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FAA-99-6411-46

Attention: Mr. Michael E. Dostert
Transport Airplane Directorate, ANM-112
NPRM, Docket No. FAA-1999-6411; Notice No. 99-18

SUBJECT: **NPRM, Docket No. FAA-1999-6411; Notice No. 99-18**

Enclosure: (a) **Lockheed Martin Aircraft Center (LMAC) Response to Federal Aviation Administration Notice of Proposed Rule Making Docket No. FAA-1999-6411; Notice No, 99-18 ; Transport Airplane Fuel Tank System Design Review, Flammability Reduction, and Maintenance and Inspection Requirements, 9 pages.**

Dear Mr. Dostert:

Please accept the attached presentation as Lockheed Martin Aircraft Center's commentary in response to the Federal Aviation Administration Notice of Proposed Rule Making Docket No. FAA-1999-6411; Notice No. 99-18; Transport Airplane Fuel Tank System Design Review, Flammability Reduction, and Maintenance and Inspection Requirements. LMAC would appreciate consideration of this response in hopes of contributing to an effective and practical means of ensuring the safety of transport category aircraft fuel systems. If there are any questions, comments, or concerns regarding this response, please contact one of the LMAC representatives shown below.

Respectfully,

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Enclosure(s) (1)

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Lockheed Martin Aircraft Center (LMAC) Response to Federal Aviation Administration Notice of Proposed Rule Making Docket No. FAA-1999-6411; Notice No. 99-18: Transport Airplane Fuel Tank System Design Review, Flammability Reduction, and Maintenance and Inspection Requirements

Response Key Issue Summary:

- **Safety Review:** Request alternate safety review requirements by conducting a qualitative design evaluation, developing an inspection/maintenance plan, and performing a **one** time inspection of the entire L-1011 fleet
- **HIRF:** Request that HIRF (High Intensity Radio Frequency) be excluded from the required types of ignition sources to be considered for the L-1011's safety review
- **Ignition** Source: Request to narrow the scope of the ignition source evaluation criteria
- **Harmonization:** Request for the worldwide harmonization of fuel system safety regulatory action
- **Compliance Schedule:** Request for a compliance schedule that allocates **time** for FAA approval of corrective actions

Contents:

I. Introduction

Foremost, LMAC would like to state that it agrees in principle with the FAA's proposed ruling and intent to ensure aircraft fuel system safety. As a participant of the industry represented Fuel System Safety Leadership Team (FSSLT), LMAC would also like to state its full support of the comments, views, and opinions of the Aviation Industry Response to FAA NPRM Notice No. 99-18. To emphasize key issues in specific regards to Lockheed Martin's existing L-l 011 fleet, LMAC is submitting the following supplemental commentary.

The following discussion presents concerns regarding compliance requirements of NPRM No. 99-18 as Interpreted and understood by LMAC with respect to the responsibility of LMAC as the design approval holder representative for the L-1011 aircraft. The intention of this NPRM response is to convey LMAC's interpretation of requirements in question and provide constructive commentary on those requirements.

II. Lockheed Mar&in L-1011 Applicability

In accordance with the applicability requirements as stated in the NPRM (p. 58652, Applicability of *the proposed SFAR*), LMAC is mandated to respond to the SFAR requirements for the Lockheed Martin L-l 011 aircraft fleet.

There are four main areas of concern addressed in the SFAR pertaining to the amendment of current regulations (p.58651, Discussion of Proposal):

A. preclusion of ignition sources within existing transport aircraft
B. preclusion of ignition sources in future designs of transport aircraft
C. flammability reduction requirements for future aircraft designs
D. incorporation of maintenance and/or inspections in operator's FAA approved program

Only area of concern (A) is directly applicable to LMAC as the OEM representative for the Lockheed Martin L-1011 aircraft. It is proposed in the NPRM that the OEM achieve compliance with this area of concern by:

(1) conducting a "one time design review of the fuel tank system for transport airplane models in the current fleet" (p. 58651, Discussion of the Proposal)
(2) "develop any specific maintenance and inspection instructions necessary to maintain the design features required to preclude the existence or development of an ignition source within the fuel tank system." (p. 58652, Maintenance Instructions)

Assistance will also be provided to operators for incorporating any developed maintenance and inspection programs.

III. LMAC Comments in response to NPRM Notice No. 99-18

A. SAFETY REVIEW

NPRM Proposal:

SAFETY REVIEW REQUIREMENTS:

The design approval holder is required to perform a safety review of the fuel tank system to show that fuel tank fires or explosions will not occur on airplanes of the approved design (p.58651, Safety Review). This would be comprised of the following:

(1) Submitting a report to the cognizant FAA ACO that substantiates that the fuel tank system is fail-safe (p.58651, Safety Review; p.58654, Fuel Tank Ignition Source Proposal)

FAIL-SAFE REQUIREMENTS:

Compliance with the fail-safe criteria must be obtained by demonstrating that.. .

- Each single failure, regardless of the probability of occurrence of the failure, must not cause an ignition source
- Each single failure, regardless of the probability of occurrence, in combination with any latent failure condition not shown to be at least extremely *remote* (i.e., not shown to be extremely remote or extremely improbable), must not cause an ignition source
- All combinations of failures not shown to be *extremely improbable* must not cause an ignition source.

"extremely remote" = not anticipated to occur to each airplane during its total life, but which may occur a few times when considering the total operational life of all airplanes of one type

***"extremely improbable"* =** so unlikely that they are not anticipated to occur during the entire operational life of all airplanes of one type

(Reference: Preliminary AC 25.981-1X, FAR 25.901(C), FAR 25.1309, and AC 25.1309-1A)

(2) Developing a failure modes and effects analysis (*FMEA*) for all components in the fuel tank system. (p.58651, Safety Review)

(3) Developing a subsequent quantitative fault tree analysis (*FTA*) to determine whether combinations of failures expected to occur in the life of the affected fleet could cause an ignition source to exist in a fuel tank system (p.58651, Safety Review)

FMEA and FTA REQUIREMENTS:

- Perform a failure analysis of all fuel system and sub systems with wiring routed into the fuel tanks. (AC 25.981-1X , p.15)
- Assume failure conditions listed in NPRM Notice No. 99-18 (Listing of Deficiencies), and any other foreseeable failures (p. 58651, Safety Review; p.58655, Fuel Tank Ignition Source Proposal)
- Use analytical methods currently used in the aviation industry in demonstrating compliance with existing regulations (25.901 and 25.1309). (AC 25.981-1X, p.12)
- Assume explosive fuel mixture is present in the fuel tank at all times. (p.58651, Safety Review)
- Consider all airplane in-flight, ground, and service conditions. (p. 58651, Safety Review)
- Consider all components or systems that could introduce a source of fuel tank ignition. (p.58651, Safety Review)
- Account for manufacturing variability, aging, wear, corrosion, and likely damage. (p.58655, Fuel Tank Ignition Source Proposal)
- Consider external environmental conditions established by certification regulations and special conditions. (p.58655, Fuel Tank Ignition Source Proposal)
- Include latent failures and subsequent failures that may lead to an ignition source in me tank. (AC 25.981-1X, p.15, Electrical Sources)

- Include failures of systems or components mounted adjacent to the exterior surface that could create a high/localized temperature at the inner surface of the tank. (temperatures are to be determined by laboratory tests or by a heat transfer analysis). (AC 25.981-1X, p.21, Determination of Maximum Temperature of Fuel Tank Surface)

TYPES OF IGNITION SOURCES TO BE CONSIDERED:

Electrical arcs
- Lightning
- Electrostatic charging
- Electromagnetic interference (EMI)
- High Intensity Radio Frequencies (HIRF)
- Failures in airplane systems/wiring that introduce high power electric energy into the fuel tank system

Friction Sparks
- Mechanical contact

Autoignition
- Failure of components within the fuel tank
- External systems/components that cause components or tank surfaces to reach high temp to ignite fuel vapors in the tanks

(Reference: p.58645, Flammability Characteristics: p.58654 Fuel Tank Ignition Source Proposal) (AC 25.981-1X, p.9, Fuel Tank Ignition Sources, AC 25.981-1X, p.17, Electromagnetic Effects, including Lighting, EMI, and HIRF)

A.1. ALTERNATE SAFETY REVIEW REQUIREMENTS

LMAC Response:
The intent of the rulemaking is...

'to *ensure that the design approval holder* completes *a comprehensive* assessment of the *fuel tank system and develops any required Inspections, maintenance, or modifications*" (p. 58651, Proposed SFAR)

It is the opinion of Lockheed Martin Aircraft Center that this objective may be more effectively achieved by alternate safety review requirements for the L-1011 fleet. The requested alternate approach would be to conduct a qualitative design evaluation, develop an inspection/maintenance plan, and perform a one time inspection of the entire fleet.

Basis of Response:

Practicality
In order to conduct a safety analysis to the level of detail required by the NPRM, a time and labor intensive design review of production drawings would be required. Conducting an extensive design review of production drawings does not effectively meet the intention of the SFAR. Many minor and major modifications, field approvals, and repairs have been performed on the L-1011 aircraft fleet in its near 30 years of service. The extent of these aircraft alterations is unknown and the complete history of all maintenance documentation cannot be tracked. Performing an in-depth evaluation of production drawings would only assess the fail-safe status of the aircraft fuel system 30 years ago as the aircraft exited the production line.

Fuel tank inspections conducted as part of the FSSLT also support this concept. Of the L-1011 aircraft inspected by Lockheed Martin, no significant production related findings resulted. Areas within the tanks of one aircraft where maintenance had been performed did result in discrepancies including damaged or missing bond straps.

Method Accuracy

LMAC also supports the viewpoint shared by the industry represented FSSLT that aircraft certified prior to the activation of the new FAR 25.1309 reliability requirements should undergo a qualitative rather than quantitative evaluation. The current version of FAR 25.1309 requires a safety analysis and a quantitative assessment (AC 25.1309-1A) to validate that a system is fail-safe. Accurate statistical reliability information needed to conduct the safety analysis is likely to be unavailable for fuel system components used nearly 30 years ago. When conducting a safety analysis, conservative assumptions are required when accurate reliability data is unavailable. The required conservative assumptions could lead to false and detrimental failure probability results. This circumstance could occur multiple times during the analysis, or even cause compounded error effects requiring even more sever corrective actions.

By the methods proposed in the NPRM, a 'representative" fuel tank system would be created based on `30 year old drawings that would be fraught with unavoidable assumptions while at the same time be required to meet the 'extremely improbable" failure condition probability criteria of $1x(10)^{-9}$. This would lead to unnecessary inspections, maintenance, repairs, and/or modifications.

To more effectively meet the intent of the SFAR, it is proposed by LMAC that a qualitative design review be conducted based on the investigative efforts of the FAA and NTSB, A/Ds, S/Bs, lessons learned as stated in the NPRM, performance history of the aircraft, results of the FSSLT fuel tank inspection program, and other factual known potential concerns.

Cost

If a safety analysis was conducted, as proposed in the NPRM, and resulted in unnecessary inspections, maintenance, repairs, and/or modifications, the result would force an unnecessary burden of analysis costs placed on the OEMs and corrective action implementation costs on the operators.

Costs, personnel demands, and compliance time of the NPRM proposed method would far exceed that required for a qualitative analysis. For the L-1011, a qualitative analysis as discussed above could be conducted by utilizing the knowledge and experience of existing in-house personnel and applying familiar methods of evaluation. Conducting an FMEA and FTA quantitative evaluation would require increased staffing, purchasing of special software applications, hiring of safety analysis experts, and training. Applying these new principles to the level of detail discussed above with new software and personnel would obviously take longer.

In addition, the labor and time cost for the quantitative analysis would be dramatically higher for older aircraft as opposed to those produced after the new FAR 25.1309 regulations. The fuel systems of aircraft certified prior to the new FAR 25.1309 reliability requirements were not evaluated to the level of detail as were aircraft certified after the new requirements. In other words, the assessment would have to start from scratch rather than simply applying additional criteria to an existing safety analysis assessment.

Summary

In summary, the method proposed in the NPRM of conducting a safety review of the Lockheed Martin L-1011 fuel tank system would...

- not effectively meet intent of the SFAR
- be impractical
- not accurately reflect the real world condition
- require unnecessary costs to the OEMs and operators

Therefore, in place of the quantitative safety analysis and design review, it is recommended that aircraft certified prior to the activation of the new FAR 25.1309 reliability requirements be evaluated by conducting a qualitative design evaluation, developing an inspection/maintenance plan, and performing a one time inspection of the entire fleet.

A.2. ELIMINATION OF HIRF REQUIREMENT

LMAC Response:

LMAC requests that HIRF (High Intensity Radio Frequency) be excluded from the required types of ignition sources to be considered for the L-1011's safety review.

Bask of Response:

HIRF effects are negligible regarding the air-worthiness of in-service aircraft with reference to its electromagnetic protection when adequate protection against lightning is used in accordance with bulletin FSAW 97-16A.

"*Operators* of older generation *aircraft* with mainly analog *electrical* /electronic *(nondigital) controls and displays, must ensure that their maintenance programs include lightning inspection tasks. These* tasks adequately *address the provision of this FSIB. None of the other provisions detailed in this FSIB* apply to this *category of aircraft.*"

This applies to...

- "potential protection degradation caused by environmental factors such as: corrosion, mechanical vibration, thermal effects, damage, repairs, and modifications."
- "electromagnetic hazards, caused by exposure to lightning and HIRF environments, and to flight critical electrical/electronic systems installed on or within the aircraft."
- "equipment hazards... due to effects on equipment and associated wiring on or within the aircraft."
- "in-service aircraft, equipment, modifications of existing aircraft or equipment, and applications of existing (of the shelf) equipment

Reference:
Flight Standards Information Bulletin for Airworthiness (FSAW)
Bulletin Number: FSAW 97-16A
Bulletin Title: Lightning/ High Intensity Radio Frequency (HIRF) Protection Maintenance
Effectivity Date: 08-04-97

A.3. IGNITION SOURCE EVALUATION CRITERIA

LMAC Response:

LMAC requests that the scope of the ignition source evaluation criteria be narrowed to a realistic and attainable level. As stated previously, to more effectively meet the intent of the SFAR, it is proposed by LMAC that a qualitative design review be conducted based on the investigative efforts of the FAA and NTSB, A/Ds, S/Bs, lessons learned as stated

in the NPRM, performance history of the aircraft, results of the FSSLT fuel tank inspection program, and other factual known potential concerns.

Basis of Response:
The degree of confidence required by the NPRM for the elimination of potential ignition sources within the fuel tank system is impossible to attain. The approach of conducting the safety analysis presented in the NPRM is based on the "find the needle in the haystack" or "hypothetical what if ?" concept. The NPRM proposal requires that...

"no ignition source may be *present"* (p. 58663, PART 25 – AIRWORTHINESS STANDARDS: TRANSPORT CATEGORY AIRPLANES)

"design approval holders ....(are to) submit substantiation *to the FAA that the design of the fuel tank system of previously* certificated airplanes *precludes the existence of ignition* sources *within the* airplane *fuel tanks."* (p. 58644, SUMMARY)

To *preclude* means "to make impossible". This obligates the design approval holder to substantiate with a certainty of one that it is impossible for any ignition source imaginable to exist anywhere in, on, or around the fuel tank system. (Reference: p. 3, FMEA and FTA REQUIREMENTS section of this report). Obviously, this unattainable.

A.4. MISCELLANEOUS COMMENTS

A.4.1. TERM INCONSISTENCY

LMAC Response:
It is recommended that terms referring to the safety review be used in a consistent manner.

Basis of Response:
The terms 'safety review", 'design review", "safety analysis", and "functional hazard assessment" were used interchangeably throughout the NPRM. Each of these terms could represent significantly different meanings. It is recommend that if it is the intent of the FAA to differentiate the meanings of these terms, that their definitions be clearly established and that they be used in the appropriate context. After interpreting the intentions and requirements of the NPRM and developing a preliminary concept of compliance, the following definitions were developed in an attempt to establish a unified understanding of the objectives:

Safety review- a comprehensive assessment of the fuel tank system that meets all the requirements of the Special Federal Aviation Regulation.
Safety Analysis – process of insuring the fuel system is fail-safe by conducting a design review and failure mode analysis
Design Review- process of reviewing all relevant engineering design drawings to insure appropriate design practices have been utilized and identify failure modes
Failure Mode Analysis – process of evaluating all identified failure modes resulting from the design review by conducting a FMEA and FTA

It is recommended that a similar set of definitions be provided in the SFAR to clarify the intentions of the ruling.

B. HARMONIZATION

LMAC Response:
LMAC view; it as essential that efforts to ensure the safely of transport aircraft fuel systems be a worldwide, harmonized effort between regulatory authorities and industry.

Basis of Response:
A harmonized effort would minimize the burden imposed on the industry by eliminating conflicting compliance regulations and unnecessary multiple assessments and inspections. Such a unification would simplify operations and reduce costs in the long run. Worldwide harmonization may also help prevent misappropriated regulations or identify more applicable methods of ensuring fuel system safety.

C. COMPLIANCE SCHEDULE

NPRM Proposal:
The NPRM proposes that 'design approval holders conduct a safety review and develop the compliance documentation and any required maintenance and inspection instructions" within 12 months of ruling activation. (p. 58653, Compliance)

The NPRM proposes that "operators... incorporate FAA approved long term fuel tank system maintenance and inspection instruction into their approved program" within 18 months of ruling activation. (p. 58654, Compliance)

LMAC Response:
It is proposed that a time table similar to the following be incorporated to allow for required steps that were not accounted for in the NPRM proposed fuel system safety process.

Time from SFAR ruling activation:

18 months: LMAC delivers L-1011 findings and proposed corrective actions to the FAA
XX months: FAA approves methods of corrective action
XX months: FAA and operator establish an agreed date for implementing the corrective action
XX months: operator incorporates the corrective action

XX = to be determined by the FAA and the effected party based on the corrective action's degree of difficulty or other influential conditions

Basis of Response:
For the L-1011, it is proposed that LMAC conduct the safety review and produce a deliverable of disposed findings and proposed corrective actions (inspections, maintenance plan, or modifications) to the FAA within 18 months of ruling activation. This is consistent with the compliance time proposed by the FSSLT. Time then needs to be allotted for the FAA to evaluate and approve the proposed corrective actions. Once these corrective actions are approved by the FAA, the effected operator must then be able to evaluate the maintenance plan and provide input for an agreed time of compliance for incorporating the plan. Depending on the severity of inspections, maintenance, and/or modifications, different compliance times will be required for the operator. The number of aircraft, variations of aircraft, variations of fuel tank systems, number of drawings, number of components, etc. are known quantities which enable the design approval holder to establish an estimated compliance time to complete the safety

review. The results of the safety review are an unknown, therefore a definite complete schedule is unable to be established prior to the identification and assessment of the resulting FAA approved inspections, maintenance, or modification plan.