

Certification Memorandum

Required material properties and structural residual strength for Fireproof / Fire-resistance compliance demonstration

EASA CM No.: CM-S-015 Issue 01 issued 07 July 2025

Regulatory requirements: CS 27/29.861, 29.1181, 27/29.1183, 27/29.1191, 27/29.1193, 27/29.1194

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Log of issues

Issue	Issue date	Change description
01	25 July 2025	First issue

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1. Introduction

1.1. Purpose and scope

The purpose of this Certification Memorandum is to provide guidelines and Interpretative Material relating to Fireproof / Fire Resistance compliance demonstration for CS-27 Category A (including specific CS-29 provisions quoted in CS-27 Appendix C) and CS-29 Category A rotorcraft.

1.2. References

It is intended that the following reference materials be used in conjunction with this Certification Memorandum:

Reference	Title	Code	Issue	Date
[1]	CS-Definition	CS-Definition	Amdt 2	16/12/2010
[2]	Certification Specifications for Large Rotorcraft	CS-29	All	N/A
[3]	Certification Specifications for Small Rotorcraft	CS-27	All	N/A
[4]	Acceptable Means of Compliance to CS-27 Book 1	CS-27 Book 2	All	N/A
[5]	Acceptable Means of Compliance to CS-29 Book 1	CS-29 Book 2	All	N/A
[6]	Powerplant Installation and Propulsion System Component Fire Protection Test Methods, Standards and Criteria with change 1	AC 20-135	Change 1	11/10/2018
[7]	Aircraft – Environmental test procedure for airborne equipment – Resistance to fire in designated fire zones	ISO 2685	-	15/12/1998

1.3. Definitions

Fire Resistance	With respect to materials, components and equipment, means the capability to withstand the application of heat by a flame, as defined for 'Fireproof', for a period of 5 minutes without any failure that would create a hazard to the aircraft. For materials this may be considered to be equivalent to the capability of withstanding a fire at least as well as aluminium alloy in dimensions appropriate for the purposes for which they are used [1]
Fireproof	With respect to materials, components and equipment, means the capability to withstand the application of heat by a flame, for a period of 15 minutes without any failure that would create a hazard to the aircraft. The flame will have the following characteristics:

	<ul style="list-style-type: none"> • Temperature 1100°C ± 80°C • Heat Flux Density 9.3 BTU/s.ft2 or 95 kW/m2 as AC 20-135 Paragraph 6.b <p>For materials this is considered to be equivalent to the capability of withstanding a fire at least as well as steel or titanium in dimensions appropriate for the purposes for which they are used [1].</p> <p>Note: In this CS definition, reference to titanium is valid for non-loaded structures.</p>
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Table 1: Fire-resistant & Fireproof Summary table

	Duration	Criteria
Fire-resistant	5 minutes	No failure that would create a hazard to the aircraft
Fireproof	15 minutes	No failure that would create a hazard to the aircraft

2. Background

Rotorcraft fire protection - General

CS-27 and CS-29 address the threats due to fire on the whole rotorcraft with specific certification specifications CS27/29.861, .1183, .1191, .1193 and .1194 and CS29.1181 that are adapted to the particular threat (e.g. engine, APU, cargo load, oxygen, battery, flammable fluids, electrical, etc). With the inherent and likely occurrence of fire due to the presence of combustion chambers, CS 27 and CS-29 contain unique fire protection certification specifications for combustion heaters, APU and engine installation.

To address those threats, the CS27/29.861, .1183 and CS29.1181 require that structure, panels, piping, equipment and wiring are capable of withstanding a certain level of fire upon being exposed to either direct effect (flame) or indirect effect of fire (heat).

Generally, CS-27 and CS-29 contain criteria for design elements to be either fireproof or fire resistant depending on if it is located in or adjacent to a fire zone respectively. Definitions of fireproof or fire resistant are defined in [1], specifying respectively 15 min. and 5 min. capability to perform the function under a 1100°C ± 80° flame having a heat flux of 9.3 BTU/s.ft2 or 95 kW/m2 as AC 20-135 Paragraph 6.b.

Thermal protection can be installed in the area exposed to fire, but the residual strength conditions should be considered for the structural elements (parts) as described in this Certification Memorandum.

Notes:

1. This CM addresses the ability of both loaded and non-loaded structure to resist the effects of fire. The loaded or non-loaded structure classification should be made for each project considering the loading condition, the safety assessment and also the criteria given in the existing standard (e.g ISO 2685). When these structural elements are part of systems, additional criteria can be applicable to demonstrate their performance under fire conditions. These criteria are not addressed in this CM. Outgassing, toxicity, backside ignition generated by the fire condition are not addressed in this CM and should be investigated according to the relevant requirement and guidance.
2. This CM only addresses the static residual strength characteristics of the components affected by fire for fireproof, fire resistance or fire condition up to the total time duration under consideration. However, for parts subject to high cycle damage accumulation in normal flight conditions, the applicant should determine the residual strength of the part during the fire exposure period considering the damage accumulated prior to fire.
3. More generally, the applicant should check if the material characteristics degradation (strength, stiffness, deformation...) under fire do not detrimentally affect the flight performances.

4. When repairs or modifications are performed, the effect on the fireproof and fire-resistance characteristics should be checked. If initially selected for certification, this CM should be considered in the compliance demonstration.

3. EASA Certification Policy

3.1. Fire protection

The conditions for fireproof and fire-resistant are addressed in the CS-Definition (see paragraph 1.3). For structural parts/components, material properties can be used to demonstrate fireproof along with other various compliance means. When the function performed under fire conditions includes loads carrying capability, the reduced material strength which occurs under these conditions should be evaluated.

This CM clarifies when the use of material properties as a means of compliance (MC 1) is acceptable or not to demonstrate fireproof for structural parts. It also clarifies the load conditions to be considered in the event of a fire.

3.2. Fire protection of structure, controls, and other parts

Whenever a material with fire withstanding capability is used for a structure, it should be capable of sustaining the appropriate loads with a positive margin of safety under heat/fire conditions. This should be demonstrated over the complete load path where heat/flame conditions exist:

- under direct flame impingement, when structural load paths are running partially or totally in a designated fire zone and
- under heat effect, when structural load paths are running partially or totally behind a shield (i.e. adjacent zone to a designated fire zone).

3.2.1. Loaded structure

The following approaches should be considered for fire protection demonstration on loaded structure:

1. The following materials that are commonly used on engine and APU mounts and have been previously accepted as fireproof by EASA can be considered fireproof provided that dimensions / loading capability under limit and ultimate load condition (no fire condition) are substantiated:
 - a. AISI 4100 series and 15-5PH CRES steels,
 - b. Inconel 718.
2. For other steel, nickel-chromium and titanium alloys, material data evidence should be provided to show that these alloys can maintain structural integrity under fire conditions, in order to be accepted as fireproof. Validated analysis may be required to justify the temperature/stress levels.
3. For other materials, such as aluminium, composites and elastomers, compliance should be shown by test, or analysis supported by test, in order to be accepted as fireproof. A similar level of compliance demonstration should be performed for loaded structure made of aluminium material to be declared fire resistant, including:
 - a. Compliance demonstration by a combination of thermal analysis and stress analysis might require intensive testing to validate the models. Analysis should include the most conservative operating conditions (i.e. Max. outside air temperature (OAT), Max. engine/APU torque/power/vibrations).
 - b. Similarly, analysis may not be appropriate for elastomeric material where vibrations have a detrimental effect on elastomeric compound integrity while under fire. If disaggregated under vibration and fire, the introduced effect on the relative freedom should be assessed.
 - c. Alternatively, a loaded fire test with representative thermal and other environmental conditions, including vibrations (with isolation or shielding, if this is part of the type design definition), can be performed.

4. The following criteria are deemed applicable to the structure including elastomeric materials:
 - a. The structure should be able to support limit flight and landing loads¹ (including engine limit torque and all engines operative (AEO) condition) without failure for at least 5 minutes. One Engine Inoperative (OEI) limits are not applicable for engine exposed to the fire.

For fireproof material, after 5 minutes and until the end of 15 minutes, the engine/APU may be assumed to be shut down and the structure should be able to support the following load conditions, consistent with any limitations given in the Flight Manual for autorotation or OEI, as applicable:

1. Max operational flight and landing loads of 27.571(a)(3), 29.571(e)(1) and 27/29.573(d)(3)(ii), as applicable, including
 - I. pull-up manoeuvres to no less than 2.0g
 - II. full pedal spot turns
2. Power-off and autorotation conditions are included and
3. Limit loads for gusts (27/29.341)

Note:

- Load conditions to be agreed with the Authority
- No probability of occurrence to be taken into account (probability of 1)

3.2.2. Non-loaded structure

1. Steel and titanium elements that have dimensions appropriate for the intended use can be declared as being fireproof in accordance with the definition in CS-Definition. Examples of acceptable minimum thicknesses are given in AC27/29.1191 which contains Figure AC 27/29.1191-1 (*TABLE OF MATERIALS AND GAGES ACCEPTABLE FOR FIREPROOF PROTECTIVE DEVICES WITH FLAT SURFACE GEOMETRIES*) Aluminium elements that have dimensions appropriate for the intended use can be declared fire resistant in accordance with the definition in [1]. The applicant should substantiate the appropriateness of the thickness of the aluminium element for the function required to be performed under fire conditions.
2. Aluminium cannot be directly considered fireproof in accordance with the definition in CS-Definition and would require justification based on tests with representative environmental conditions.

Composite and other material would require justification based on tests with representative environmental conditions. Further guidance can be found in AC [9] and ISO [10].

3.3. Who this Certification Memorandum affects

CS 27 Category A and CS 29 Category A rotorcraft.

4. Remarks

1. For any question concerning the technical content of this EASA Certification Memorandum, please contact:

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¹ Limit load is considered as ultimate, i.e. safety factor = 1.0. No failure permitted and deformation should not prevent continued safe flight and landing. This is also applicable for the continued fire situation.