

JAA Administrative & Guidance Material

Section Two: Maintenance Part Three: Temporary Guidance

LEAFLET N° 47 – Guidance on CJAA Interim policy on Fuel Tank Safety (INT/POL/25/12)

1 INTENT

This Temporary Guidance Leaflet (TGL) provides guidelines on the interpretation and implementation for JAA Member States, recommending a common approach for continued airworthiness of Fuel Systems. This guidance material applies to those aeroplanes identified in paragraph 4 of this TGL 47 which has applicability to Type Certificate/ Supplemental Type certificate/Major modification holders and in addition to JAR-Ops Operators and their maintenance organisations.

2 INTRODUCTION

In recent years the aviation industry has experienced a number of incidents or accidents involving fuel tank explosions. These experiences suggest that on some aircraft types, the fuel tank system installation does not provide as high a level of protection against explosion as had been expected. .

The FAA has issued a set of new rules related to fuel tank safety including SFAR 88 and appropriate amendments to parts of 14 CFR that require fuel tank system design reviews, associated modification reviews and improved maintenance procedures and practices.

The JAA-NAA's were requested to mandate this policy requiring holders of Type Certificates and Major Modification approvals directly related to the fuel tank system installation to undertake safety reviews based upon additional failure criteria. Where identified necessary by such safety reviews the introduction of corrective actions such as modifications, configuration critical items, improved maintenance practices and training will be introduced.

The purpose of this TGL is to notify the current JAA policy and associated actions necessary to comply with the above.

3 GENERAL

JAA-NAA's have been tasked with implementing the JAA Interim Policy for continued fuel tank safety through their national systems. This TGL interprets the interim policy by providing additional guidance in order that a harmonised approach can be achieved within the JAA community and that of the FAA.

The JAA Interim Policy highlights the need for a safety review based on JAR 25.1309 practices, and taking into consideration in-service experience. The reviews are to be carried out by the applicable Type Certificate Holder, Supplemental Type Certificate Holder, major Modification Approval Holder or an appropriately Approved Design Organisation, which for the purposes of this TGL will be referred to as the Certificate Holder. Where such reviews identify unsafe conditions, action to correct these will be mandated on a national basis by individual NAA's.

Where the safety review does not identify an unsafe condition but identifies a non-compliance with JAA interim policy, then the Certificate Holder is to establish the need for revisions to relevant continued airworthiness instructions, maintenance requirements and improved maintenance practices required to maintain a satisfactory level of safety. Operators and Certificate Holders will need to comply with the contents of this TGL as appropriate.

4 APPLICABILITY

The JAA Interim Policy applies to all turbine powered Large Transport Aeroplanes certificated after 1 January 1958 with a Type Certificated passenger capacity of 30 seats or more, or a payload of 3402 kg or more.

JAA Administrative & Guidance Material

Section Two: Maintenance Part Three: Temporary Guidance

5 REQUIREMENT

JAA-NAA's require holders of certificates directly related to the fuel system installation on applicable aeroplanes to carry out a safety assessment in accordance with the principles of JAR 25.1309, using the guidance material provided in Appendix A to this TGL. It must be shown that an ignition source within the fuel system cannot result from a single failure and is extremely improbable. For the purpose of this analysis, the whole fuel system should be assumed to be in the flammable range. In addition it should be shown that no heat transfer can lead to fuel auto-ignition within the fuel system. All systems, including the fuel system, which can release heat, in normal and failure conditions to the fuel system should be considered.

Although the assumption is that the fuel tank will always be considered to be flammable, it is recognised that not all non-compliances with JAR 25.1309 necessarily result in an unsafe condition. Harmonised criteria have been developed to determine those non-compliances which result in a potential unsafe condition that requires Mandatory corrective action~~—~~. These criteria, including assessment of the fuel tank flammability, are defined in Appendix A to this TGL.

Operators are required to identify and list all aircraft fuel tank system major modifications installed on their aircraft, advising the applicable Certificate Holder in order that they may carry out the above safety review. In cases where the Certificate Holder is unable or unwilling to carry out the safety review then the Operator must engage the services of an appropriately approved design organisation to carry out such safety reviews.

The outcome of these review exercises is expected to be the identification of modifications and critical configuration features etc. necessary to address unsafe conditions, additional Airworthiness Limitations, new or revised Service Information, revised inspection standards, and amendment of Maintenance Manuals including the revision of Standard Practices.

As a result of these safety reviews Operators and their maintenance organisations may need to provide appropriate training for maintenance personnel, review maintenance procedures, and propose suitable amendments to Approved Maintenance Programmes together with associated tasks and inspections to address such reviews.

Operators must ensure that all scheduled maintenance tasks, inspection standards and maintenance procedure revisions arising as a result of compliance with this TGL or SFAR 88 are complied with.

6 COMPLIANCE

Where safety reviews identify unsafe conditions Airworthiness Directives will be developed including relevant compliance time frames. Where non-compliances with the Interim policy are determined, which do not present an unsafe condition, action will be identified and their associated maintenance and inspection tasks will be handled through the traditional methods. Operators are expected to implement improved maintenance procedures identified by the safety reviews by 6 December 2004. Further harmonised guidance may be found in FAA AC 120-XX, Process for Approval of SFAR 88 related Instructions for Continued Airworthiness when published~~—~~. It is also anticipated that this TGL will be amended to provide additional information in due course.

JAA Administrative & Guidance Material
Section Two: Maintenance Part Three: Temporary Guidance

TGL No. 47

Appendix A

Issue 1
November 2002

Interpretative Material (IM) to INT/POL/25/12
Fuel Tank Safety – Fuel Tank Ignition Sources

1 INTRODUCTION

Service history has shown that ignition sources have developed in aircraft fuel tanks due to unforeseen failure modes or factors that may not have been considered at the time of original certification of the aircraft. The purpose of this material is to provide guidance in order to show compliance with INT/POL/25/12 published by JAA on 1st of October 2000.

Each applicant should review aircraft service records, flight logs, inspection records, and component supplier service records to assist in establishing any unforeseen failures, wear or other conditions that could result in an ignition source within the fuel system. In addition, in some cases changes to components may have been introduced following certification without consideration of possible effects of the changes to the requirements to preclude ignition sources. Therefore, results of reviewing this service history information and a review of changes to components from the original type design should be documented as part of the fuel tank system design review and safety analysis.

2 BACKGROUND

There are three primary phenomena that can result in ignition of fuel vapours in aeroplane fuel tanks. The first is electrical arcs. The second is friction sparks resulting from mechanical contact of rotating equipment in the fuel tank. The third is hot surface ignition or auto ignition.

The conditions required to ignite fuel vapours from these ignition sources vary with pressures and temperatures within the fuel tank and can be affected by sloshing or spraying of fuel in the tank. Due to the difficulty in predicting fuel tank flammability and eliminating flammable vapours from the fuel tank, design practices have assumed that a flammable fuel air mixture exists in aircraft fuel tanks and require that no ignition sources be present.

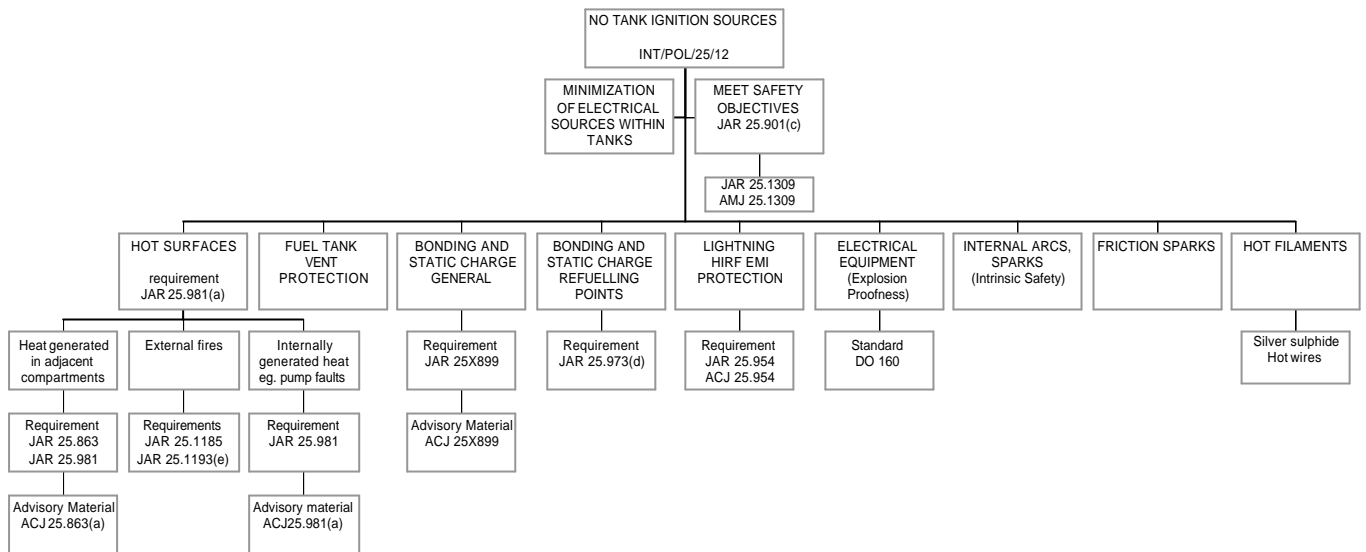
Any components located in or adjacent to a fuel tank must be qualified to meet standards that assure, during both normal and failure conditions, ignition of flammable fluid vapours will not occur. This is typically done by a combination of design standards, component testing and analysis. Testing of components to meet explosion proof requirements is carried out for various single and combinations of failures to show that arcing, sparking, auto ignition or flame propagation from the component will not occur. Testing for components has been accomplished using standards and component qualification tests. The standards include for example Eurocae / RTCA DO160 and BS 3G 100 that defines explosion proof requirements for electrical equipment and analysis of potential electrical arc and friction sparks.

Therefore the focus of this re-evaluation of the aircraft fuel system should be to identify and address potential internal and external sources of ignition in the fuel tank system, which may not previously have been considered to be unsafe.

JAA Administrative & Guidance Material

Section Two: Maintenance Part Three: Temporary Guidance

FUEL SYSTEM IGNITION PREVENTION



JAA Administrative & Guidance Material

Section Two: Maintenance Part Three: Temporary Guidance

3 IGNITION SOURCES

3.1 Electrical Arcs and Sparks

Ignition sources from electrical arcs can occur as a result of electrical component and wiring failures, direct and indirect effects of lightning, HIRF / EMI, and static discharges.

The level of electrical energy necessary to ignite fuel vapours is defined in various standards. The generally accepted value is 0.2 millijoules. An adequate margin needs to be considered, when evaluating the maximum allowable energy level for the fuel tank design.

3.2 Friction Sparks

Rubbing of metallic surfaces can create friction spark ignition sources. Typically this may result from debris contacting a fuel pump impeller or an impeller contacting the pump casing.

3.3 Hot Surface Ignition

Guidance provided in AC25-8 has defined hot surfaces which come within 30 degrees Centigrade (50°F) of the autogenous ignition temperature of the fuel air mixture for the fluid as ignition sources. It has been accepted that this margin of 30 degrees Centigrade supported compliance to JAR 25.981(a). Surface temperatures not exceeding 200°C have been accepted without further substantiation against current fuel types.

4 Lessons learned

4.1 Introduction

As detailed above, the fuel system criticality may not have been addressed in the past against current understanding as far as the ignition risk is concerned. Inspections and design review have been performed, resulting in findings detailed below. One the main lessons learned is to minimize electrical sources within fuel tanks (see § 4.3).

4.2 Components in-service experience

The following sections intend to present a list of faults which have occurred to fuel system components. By its nature it cannot be an exhaustive list, but is only attempting to provide a list of undesirable features of fuel system components that should be avoided when designing fuel tanks.

Pumps

- (a) Pump inducer failures have occurred resulting in ingestion of the inducer into the pump impeller and generation of debris into the fuel tank.
- (b) Pump inlet check valves have failed resulting in rubbing on pump impeller.
- (c) Stator windings have failed during operation of the fuel pump. Subsequent failure of a second phase of the pump caused arcing through the fuel pump housing.
- (d) Thermal protective features incorporated into the windings of pumps have been deactivated by inappropriate wrapping of the windings.
- (e) Cooling port tubes have been omitted during pump overhaul.
- (f) Extended dry running of fuel pumps in empty fuel tanks, violation of manufacturers recommended procedures, are suspected causing in two incidents.
- (g) Use of steel impellers which might produce sparks if debris enters the pump.
- (h) Debris has been found lodged inside pumps.
- (I) Pump power supply connectors have corroded allowing fuel leakage and electrical arcing.

JAA Administrative & Guidance Material

Section Two: Maintenance Part Three: Temporary Guidance

- (j) Electrical connections within the pump housing have been exposed and designed with inadequate clearance to pump cover resulting in arcing.
- (k) Resettable thermal switches resetting at higher trip temperature.
- (l) Flame arrestors falling out of their respective mounting.
- (m) Internal wires coming in contact with the pump rotating group, energising the rotor and arcing at the impeller / adapter interface.
- (n) Poor bonding across component interfaces.
- (o) Insufficient ground fault current capability.
- (p) Poor bonding of components to structure.
- (q) Loads from the aeroplane fuel feed plumbing were transferred.
- (r) Premature failure of fuel pump thrust bearings allowing steel rotating parts to contact the steel pump side plate.

Wiring to Pumps located in metallic conduits or adjacent to fuel tank walls.

Wear of Teflon sleeving and wiring insulation allowing arcing to conduit causing an ignition source in tank, or arcing to the tank wall.

Fuel Pump Connectors

Electrical arcing at connections within electrical connectors has occurred due to bent pins or corrosion.

FQIS Wiring

Degradation of wire insulation (cracking) and corrosion (copper sulphate deposits) at electrical connectors, unshielded FQIS wires have been routed in wire bundles with high voltage wires.

FQIS Probes

Corrosion and copper sulphide deposits have caused reduced breakdown voltage in FQIS wiring, FQIS wiring clamping features at electrical connections on fuel probes has caused damage to wiring and reduced breakdown voltage. Contamination in the fuel tanks including: steel wool, lock wire, nuts, rivets, bolts; and mechanical impact damage, caused reduced arc path between FQIS probe walls.

Bonding Straps

Corrosion, inappropriately attached connections (loose or improperly grounded attachment points). Static bonds on fuel system plumbing connections inside the fuel tank have been found worn due to mechanical wear of the plumbing from wing movement, and corrosion.

Failed or aged seals

Seal deterioration may result in leak internal or external to fuel system, as well as fuel spraying.

4.3

Minimizing electrical components hazards within fuel tanks

One of the lessons learned listed above is the undesirable presence of electrical components within fuel tanks. Power wiring has been routed in conduits when crossing fuel tanks, however, chaffing has occurred within conduits. It is therefore suggested that such wiring should be routed outside of fuel tank to the maximum extent possible. At the equipment level, connectors and adjacent area should be taken into account during the explosion proofness qualification of the equipment (typically, pumps).

However, for some wiring, such FQIS or sensor wiring, it might be unavoidable to route them inside of tanks, and therefore they should be qualified as intrinsically safe. The Safety

JAA Administrative & Guidance Material

Section Two: Maintenance Part Three: Temporary Guidance

Assessment section below indicates how any residual fuel tank wiring may be shown to meet the required Safety Objectives.

5 SAFETY ASSESSMENT

5.1 Introduction

The fuel system must comply with JAR 25.901(c), which requires compliance to JAR 25.1309. According to INT/POL/25/12, the applicant should perform a Safety Assessment of the fuel system showing that the presence of an ignition source within the fuel system is Extremely Improbable and does not result from a single failure, as per JAR 25.1309 and the corresponding AMJ 25.1309 principles.

Advisory Material Joint (AMJ) 25.1309, "System Design and Analysis" describes methods for completing system safety assessments (SSA). The depth and scope of an acceptable SSA depends upon the complexity and criticality of the functions performed by the system under consideration, the severity of related failure conditions, the uniqueness of the design and extent of relevant service experience, the number and complexity of the identified causal failure scenarios, and the ability to detect contributing failures. The SSA criteria, process, analysis methods, validation and documentation should be consistent with the guidance material contained in AMJ 25.1309.

Failure rates of fuel system component should be carefully established as required using in-service experience to the maximum extent.

5.2 Assumptions and Boundary Conditions for the Analysis:

The analysis should be conducted based upon assumptions described in this section.

5.2.a Fuel Tank Flammability

The system safety analysis should be prepared considering all aircraft flight and ground conditions, assuming that an explosive fuel air mixture is present in the fuel tanks at all times.

5.2.b Failure Condition Classification

Unless design features are incorporated that mitigate the hazards resulting from a fuel tank ignition event, (e.g. polyurethane foam), the SSA should assume that the presence of an ignition source is a catastrophic failure condition.

5.2.c Failure conditions

The analysis should be conducted assuming deficiencies and anomalies, failure modes identified by the review of service information on other product as far as practical, and any other failure modes identified by the fuel tank system functional hazard assessment. The effects of manufacturing variability, ageing, wear, corrosion, and likely damage should be considered.

In service and production functional tests, component acceptance tests and maintenance checks may be used to substantiate the degree to which these states must be considered. In some cases, for example component bonding or ground paths, a degraded state will not be detectable without periodic functional test of the feature. For these features, inspection/test intervals should be established based on previous service experience on equipment installed in the same environment. If previous experience on similar or identical components is not available, shorter initial inspection/test intervals should be established until design maturity can be assured.

Fuel Pumps.

Service experience shows that there have been a significant number of failure modes, which have the capability of creating an ignition source within the tank. Many of these are as the result of single failures, or single failures in combination with latent failures. Where fuel pumps can be uncovered during normal operation, modifications will be required to ensure that pumps do not

JAA Administrative & Guidance Material

Section Two: Maintenance Part Three: Temporary Guidance

become uncovered (by fuel) or that pump failures will not cause tank fires or explosions. For the purposes of this Fuel Tank Safety Review, this will not be applied to fuel pumps, which only become uncovered at the point of complete fuel exhaustion.

Fuel Pump Wiring.

Despite precautions to prevent fuel pump wire chafing, arc faults have occurred. For pump wire installations within the tank or adjacent to the tank wall to remain acceptable, additional means must be provided to isolate the electrical supply, in the event of arc faults. The means must be effective in preventing continued arcing to the conduit or the tank wall.

FQIS Wiring.

Although in recent times, constructors have made attempts to segregate FQIS wiring from other aircraft wiring, it is recognised that it is not possible to be confident, at the design stage, that the segregation will remain effective over the whole fleet life. Subsequent aircraft modifications in service may negate the design intentions. To counter this threat to FQIS wiring, additional design precautions must be provided to positively prevent any unwanted stray currents entering the tank. The precautions taken must remain effective, even following anticipated future modifications.

Bonding Schemes.

Service experience has shown that the required Safety Objectives can be met with a dual, redundant bonding scheme, with appropriate level of inspection. No definitive advice can be given about the inspection period, but it is expected that the design and qualification of the bonding leads and attachments (or alternative bonding means) will be sufficiently robust, so that frequent inspections will not be needed.

5.2.d External Environment

The severity of the external environmental conditions that should be considered are those established by certification regulations and special conditions (e.g., HIRF, lightning), regardless of the associated probability. For example, the probability of lightning encounter should be assumed to be one.

5.3 Qualitative Safety Assessment

The level of analysis required to show ignition sources will not develop will depend upon the specific design features of the fuel tank system being evaluated. Detailed quantitative analysis should not be necessary if a qualitative safety assessment shows that features incorporated into the fuel tank system design protect against the development of ignition sources within the fuel tank system. For example, if all wiring entering the fuel tanks was shown to have protective features such as separation, shielding or surge suppressors, the compliance demonstration would be limited to demonstrating the effectiveness of the features and defining any long term maintenance requirements so that the protective features are not degraded.

5.4 Component Qualification Review

Qualification of components such as fuel pumps, using the specifications has not always accounted for unforeseen failures, wear, or inappropriate overhaul or maintenance. Service experience indicates that the explosion proofness demonstration needs to remain effective under all of the continued operating conditions likely to be encountered in service. Therefore an extensive evaluation of the qualification of components may be required if qualitative assessment does not limit the component as a potential ignition source.

5.5 Electrical Sparks

The Applicant should perform a failure analysis of all fuel system and sub systems with wiring routed into fuel tanks. Systems that should be considered include, temperature indication, Fuel Quantity Indication System, Fuel Level sensors, fuel pump power and control and indication, and

JAA Administrative & Guidance Material

Section Two: Maintenance Part Three: Temporary Guidance

any other wiring routed into or adjacent to fuel tanks. The analysis must consider system level failures and also component level failures mentioned in Section 4.2 and discussed below. Component failures, which have been experienced in service, are to be considered as probable, single failures. The analysis should include existence of latent failures, such as contamination, damage/pinching of wires during installation or corrosion on the probes, connectors, or wiring and subsequent failures that may lead to an ignition source within the fuel tank. The wire routing, shielding and segregation outside the fuel tanks should also be considered. The evaluation must consider both electrical arcing and localised heating that may result on equipment, fuel quantity indicating system probes, and wiring.

5.5.a Electrical Short Circuits

5.5.a.1 Effects of electrical short circuits, including hot shorts, on equipment and wiring which enter the fuel tanks should be considered, particularly for the fuel quantity indicating system wiring, fuel level sensors and probes.

5.5.a.2 The evaluation of electrical short circuits must consider shorts within electrical equipment.

5.5.b Electromagnetic Effects, including Lightning, EMI, and HIRF

5.5.b.1 Effects of electrical transients from lightning, EMI or HIRF on equipment and wiring within the fuel tanks should be considered, particularly for the fuel quantity indicating system wiring and probes.

5.5.b.2 Latent failures such as shield and termination corrosion, shield damage, and transient limiting device failure should be considered and appropriate indication or inspection intervals established.

5.5.b.3 The evaluation of electromagnetic effects from lightning, EMI, or HIRF must be based on the specific electromagnetic environment of a particular aircraft model. Standardized tests such as those in EUROCAE/RTCA DO-160 Sections 19, 20 and 22 are not sufficient alone, without evaluation of the characteristics of the specific electromagnetic environment for a particular aircraft model to show that appropriate standardised DO-160 test procedures and test levels are selected. Simulation of various latent failures of fuel system components within the tanks may be required to demonstrate the transient protection effectiveness.

5.6 Friction Sparks:

The analysis should include evaluation of the effects of debris entering the fuel pumps, including any debris that could be generated internally such as any components upstream of the pump inlet. Service experience has shown that pump inlet check valves, inducers, nuts, bolts, rivets, fasteners, sealant, lock wire etc. have been induced into fuel pumps and contacted the impeller. This condition could result in creation of friction sparks and should be an assumed failure condition when conducting the system safety assessment.

6 INSTRUCTIONS FOR CONTINUED AIRWORTHINESS FOR THE FUEL TANK SYSTEM

The analysis conducted to show compliance with INT/POL/25/12 may result in the need to define certain required inspection or maintenance items. Any item that is required to assure that an ignition source does not develop within the fuel tank or maintain protective features incorporated to preclude a catastrophic fuel tank ignition event must be incorporated in the limitation section of the instructions for continued airworthiness.

Also, any information necessary to maintain those design features that have been defined in the original type design to preclude ignition sources should be included in the critical design configuration control limitations. This information is essential to ensure that maintenance, repairs or modifications do not unintentionally violate the integrity of the original fuel system type design. The original design approval holder must define a method of ensuring that this essential information will be evident to those that may perform and approve such repairs and modifications.

JAA Administrative & Guidance Material
Section Two: Maintenance Part Three: Temporary Guidance

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