the added system meets the installation requirements of part 25.

l. System Reliability Considerations.

(1) Master Minimum Equipment List (MMEL) Interval. Inerting systems are considered added levels of protection above that provided by design features incorporated to prevent ignition sources in fuel tanks. The system is not considered flight critical and airplanes may be dispatched with the system inoperative for short periods of time. The FAA Flight Operations Evaluation Board (FOEB) would establish the MMEL dispatch relief interval for the inerting system based on data submitted by the applicant to the FAA. This value should reflect the value the applicant uses in the reliability analysis. The system reliability analysis may be conducted using the Monte Carlo Model. As shown in section 3.2 of the Users Manual, inputs needed to conduct an analysis include, mean time between failures (MTBF) of the FRM, average time to restore the system function after it is placed on the Minimum Equipment List (MEL), and the number of flights before a failed FRM would be detected. These inputs are discussed in more detail in the Users Manual.

(2) Reliability Reporting. The regulation requires that the applicant demonstrate effective means to ensure collection of FRM reliability data so that the effects of component failures can be assessed on an on-going basis. The reporting requirement applies to applicants and holders of the affected type certificates (TC), supplemental type certificates (STC), and field approvals.

(3) The proposed rule requires the TC or STC holder to provide the FAA with summaries of the FRM reliability data and compliance with Appendix K of the proposed rule on a quarterly basis for the first five years after the FRM is installed and operational. After that time, continued quarterly reporting requirements may be replaced with other reliability tracking methods approved by the FAA oversight office. The requirement for quarterly reports may be eliminated if the FAA determines that the reliability of the FRM meets, and will continue to meet, the requirements of the proposed rule.

(4) Operators are not required to report FRM reliability information. Type certificate holders are required to gather the needed data and may use existing reporting systems that are currently used for airplane maintenance, reliability and warranty claims to gather the data from operators using existing business arrangements between the TC holders and the airlines.

(5) The reliability report should include information regarding overall system dispatch reliability, including identification of the component that caused the failure of the system, and the number of days on average the system was placed on the MMEL. The report should be submitted to the local Aircraft Certification Office (ACO) by a letter on a quarterly basis as required by the regulation.

m. Indications.

(1) Since inerting systems are considered a safety enhancing system, similar to a flight data recorder, no indication to the flightcrew of the flammability of the fuel tank, and associated flightcrew procedures for fuel tank flammability or oxygen concentration are specifically required within the regulation. The need to provide indication of the FRM status will depend on the particular FRM design. Various design methods may be used to make sure an FRM meets the reliability and performance requirements. These may include a combination of system integrity monitoring and indication, redundancy of components, and maintenance actions. A combination of maintenance indication or maintenance check procedures could be used to limit exposure to latent failures within the system, or high inherent reliability may be used to make sure the system will meet the fuel tank flammability exposure requirements.

(2) The need for FRM indications and the frequency of checking system performance (maintenance intervals) must be determined as part of the FRM fuel tank flammability exposure analysis. The determination of a proper maintenance interval and procedure will follow completion of the certification testing and demonstration of the system's reliability and performance prior to certification or as part of the FAA review process for airplanes manufactured under existing TCs or auxiliary fuel tanks under existing STCs.

(3) Appropriate maintenance level indications and limitations should be placed in the MMEL to maintain the reliability of the inerting system to the level required by the regulations. For example, maintenance level messages would likely be needed to meet the reliability requirements for an FRM to show when the system is not functioning properly so the inoperative interval that goes into the reliability analysis can be limited to short periods. Installation of an oxygen sensor to measure the oxygen concentration, and appropriate maintenance messages, is a desirable feature that may eliminate the need for frequent maintenance checks.

n. Inerting System Safety Considerations.

(1) For inerting systems that generate NEA on board, the waste gas may create additional fire hazards or change the hazards within certain areas of the airplane. Therefore, these effects should be considered a potential hazard to the airplane. By the very nature of the process of separating nitrogen from air, the waste gas will be of a higher concentration of oxygen than normal air. Since higher concentrations of oxygen may lead to a greater likelihood of ignition, given the availability of fuel vapor and a spark, safety assessment and special precautions may be required.

(2) Special maintenance procedures may be required to meet the reliability and performance requirements for fuel tanks that utilize nitrogen inerting. Maintenance actions that require entry into a fuel tank that contains inert gas or an area adjacent to an inerted fuel tank, may be hazardous if appropriate safety precautions are not utilized. The fuel tank should be ventilated and appropriate air source provided. Appropriate

warning information should be included in the maintenance manuals and placards placed at fuel tank entry points warning maintenance personnel.

(3) Confined spaces are compartments or enclosures with limited openings for entry and exit, not intended for continuous human occupancy, and only suitable for temporary work such as inspections, maintenance, or repairs. A fuel tank has potential hazards that include toxic chemicals, insufficient oxygen with a concentration that is below 19.5 percent or excess oxygen that is above 23.5 percent, and a flammable gas, vapor, or mist in excess of 10 percent of its LFL. (Reference U.S. Department of Labor Occupational Safety & Health Administration (OSHA), 29 CFR §1910.146(b)). Specific procedures must be in place that identify, control, or eliminate these hazards prior to maintenance personnel entering into fuel tanks.

(4) A large percentage of the work involved in properly inspecting and modifying airplane fuel tanks and their associated systems must be done in the interior of the tanks. Performing the necessary tasks requires inspection and maintenance personnel to physically enter the tank, where environmental hazards exist. These hazards exist in any fuel tank (regardless of whether a nitrogen inerting system is installed) and include fire and explosion, toxic and irritating chemicals, oxygen deficiency, and the confinement to the fuel tank itself. To prevent related injuries, operator and repair station maintenance organizations have developed specific procedures for identifying, controlling, or eliminating the hazards of fuel-tank entry. In addition, government agencies have adopted safety requirements for used when entering fuel tanks and other confined spaces. These same procedures along with additional markings would be applied to the reduced oxygen environment likely to be present in and adjacent to an inerted fuel tank.

(5) Confined and Adjacent Space Markings. The addition of a system that utilizes inerting to reduce the flammability of a fuel tank may result in reduced oxygen concentrations due to leakage of the inert gas in locations in the airplane where service personnel would not expect it.

(6) A worker is considered to have entered a confined space just by putting his or her head across the plane of the opening. If the confined space contains high concentrations of inert gases, workers who are simply working near the opening may be at risk. These gases may be under pressure because of the design of the inerting system, and any hazards associated with working in adjacent spaces near the opening, should be identified in the marking of the opening to the confined space.

(7) Introduction of NEA within the fuel tanks and the possibility of NEA in compartments adjacent to the fuel tanks if leakage occurs creates additional risk. Lack of oxygen in these areas could be hazardous to maintenance personnel, and in some cases could affect the passengers, or flightcrew. Existing certification requirements address these hazards. The regulation requires markings to emphasize the potential hazards associated with confined spaces and areas where a hazardous atmosphere could be present as a result of the addition of FRM. We would require that the access doors and panels to the fuel tanks with FRMs and to any other enclosed areas that could contain

hazardous atmosphere under either normal conditions or failure conditions be permanently stenciled, marked, or placarded to warn of hazards.

(8) Fuel tanks are confined spaces and contain high concentrations of fuel vapors that must be exhausted from the fuel tank before entry. Other precautions such as measurement of oxygen concentrations before entering a fuel tank are already required.

(9) Designs currently under consideration locate the FRM in the fairing below the center wing fuel tank. Access to these areas is obtained by opening doors or removing panels which allow some ventilation of the spaces adjacent to the FRM. We are currently in the process of conducting tests to assess possible reduction in oxygen concentrations. Results of these tests will be contained in a report that will be published by the FAA. Until the results of this testing are available, any associated hazards must be addressed. Unless the design eliminates this hazard, we intend that marking be provided to warn service personnel of possible hazards associated with the reduced oxygen concentrations in the areas adjacent to the FRM. Appropriate markings would be required for all inerted fuel tanks, tanks adjacent to inerted fuel tanks and all fuel tanks connected to the inerted tanks via plumbing. The plumbing includes, but is not limited to, plumbing for the vent system, fuel feed system, refuel system, transfer system and cross-feed system. The markings should also be stenciled on the external upper and lower surfaces of the inerted tank adjacent to any openings to ensure maintenance personnel understand the possible contents of the fuel tank.

(10) Markings/placards. The regulation requires that if an inerting system is installed on an airplane, the access doors and panels to the fuel tank(s) and any other enclosed areas that could contain hazardous atmosphere under either normal conditions or failure conditions must be permanently stenciled, marked, or placarded to warn of hazards. These placards would be considered CDCCL.

The following is an example of wording that may be used:

- Low Oxygen content possible during Nitrogen Generation System operation.
- Obey employer safety procedures.
- Failure to obey may cause injury.



Figure 2. Placard.



Figure 3. Placard.

12. IGNITION MITIGATION MEANS (IMM).

a. Acceptable Means to Mitigate the Effects of an Explosion.

(1) One means to meet § 25.981 is to protect a tank from structural and systems damage that could prevent continued safe flight and landing of the airplane. This alternative recognizes that an applicant may choose to accept a high flammability exposure in a given tank and to provide additional protection to extinguish or suppress an explosion in a tank if an ignition occurs.

(2) The use of appropriate foams to fill the fuel tank and thereby control the pressure rise following an ignition of the fuel vapor/air mixture has been demonstrated to be effective by the United States Air Force (USAF) and other military forces. Foams are in use on several civilian transport category airplane types. Detailed design information regarding use of reticulated polyurethane safety foam for explosion suppression is provided in paragraph 4e(2) of this AC. The applicant may use such a foam installation to satisfy the requirement of § 25.981. The foam type should be demonstrated to be effective in suppressing explosions to a level where structural and system damage is prevented. The applicant should:

(a) Provide data on the foam, including material, pore size, and intended method for installing the foam in the tank.

(b) Address the potential for, and the effects of, degradation of the foam, from any environmental effects and long term aging, on both the airplane and engine fuel systems. If the foam has a limited useful life, particular installation requirements, or other features that are essential for the IMM to perform its intended function, they should be defined as CDCCLs.

(c) Address the effects of the foam installation on fuel system performance, including engine feed, venting, unusable fuel, sump capacity, expansion space capacity, fueling, and defueling, including the effect of the foam on electrostatic buildup in the tank.

(d) Address the effect of the foam installation on the airplane fuel system, as well as the auxiliary power unit (APU) and engine fuel systems, and develop maintenance procedures to ensure the foam is correctly installed, both initially and when reinstalled, if removed for access to the tank.

APPENDIX 1

CONSIDERATIONS FOR FUEL TANK THERMAL MODELS

1. The type of thermal model that is needed to show compliance will depend upon the method of compliance selected for the different requirements. For fuel tanks that allow the use of showing equivalent flammability to that of an unheated aluminum wing fuel tank, a fuel tank thermal model may not be needed if the qualitative flammability assessment method defined in paragraph 11 of this AC is used. For other tanks where specific flammability levels must be shown, thermal modeling will be needed if fuel temperature affects fuel tank flammability.

2. Validating fuel tank thermal coefficients, “Tau,” for use in the Monte Carlo Model.

a. When a fuel tank is heated or cooled by a change in air temperature, the response of the fuel temperature is to increase or decrease, respectively, following an exponential decay law. On the ground, air temperature is considered to be ambient temperature at the airplane location, and in flight it will be the Total Air Temperature (TAT) experienced by the airplane. This exponential trend is driven by the temperature difference between the fuel and TAT, and the response of the mass of the fuel and tank. It can be represented by the system exponential decay time constant Tau, and an equilibrium temperature that the fuel temperature will eventually reach. The equilibrium temperature for a totally unheated tank will be very close to the air temperature, and can be expressed as a temperature difference from ambient temperature on the ground and TAT in flight. For this method, the temperature difference will be called Delta T.

b. By taking data from a flight test, the values for Tau and Delta T can be approximated as a function of fuel load and air temperature. This method requires recording fuel tank temperatures and TAT at regular intervals during critical operational ground and flight test conditions so that the fuel tank thermal characteristics can be established.

3. Compliance Testing. Testing should include ground and flight conditions with variable fuel quantities, and any heat transfer from airplane generated sources to the fuel tank at the critical conditions. The Monte Carlo Model includes the capability to use 6 different Tau values, and sufficient testing to confirm the validity of each of the values used in the model should be done. In addition, the thermal characteristics of the critical portion of the fuel tank relative to formation of flammable vapors should be used in the Monte Carlo Model and validated by the testing. Baffling incorporated into most fuel tanks results in segmented volumes that may significantly affect heat transfer and, therefore, the flammability within the tank volume. If barriers or walls result in separate volumes within the tank and prevent mixing of the fuel and/or vapors in the tank, then each of these volumes should be evaluated independently to determine the worst case exposure for that tank. The validation may include a qualitative assessment of the heat sources (warm fuel transfer, hydraulic heat exchanges, fuel return lines, ECS packs, etc.)

and thermal characteristics of different portions of the fuel tank to substantiate critical location for the test evaluation of the Taus.

a. Temperature Measurement. The location of test instrumentation should consider tank configuration and operational factors to determine which locations in the fuel tank require evaluation. The fuel temperature should be measured at critical locations in the tank for each of the critical fuel loading conditions.

b. Test Conditions. The applicant should conduct sufficient flight testing that simulates the actual operation of the airplane type so that a validated fuel tank thermal model can be developed that will accurately model the fuel tank. Fuel tank temperatures should be measured so that the change in temperature in each affected tank on the ground and in-flight versus time can be determined. The minimum number of test conditions needed to validate the thermal modeling of the fuel tank will depend upon the number of variables that may affect the fuel tank temperature. For example, a minimum of two test flights would be required, one representative of a short mission for the airplane and one representative of a long mission for a typical CWT design so that variability in gate time and fuel quantities could be addressed. The short mission should include at least 30 minutes of ground operation prior to flight, and the long mission at least 90 minutes of ground operation prior to flight. For the entire mission (i.e., from the start-up of airplane systems to completion of the flight), temperatures should be recorded in the test tank(s) at locations to represent the bulk fuel temperature in each separate section of the test tank(s) unless less a qualitative assessment shows that fewer locations can be justified. For this discussion, TAT is used to represent ambient temperature on the ground and TAT in flight. The fuel temperature and TAT shall be recorded at no less than 1-minute intervals.

4. Example of a Flight Test. The sample flight test shown below is an illustration of how to demonstrate that the temperature modeling used in the Monte Carlo Model, based upon use of Time Constant Tau, is acceptable for the particular tank type. The flight test shown is for a typical tank on a long-range airplane. The data includes operational time before and after the flight as required by the method. The tank temperature is recorded every minute, (Data at 10 minute intervals is shown for the example, to save space.) The Tau value is estimated for a full tank and decreased as the fuel is burned off in flight. Using the value of Tau, the tank temperatures can be estimated using the exponential decay equation, $(\text{Temperature Change in time } t)/(\text{Fuel Temp}-\text{TAT})= 1-e^{-(t/\text{Tau})}$. The resultant estimated fuel temperature is then compared to the actual and the Tau values corrected until a satisfactory match is obtained. This can be done manually or using a computer solver approach. If there is no heating of the tank, the Tau values can be obtained directly. If there is significant heating of the tank, the equilibrium temperature can be found by increasing the value for TAT to $(\text{TAT} + \text{Delta } T)$, where Delta T is the tank equilibrium temperature offset from TAT. In this case, both the values for Tau and Delta T must be found for the tank. The Tau used in the Monte Carlo Model should be shown to predict fuel tank temperatures with an error of less than 3 degrees for a period of time not to exceed 5 minutes. If the accuracy does not meet this level, the applicant may choose to use a Tau that is adjusted so that the predicted temperature would be

higher and produce a conservative flammability level or propose an alternative method of modeling fuel tank temperatures.

Example - Wing Fuel Tank Flight Test Results

Shown at 10 minute increments only

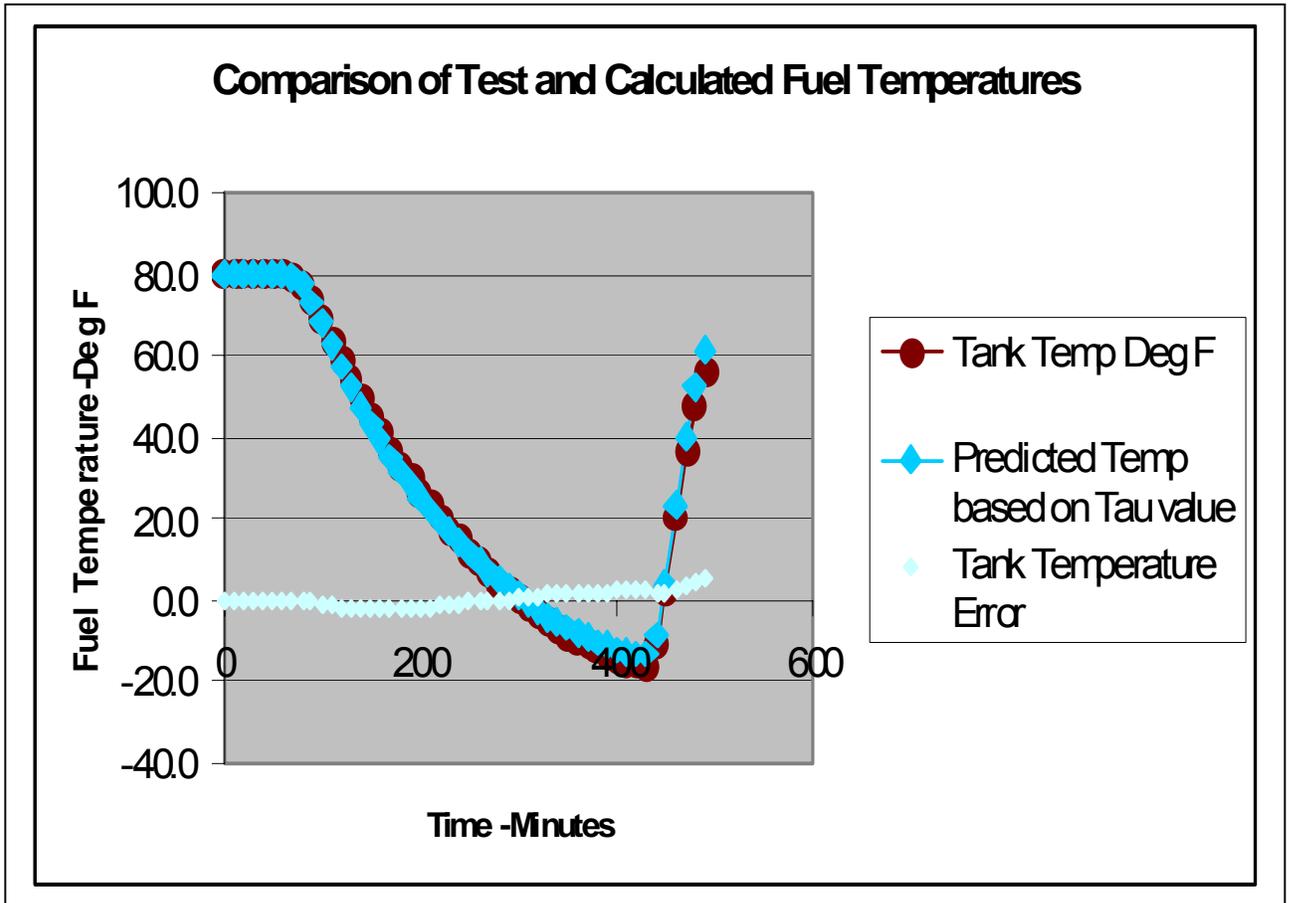
Time min	OAT Deg F	Mach Number	TAT Deg F	Altitude Ft	Fuel Load %	Tank Temp Deg F	Delta T	Estimated Tau	Pre Tem bas Tau
							Temp Difference Fuel Temp- TAT Deg F		
0	80	0.00	80.0	0	100	80.0	0.0	149.8	8
10	80	0.00	80.0	0	100	80.0	0.0	149.8	8
20	80	0.00	80.0	0	100	80.0	0.0	149.8	8
30	80	0.00	80.0	0	100	80.0	0.0	149.8	8
40	80	0.00	80.0	0	100	80.0	0.0	149.8	8
50	80	0.00	80.0	0	100	80.0	0.0	149.8	8
60	80	0.00	85.9	0	100	80.0	-5.8	149.8	8
70	42.5	0.43	58.2	8750	100	79.5	21.2	149.8	7
80	5	0.57	32.7	17500	100	77.4	44.6	149.8	7
90	-32.5	0.71	8.5	26250	100	73.9	65.4	149.8	7
100	-70	0.86	-18.7	35000	100	69.2	87.8	149.8	6
110	-70	0.86	-18.7	35000	100	63.8	82.5	149.8	6
120	-70	0.86	-18.7	35000	100	58.8	77.4	149.8	5
130	-70	0.86	-18.7	35000	100	53.9	72.6	149.8	5
140	-70	0.86	-18.7	35000	100	49.4	68.1	149.8	4
150	-70	0.86	-18.7	35000	100	45.1	63.8	149.8	4
160	-70	0.86	-18.7	35000	100	41.0	59.7	149.8	3
170	-70	0.86	-18.7	35000	100	37.2	55.9	149.8	3
180	-70	0.86	-18.7	35000	100	33.6	52.3	149.8	3
190	-70	0.86	-18.7	35000	100	30.2	48.9	149.8	2
200	-70	0.86	-18.7	35000	100	26.9	45.6	149.8	2
210	-70	0.86	-18.7	35000	98	23.7	42.4	146.9	2
220	-70	0.86	-18.7	35000	94	20.7	39.3	142.2	1
230	-70	0.86	-18.7	35000	90	17.7	36.4	137.5	1

Example Wing Fuel Tank Flight Test Results

Shown at 10 minute increments only

Time min	OAT Deg F	Mach Number	TAT Deg F	Altitude Ft	Fuel Load %	Tank Temp Deg F	Delta T	Estimated Tau	Pre Tem bas Tau
							Temp Difference Fuel Temp- TAT Deg F		
240	-70	0.86	-18.7	35000	87	14.9	33.6	132.8	1
250	-70	0.86	-18.7	35000	83	12.2	30.9	128.1	1
260	-70	0.86	-18.7	35000	79	9.7	28.3	123.4	1
270	-70	0.86	-18.7	35000	76	7.2	25.9	118.7	1
280	-70	0.86	-18.7	35000	72	4.9	23.6	114.0	1
290	-70	0.86	-18.7	35000	68	2.7	21.3	109.3	1
300	-70	0.86	-18.7	35000	65	0.6	19.3	104.6	1
310	-70	0.86	-18.7	35000	61	-1.4	17.3	99.9	1
320	-70	0.86	-18.7	35000	57	-3.3	15.4	95.2	1
330	-70	0.86	-18.7	35000	54	-5.0	13.7	90.5	1
340	-70	0.86	-18.7	35000	50	-6.6	12.0	85.8	1

350	-70	0.86	-18.7	35000	46	-8.2	10.5	81.1	-
360	-70	0.86	-18.7	35000	43	-9.6	9.1	76.4	-
370	-70	0.86	-18.7	35000	39	-10.9	7.8	71.7	-
380	-70	0.86	-18.7	35000	35	-12.1	6.6	67.0	-
390	-70	0.86	-18.7	35000	31	-13.2	5.5	62.3	-
400	-70	0.86	-18.7	35000	28	-14.1	4.5	57.6	-
410	-70	0.86	-18.7	35000	24	-15.0	3.7	52.9	-
420	-70	0.86	-18.7	35000	20	-15.8	2.9	48.2	-
430	-70	0.86	-9.8	33906	17	-16.2	-6.5	43.5	-
440	-20	0.67	22.1	22969	17	-10.4	-32.5	38.8	-
450	30	0.48	55.6	12031	16	2.4	-53.2	34.1	-
460	80	0.28	80.0	1094	15	20.8	-59.2	29.9	2
470	80	0.00	80.0	0	15	36.2	-43.8	29.9	4
480	80	0.00	80.0	0	15	47.6	-32.4	29.9	5
490	80	0.00	80.0	0	15	56.0	-24.0	29.9	6



5. Compliance Reporting. In order to show the fuel tank temperature modeling is acceptable using this method, the compliance report should include plots of the flight test data, as well as the predicted fuel tank temperatures and the associated error between the predicted temperature and those measured during the flight test.

APPENDIX 2

MEASUREMENT OF OXYGEN CONCENTRATION IN AIRPLANE FUEL TANKS

1. Introduction.

a. Background on Oxygen.

(1) Oxygen is the element most associated with life on our planet. It has an atomic number of 16 and is classified as an oxidizer, which means it reacts readily with other elements and is key to any reaction taking place. Oxygen is essential to every living thing. Air is a mixture made of 99.9 percent oxygen and nitrogen existing primarily on the molecular level in a single bond with itself, thus we use the chemistry term O_2 when describing oxygen and N_2 when describing nitrogen.

(2) Measuring oxygen in a given environment is accomplished by exposing a gas sample to a sensor designed to give feedback for a changing amount of oxygen in the sample. The various sensing technologies rely on one of several different natural properties of oxygen to change the voltage in a circuit, or more directly, the number of counts on an A/D converter. Virtually all oxygen sensors do not sense the volume percentage of oxygen in a sample, but rather, the partial pressure of oxygen in the gas sample in question. The analyzer is then calibrated for volume percent oxygen given a fixed sample pressure, flow, and temperature.

b. Types of Oxygen Sensors.

(1) Most sensing technologies work on some type of chemical reaction. A galvanic cell is a sensor containing a small amount of a liquid solution that reacts with oxygen, retained within a permeable membrane. The gas sample is exposed to the sensor membrane and oxygen from the sample enters or leaves the sensor solution to create equilibrium. The solution in these sensors is separated by an anode and cathode. A fixed current source changes the voltage across the anode and cathode given a changing amount of oxygen in the sensor solution (see Reference 4-1 of this chapter). This voltage can be converted to a fixed output with a voltage divider and some linearizing circuitry. Some sensors simply have a piece of chemical compound (i.e., zirconium oxide) reacting between two electrodes. When a gas sample is exposed to the quantity of compound, the oxygen in the sample reacts with the compound and changes the voltage across the electrodes (see Reference 4-2 of this chapter).

(2) Virtually all sensors have a finite life, due to the fact that the reactants and solutions degrade and dilute over time. It is possible to measure oxygen with a truly non-consumable sensor. One commercially available oxygen analyzer uses the principals of paramagnetism of oxygen to measure the volume concentration of oxygen. Because

oxygen becomes magnetic when exposed to a magnetic field and the other constituents of air (nitrogen, carbon dioxide, and water vapor) do not, it is possible to make a detector that is sensitive to the amount of paramagnetic oxygen in an otherwise diamagnetic mixture of gases. In the case of the Rosemount 755R paramagnetic oxygen analyzer, a dumbbell-shaped, nitrogen-filled, hollow glass sensing body, wrapped with a single platinum wire, is suspended on a platinum/nickel alloy ribbon. When the sensing body is surrounded by a gas sample, “magnetic buoyancy” occurs creating a torque on the dumbbell. The current required to counteract the torque and restore the dumbbell to its null position is directly proportional to the amount of paramagnetic gas (oxygen) in the sample (see Reference 4-3 of this chapter).

(3) Some sensors do not require a dedicated gas sample to be removed from the environment to be measured, and thus can be used in situ, or literally in place. Some of these sensors work on the fluorescence properties of light, which change with partial pressure of oxygen in a given environment. These sensors detect changing fluorescence properties (intensity, time decay, etc.) of the light reflected from a coherent source using a spectrometer (see Reference 4-4 of this chapter). This measurement method is best applied in a controlled environment as the process is very sensitive to changes in temperature and pressure and all in situ methods impose unique calibration problems. In general, sensors that are reacting with oxygen make poor in situ sensors due to their propensity to consume oxygen in the general area of the measurement causing a type of sensor drift during measurements of quiescent environments.

2. Choosing a Measurement Method. To choose a measurement method several considerations must be made. The quantity of data as well as the number of gas sample locations required will determine the method of acquiring oxygen concentration for a flight test. The primary methods of measuring the oxygen concentration in a fuel tank ullage applied to date are continuous sampling, in situ measurements, and discrete sample measurements. Each primary method of measurement has an analyzer/sensor technology that is best applied given the measurement requirements. Each sensor and analyzer combination will have specific gas sample requirements. In the case of in situ measurements, sensitive sensors and fiber optic cables may need special protection. Discrete (individual) measurements made during any test always require the carefully choreographed and documented actions of test personnel during the test. This can lead to problems with post-test analysis of the data if information becomes lost or mishandled.

a. Continuous Sampling. The ideal measurement of oxygen concentration in a fuel tank environment is instantaneous and continuous. This, however, is not very practical as some finite time is required to sample ullage gas and excite a particular sensor. By keeping gas sample lines short and small (diameter), while maintaining a relatively high sample flow rate, a gas sample system with a relatively short response time can be developed. Traditional sensors generally have a response time between 500 mS and 5 seconds, depending upon the technology applied.

(1) Flow Through Sensor System.

(a) One such method of continuous sampling was developed and applied by the FAA using flow through galvanic cells and a pressure regulated sample train. The sample train uses a powerful pump to draw a gas sample from the ullage sample location in question, through a forward pressure regulator, which regulates the pressure on the input of the sample train to a vacuum pressure lower than the lowest expected pressure in the sample environment (2.73 psia or 141 Torr @ 40,000 feet). The gas sample is then pumped up to a pressure to that just above sea level (14.7 psia or 760 Torr), allowing the gas sample to flow through a flow meter, the galvanic sensor, and then a check valve. Lastly, the gas sample passes through a pressure controller that regulates the back pressure to a fixed value that can be maintained throughout the flight cycle. This pressure is critical to maintaining the calibration of the analyzer with the galvanic cell sensor. The gas sample can then be returned to the ullage to allow for a minimal effect on the sample environment.

(b) Calibration of this measurement methodology is accomplished easily by having a selector valve in the sample train before the input pressure regulator. The sample train is completely pressure regulated, providing calibration gas to the system input, allowing time for the system to stabilize, and adjusting the analyzer gain allows for calibration. It is best to check for adherence of your oxygen measurement system to a wide variety of calibration gases at least once before and after a test program. This is accomplished by calibrating in the traditional manner, and then checking several other calibration gases with different oxygen concentrations within the measurement range of the testing.

(c) When applying this measurement method to an airplane flight test, care must be taken to preclude liquid fuel or vapors from entering the cabin from the fuel tank gas sample lines. Traditionally, all sample lines are double walled and the shroud (outer wall) space is vented overboard to the exterior of the cabin. Leak checks of both the line and shroud prior to testing are essential. The measurement system sample volume should be isolated from the fuel tank with flash arrestors in the event of a failure that creates an ignition within the measurement system itself. Most oxygen sensors operate on very low power; however, complete isolation of the sensor, and other sources of energy within the sample system, from the fuel tank is essential in the event of a failure that could create a reaction within any portion of the flammable sampling system.

(d) The sampling of liquid fuel should be precluded by use of float valves on the ends of each sample tube in the fuel tank. Also, in the event of a failure that allowed liquid fuel into the sample lines, fuel should be prevented from entering the measurement system with either an automatic float shut-off switch or a warning system that allows for the operator to shut-down the sample system. The measurement system itself should also be shrouded and ventilated to allow for protection of the cabin environment in the case of a sample train leak. During ground operation, when natural suction is not available from the cabin exterior, the measurement system housing should also be continuously purged.

(e) A complete description of the galvanic cell continuous sample system applied by the FAA for the purposes of studying in-flight fuel tank inerting is given in Reference 4-5 of this chapter.

(2) Flow-by Sensor System

(a) Some sensors react significantly with the sample, and therefore may not be appropriate for returning the sample to the tank. A method of applying this type of sensor to a fuel tank environment is to create a volume flow sample train similar to the one described in the previous section. A small amount of this sample is then removed from the loop, in the positive pressure portion of the flow train, allowed to flow through the reacting sensor in question, and then deposited overboard. Minimizing the flow to the sensor helps minimize the effect of the consumed sample and creates a safer environment should the reaction of the ullage sample with the sensor become hazardous. It may be necessary to remove flammable fuel tank vapors from the sample gas to safely apply some sensors for measuring ullage gas.

(b) Calibration of this measurement methodology is accomplished easily by having a selector valve in front of the sensor housing, outside of the primary sample loop. Care must be taken to ensure that the calibration gases flow through the sensor at same pressure and flow rate as the flow by sample. The flow-by sensor should stabilize quickly, allowing for adjustment of the analyzer gain. Again, it is best to check for adherence of your oxygen measurement system to a wide variety of calibrations gases at least once before and after a test program.

(c) Ensuring safety of a flow-by sensor installation is done much in the same manner as described in the previous section. Special care may need to be taken to ensure the reaction between the sensor and the ullage gas sample remains completely benign to the measurement system and the aircraft in general. It is for this reason that high energy sensors have not been applied to in-flight measurement applications. Whatever installation is chosen, careful analysis and application is required, within the confines of the regulations, to minimize risk in accordance with the individual program plan developed.

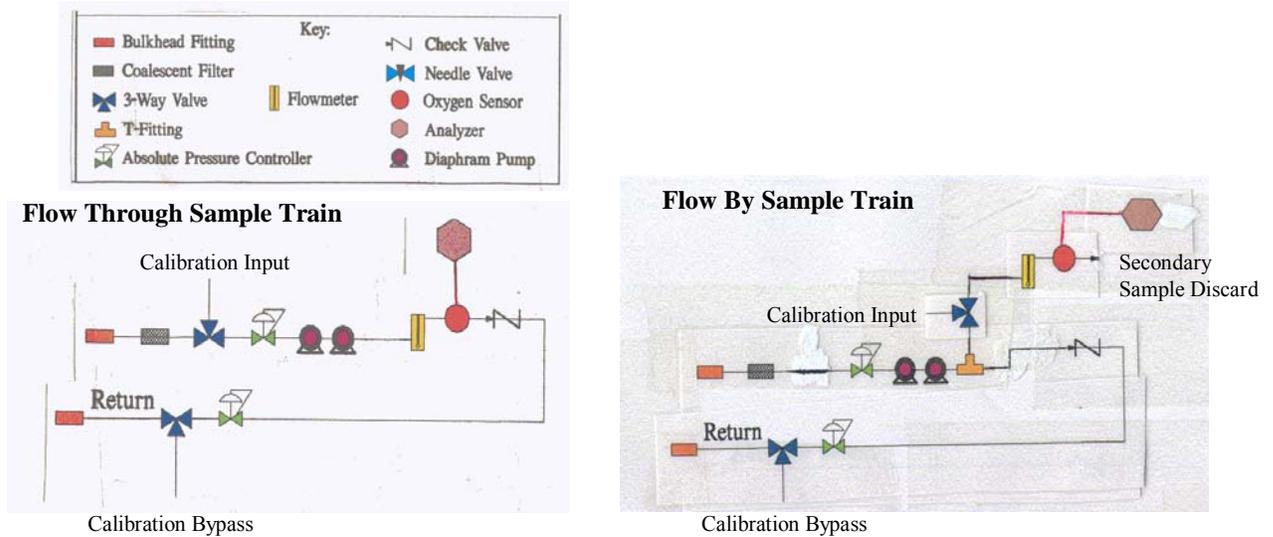


Figure 1: Block Diagrams of Flow Through and Flow Bypass Sample Systems

b. In Situ Measurements.

(1) Application of in situ sensors for measuring fuel tank ullage oxygen concentration has been applied and observed by the FAA on a limited basis. However, recent advances in application of these sensor technologies make them a viable option for future in-flight oxygen concentration measurement in a fuel tank ullage. Optical methods such as fluorescence quenching are attractive to apply to measurements in fuel tanks due to the intrinsically safe nature of the energy required for the sensor, and in situ methods in general alleviate the need to remove flammable ullage gas from the fuel tank for sampling.

(2) Each in situ sensor will have its own unique installation issues due to the sensor size and shape, as well as any environmental limitations such as temperature. Routing of any fiber optic cables will need to be within the requirements for the cable.

(3) The main difficulty with applying in situ sensors is the need to calibrate the sensor in place. This is not practical on a daily basis in an airplane fuel tank. This is complicated by the fact that optical methods generally have a very nonlinear response and need to be calibrated for a changing ullage temperature. In previous applications of fluorescence quenching sensors, the calibration was done in a controlled environment using multiple gases at multiple temperatures. The system was then installed in the tank and each channel was then “normalized” to a baseline intensity using air at some middle calibration temperature. This proved to be problematic given the variable of the baseline intensity of the different channels between the lab and airplane.

(4) To alleviate this, a sleeve assembly could be fabricated for the sensor that allows the sensor to be immersed in calibration gas through the sleeve, deposited from the outside of the fuel tank, to allow for daily checking of the calibration for several gases. At the very least, the sensors would need to be validated at a single point before

every flight. This has been accomplished in the past by having the inert gas generation system create a fixed oxygen concentration gas for an extended period of time. This will eventually stabilize the tank at a single oxygen concentration and temperature to allow for validation of each sensor in the tank. It is easy to see that this could quickly become expensive and time consuming if the calibration had to be checked multiple times and/or with multiple gases on a daily basis.

(5) Safety requirements for equipment located within a fuel tank such as in situ measurement systems are already established in the existing § 25.981 and related sections (See AC 25.981-1C). These safety requirements establish limitations on power required for instruments installed and places limitations on materials for use in fuel tanks. Part 25 addresses analysis of failure modes in general (§ 25.1309) and sets general installation requirements (subpart F). The power required for any sensor installed in a fuel tank needs to be calculated to be less than the minimum ignition energy prescribed by the FAA for fuel tank installations. Any cables that need to be installed should be routed in accordance with standard industry practices within the requirements of all airworthiness regulations. Each individual installation needs to be analyzed and evaluated for risk within the confines of the regulations and agreed upon by all project stakeholders.

c. Discrete Sampling. Although not desirable, it is possible to evaluate the capability of a particular inerting system to allow for protection of a given fuel tank without acquiring continuous oxygen concentration data throughout a complete flight cycle. This may be because of advances in ullage oxygen concentration modeling or because of the existence of a large quantity of previously acquired data for a similar inerting system and application. Regardless, collection of discrete samples at several critical times for a few different ullage locations can provide a complete picture of capability of an inerting system to maintain an inert ullage in a specified fuel tank during a flight cycle for some applications. Discrete methods may provide a cost advantage over continuous sampling measurements and can be considerable less complex if large quantities of gas samples are not required. The primary methods of acquiring discrete samples are through vacuum bottle sampling or through single point calibration and sampling.

(1) Vacuum Bottle Sampling.

(a) One method of acquiring discrete ullage gas samples at various times is by the use of vacuum sample bottles, which are previously cleaned, evacuated, and hermetically sealed. Vacuum bottles are generally used by plumbing several bottles in series. Each bottle has an individual hand operated valve to let in a gas sample, to the desired sample line, which is located within the ullage of the fuel tank in question. Each vacuum sample bottle in the series will provide a single, discrete gas sample in time at that particular ullage sample location. A vacuum sample bottle generally has a second vacuum bottle adjacent to it which is deployed (valve opened) before deploying the actual vacuum sample bottle. This is done to “update” the sample line with a fresh ullage gas sample before opening the sample bottle to acquire the gas sample.

(b) Each sample location will have an associated series of vacuum sample bottles, depending upon the number of samples required and the individual test setup. Typically these bottles are analyzed after completion of the test for oxygen content and whatever additional gas analysis is desired, by a laboratory that specializes in this kind of gas sample. It is critical to have a simple, well documented, plan for gas sampling to ensure that test personnel acquire the required gas samples at the appropriate time and allow for adequate documentation. As is always the case with human/test interaction, a series of procedures and checks are required to minimize the possibility of human error.



Figure 2: Vacuum Bottle Sample System Installed on an NTSB Test Aircraft

(c) The primary safety concerns with a vacuum bottle sample system are similar to those for a continuous sample system. All sample lines penetrating the pressurized bulkhead should be leak checked and shrouded to preclude the possibility of ullage gas or fuel entering the cabin. Additionally, each sample bottle series should be housed in a shroud which is ventilated overboard to the cabin exterior. The advantage of analyzing the gas samples after the flight test is that no additional safety features are required to protect the aircraft fuel tank from the potential ignition source of a sensor or associated gas sample regulation equipment.

(2) Angle Point Calibration and Sampling

(a) It is possible to use an analyzer and sample train to obtain discrete oxygen concentration measurements during a flight test. This can be accomplished by rapidly calibrating an analyzer sensor with a calibration sample gas, and then exposing the sensor to the desired ullage gas sample. This method would probably only be

effective for measuring the oxygen concentration at times and tank locations with a relatively stable pressure, temperature, and oxygen concentration within the fuel tank ullage.

(b) All of the safety considerations associated with single point calibration and sample methods are identical to those of continuous sampling methods. For this reason alone, it may not be desirable to apply this methodology to a flight test scenario. Most of the cost and complexity of a gas sample system installation for a flight test environment is attributable to the safety features (sample line shrouds, box ventilation system, and system safety analysis). To apply these methods and not install the additional equipment to continuously sample, at a relatively small cost and complexity, does not seem cost effective. Again, every installation and application needs to be analyzed for certification requirements, data ranges, and program risk, within the confines of the regulations, to ensure a successful, cost effective flight test.

3. Selections of Sample Locations. The primary consideration when selecting the location and number of gas sample ports is the physical geometry of the fuel tanks, as well as the compartmentalization of the fuel tank. The two types of fuel tanks considered are single bay tanks and multiple bay tanks.

a. Single Bay Fuel Tanks.

(1) Single bay fuel tanks have a single volume, broken up only by structural members, which do not impede the flow of vapors inside the tank. It is possible to select a single gas sample location that is representative of the entire ullage average oxygen concentration, but without prior measurements during similar inerting testing or extensive computation calculations, it is difficult to ensure a single measurement location is representative of the entire ullage. For fuel tanks where air enters the fuel tank during descent, a continuous measurement of ullage oxygen concentration during a specified aircraft descent profile is essential to determining the level of protection afforded the tank by the inerting system and is the best measure of the sizing of inerting system for the specified fuel tank. The critical sampling location would typically be located near where outside air enters the tank. Therefore if a single sampling location is proposed, substantiation that the selected sampling location will provide oxygen measurements that demonstrate the tank is inert must be provided.

(2) Measurements too close to the airplane vent (air deposit) or the NEA deposit nozzle can provide a biased measure of the average ullage oxygen concentration. It is possible that during the mixing of NEA and vent air into the tank, brief pockets of high or low oxygen concentration ullage gas may exist within the ullage. Without compartmentalized bay walls, these pockets will be transient and difficult to identify. Mixing can be problematic in the vertical direction (between the top and bottom of the tank), particularly when considering low flow rates of air or NEA entering a tall thin fuel tank. If a fuel tank has associated radiant heat on the bottom (heated CWT), this problematic mixing will be small in nature and short lived.

(3) At the end of every test the aircraft fuel tank ullage will have a measured average ullage oxygen concentration after the aircraft has come to a complete stop and the inerting system has been shut off. By continued examination of this average over a period of 20-60 minutes during the operation of the aircraft air cycle machines (bottom heat), good vertical mixing can be validated. Any change in the average ullage oxygen concentration after the test is complete, with no additional air or NEA is entering the tank, can only be caused by changing oxygen concentration readings due to the mixing of the resulting ullage constituency. Again, without prior knowledge, the only way to ensure the inerting system is appropriate for the aircraft fuel tank is by the continuous measure of oxygen concentration at several strategic locations within the ullage during an appropriate descent flight test.

b. Multiple Bay Fuel Tanks.

(1) Multiple bay tanks are fuel tanks broken into several smaller volumes by solid or nearly solid web structures. These structures can be somewhat limited in their partitioning with large openings and extensive gaps between the web and the tank structure as is the case with many wing fuel tanks. These web structures can also be very solid in nature, with the only large openings being doors removed during maintenance and small web gaps for equalizing fuel and ullage gas, making a very compartmentalized tank.

(2) Fuel tanks with relatively open partitions may only require a few gas sample locations across many bays to allow for the accurate measurement of the overall fuel tank ullage average. Previous research highlighting inert gas distribution behavior during ground inerting may be beneficial to determining the number and location of gas sample ports. However this is not a guarantee of good air redistribution given the different nature of the NEA deposit and the vent opening. In the end, several more oxygen concentration sample locations and oxygen measurement channels may be necessary to allow for validation of inert gas distribution and ullage gas mixing during certain flight tests. These additional sample locations can be utilized when the mixing of the tank needs to be examined or validated using oxygen measurement channels redundant at that time.

(3) In the case of very compartmentalized fuel tanks, inert gas distribution may be problematic, depending on the sizing of the inerting system and the NEA deposit scheme selected. This generally requires at least one gas sample in each compartment, with long thin compartments perhaps requiring two gas sample locations. Bays that have a large vertical height, while still remaining relatively thin, may require an additional sample port at the bottom of the bay. Again, any differences in the oxygen concentration of the top and bottom of an ullage compartment will be transient in nature, but the knowledge of this behavior may allow for an explanation of an unusual measurement obtained and could allow for the validation of fuel tank inerting models being utilized.

4. References.

1. Advanced Instruments, “GPR-29 % O2 Analyzer Owner’s Manual”
2. Doebelin, E., Measurement Systems Application and Design, McGraw-Hill, 1990, pages 729-730.
3. Rosemount Analytical, “Model 755R Oxygen Analyzer Instruction Manual,” 748213-S, April 2002.
4. Ocean Optics .
5. Burns, Michael and Cavage, William M., “A Description and Analysis of the FAA Onboard Oxygen Analysis System,” FAA report DOT/FAA/AR-TN03/52, June 2003.

APPENDIX 3

DEVELOPING CRITICAL DESIGN CONFIGURATION CONTROL LIMITATIONS

1. Introduction.

This appendix provides guidance for developing Critical Design Configuration Control Limitations (CDCCL) for fuel tank systems to prevent the fuel tank from exceeding the applicable flammability exposure limits established in the Fuel Tank Flammability Reduction Rule.

2. Definitions.

- a. Aircraft Maintenance Manual (AMM). A manual developed by the manufacturer of a particular airplane that contains information necessary for the continued airworthiness of that airplane.
- b. Airworthiness Limitation Item (ALI). Mandatory maintenance of the fuel system that can include CDCCL, inspections, or other procedures determined necessary to ensure the unsafe conditions identified by the SFAR 88 Mandatory Action Advisory Board do not occur and are not introduced into the fuel system as a result of maintenance actions, repairs, or alterations throughout the operational life of the airplane.
- c. Component Maintenance Manual (CMM). A manual developed by a manufacturer that contains information necessary for the continued airworthiness of a particular component.
- d. Critical Design Configuration Control Limitations (CDCCL). A limitation requirement to preserve a critical ignition source prevention, ignition mitigation or flammability reduction system, feature of the fuel system design that is necessary for the design to meet the performance standards of § 25.981 throughout the life of the airplane model. The purpose of the CDCCL is to provide instructions to retain the critical features during configuration changes that may be caused by alterations, repairs, or maintenance actions.
- e. Design Approval Holders. In the context of this policy statement, type certificate (TC) and supplemental type certificate (STC) holders for large transport airplanes—as defined below—are design approval holders.
- f. Instructions for Continued Airworthiness (ICA). Maintenance instructions required by 14 CFR 25.1529 and prepared to meet the specific requirements of 14 CFR part 25, Appendix H, for a design approval holder.
- g. Large Transport Airplanes. The group of airplanes defined in the applicability of 14 CFR part 25, Subpart I, relating to flammability reduction. That group consists of turbine-powered transport category airplanes, provided that the type certificate for the airplane was issued after January 1, 1958, and that the airplane has either a maximum type certificated passenger capacity of 30 or more or a maximum payload capacity of

7,500 pounds or more, resulting from the original certification of the airplane or later increase in capacity.

3. Discussion.

a. Critical Design Configuration Control Limitations include those features of the design that must be present and maintained to achieve the safety level intended by § 25.981 for the operational life of the airplane. For example, certain fuel tanks may rely on natural cooling to meet the flammability exposure levels applicable to the particular fuel tank. Changes to the airplane, such as installing a fuel re-circulation system, hydraulic heat exchanger in the fuel tank, or a heat source adjacent to the fuel tank, may affect fuel tank flammability exposure. A CDCCL would be necessary in this example to prohibit the addition of heat to the fuel tank. Another example of a CDCCL might be limits on operation with certain fuel types such as JP-4. The CDCCL would also control or prohibit the kinds of modifications to airplanes, like the addition of auxiliary fuel tanks, that could adversely change the flammability exposure of fuel tanks to which it may be connected. All fuel tanks, even those in airplanes that do not have high flammability fuel tanks, will need to have CDCCL defined so that future modifications do not increase the flammability above the regulatory limit. This application of CDCCL to FRM and IMM is similar to the requirements already applied to fuel tank ignition source prevention in Amendment 25-102 to § 25.981.

b. The flammability reduction rule also includes the requirement that visible means identifying CDCCL be present. This is required to prevent alterations to critical features of the system. As the visible identifications are critical to the FRM or IMM system, they are also considered to be CDCCL. Any tampering or removal would be in violation of the CDCCL. These CDCCLs, inspections, or other procedures would be documented as airworthiness limitations in the ICA.

c. The CDCCLs for fuel tank flammability include any information necessary to maintain those design features that have been determined by analysis of the fuel tank system (e.g., fault tree analysis, failure modes and effects analysis) as needed to maintain the performance of the FRM or IMM, or maintain the fuel tank flammability within the limits established by the applicable regulations. AC 25-981-1B contains additional guidance on how to perform the analysis. Critical Design Configuration Control Limitations are intended to preclude the occurrence of any maintenance or inspection task or procedure that could result in a failure, malfunction, or defect that would compromise the intended function of the critical part, component of design feature that ensures the fuel tank flammability exposure does not exceed the regulatory limits. This information is essential to ensure that maintenance, repairs, or alterations do not unintentionally violate the integrity of the original type design of the fuel tank system. CDCCLs may be required that define the critical features, such as--

- flammability exposure of the unheated aluminum wing tank, and associated cooling rate,

- limits on heat input such as adding heat blankets or additional hydraulic heat exchangers,
- limits on how an auxiliary fuel tank is integrated with an existing airplane fuel tank system, such as limiting venting into a tank with FRM based upon inerting or transferring warm fuel from the auxiliary tank,
- limits on airplane systems such as minimum quantity of engine bleed air flow or electricity that is required to supply power to an FRM,
- limits on use of high volatility fuels such as JP-4, quantity of engine bleed air flow that is used for inerting,
- limits on penetrations of the fuel tank,
- limits on any changes to fuel management that may affect FRM,
- limits on changes to any placards or means used to visibly identify critical design features of the fuel tank system that must not be compromised for the operational life of the airplane,
- life limits on parts such as polyurethane foam used as an IMM, the air separation modules used in an inerting system.

d. Airworthiness limitations are part of the ICA. Design approval holders (DAH) need to make available to affected parties pertinent changes to the ICAs. (The term “make available” is used in the same sense that it is used in § 21.50.) The rule is not intended to alter or interfere with the existing commercial relationships between TC holders and these other persons. The FAA anticipates that DAHs would be able to be reasonably compensated for developing these documents, as they are under current practice.

e. The rule requires creation of an Airworthiness Limitations Section (ALS), unless previously established. The ALS is required by current part 25 and includes those items that have mandatory inspection or replacement times related to fuel systems and structure. The ALS is included in the ICA, approved as part of type certification, and distributed with an airplane on delivery. In this way the ALS is visible to all who need it and who would be required to comply with it under §§ 91.1509, 121.917, 125.509 and 129.117. For those airplanes that currently do not have an ALS, the rule requires an ALS only for fuel tank safety related limits. This rule does not require that the ALS for these airplanes include the other requirements for an ALS established under Amendment 25-54 to part 25, or a later amendment. For those DAH or applicants with airplanes certified to Amendment 25-54 or later, the existing ALS would be revised to include the fuel tank system ALI.

f. The ICA developed by the DAH using the guidance in this advisory circular must be approved by the responsible FAA Oversight Office. Those approved instructions are required by related operational rules to be used by operators to develop and propose changes in their maintenance programs and incorporate design changes needed to maintain the fuel tank flammability within the approved limits and to ensure continued airworthiness of certain features of the FRM and IMM for the operational life of the

airplane. These changes to the maintenance programs must be reviewed and approved by the operator's designated FAA inspector or Principal Inspector.

4. Development of Critical Design Configuration Control Limitations

a. The CDCCLs, which are a type of Airworthiness Limitation, are the primary means of managing and controlling the configuration of the FRM, IMM or design features that affect the flammability of any fuel tank that does not require an FRM or IMM. In the context of this AC, CDCCLs provide limitation requirements for configuration management to preserve the integrity of certain critical flammability features of the fuel tank system design. These critical features are essential to ensure fuel tank flammability does not increase above limits defined in the regulations as a result of configuration changes caused by maintenance action, repair, or alteration of those critical features. While initial inspections may be necessary to ensure that a CDCCL has not been compromised (e.g. because of aging, wear, maintenance, alterations, etc.), they are not intended to require repetitive inspections. Rather the intent of the CDCCL is to ensure that all affected maintenance personnel are aware of the need to make sure the configuration identified by the CDCCL is preserved for the operational life of the airplane.

b. The DAH may determine that the CDCCLs are applicable at the individual part level or at the component level. In the context of this guidance, components are assembled from parts. Design approval holders may elect to identify a CDCCL that applies to the component for the purposes of reducing tracking of ALIs that may apply to individual parts of the component. If the component level is used, the design approval holder is responsible for revising the Component Maintenance Manual (CMM) instructions to identify all of the critical features of the component design for approval by the FAA Oversight Office.

c. To identify the parts or components to which the CDCCLs are applicable, the DAH must first conduct a configuration assessment of the fuel tank system design. The purpose is to identify any foreseeable maintenance or inspection actions or other causes that could compromise the configuration of a critical feature of the fuel tank system. In the context of this guidance, foreseeable causes are those that have occurred in service in the past or those that engineering judgment predicts could compromise the critical feature of a part or component of a fuel tank system. The DAH must develop maintenance and inspection instructions to prevent those foreseeable changes to the design configuration of the critical ignition source prevention features.

d. Airworthiness Limitations Section Content. The ALIs should include the following:

- The Limitation Statements shown below,
- A brief description of the flammability reduction, ignition mitigation means features,

- The flammability issue associated with inadvertent changes to the configuration of each of those design features, and
- The reference to maintenance instructions, if applicable, and other information in manuals (such as airplane maintenance, standard wire practices manual, etc.,) that have been revised or created to advise affected personnel of the CDCCLs.

e. Limitation Statement: The Critical Design Configuration Control Limitation statements are as follows:

LIMITATIONS.

1. The critical features of the parts or components identified in the CDCCLs must be maintained in a configuration identical to an approved type design for the airplane.
2. Any repairs or overhauls to the critical features of the parts or components that are identified must be maintained in accordance with the design approval holder's maintenance manual or with other acceptable repair or overhaul specifications and parts approved by the FAA Oversight Office specifically for that part or component.
3. In cases where the critical features of a component are specified, any test equipment or tooling utilized to repair or overhaul the component must be in accordance with the CMM or otherwise comply with 14 CFR 43.13(a) and be substantiated and documented as equivalent.

5. Identification and Awareness of CDCCLs.

a. The DAH should list the parts components or features to which the CDCCLs are applicable for a particular airplane in the service information (e.g. maintenance planning document or special certification item document) documenting the CDCCL. This is the mechanism for identifying critical features and requiring their control. To ensure that the operator introducing a modification or the mechanic is aware of the need to consider these critical features, it will be necessary to insert cross-references in certain documents to comply with the CDCCLs.

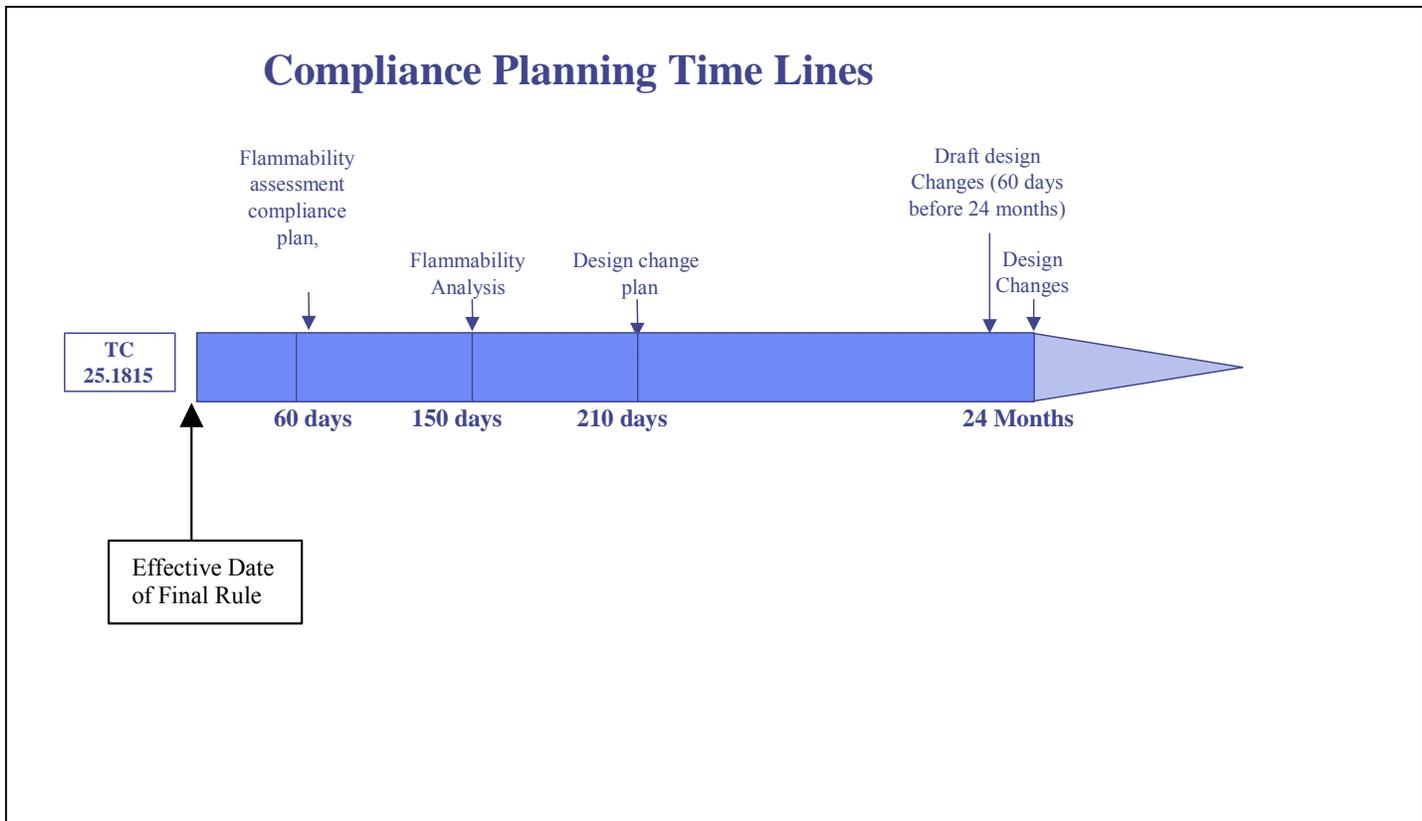
1. The DAH should identify a task with WARNING or CAUTION notes for a component or part that has a critical design feature in the Airplane Maintenance Manual (AMM). The operator should incorporate acceptable procedures to ensure compliance with the CDCCLs.

2. The DAH should include information in standard practices manuals to ensure the CDCCL information is provided to those making modifications or maintaining the type design. (see draft AC 25-YY available on the internet at: http://www.airweb.faa.gov/Regulatory_and_Guidance_Library/rgDAC.nsf/0/E78F9F9E99E0999886257092004AA7AD?OpenDocument, for guidance on preparation of these manuals).
3. The DAH should identify the appropriate CMM. In addition, the design approval holder should ensure that a statement is inserted into both the CMM and the Airplane Maintenance Manual that the component is controlled by the CDCCL and, therefore, that it may be repaired or overhauled only in accordance with the CMM or other acceptable maintenance procedures and parts approved by the FAA Aircraft Certification Office.
4. These documents should include that the part, component or design feature component is controlled by the CDCCL and, therefore, that it may be repaired or overhauled only in accordance with the CMM or other acceptable maintenance procedures approved by the FAA Oversight Office.

APPENDIX 4

COMPLIANCE WITH SUBPART I SECTIONS 25.1815, 25.1817, 25.1819, AND 25.1821 ²

1. Section 25.1815 Holders of type certificates: Fuel tank flammability safety. This section requires TC holders of large transport category airplanes to analyze the flammability exposure of all their airplanes’ fuel tanks and develop service instructions for those tanks that exceed limits defined in the rule. For example, a TC holder of an airplane with any fuel tank that is normally emptied and is determined by the analysis to have high flammability exposure (over 7 percent) would be required to develop service instructions for IMM or FRM if any portion of the fuel tank is located within the fuselage contour. The affected TC holders would also be required to submit compliance plans for the flammability analysis and the development of service instructions for an FRM or IMM. The due dates for items required by this regulation are as follows:



² This appendix is excerpted from the Notice of Proposed Rulemaking, “Reduction of Fuel Tank Flammability in Transport Category Airplanes,” 70 FR XX (November 15, 2005)

a. Applicability. Section 25.1815 (a) states that this rule would apply, with some exceptions listed in paragraph (i), to *“transport category turbine-powered airplanes with a maximum type-certificated capacity of 30 or more passengers, or a maximum payload capacity of 7500 pounds or more resulting from the original certification of the airplane or later increase in capacity.”*

The reference to the originally certificated capacity, or later increase in capacity, is intended to address two situations:

- In the past, some designers and operators have gotten design change approval for a slightly lower capacity to avoid applying requirements mandated only for airplanes over specified capacities. By referencing the capacity resulting from original certification, this proposal would remove this possible means of avoiding compliance.

- It is also possible that an airplane design could be originally certified with a capacity slightly lower than the minimum specified in this section, but through later design changes, the capacity could be increased above this minimum. The reference to later increases in capacity would ensure that, if this occurs, the design would have to meet the requirements of this section.

(1) Exceptions. Certain vintage airplanes type certificated before 1958, the beginning of the jet age, would be excluded from the requirements of this proposal. They are named in § 25.1815(i). There are no known reciprocating-powered transport category airplanes currently in scheduled passenger service, and the few remaining in cargo service would be excluded. Compliance is not required for these specific older airplanes because their advanced age or small numbers would likely make compliance economically impractical.

(2) Foreign Type Certificate Holders. This paragraph applies not only to domestic TC holders, but also to foreign TC holders. In this sense, this section is different from most type certification programs, where foreign applicants typically work with their responsible certification authority, and the FAA relies, to some degree, upon that authority’s findings of compliance under bilateral airworthiness agreements. Since this rulemaking is not harmonized in all cases, the FAA will retain the authority to make all the necessary compliance determinations, and where appropriate, may request certain compliance determinations by the appropriate foreign authorities using procedures developed under the bilateral agreements. The compliance planning provisions of this section (discussed later) are equally important for domestic and foreign TC holders and applicants, and we will work with the foreign authorities to ensure that their TC holders and applicants perform the planning necessary to comply with the requirements of this section.

b. Flammability Determination and Service Instructions.

(1) **Flammability Analysis.** Paragraph 25.1815 (b) requires holders of TCs for large transport category airplanes to submit a flammability exposure analysis for approval by the FAA oversight office. The compliance time for the submission is 150 days after the effective date of the final rule. This analysis is not required for fuel tanks for which the TC holder provides IMM meeting the requirements of § 25.981(d), discussed earlier.

(2) **Model Variations and Derivatives.**

(a) Paragraph 25.1815 (b) would also specify that the flammability analysis must include any model variations and derivatives for which the TC holder has obtained approval that affects fuel tank flammability exposure. Model variations that may affect fuel tank flammability could include changing the fuel tank volume or usable fuel capacity, changes in the fuel management procedures, engine changes that might affect parameters such as airplane climb rate or bleed air available if needed by an FRM. Other examples of configuration differences that may affect fuel tank flammability exposure are provided in the discussion of § 25.1817. It would also include all modifications and changes mandated by Airworthiness Directives (AD) that affect fuel tank flammability exposure as of the effective date of the rule. These ADs would only be those issued against any configurations developed by TC holders. This would include any ADs issued against modifications defined by a third party STC installed on affected airplanes. The result would be a configuration that is clearly understood by both industry and the FAA.

(b) An example of a model variation is an airplane certificated with the same model and series designation that could have different maximum takeoff gross weights, changes in fuel tank configuration or engine type or thrust, equipment installations, or passenger versus all-cargo carrying capabilities. Derivatives, in most cases, are those model airplanes that historically incorporate significant design changes from the original approved type design. In general, these derivative models would have to comply with later airworthiness standards for those areas incorporating the significant design changes. The derivative models are listed on the same TC data sheet with the original certificated model. Various segments of industry have also defined these changes as “variants.” For the purpose of this regulation, we consider the terms “derivatives” and “variants” to be synonymous.

(3) **Service Instructions and Service Bulletins.** If the flammability exposure analysis shows that the average exposure for any fuel tank exceeds 7 percent, paragraph (c) would require the TC holder to develop design changes and service instructions for either FRM or IMM. Modifications incorporated into existing airplanes, including safety related changes (design and/or maintenance) that are mandated by AD, are typically made by operators using service instructions developed by the TC holders. These service instructions are commonly referred to as service bulletins. In this regulation, service instructions must contain sufficient information for the operator to incorporate the design change and any associated procedures and airworthiness limitations. They may include specific step-by-step procedures and information needed by the operator, such as parts

lists, drawings, etc. Therefore, the paragraph requires TC holders to develop and submit for approval by the FAA, not just data defining a proposed design change, but a package of complete information that includes all of the information necessary to enable an operator to comply with the operational rules, discussed later. This information should be formatted and completed to a point similar to what would be submitted to the FAA if the FAA were to be issuing a mandatory action.

(4) Flammability Levels.

(a) The guidance in this paragraph would apply the new FRM or IMM requirements of § 25.981(c) and (d), and Appendix K, to existing fuel tanks that exceed 7 percent average flammability exposure. For any fuel tank that is normally emptied and exceeds 7 percent average flammability exposure, the rule requires TC holders to develop IMM or FRM that reduces the flammability exposure to 3 percent average flammability exposure and 3 percent specific risk requirements if any portion of the tank is located in the fuselage contour. The specific risk requirement would limit the average flammability exposure of the tank for each of the ground, takeoff and climb phases of the airplane operation during warm days to 3 percent average flammability exposure. The flammability exposure limit for these particular tanks has been established in consideration of the service experience that shows these tanks to have a higher risk for fuel tank explosion than other tanks. For all other fuel tanks located in other portions of the airplane (for example, the wing and empennage), the proposal would require TC holders to develop IMM or FRM that reduces the flammability exposure below 7 percent and apply the requirements for an FRM of subparagraph K25.2, K25.3, K25.4 of Appendix K if an FRM is selected as the means of compliance. This proposed rule is not expected to result in the need for FRM or IMM in any fuel tanks located in the wings of airplanes in the existing fleet because previous assessments estimate these tanks have flammability exposure below 7 percent. However, the analysis required by this proposal may reveal some fuel tanks located within the wing that exceed 7 percent.

(b) The definition of tanks that are normally emptied and auxiliary fuel tanks used in this section are the same as that discussed in the preamble to the flammability reduction rulemaking associated with this AC.

c. Compliance Times.

(1) Paragraph (c) contains a table of compliance dates for the required submissions. This table provides specific dates for each Boeing and Airbus model airplane that has fuel tanks exceeding 7 percent flammability exposure. It also has a compliance time of 24 months after the effective date of the final rule that applies to all other models subject to this proposal if the flammability exposure analysis shows an average exposure exceeding 7 percent.

(2) The compliance times stated in this section are also used as the basis for the compliance dates for introduction of these systems into the operators' fleets under parts 91, 121, 125, and 129. Extension of the compliance dates for development of the service

instructions by the certificate holders would either reduce the amount of time available to operators or delay full deployment of these safety improvements. Incorporation of FRM or IMM will likely require access inside the fuel tanks. Typically fuel tanks are only accessed during heavy maintenance checks that are done on a schedule established during development of the maintenance program. The compliance dates for the operational rules were established to allow a majority of the modifications to be done during these heavy maintenance checks. Introduction of FRM or IMM outside of normally scheduled maintenance would increase the cost to the operators because extra tank entry and airplane down time would be needed.

d. Critical Design Configuration Control Limitations.

(1) Paragraph (d) requires that for all fuel tanks, regardless of flammability exposure, holders of TCs affected by this section must establish airworthiness limitations consisting of CDCCL, inspections, or other procedures. The purpose of these limitations is to prevent increasing the flammability exposure of the tanks above that permitted under this section and to prevent degradation of the performance of any means installed in accordance with this section. Appendix 3 of this AC provides additional guidance regarding development of CDCCL. For example, certain fuel tanks may rely on natural cooling or use of certain fuel types to meet the flammability levels within this proposal. Therefore, CDCCL may be required that define the critical features, such as--

- flammability exposure of the unheated aluminum wing tank,
- cooling rate,
- limits on heat input,
- limits on use of high volatility fuels such as JP-4,
- quantity of engine bleed air flow that is used for inerting,
- limits on penetrations of the fuel tank,
- limits on any changes to fuel management that may affect FRM,
- limits on changes to any placards or means used to visibly identify critical design features of the fuel tank system that must not be compromised for the operational life of the airplane.

(2) Instructions for Continued Airworthiness. As discussed below, airworthiness limitations, such as those in this section, are part of the ICA. Section 21.50 requires that TC holders make changes to the ICA available to persons required to comply with them. As used throughout this notice, the term “make available” is used in the same sense that it is used in § 21.50.

e. Airworthiness Limitations.

(1) Paragraph (e) requires creation of an Airworthiness Limitations Section (ALS), unless previously established. The ALS is required by current part 25 and includes those items that have mandatory inspection or replacement times related to fuel systems and structure. The ALS is included in the ICA, approved as part of certification, and distributed with an airplane on delivery. In this way the ALS is visible to all who need it and who would be required to comply with it under §§ 91.1509, 121.917, 125.509

and 129.117 of this proposed rule. The current part 25 ALS and ICA requirements apply only to airplane types originally certified after Amendment 25-54 (adopted in 1981) and were developed for structural considerations. As a result, they are not applicable to many current airplanes and do not currently contain information for other systems.

(2) For those TC holders of airplanes that currently do not have an ALS, the regulation only requires establishing an ALS to include fuel tank safety related limits. This would not require that the ALS for these airplanes include the other requirements for an ALS established under Amendment 25-54 to part 25, or a later amendment. For those TC holders or applicants with airplanes certified to Amendment 25-54 or later, the existing ALS would be revised to include the fuel tank system ALI.

f. Compliance Planning.

(1) Historically, the FAA has worked together with the TC holders when safety issues arise to identify solutions and actions that need to be taken. Some of the safety issues that have been addressed by this process include those involving aging aircraft structure, thrust reversers, cargo doors, and wing icing protection. In some cases service instructions have not been developed in a timely manner. While some manufacturers have addressed these safety issues and developed service instructions, others have not applied the resources necessary to develop service instructions in a timely manner. This has caused delay in the adoption of corrective action(s). The compliance planning requirements of § 25.1815(f) and (g) are intended to provide TC holders and the FAA with assurance that they understand what means of compliance is acceptable and have taken necessary actions, including assigning sufficient resources, to achieve compliance with this section. This paragraph is based substantially on “The FAA and Industry Guide to Product Certification,” which describes a process for developing project-specific certification plans for type certification programs. This Guide may be found in the docket. This planning requirement would not apply to future applicants for TC because, as described in the Guide, this type of planning routinely occurs at the beginning of the certification process.

(2) The Guide recognizes the importance of ongoing communication and cooperation between applicants and the FAA. Section 25.1815, while regulatory in nature, is intended to encourage establishment of the same type of relationship in the process of complying with this section.

(3) One of the items required in the plan is, "If the proposed means of compliance differs from that described in FAA advisory material, a detailed explanation of how the means will comply with this section." FAA advisory material is never mandatory because it describes one means, but not the only means of compliance. In the area of type certification, applicants frequently propose acceptable alternatives to the means described in advisory circulars. But when an applicant chooses to comply by an alternative means, it is important to identify this as early as possible in the certification process to provide an opportunity to resolve any issues that may arise that could lead to delays in the certification schedule.

(4) The same is true for this requirement. As discussed earlier, compliance with this section on time is necessary to enable operators to comply with the operational requirements of this notice. Therefore, this item in the plan would enable the FAA oversight office to identify and resolve any issues that may arise with the compliance plan without jeopardizing the TC holders ability to comply with this section by the compliance time.

(a) Compliance Plan for Flammability Exposure Analysis. Paragraph (f) requires submittal of a compliance plan within 60 days of the effective date of the final rule for the flammability exposure analysis required by this section. The intent of the proposal is to promote early planning and communication between the certificate holders and the FAA. The affected design approval holders would be required to submit a compliance plan that addresses the following:

- A proposed project schedule, identifying all major milestones, for meeting the compliance dates of this rule.
- A proposed means of compliance with this section, identifying all required deliverables, including all compliance items and all data to be developed to substantiate compliance. If the TC holder has already initiated compliance, the FAA oversight office will review the results of those efforts to ensure that the results are acceptable.
- A detailed explanation of how the proposed means will be shown to comply with this section if the TC holder proposes a means of compliance that differs from that described in FAA advisory material.

(b) Compliance Plan for Design Changes and Service Instructions.

1 Paragraph (g) provides 210 days for each holder of a TC required to comply with paragraph (c) to submit to the FAA oversight office a compliance plan for their project. In addition to items corresponding to those required for the compliance plan in paragraph (f), this plan requires--

- A proposal for submitting a draft of all compliance items required by paragraph (c) for review by the FAA oversight office at least 60 days before the compliance time specified in that paragraph, and
- A proposal for how the approved service information and any necessary modification parts will be made available to affected persons.

2 This paragraph is intended to ensure that affected persons and the FAA have a common understanding and agreement of what is necessary to achieve compliance with this section. Integral to the compliance plan will be the inclusion of procedures to allow the FAA to monitor progress toward compliance. These aspects of the plan will help ensure that the expected outcomes will be acceptable and on time. The schedule for the availability of the service information and any required parts is critical to the affected operators ability to schedule the modification of their airplanes and make changes to their maintenance or inspection programs in accordance with the operational rules. We would expect each TC holder to work with the FAA oversight office to

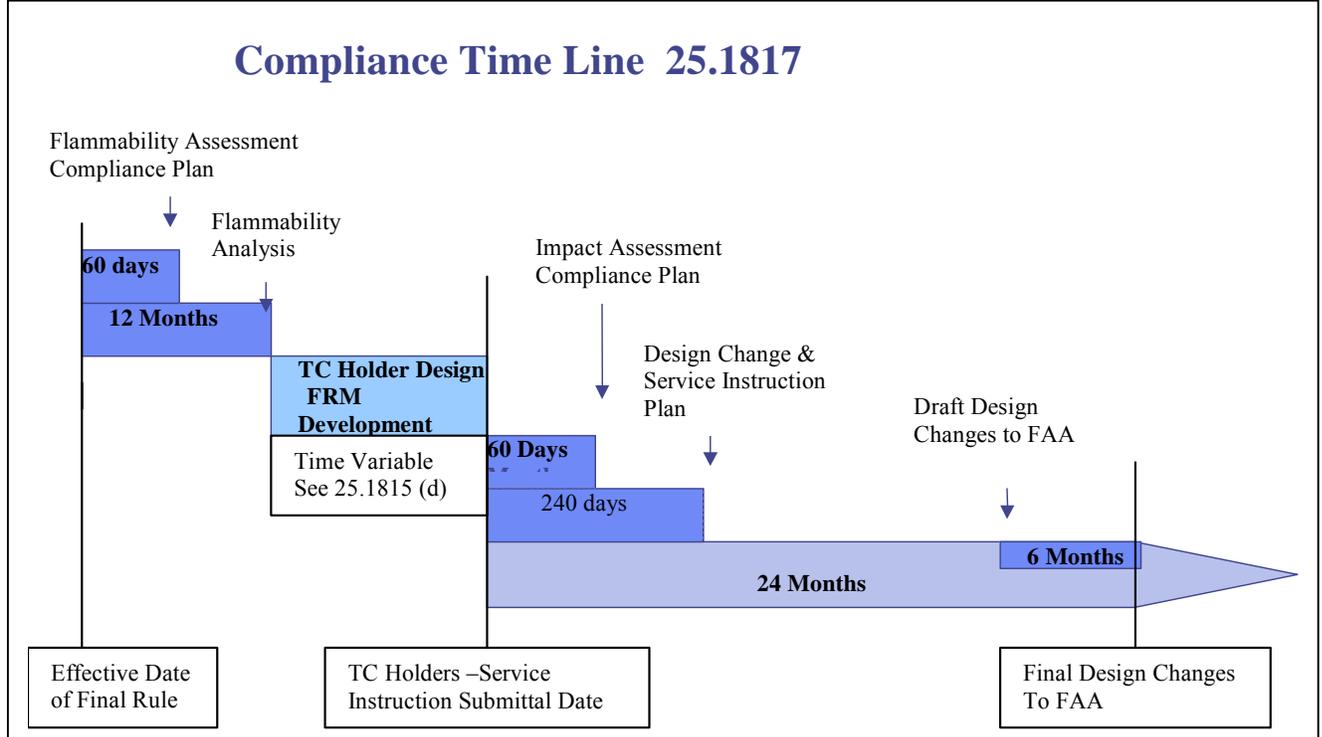
develop a plan to create the required service instructions within the specified time. The plan should include periodic reviews with the FAA office.

3 The success of this fuel tank safety initiative hinges upon the timely development of service instructions and production incorporation of FRM or IMM by the affected certificate holders. If service instructions are not available when required, operators will not be able to begin incorporation of the FRM or IMM into their fleet as their airplanes undergo normally scheduled maintenance checks. Delay in availability of the service instructions could result in the need for operators to do unscheduled maintenance to comply with the operational requirements, resulting in significant unnecessary cost.

g. Compliance Plan Deficiencies. Paragraph (h) would require TC holders and applicants to correct a deficient plan, or deficiencies in implementing the plans as approved under paragraphs (e) and (f), in a manner identified by the FAA oversight office. Deficiencies in the compliance plan would need to be corrected within 30 days of notification by the FAA. Before the FAA formally notifies a TC holder or applicant of deficiencies, we will have communicated with them to try to achieve an understanding of the deficiencies and means of correcting them. Therefore, the notification referred to in this paragraph should document the agreed corrections.

2. Section 25.1817 Changes to type certificates: Design changes and auxiliary fuel tanks affecting fuel tank flammability.

This section addresses changes to TCs, including installing auxiliary fuel tanks or changes in the capacity of fuel tanks that may result in increased fuel tank flammability exposure or adversely affect FRM or IMM. Introduction of FRM or IMM in a fuel tank of the original type certificated airplane model may result in adverse effects on the flammability of any auxiliary fuel tank installed by STC. In addition, the auxiliary fuel tank STC may result in adverse effects on any FRM or IMM developed by the TC holder as required by § 25.1815. This section requires those affected to conduct a flammability exposure analysis of their design, an impact assessment to determine any adverse impact their design may have on the original or modified type design, and development of design changes to address adverse changes in flammability exposure. The dates for demonstrating compliance are shown as follow:



a. Applicability.

Paragraph 25.1817 (a) states that this section would apply to the following design changes to airplanes subject to § 25.1815(a):

- For holders of STCs and applicants for STCs or amendments to TCs applied for before the effective date of the final rule, this section would apply to installation of an auxiliary fuel tank.
- For applicants for STCs or amendments to TCs applied for on or after the effective date of the final rule, this section would apply to installation of an auxiliary fuel tank, changes to fuel tank capacity, and changes that may increase the flammability exposure of an existing fuel tank.

(1) Existing STCs. For existing STCs this proposal excludes design changes other than auxiliary fuel tank installations. The meaning of “auxiliary fuel tank” is explained earlier in the discussion of § 25.981. As discussed in the background section of the preamble to the flammability rulemaking associated with this AC, SFAR 88 included review of all changes to the airplane that could result in the development of ignition sources. We reviewed the fuel system related STCs in the fleet and did not identify any changes that would significantly increase fuel tank flammability. Therefore we have tentatively determined that application of this proposal to current STC holders,

other than those relating to auxiliary fuel tank installations, would not improve fuel tank safety.

(2) Applicants for STCs or TC amendments.

(a) For applicants for STCs and TC amendments, this proposal includes other design changes that could affect flammability exposure. Because this proposed rule requires retrofit of airplanes to reduce flammability exposure, it would be counterproductive to allow future design changes that might negate the safety benefits of those retrofits.

(b) Changes that increase capacity may include activation of dry sections of the airplane that were not originally certificated to contain fuel. For example, the center wing box structure on some versions of certain airplane models did not originally carry fuel but later models of the airplane included fuel in these areas. In addition to the differences in airplane configuration discussed in § 25.1815(b), examples of other changes that may increase fuel tank flammability exposure include installation of hydraulic or electronics system heat exchangers in a fuel tank, installation of heater blankets on the wing, modification of the fuel management that results in changes in fuel tank flammability, installation of a fuel re-circulation system that transfers heat from the engine to the fuel tank, or changes to the flight manual to use lower flash point fuels such as JP-4 or Russian or Chinese fuels.

(3) Auxiliary Fuel Tanks Installed Under an STC. The regulation applies to auxiliary fuel tanks installed under an STC on large transport category airplanes. There are 74 different STCs for auxiliary fuel tanks in these airplanes. The list of these STCs is included in Appendix 5 to this AC. Data submitted to the FAA as a result of SFAR 88 show that fifteen of these STCs have high flammability exposure fuel tanks. Some of these STCs have been installed in airplanes such as the DC-9 and DC-10 that do not have any other fuel tanks with high flammability exposure.

b. Compliance Times.

(1) Paragraph (b) establishes a timeframe in which the affected persons must submit for approval (to the FAA oversight office) a flammability exposure analysis for their design changes. The proposal includes a 12-month timeframe to complete the analysis. Any applicant whose STC or TC amendment is not approved within the 12-month compliance period would have to complete the analysis before approval. Supplemental type certificate holders or applicants affected by this section would need to conduct a flammability analysis using the method defined in Appendix L of the proposed rule. A number of inputs are required to conduct this analysis. Airplane specific data, such as flight length distributions or airplane climb rate, may not be readily available from the original TC holder. We intend the STC holders to obtain the information by working with the operators of airplanes that have their STC installed. Applicants would need to work with prospective customers. Operators have business agreements with the

original TC holders and access to information they obtained when they purchased the airplane. Conservative assumptions or business agreements with the original TC holders are other possible methods of gathering airplane type specific data needed for the analysis.

(2) As discussed below, the flammability analysis required by this section is intended to identify fuel tank installations that would require incorporation of FRM or IMM. Additional analysis after obtaining the CDCCL from the TC holder may result in the need to do additional assessments of the fuel tank flammability to demonstrate that the final configuration complies with the applicable flammability requirements and does not violate the CDCCL defined by the original TC holder.

c. Impact Assessment.

(1) Paragraph (c) requires affected persons to submit for approval (to the FAA oversight office) an impact assessment of the fuel tank system, as modified by their design change. The purpose of the rule is to identify any features of the modification to the original type design that may violate the critical design configuration control limitations developed by the original TC holder under § 25.1815(d). For example, if an FRM that utilizes inerting were incorporated into an airplane, a CDCCL would likely be developed that would limit venting of air into the fuel tank because it could introduce oxygen into the tank, resulting in a flammable vapor space. In this case the STC holder would need to assess its design and identify any violation of the CDCCL identified for the FRM. Results from the analysis would be provided to the FAA in the form of a report or summary letter.

(2) Supplemental type certificate holders would have to submit the safety assessment within six months after we approve the TC holder's CDCCLs. Applicants whose design changes are not approved within that six-month period would have to submit the assessment before approval of the change. Once the CDCCLs are approved, the TC holder would be required to make them available to other affected persons, including those subject to this section. We consider the six-month period more than enough to perform the required assessment.

d. Development of Service Instructions. Paragraph (d) requires development of design changes and service instructions as stated in paragraphs (d)(1), (d)(2), (d)(3) and (d)(4). These service instructions would be required to show compliance with the applicable flammability requirements and to address any adverse effects of the design change on any IMM or FRM developed by the TC holder.

(1) Paragraph (d)(1) requires holders of existing STCs and applicants for STCs and amended TCs for which application was made before June 6, 2001, to incorporate IMM or FRM in all tanks that exceed 7 percent average flammability exposure, as determined under paragraph (b) of this section. If FRM is selected as the means of compliance, the flammability reduction that is necessary depends upon features of the tank design and operation. The flammability of any fuel tank that is normally emptied

must be reduced to meet the average flammability exposure requirements of Appendix K of the proposed rule if any portion of the tank is located within the fuselage contour. The flammability exposure of other fuel tanks must be reduced below 7 percent.

(2) Paragraph (d)(2) requires applicants for STCs and amended TCs for which application is made after June 6, 2001, to incorporate IMM or FRM in any proposed auxiliary fuel tank that exceeds the average flammability of an unheated aluminum wing tank. Because these changes were applied for after the adoption of Amendment 25-102, they already must meet the current requirement of § 25.981(b) to “minimize flammability.” If FRM were selected as the means of compliance, it would have to meet the requirements of § 25.981.

(3) Various methods described in this AC are available for meeting the flammability exposure requirements. The exact modifications needed to comply depend upon specific details of the particular design and choices made by the designers. The most likely solutions include inerting, cooling of the tank, installation of polyurethane foam and pressurizing the tank similar to other tanks that use air pressure for fuel transfer.

(4) For any design change that adds an auxiliary fuel tank or changes the capacity of an existing tank, paragraph (d)(3) would require development of CDCCLs, inspections, or other procedures to prevent increasing the tank’s flammability exposure above that permitted by this section. If the design includes FRM or IMM, CDCCLs, inspections, or other procedures would also be required to prevent degradation of the performance of these systems. These requirements are similar to provisions of §§ 25.981(e) and 25.1815(d). To give them binding effect, the CDCCLs, inspections, or other procedures would be documented in the ALS of the ICA.

(5) Paragraph (d)(4) includes requirements that apply if the impact assessment required by paragraph (c) of this section shows that a design change compromises any CDCCL applicable to any airplane on which the change is eligible for installation. The holder or applicant would have to develop a means, referred to as a Flammability Impact Mitigation Means (FIMM), to comply with all applicable CDCCLs. FIMM could include either additional design changes or limitations or other procedures. If FIMMs are necessary, the applicant or holder would also have to show that their design change, as modified by the FIMM, would still meet the other requirements of this section. This paragraph is necessary to ensure that the safety improvements in this rule are not degraded by later design changes.

e. Compliance Times. Paragraph (e) establishes timeframes in which holders of STCs and applicants for TCs and amendments to TCs must comply with the requirements of paragraph (d). Supplemental type certificate holders would have 24 months after the TC holder complies with § 25.1815(c). Applicants whose applications are pending at that time would have to comply before the FAA would issue their approval.

f. Compliance Planning. Paragraph (f) requires compliance plans for the actions required by this section. Compliance planning is discussed earlier in this Appendix with guidance for § 25.1815. Because STC holders and applicants would need the TC holders' CDCCLs to comply with paragraphs (c) and (d) of this section, the compliance times for submitting those plans provide adequate time after the TC holders would be required to comply with § 25.1815.

g. Deficiencies in Compliance Plans. Each person subject to this section must implement the compliance plans as approved under paragraph (f) of this section. The FAA Oversight Office will notify the affected person of deficiencies in the compliance plan, or in the person's implementation of the plan, and of the means for correcting those deficiencies. The person must submit a corrected plan to the FAA oversight office within 30 days after such notification, and implement the corrected plan.

APPENDIX 5**LIST OF AFFECTED MODELS – SUBPART I SECTIONS 25.1815, AND 25.1817**

Airplanes with 30 passengers or more, or a payload of 7500 lbs or more.

Manufacturer	Model(s)
Aerospatale	ATR 42, ATR 72
Airbus Industries	A300, A310, A318, A319, A320,A321, A330, A340
BAE System	ATP, Bae 146, BAe 146 RJ, HS748, Jetstream 4101
Boeing	DC-8,DC-9, MD-80, MD-90, MD-10, MD-11, 717, DC-10, KC-10
Boeing	707, 727, 737, 747, 757, 767, 777,
Bombardier - Short Brothers	SD3-30, SD3-60
Bombardier Inc.	DHC-7, DHC-8-1,2,3, DCH-8-400, CRJ 200, CRJ 700
CASA	CN 235, CN 295
Dornier	328-100/-300
Embraer	EMB-120, EMB-145/135
Fokker	F-28,
Lockheed	L-1011, L382
SAAB Aircraft	SAAB 340, SAAB 2000

Affected STC from SFAR 88 review

Revised 6/3/04 Models	STC Number	Holder's Name	STC Description	FAA office	FAA contact	Flammability (Based on STC design review)	Comments
B727-100	SA1350NM	South-East Aero-tek	Install Aux Tank Fuel System	Atlanta	Bob Bosak, 770-703-6094	a. Low Flammability.	Mandatory action to incorporate STC SA2561SO, which uses cabin air to provide fuel transfer.
B727-100	SA1398NM	Rogerson ATS	2445 Gal Cylindrical Aux fuel tank system	Los Angeles	Serj Harutunian, 562-627-5254	a. Low Flammability.	Body tank use air as motive force.
B727-100	SA1979NM	Rogerson ATS	2445 Gal Cylindrical Aux fuel tank system	Los Angeles	Serj Harutunian, 562-627-5254	a. Low Flammability.	Body tank use air as motive force.
B727-100	SA2033NM	South-East Aero-tek	Install Aux Tank Fuel System	Atlanta	Bob Bosak, 770-703-6094	a. Low Flammability.	Mandatory action to incorporate STC SA2561SO, which uses cabin air to provide fuel transfer.
B727-100	SA3810WE	Rogerson ATS	2830 Gal Cylindrical Aux fuel tank system	Los Angeles	Serj Harutunian, 562-627-5254	a. Low Flammability.	Body tank use air as motive force.
B727-100	SA3920NM	Rogerson ATS	1100 Gal Cylindrical Aux fuel tank system	Los Angeles	Serj Harutunian, 562-627-5254	a. Low Flammability.	Body tank use air as motive force.
B727-100	ST01587AT	South-East Aero-tek	Install Aux Tank Fuel System	Atlanta	Bob Bosak, 770-703-6094	a. Low Flammability.	Mandatory action to incorporate STC SA2561SO, which uses cabin air to provide fuel transfer.
B727-100	ST01623AT	South-East Aero-tek	Install Aux Tank Fuel System	Atlanta	Bob Bosak, 770-703-6094	a. Low Flammability.	Mandatory action to incorporate STC SA2561SO, which uses cabin air to provide fuel transfer.
B727-100 and - 200 series	SA387NE	PATS	Installation of two aux fuel tanks.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
B727-100 series	SA392NE	PATS	Installation of five aux fuel tanks.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.

B727-100 series	SA530NE	PATS	Installation of two-section aux fuel tank or three-section fuel tank.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
B727-100 series	SA62NE	PATS	Installation of six-tank aux fuel system.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
B727-100 series	ST00466NY	PATS	Installation of a six tank aux fuel system.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
B727-200	SA1051WE	Rogerson ATS	1870 Gal Cylindrical Aux fuel tank system	Los Angeles	Serj Harutunian, 562-627-5254	a. Low Flammability.	Body tank use air as motive force.
B727-200	SA1474SO	South-East Aero-tek	Install Aux Tank Fuel System	Atlanta	Bob Bosak, 770-703-6094	a. Low Flammability.	Mandatory action to incorporate STC SA2561SO, which uses cabin air to provide fuel transfer.
B727-200	SA3483WE	Rogerson ATS	2430 Gal Cylindrical Aux fuel tank system	Los Angeles	Serj Harutunian, 562-627-5254	a. Low Flammability.	Body tank use air as motive force.
B727-200	SA3494NM	Rogerson ATS	2200 Gal Cylindrical Aux fuel tank system	Los Angeles	Serj Harutunian, 562-627-5254	a. Low Flammability.	Body tank use air as motive force.
B727-200 series	SA450NE	PATS	Installation of three aux fuel tanks.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
B727-200 series	SA496NE	PATS	Installation of fuel transfer system.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
B737 - 700IGW and 737-800	ST01384NY	PATS	Installation of three or four tank aux. Fuel system.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
B737 - 700IGW and B737-800	ST00936NY	PATS	Installation of a three, four or five tank aux fuel sys (Structural provisions only)	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force. (Note: Not sure if this is an affected tank instalation)
B737 500 series	ST01337NY	PATS	Installation of a three tank aux fuel system.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.

B737-500	ST00040NY	PATS	Tanks only installed on s/n24970 airplane. Tanks are life limited to 13 years. Must be removed after Sept 2006.	New York	James Delisio, 516-256-7522	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
B737-200	SA1078NE	PATS	Installation of three aux fuel tanks.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
B737-200 series	SA84NE	PATS	Installation of a seven tank aux fuel system.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
B737-269	SA1265EA	PATS	Installation of 2800 gal aux fuel tanks.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
B737-269	SA83NE	PATS	Config 1: installation of three aux fuel tanks; Config 2: installation of seven aux fuel tanks.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
B737-300 and -400 series	SA553NE	PATS	Installation of one 425 or 500 US gallon aux fuel tank.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
B737-300 series	SA500NE	PATS	Installation of one aux fuel tank.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
B737-300 series	SA542NE	PATS	Installation of one aux fuel tank.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
B737-300 series	SA770NE	PATS	Installation of a fuel summation unit.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
B737-300, -400, -200, -200C, and -500 series	SA725NE	PATS	Installation of 1000 gal 2 tank aux fuel system.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
B737-400	SA3980NM	Rogerson ATS	Structural Provisions and wiring for installing Aux Tanks	Los Angeles	Serj Harutunian, 562-627-5254	a. Low Flammability.	Body tank use air as motive force.

B737-400/500	SA3992NM	Rogerson ATS	1000 Gal Aux Tank in Aft Cargo Compt. Box/Liner	Los Angeles	Serj Harutunian, 562-627-5254	a. Low Flammability.	Body tank use air as motive force.
B757	SA979NE	PATS	Installation of a aux fuel tank.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
B767 - 200	ST00840NY	PATS	Installation of a five tank aux fuel system	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
BAC111-400	SA2971WE	Rogerson ATS	1181 Gal Cylindrical Aux fuel tank system	Los Angeles	Serj Harutunian, 562-627-5254	a. Low Flammability.	Body tank use air as motive force.
CL600-2B19	ST00365NY	PATS	Installation of a two tank system.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
DC8-62	SA936NE	PATS	Installation of a long range aux fuel tank and transfer system.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
DC9-14	SA1334NM	South-East Aero-tek	Install Aux Tank Fuel System	Atlanta	Bob Bosak, 770-703-6094	a. Low Flammability.	Mandatory action to design change, which uses cabin air to provide fuel transfer.
DC9-15	SA1050NW	Rogerson ATS	1564 Gal Cylindrical Aux Fuel tank system	Los Angeles	Serj Harutunian, 562-627-5254	a. Low Flammability.	Body tank use air as motive force.
DC9-30	SA1710SO	South-East Aero-tek	Install Aux Tank Fuel System	Atlanta	Bob Bosak, 770-703-6094	a. Low Flammability.	Mandatory action to design change, which uses cabin air to provide fuel transfer.
DC9-30	SA3436NM	Rogerson ATS	1800 Gal Cylindrical Aux fuel tank system	Los Angeles	Serj Harutunian, 562-627-5254	a. Low Flammability.	Body tank use air as motive force.
DC9-32	SA1358NM	South-East Aero-tek	Install Aux Tank Fuel System	Atlanta	Bob Bosak, 770-703-6094	a. Low Flammability.	Mandatory action to design change, which uses cabin air to provide fuel transfer.
DC9-33F	ST00605NY	PATS	Installation of a six tank aux fuel system.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
MD81, MD82, MD83	ST00409NY	PATS	Installation of two tank Aux fuel system.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.

MD83	ST00218AT	PATS	Installation of a nine tank aux fuel system.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
MD87	ST00523NY	PATS	Installation of a ten tank aux fuel system.	New York	James Delisio, 516-256-7521	a. Low Flammability.	PATs reported that all their tanks are body tanks and use cabin air as motive force.
B727-100	SA2734WE	Rogerson ATS	3100 Gal AUX Tank in Fwd. Aft Cargo Compt. Box / Liner	Los Angeles	Serj Harutunian, 62-627-5254	b. High Flammability	Body tank uses electrical pumps. No flammability mitigation planned. SFAR 88 actions based on high flammability tank.
B727-100	SA2970WE	Rogerson ATS	300 Gal AUX Tank in Aft Cargo Compt. Box / Liner	Los Angeles	Serj Harutunian, 562-627-5254	b. High Flammability	Body tank uses electrical pumps. No flammability mitigation planned. SFAR 88 actions based on high flammability tank.
B727-100	SA3157WE	Rogerson ATS	1200 Gal AUX Tank in Fwd. Cargo Compt. Box / Liner	Los Angeles	Serj Harutunian, 562-627-5254	b. High Flammability	Body tank uses electrical pumps. No flammability mitigation planned. SFAR 88 actions based on high flammability tank.
B727-100	SA3319WE	Rogerson ATS	1600 Gal AUX Tank in Fwd. Aft Cargo Compt. Box / Liner	Los Angeles	Serj Harutunian, 562-627-5254	b. High Flammability	Body tank uses electrical pumps. No flammability mitigation planned. SFAR 88 actions based on high flammability tank.
B727-100	SA3559WE	Rogerson ATS	1932 Gal AUX Tank in Fwd. Aft Cargo Compt. Box / Liner	Los Angeles	Serj Harutunian, 562-627-5254	b. High Flammability	Body tank uses electrical pumps. No flammability mitigation planned. SFAR 88 actions based on high flammability tank.
B727-100	SA3674WE	Rogerson ATS	2700 Gal AUX Tank in Fwd. Aft Cargo Compt. Box / Liner	Los Angeles	Serj Harutunian, 562-627-5254	b. High Flammability	Body tank uses electrical pumps. No flammability mitigation planned. SFAR 88 actions based on high flammability tank.
B727-200	SA3065WE	Rogerson ATS	3435 Gal Aux Tank in Fwd.Aft Cargo Compt. Box/Liner	Los Angeles	Serj Harutunian, 562-627-5254	b. High Flammability	Body tank uses electrical pumps. No flammability mitigation planned. SFAR 88 actions based on high flammability tank.
B737-200	SA1054NW	Rogerson ATS	2595 Gal Aux Tank in Fwd.Aft Cargo Compt. Box/Liner	Los Angeles	Serj Harutunian, 562-627-5254	b. High Flammability	Body tank uses electrical pumps. No flammability mitigation planned. SFAR 88 actions based on high flammability tank.
B737-200	SA1082NW	Rogerson ATS	880 Gal Aux Tank in Fwd.Aft Cargo Compt. Box/Liner	Los Angeles	Serj Harutunian, 562-627-5254	b. High Flammability	Body tank uses electrical pumps. No flammability mitigation planned. SFAR 88 actions based on high flammability tank.

B737-200	SA2153WE	Rogerson ATS	1980 Gal Aux Tank in Fwd.Aft Cargo Compt. Box/Liner	Los Angeles	Serj Harutunian, 562-627-5254	b. High Flammability	Body tank uses electrical pumps. No flammability mitigation planned. SFAR 88 actions based on high flammability tank.
BAC111-400	SA1626WE	Rogerson ATS	1185 Gal Aux Tank in Fwd.Aft Cargo Compt. Box/Liner	Los Angeles	Serj Harutunian, 562-627-5254	b. High Flammability	Body tank uses electrical pumps. No flammability mitigation planned. SFAR 88 actions based on high flammability tank.
BAC111-400	SA1995WE	Rogerson ATS	1185 Gal Aux Tank in Fwd.Aft Cargo Compt. Box/Liner	Los Angeles	Serj Harutunian, 562-627-5254	b. High Flammability	Body tank uses electrical pumps. No flammability mitigation planned. SFAR 88 actions based on high flammability tank.
BAC111-400	SA3819WE	Rogerson ATS	1478 Gal Aux Tank in Fwd.Aft Cargo Compt. Box/Liner	Los Angeles	Serj Harutunian, 562-627-5254	b. High Flammability	Body tank uses electrical pumps. No flammability mitigation planned. SFAR 88 actions based on high flammability tank.
DC9-15	SA2587WE	Rogerson ATS	1755 Gal Aux Tank in Fwd.Aft Cargo Compt. Box/Liner	Los Angeles	Serj Harutunian, 562-627-5254	b. High Flammability	Body tank uses electrical pumps. No flammability mitigation planned. SFAR 88 actions based on high flammability tank.
DC9-15	SA3558NW	Rogerson ATS	535 Gal Aux Tank in Fwd.Aft Cargo Compt. Box/Liner	Los Angeles	Serj Harutunian, 562-627-5254	b. High Flammability	Body tank uses electrical pumps. No flammability mitigation planned. SFAR 88 actions based on high flammability tank.
B707	SA1308NM	Rogerson ATS	2970 Cylindrical Aux fuel tank system	Los Angeles	Serj Harutunian, 562-627-5254	c. Flammability unknown.	SFAR 88 exemption Requested:
B707	SA4053WE	Rogerson ATS	3000 Gal AUX Tank in Fwd. Aft Cargo Compt. Box / Liner	Los Angeles	Serj Harutunian, 562-627-5254	c. Flammability unknown.	SFAR 88 exemption Requested:
B727 - 1H2	SA800CE	Boeing Wichita DAS	Aux fuel tank installation (3 fwd/3 aft).	Wichita	Jeff Janusz, 316-946-4148	c. Flammability unknown.	Similar to production configuration which is being assessed by Boeing. Need to follow up to determine flammability
B727-2JO	SA1235CE-D	Boeing Wichita DAS	Fwd 880 Gal. Aux Fuel Tank Installation	Wichita	Jeff Janusz, 316-946-4148	c. Flammability unknown.	Similar to production configuration which is being assessed by Boeing. Need to follow up to determine flammability
B767-200	SA5544NM	Rogerson ATS	Aux fuel tank system	Los Angeles	Serj Harutunian, 562-627-5254	c. Flammability unknown.	SFAR 88 exemption requested. AA removing aux tank. Also installed on military airplane.

BAC 1-11	SA3EU	Marshall of Bambridge Aerospace Ltd.	Long range fuel tanks	ANM-116	Todd Thompson 425-227-1175	c. Flammability unknown.	SFAR 88 report not received.
C9B	SA3495NM	Rogerson ATS	Aux fuel tank system	Los Angeles	Serj Harutunian, 562-627-5254	c. Flammability unknown.	SFAR 88 exemption requested. Military is phasing out airplane.
DC9-30	ST00402AT	Lockheed, Greenville	Install Aux Tank Fuel System	Atlanta	Bob Bosak, 770-703-6094	c. Flammability unknown.	Design changed to Rodgerson STC SA3495NM. SFAR 88 SFAR 88 exemption requested. Military is phasing out a/p.
DC9-31/- 32(VC-9C)/- 32F(C-9A, C- 9B)/-33F/-34/- 34F/-41/-81/- 82/-83/-87	SA1411GL	Airborne Express Inc.	Installation of Ferry Fuel Tanks	Chicago	Mike Downs, 847-294-7870	c. Flammability unknown.	Petition for SFAR 88 exemption.
DHC7 - 102	SA1050NE	Field Aviation Co. Inc of Toronto	Installation of inboard fuel tanks	New York	James Delisio, 516- 256-7521	c. Flammability unknown.	SFAR 88 report recived and under FAA review.
DHC7-102, 103	ST00180DE	California Microwave, Inc.	Installation of Long Range Fuel System.	New York	James Delisio, 516-256-7521	c. Flammability unknown.	SFAR 88 report recived and under FAA review.
Short Bros. SD360	SA00404AT	Atlantic Reconnaissance	Install Aux Tank Fuel System	Atlanta	Bob Bosak, 770-703-6094	c. Flammability unknown.	STC holder not responding.

APPENDIX 6**REQUIREMENTS FOR AIRPLANE OPERATORS****1. Requirement to Install and Operate FRM, IMM or FIMM.**

a. The operational rules prohibit certificate holders from operating any affected airplane after dates specified unless IMM, FRM or FIMM, as applicable, are installed and operational for any fuel tank for which they are required. The safety objective of these proposed rules is to have the required modifications installed and operational at the earliest opportunity.

b. These rules require that operators of the affected airplanes incorporate applicable maintenance program changes before returning an airplane to service after accomplishing any required modifications.

c. For some of the affected airplanes, manufacturer compliance with the proposed requirements may not result in any design changes, but would result in development of airworthiness limitations in the form of maintenance actions, operational procedures, or CDCCL, as previously discussed, to either achieve the required level of flammability exposure or to ensure that the acceptable flammability exposure for certain tanks is not compromised for the operational life of the airplane. In these cases the affected operators would be required to incorporate these limitations within one year after their approval by the FAA oversight office. The FAA oversight office will inform the affected operators and principal inspectors of the availability of the approved information.

The operator needs to review the data and documents intended for the use by the operators and modifications approved by the FAA oversight office that may include information provided by the TC holder, STC holder, or a third party that are applicable to the affected airplanes. This review should also include records check or airplane inspections to determine if any affected airplanes within its fleet have auxiliary fuel tanks installed by STC or field approval and whether these auxiliary tanks are in use or have been deactivated. As discussed in Paragraph x of this AC, holders of STCs for auxiliary fuel tanks are required to conduct a flammability exposure analysis, an impact assessment and develop the associated service instructions, including any airworthiness limitations. In cases where an operator has an auxiliary fuel tank installed by field approval on the affected airplane models, the operator is responsible for showing the auxiliary fuel tank installation meets the same requirements as a STC holder as stated in § 25.1817. Compliance planning is required of all affected design approval holders. Those operators who are also DAH for auxiliary fuel tanks must develop, submit, and implement their compliance plan as approved by the FAA oversight office per the regulations. AC 25-XX provides generic guidance regarding the roles and responsibilities of the DAH in the development and implementation of the compliance plan.

d. The FAA understands that there may be several options for addressing auxiliary fuel tank installations. In determining what option should be taken with an auxiliary fuel tank such as an alteration that would reduce the flammability exposure of an operational tank, deactivation of the tank, or removal, the following should be considered:

(1) Most unpressurized auxiliary fuel tanks located within the cargo compartment do not cool and become flammable as the airplane climbs.

(2) Some auxiliary fuel tanks feed into other fuel tanks that may have high flammability exposure, e.g., center tank, that will require installation of FRM. Consequently, not only may FRM be required in the auxiliary fuel tank, it must also be shown by the DAH that its auxiliary fuel tank does not adversely affect the flammability exposure regulatory requirements of the tank that it feeds.

(3) Deactivation of a fuel tank may not be a practical method of compliance. Any residual fuel in an empty deactivated fuel tank could result in the tank becoming flammable. This condition must be addressed.

(4) Removal of the fuel tank in accordance with an FAA approved method is an acceptable means of compliance.

e. For those cases where the operator intends to continue operation of an auxiliary fuel tank there may be one or more alterations required to be incorporated including airworthiness limitations. An FRM and FIMM may be required to ensure the flammability exposure of the auxiliary tank meets the requirements and that the flammability exposure of the fuel tank that is fed by the auxiliary fuel tank is not compromised. Because of the variety of configurations that may be in the operator's affected fleet, the operator's review of the approved data, documents, and design changes needs to ensure the information for the installed auxiliary fuel tank is applicable to the TC holder fuel tank to which it may be connected. In the future, installation of auxiliary fuel tanks will not be allowed by field approval. Design change to a TC subject to the requirements in the rule that adds an auxiliary fuel tank, increases fuel tank capacity, or increases the flammability exposure of the existing fuel tank, must meet the requirements of § 25.981. This requirement is intended to apply primarily to future design changes, but it may also apply to design change projects that are pending when this rule is issued.

f. Having determined what approved data, documents, and modifications are applicable to the operators affected fleet, the operator needs to develop a plan for incorporation of the approved information. This plan not only identifies which airplanes are affected and when incorporation of the approved information is planned in whole or in part, but also the location of the approved information in the operators approved maintenance program manuals. Certain CDCCL may need to be located in different documents such as AMM, SWPM, and MPD to ensure the limitation is observed whether there is maintenance in accordance with the AMM or SWPM. There may be other documents that should also contain CDCCL. The TC holder will incorporate the CDCCL

in a number of documents to ensure the effectiveness of the CDCCL. Operators should as a minimum incorporate CDCCL in the same or equivalent documents as did the TC holder. The operators Principal Inspector of the cognizant FSDO will be informed by the FAA oversight office of the recommended locations for inclusion of the airworthiness limitations.

g. The operational rules require operators to submit the proposed maintenance and inspection program changes to their FAA Principal Inspector or cognizant FSDO for review and approval.³ This review would include the integration of the applicable airworthiness limitations for the TC and any STC and field approved auxiliary fuel tank to ensure their consistency and compatibility in the maintenance or inspection program. Guidance will be provided to operators and principal inspectors regarding how to address any deviations that may be proposed by the affected operators from the information approved by the FAA oversight office. As airworthiness limitations, these cannot be changed without approval by the local FAA ACO. The airworthiness limitations are not subject to maintenance review board or other maintenance program development processes.

h. Once an operator revises its maintenance or inspection program, it is important to make sure that later alterations to the airplane do not degrade the level of safety provided by these revisions. These rules require future applicants for approval of design changes to develop new airworthiness limitations for new auxiliary fuel tanks and other design changes affecting fuel tank flammability. To ensure that these airworthiness limitations are implemented, operators who incorporate these design changes into their airplanes would be required to revise their maintenance and inspection programs to incorporate the corresponding airworthiness limitations.

2. Authority to Operate with an Inoperative FRM, IMM or FIMM.

a. Generally the FAA does not require operators to use or maintain equipment installed on airplanes prior to a uniform compliance date. In this proposal, we take a different approach. The safety advantages associated with a fuel tank system equipped with an FRM or IMM design, as modified by any FIMM, are so compelling that we propose requiring that operators use these systems as soon as they are available. We have accommodated the difficulties faced by operators in making the required design changes by providing a phased-in compliance schedule that extends up to seven years after the manufacturer's compliance date for each model. Accordingly, an operator may not operate any airplane with fuel tanks equipped with FRM, IMM or FIMM, unless those systems are fully operational. The sole exception is when the systems are inoperative and the conditions and limitations specified in the operator's Minimum Equipment List (MEL) are met.

³ A part 91 operators would send the relevant information to either their principal inspector or Flight Standards District Office, as applicable.

b. The method used to allow operation of an airplane when an FRM is inoperative would be to include the FRM dispatch relief in the FAA-approved MEL. The MEL contains a list of equipment that may be inoperative for a defined period of time. Under § 91.213 and similar regulations, the airplane may be dispatched with inoperative equipment in accordance with the MEL.

c. The FAA FOEB would establish the MMEL dispatch relief interval for an FRM based on data submitted by the applicant to the FAA. The expected MMEL dispatch relief interval is one of the contributing factors affecting the overall system reliability analyses that must be established early in the design of the FRM. The proposed requirements of Appendix K of the proposed rule allow the designer to choose to design a highly reliable FRM and then request longer MMEL dispatch relief intervals when submitting their data to the FOEB.

d. The requirements do not recommend the adoption of a specific MMEL dispatch inoperative interval at this time. However, the comments received from the NTSB on the special conditions for the Boeing Model 747 indicate that the FRM should be treated like other non-redundant safety equipment, such as the flight data recorder. The recorders are allowed a 3-day MMEL inoperative interval.

3. Compliance Schedule.

a. To achieve the safety benefits of this initiative, we believe it is necessary to have a mandatory schedule for phasing in the design changes rather than to rely solely on market forces to drive the production and availability of parts and normal maintenance scheduling for the installation of the FRM, IMM, or FIMM. Accordingly, this rule requires at least 50 percent of the affected airplanes be modified within four years after the relevant TC holder is required to comply with the proposed requirements. The remainder of the operator's fleet would have to comply with the final rule within seven years after the specified date. The affected fleet would include those airplanes that have field or STC approved auxiliary fuel tanks. Certificate holders that operate only one airplane of an affected model would have to modify that airplane within the seven-year compliance period.

b. The compliance schedule of 7 years after TC holders to develop service instructions, while long, should allow for the approval of the service instructions for IMM, FRM, or FIMM, manufacture of modification parts for a large fleet of airplanes, and accomplishment of the modifications with minimum disruption of normal maintenance schedules. Typically, fuel tanks are only accessed during heavy maintenance checks that are done on a schedule that is established during development of the maintenance program. The compliance dates proposed for the operational rules were developed to allow for the majority of the modifications to be done during these heavy maintenance checks. Introduction of FRM, IMM or FIMM outside of normally scheduled maintenance would increase the cost to the operators because extra tank entry and airplane down time would be needed.

4. Incorporating Changes During Normally Scheduled Maintenance. Incorporation of FRM will require tank entry to install features within the fuel tank. Some airplane types or specific airplanes within an operator's fleet may not be scheduled for normally scheduled maintenance, where the fuel tanks would be opened, during the 7-year compliance time after service instructions become available. These airplanes would require incorporation of modifications outside of the normally scheduled maintenance. The number of airplanes that would be affected is small and that further lengthening the compliance period would not achieve the safety benefits of this proposal in a timely way. To minimize the impact on operators, manufacturers have suggested that service instructions may be developed that will allow operators to install the FRM in stages to allow the operators to install those parts of the FRM located outside the fuel tank during intermediate maintenance checks when the fuel tank entry is not typically needed. This may reduce any out of service time should tank entry be needed for a particular airplane. Also, some of the ADs needed to address ignition source issues resulting from SFAR 88 will occur in this time period and in some cases require fuel tank entry. These occasions may provide additional opportunities for incorporating approved FRM, IMM or FIMM if not occurring during normal scheduled maintenance. However, upon complete installation of FRM, FIMM or IMM in accordance with the regulations the maintenance program must be revised based on the data and documents approved by the FAA oversight office before return to service.