6 *Electrical Properties of Composite Structure*

6.1 In the case of lightning protection, for the partial conductors the method of surface protection will vary with the criticality of the structure in question. Deterioration of the means of protection or possible hidden damage to the material which may affect its structural integrity, need to be considered. While such materials provide a measure of electro-magnetic screening, the need for additional measures will be a function of the location of the material in relation to critical equipment and wiring in the aircraft. Particular attention will also have to be given to the protection required near fuel systems – e.g. fuel tanks.

For non-conducting materials which have no intrinsic lightning protection or screening properties, the measures taken will again depend on the relative locations of the material and critical systems or fuel and the possible loss of the components due to internal air pressures in the event of a strike.

6.2 The partial conducting materials should present no problem in dissipating P-static but problems can arise with the non-conductors. Depending upon the location of the material, protection may be required.

6.3 Electrical currents, other than lightning, can flow in some partial conducting materials and means may be required to limit this by provision of alternative current paths if the effect of large voltage drop is important or if such currents can damage the material.

6.4 Particular care has to be taken that all joints, permanent and temporary, are capable of carrying any currents which may flow particularly those resulting from lightning strikes. Structural damage and loss of screening capabilities may occur if these are not adequately controlled.

6.5 The adequacy of the material in supplying a ground plane for antenna may have to be considered. Again it will vary with the material and the radio frequency of the system.

[Amdt 25/26]

SUBPART E – POWERPLANT

GENERAL

CS 25.901 Installation

ED Decision 2016/010/R

(a) For the purpose of this CS-25 the aeroplane powerplant installation includes each component that –

(1) Is necessary for propulsion;

(2) Affects the control of the major propulsive units; or

(3) Affects the safety of the major propulsive units between normal inspections or overhauls.

(b) For each powerplant –

(1) The installation must comply with –

(i) The installation instructions provided under CS-E 20(d) and (e); and

(ii) The applicable provisions of this Subpart (see also AMC 20-1).

(2) The components of the installation must be constructed, arranged, and installed so as to ensure their continued safe operation between normal inspections or overhauls. (See AMC 25.901(b)(2).)

(3) The installation must be accessible for necessary inspections and maintenance; and

(4) The major components of the installation must be electrically bonded to the other parts of the aeroplane. (See AMC 25.901(b)(4).)

(c) The powerplant installation must comply with CS 25.1309, except that the effects of the following need not comply with CS 25.1309(b):

(1) Engine case burn through or rupture;

(2) Uncontained engine rotor failure; and

(3) Propeller debris release.

(See AMC 25.901(c) Safety Assessment of Powerplant Installations and AMC 25-24: Sustained Engine Imbalance)

[Amdt 25/1]
[Amdt 25/3]
[Amdt 25/8]
[Amdt 25/18]

AMC 25.901(b)(2) Assembly of Components

ED Decision 2003/2/RM

The objectives of CS 25.671(b) should be satisfied with respect to powerplant systems, where the safety of the aeroplane could otherwise be jeopardised.

AMC 25.901(b)(4) Electrical Bonding

ED Decision 2003/2/RM

Where the engine is not in direct electrical contact with its mounting, the engine should be electrically connected to the main earth system by at least two removable primary conductors, one on each side of the engine.

AMC 25.901(c) Safety Assessment of Powerplant Installations

ED Decision 2005/006/R

1. PURPOSE. This Acceptable Means of Compliance (AMC) describes an acceptable means for showing compliance with the requirements of CS 25.901(c). This document describes a method of conducting a "System Safety Assessment" of the powerplant installation as a means for demonstrating compliance. This guidance is intended to supplement the engineering and operational judgement that must form the basis of any compliance findings. The guidance provided in this document is meant for aeroplane manufacturers, modifiers, foreign regulatory authorities, and EASA Large Aeroplane type certification engineers. Like all AMC material, this AMC is not, in itself, mandatory, and does not constitute a requirement. It is issued to describe an acceptable means, but not the only means, for demonstrating compliance with the powerplant installation requirements for Large Aeroplanes. Terms such as "shall" and "must" are used only in the sense of ensuring applicability of this particular method of compliance when the acceptable method of compliance described in this document is used.

2. RELATED CERTIFICATION SPECIFICATIONS. CS 25.571, CS 25.901, CS 25.903, CS 25.933, CS 25.1309, and CS 25.1529; CS E-50 and E-510, CS P-150 and P-230.

3. APPLICABILITY. The guidance provided in this document applies to powerplant installations on Large Aeroplanes that are subject to the requirements of CS 25.901. This guidance specifically concerns demonstrating compliance with the requirements of CS 25.901(c), which states:

   "(c) The powerplant installation must comply with CS 25.1309, except that the effects of the following need not comply with CS 25.1309(b):

   (1) Engine case burn through or rupture;

   (2) Uncontained engine rotor failure; and

   (3) Propeller debris release."

   CS 25.901(c) is intended to provide an overall safety assessment of the powerplant installation that is consistent with the requirements of CS 25.1309, while accommodating unique powerplant installation compliance policies. It is intended to augment rather than replace other applicable CS-25 design and performance standards for Large Aeroplanes.

   In accommodating unique policies related to powerplant compliance, EASA has determined that specific guidance relative to demonstrating compliance with CS 25.1309(b) is needed; such guidance is contained in this AMC. (No unique compliance requirements for CS 25.1309(a) and (c) are required for powerplant installations.)

   Wherever this AMC indicates that compliance with other applicable requirements has been accepted as also meeting the intent of CS 25.901(c) for a specific failure condition, no additional dedicated safety analysis is required. Where this AMC may conflict with AMC 25.1309 ("System Design and Analysis"), this AMC shall take precedence for providing guidance in demonstrating compliance with CS 25.901(c).

When assessing the potential hazards to the aircraft caused by the powerplant installation, the effects of an engine case rupture, uncontained engine rotor failure, engine case burn-through, and propeller debris release are excluded from CS 25.901(c)/CS 25.1309. The effects and rates of these failures are minimised by compliance with CS-E, Engines; CS-P, Propellers; CS 25.903(d)(1), CS 25.905(d), and CS 25.1193.

Furthermore, the effects of encountering environmental threats or other operating conditions more severe than those for which the aircraft is certified (such as volcanic ash or operation above placard speeds) need not be considered in the CS 25.901(c)/CS 25.1309 compliance process. However, if a failure or malfunction can affect the subsequent environmental qualification or other operational capability of the installation, this effect should be accounted for in the CS 25.901(c)/CS 25.1309 assessment.

The terms used in this AMC are intended to be identical to those used in AMC 25.1309.

4. BACKGROUND.

JAR-25 was the Joint Aviation Authorities Airworthiness Code for Large Aeroplanes. It was developed from the U.S. Federal Aviation Regulations Part 25 (FAR 25) during the 1970s. Early versions (Changes) of JAR-25 consisted of only the differences from FAR 25.

In 1976, JAR-25 Change 3 was published and introduced, for the first time, requirement JAR 25.1309 and ACJ Nos. 1 to 7 to JAR 25.1309. Requirement JAR 25.1309 was almost the same as the (then) existing FAR regulation (Amdt. 25-37), but the advisory material given in the ACJ provided interpretation of and acceptable means of compliance with, the requirement. Specific advice was given on how to show that the inverse relationship existed between the criticality of the Failure Condition and its probability of occurrence.

JAR-25, Change 3, did not include any specific JAR-25 requirement for powerplant installation safety assessment and so FAR 25.901(c) was also valid for JAR-25. FAR 25.901(c) text (Amdt. 25-23, Effective 8 May 1970) stated:

"25.901 Installation

(c) The powerplant installation must comply with § 25.1309".

At Change 4 of JAR-25, effective 19 July 1978, JAR 25.901(c) was introduced using the same FAR 25 words as shown above (viz.):

"JAR 25.901 Installation

(c) The power-plant installation must comply with JAR 25.1309."

However, at about that time, the FAA had been reviewing a proposal to revise FAR 25.901(c), to introduce the wording "… no single failure or probable combination …". This revised text was introduced at Amdt. 25-40, effective 2 May 1977.

The revisions introduced by Amdt. 25-40 were reviewed by the JAR-25 Study Groups and in two letters (Refs.: JAR/JET/2416/BT dated 21 July 1977 and JAR/JET/2467/BT dated 21 October 1977), the JAR-25 Powerplant Study Group recommended that, for JAR 25.901(c), the text should remain the same as the pre-Amdt. 25-40 version of FAR 25.901(c).

Since that time, JAR 25.901(c) and CS 25.901(c) have continued to refer to JAR / CS 25.1309 and for EASA/JAA, powerplant installations have been treated in the same way as for other aircraft systems when assessing the effects of failures and malfunctions.

One traditional exception to this has been the assessment of hazards resulting from an engine rotor failure. Previous ACJ No. 1 to JAR 25.1309 allowed for an explicit exception to the quantitative objective for a given catastrophic failure condition, for cases where the state of the art does not permit it to be achieved. This is the case for engine rotor failure and the 'minimisation of hazard' requirement of CS 25.903(d)(1) has been used instead of CS 25.1309 to cover this risk.

5. GENERAL SYSTEM SAFETY ASSESSMENT GUIDANCE.

Compliance with CS 25.901(c)/CS 25.1309 may be shown by a System Safety Assessment (SSA) substantiated by appropriate testing and/or comparable service experience. Such an assessment may range from a simple report that offers descriptive details associated with a failure condition, interprets test results, compares two similar systems, or offers other qualitative information; to a detailed failure analysis that may include estimated numerical probabilities.

The depth and scope of an acceptable SSA depend on:

— the complexity and criticality of the functions performed by the system(s) 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 detectability of contributing failures.

The SSA criteria, process, analysis methods, validation and documentation should be consistent with the guidance material contained in AMC 25.1309. Wherever there is unique guidance specifically for powerplant installations, this is delineated in Section 6, below.

In carrying out the SSA for the powerplant installation for CS 25.901(c)/CS 25.1309, the results of the engine (and propeller) failure analyses (reference CS P-150 and CS E-510) should be used as inputs for those powerplant failure effects that can have an impact on the aircraft. However, the SSA undertaken in response to CS-E and CS-P may not address all the potential effects that an engine and propeller as installed may have on the aircraft.

For those failure conditions covered by analysis under CS-E and CS-P, and for which the installation has no effect on the conclusions derived from these analyses, no additional analyses will be required to demonstrate compliance to CS 25.901(c)/CS 25.1309.

The effects of structural failures on the powerplant installation, and vice versa, should be carefully considered when conducting system safety assessments:

a. Effects of structural failures on powerplant installation. The powerplant installation must be shown to comply with CS 25.901(c) following structural failures that are anticipated to occur within the fleet life of the aeroplane type. This should be part of the assessment of powerplant installation failure condition causes.

   Examples of structural failures that have been of concern in previous powerplant installations are:

   (1) Thrust reverser restraining load path failure that may cause a catastrophic inadvertent deployment.

   (2) Throttle quadrant framing or mounting failure that causes loss of control of multiple engines.

   (3) Structural failures in an avionics rack or related mounting that cause loss of multiple, otherwise independent, powerplant functions/components/systems.

b. Effects of powerplant installation failures on structural elements. Any effect of powerplant installation failures that could influence the suitability of affected structures, should be identified during the CS 25.901(c) assessment and accounted for when demonstrating compliance with the requirements of CS-25, Subpart C ("Structure") and D ("Design and Construction"). This should be part of the assessment of powerplant installation failure condition effects.

Some examples of historical interdependencies between powerplant installations and structures include:

(1) Fuel system failures that cause excessive fuel load imbalance.

(2) Fuel vent, refuelling, or feed system failures that cause abnormal internal fuel tank pressures.

(3) Engine failures that cause excessive loads/vibration.

(4) Powerplant installation failures that expose structures to extreme temperatures or corrosive material.

6. SPECIFIC CS 25.901(c) SYSTEM SAFETY ASSESSMENT GUIDANCE.

This section provides compliance guidance unique to powerplant installations.

a. Undetected Thrust Loss. The SSA discussed in Section 5 should consider undetected thrust loss and its effect on aircraft safety. The assessment should include an evaluation of the failure of components and systems that could cause an undetected thrust loss, except those already accounted for by the approved average-to-minimum engine assessment.

(1) In determining the criticality of undetected thrust losses from a system design and installation perspective, the following should be considered:

(i) Magnitude of the thrust loss,*

(ii) Direction of thrust,

(iii) Phase of flight, and

(iv) Impact of the thrust loss on aircraft safety.

(*Although it is common for safety analyses to consider the total loss of one engine's thrust, a small undetected thrust loss that persists from the point of take-off power set could have a more significant impact on the accelerate/stop distances and take-off flight path/obstacle clearance capability than a detectable single engine total loss of thrust failure condition at V1)

(2) In addition, the level at which any thrust loss becomes detectable should be validated. This validation is typically influenced by:

(i) Impact on aircraft performance and handling,

(ii) Resultant changes in powerplant indications,

(iii) Instrument accuracy and visibility,

(iv) Environmental and operating conditions,

(v) Relevant crew procedures and capabilities, etc.

(3) Reserved.

b. Detected Thrust Loss. While detectable engine thrust losses can range in magnitude from a few percent to 100% of total aircraft thrust, the total loss of useful thrust (in-flight shutdown/IFSD) of one or more engines usually has the largest impact on aircraft capabilities and engine-dependent systems. Furthermore, single and multiple engine IFSD's tend to be the dominant thrust loss-related failure conditions for most powerplant installations. In light of this, the guidance in this AMC focuses on the IFSD failure conditions. The applicant must consider other engine thrust loss failure conditions, as well, if they are anticipated to occur more often than the IFSD failure condition, or if they are more severe than the related IFSD failure condition.

(1) Single Engine IFSD. The effects of any single engine thrust loss failure condition, including IFSD, on aircraft performance, controllability, manoeuvrability, and crew workload are accepted as meeting the intent of CS 25.901(c) if compliance is also demonstrated with:

— CS 25.111 ("Take-off path"),

— CS 25.121 ("Climb: one-engine-inoperative"), and

— CS 25.143 ("Controllability and Manoeuvrability -- General").

(i) Nevertheless, the effects of an IFSD on other aircraft systems or in combination with other conditions also must be assessed as part of showing compliance with CS 25.901(c)/CS 25.1309. In this case, it should be noted that a single engine IFSD can result from any number of single failures, and that the rate of IFSD's range from approximately $1x10^{-4}$ to $1x10^{-5}$ per engine flight hour. This rate includes all failures within a typical powerplant installation that affect one -- and only one -- engine. Those failures within a typical powerplant that can affect more than one engine are described in Section 6.b.(2), below.

(ii) If an estimate of the IFSD rate is required for a specific turbine engine installation, any one of the following methods is suitable for the purposes of complying with CS 25.901(c)/ CS 25.1309(b):

(A) Estimate the IFSD rate based on service experience of similar powerplant installations;

(B) Perform a bottom-up reliability analysis using service, test, and any other relevant experience with similar components and/or technologies to predict component failure modes and rates; or

(C) Use a conservative value of $1x10^{-4}$ per flight hour.

(iii) If an estimate of the percentage of these IFSD's for which the engine is restartable is required, the estimate should be based on relevant service experience.

(iv) The use of the default value delineated in paragraph 6.b.(1)(ii)(C) is limited to traditional turbine engine installations. However, the other methods (listed in 6.b.(1)(ii)(A) and (B), above) are acceptable for estimating the IFSD rates and restartability for other types of engines, such as some totally new type of engine or unusual powerplant installation with features such as a novel fuel feed system. In the case of new or novel components, significant non-service experience may be required to validate the reliability predictions. This is typically attained through test and/or technology transfer analysis.

(v) Related issues that should be noted here are:

(A) CS 25.901(b)(2) sets an additional standard for installed engine reliability. This requirement is intended to ensure that all technologically feasible and economically practical means are used to assure the continued safe operation of the powerplant installation between inspections and overhauls.

(B) The effectiveness of compliance with CS 25.111, CS 25.121 and CS 25.143 in meeting the intent of CS 25.901(c) for single engine thrust loss is dependent on the accuracy of the human factors assessment of the crew's ability to take appropriate corrective action. For the purposes of compliance with CS 25.901(c) in this area, it may be assumed that the crew will take the corrective actions called for in the aeroplane flight manual procedures and associated approved training.

(2) Multiple Engine IFSD. Typical engine IFSD rates may not meet the AC 25.1309-1B guidance that calls for 1×10^{-9} per hour for a catastrophic multiple engine IFSD. However, engine IFSD rates been part of the historically-accepted service experience upon which that guidance was based, and these IFSD rates are continuously improving. Consequently:

(i) Current typical turbine engine IFSD rates, and the resulting possibility of multiple independent IFSD's leading to a critical power loss, are considered inherently acceptable for compliance with CS 25.901(c) without the need for quantitative assessment.

(ii) Nevertheless, some combinations of failures within aircraft systems common to multiple engines may cause a catastrophic multiple engine thrust loss. These should be assessed to ensure that they meet the extremely improbable criteria. Systems to be considered include:

— fuel system,

— air data system,

— electrical power system,

— throttle assembly,

— engine indication systems, etc.

(iii) The means of compliance described above is only valid for turbine engines, and for engines that can demonstrate equivalent reliability to turbine engines, using the means outlined in Section 6.a. of this AMC. The approach to demonstrating equivalent reliability should be discussed early in the program with the Agency on a case-by-case basis.

c. Automatic Take-off Thrust Control System. CS-25, Appendix I ["Automatic Take-off Thrust Control System (ATTCS)"], specifies the minimum reliability levels for these automatic systems. In addition to showing compliance with these reliability levels for certain combinations of failures, other failure conditions that can arise as a result of introducing such a system must be shown to comply with CS 25.901(c)/CS 25.1309.

d. Thrust Management Systems. A System Safety Assessment is essential for any aeroplane system that aids the crew in managing engine thrust (i.e., computing target engine ratings, commanding engine thrust levels, etc.). As a minimum, the criticality and failure hazard classification must be assessed. The system criticality will depend on:

— the range of thrust management errors it could cause,

— the likelihood that the crew will detect these errors and take appropriate corrective action, and

— the severity of the effects of these errors with and without crew intervention.

The hazard classification will depend on the most severe effects anticipated from any system. The need for more in-depth analysis will depend upon the systems complexity, novelty, initial failure hazard classification, relationship to other aircraft systems, etc.

(1) Automated thrust management features, such as autothrottles and target rating displays, traditionally have been certified on the basis that they are only conveniences to reduce crew workload and do not relieve the crew of any responsibility for assuring proper thrust management. In some cases, malfunctions of these systems can be considered to be minor, at most. However, for this to be valid, even when the crew is no longer directly involved in performing a given thrust management function, the crew must be provided with information concerning unsafe system operating conditions to enable them to take appropriate corrective action.

(2) Consequently, when demonstrating compliance with CS 25.901(c)/CS 25.1309, failures within any automated thrust management feature which, if not detected and properly accommodated by crew action, could create a catastrophe should be either:

(i) considered a catastrophic failure condition when demonstrating compliance with CS 25.901(c)/CS 25.1309(b); or

(ii) considered an unsafe system operating condition when demonstrating compliance with the warning requirements of CS 25.1309(c).

e. Thrust Reverser. Compliance with CS 25.933(a) (“Reversing systems”) provides demonstration of compliance with CS 25.901(c)/CS 25.1309 for the thrust reverser in-flight deployment failure conditions. A standard CS 25.901(c)/CS 25.1309 System Safety Assessment should be performed for any other thrust reverser-related failure conditions.

7. TYPICAL FAILURE CONDITIONS FOR POWERPLANT SYSTEM INSTALLATIONS.

The purpose of this section is to provide a list of typical failure conditions that may be applicable to a powerplant system installation. This list is by no means all-encompassing, but it captures some failure conditions that have been of concern in previous powerplant system installations. The specific failure conditions identified during the preliminary SSA for the installation should be reviewed against this list to assist in ensuring that all failure conditions have been identified and properly addressed.

As stated previously in this AMC, the assessment of these failure conditions may range from a simple report that offers descriptive details associated with a failure condition, interprets test results, compares two similar systems, or offers other qualitative information; to a detailed failure analysis that may include estimated numerical probabilities. The assessment criteria, process, analysis methods, validation, and documentation should be consistent with the guidance material contained in AMC 25.1309.

a. Fire Protection System - Failure Conditions:

(1) Loss of detection in the presence of a fire.

(2) Loss of extinguishing in the presence of a fire.

(3) Loss of fire zone integrity in the presence of a fire.

(4) Loss of flammable fluid shut-off or drainage capability in the presence of a fire.

(5) Creation of an ignition source outside a fire zone but in the presence of flammable fluids.

b. Fuel System -- Failure Conditions:

(1) Loss of fuel feed/fuel supply.

(2) Inability to control lateral and longitudinal balance.

(3) Hazardously misleading fuel indications.

(4) Loss of fuel tank integrity.

(5) Loss of fuel jettison.

(6) Uncommanded fuel jettison.

c. Powerplant Ice Protection - Failure Conditions:

(1) Loss of propeller, inlet, engine, or other powerplant ice protection on multiple powerplants when required.

(2) Loss of engine/powerplant ice detection.

(3) Activation of engine inlet ice protection above limit temperatures.

d. Propeller Control - Failure Conditions:

(1) Inadvertent fine pitch (overspeed, excessive drag).

(2) Inadvertent coarse pitch (over-torque, thrust asymmetry)

(3) Uncommanded propeller feathering.

(4) Failure to feather.

(5) Inadvertent application of propeller brake in flight.

(6) Unwanted reverse thrust (pitch).

e. Engine Control and Indication -- Failure Conditions:

(1) Loss of thrust.

(2) Loss of thrust control, including asymmetric thrust, thrust increases, thrust decreases, thrust fail fixed, and unpredictable engine operation.

(3) Hazardously misleading display of powerplant parameter(s).