Certification Memorandum

Composite Materials - The Safe Design and Use of Monocoque Sandwich Structures in Principal Structural Element Applications

EASA CM No.: CM–S-010 Issue 01 issued 29 November 2018

Regulatory requirement(s): AMC 20-29 (CS-23 – commuter aircraft, CS-25, CS-27 and CS-29)

In accordance with the EASA Certification Memorandum procedural guideline, the European Aviation Safety Agency proposes to issue an EASA Certification Memorandum (CM) on the subject identified above.
All interested persons may send their comments, referencing the EASA Proposed CM Number above, to the e-mail address specified in the “Remarks” section, prior to the indicated closing date for consultation.

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Log of issues

Issue	Issue date	Change description
01	29.11.2018	First issue.

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1. Introduction

1.1. Purpose and scope

The intent of this Certification Memorandum (CM) is to support the safe design and use of sandwich structures, particularly monocoque sandwich structures classified as Principle Structural Elements (PSEs).

This CM was developed, with the support of industry and other regulators.

As indicated in the title sheet, a CM is intended to provide 'complimentary information and guidance'. Therefore, it does not replace existing established rules and guidance, e.g. CS2x.573, AMC 20-29, AC 29-2C etc, but highlights some themes which experience has demonstrated can be problematic and which may require particular attention.

This CM does not specifically address fixed wing or rotorcraft applications, but focuses on the broader concept of monocoque sandwich structures.

The intent of this CM has already been implemented, in part, in some recent projects via EASA Means of Compliance (MoC) Certification Review Items (CRIs). The CM highlights issues which have been a challenge to some sandwich structures and which could be of particular relevance to the potentially more critical subset of monocoque sandwich structures. This CM acknowledges that there exist established examples of sandwich structures which have been used safely in critical applications, e.g. rotor blades, some small aircraft wing structures etc. However, these typically include mitigating factors relative to other designs, e.g. configurations defined by limited dominant load cases, progressive and readily evident damage modes, very low strain levels etc. Therefore, the CM does not attempt to change such established practices, but encourages the use of such practices and other mitigating actions when designing monocoque sandwich structures.

It is recognized that the performance of sandwich structures is dependent upon following strict process controls and the use of appropriate configuration details. Furthermore, it is also recognised that more recent applications of monocoque sandwich structures tend to be associated with thicker skin and heavier core configurations than is typical of control surface and high lift device designs. Therefore, this CM does not attempt to address all issues associated with these lighter weight sandwich structures, such as the effect of pressure cycles upon CS25 control surfaces*. However, this CM does benefit from some of the applicable 'lessons learned' relating to this activity.

*Pressure cycles may occur in a sealed open cell sandwich structure due to changes in the external atmospheric pressure and/or changes in temperature of the gases in the core and have resulted in the failure of thinner skin and lower density core sandwich structures, including repairs to such structure. This is the subject of a current CMH-17 task group activity and may result in subsequent CM action.

1.2. References

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

Reference	Title	Code	Issue	Date
CS 2X.305	Strength and Deformation	CS-2X	---	---
CS 2X.307	Proof of Structure	CS-2X	---	---

Reference	Title	Code	Issue	Date
CS 2x.57X	Damage Tolerance and Fatigue	CS-2X	---	---
CS 23.573(a)(5) Note: CS23 is under revision, ref. NPA 2016-05. The existing intent of CS 23.573(a)(5) at the time of publication of this CM is to be continued in subsequent related guidance material, e.g. CMH-17, ASTM etc	Damage tolerance and fatigue evaluation of structure (a) Composite airframe structure	CS-23	---	---
CS 2X.601	General	CS-2X	---	---
CS 27/29.602	Critical Parts	CS-27/29	---	---
CS 2X.603	Materials and workmanship	CS-2X	---	---
CS 2X.605	Fabrication Methods	CS-2X	---	---
CS 2X.613	Material Strength Properties and Design Values	CS-2X	---	---
AMC 20-29	Composite Aircraft Structure	CS-2X	---	---
AC 27/29.573	Damage Tolerance and Fatigue Evaluation of Composite Rotorcraft Structures	CS-27/29	---	---
REPORTS				
DOT/FAA/AR-99/49	Review of Damage Tolerance of Composite Sandwich Airframe Structures			08/1999
DOT/FAA/AR-02/121	Guidelines for Analysis, Testing, and Nondestructive Inspection of Impact-Damaged Composite Sandwich Structures			03/2003
CMH-17 Vol.6	Structural Sandwich Composites			2013
MEETINGS				

Reference	Title	Code	Issue	Date
https://www.easa.europa.eu/newsroom-and-events/events/european-bonded-structure-meeting#group-easa-downloads	Proceedings - EASA Bonded Structure Workshop - June 2013			2013
http://www.easa.europa.eu/newsroom-and-events/events/easafaa-sandwich-structure-workshop#group-easa-downloads	Proceedings – EASA/FAA Sandwich Structure Workshop - October 2016			2016
Outcome available at subsequent CMH-17 meetings	Proceedings – CMH-17 Disbond/Delamination TG, EASA/FAA Meeting – 19-20th September 2017			2017

1.3. Abbreviations

AMC	Acceptable Means of Compliance
BC	Boundary Conditions
BDID	Barely Detectable Impact Damage (rotorcraft)
BVID	Barely Visible Impact Damage
CM	Certification Memorandum
CMH-17	Composite Material Handbook-17
CS	Certification Specification
DD	Detectable Damage (rotorcraft)
DT & F	Damage Tolerance and Fatigue (rotorcraft)
FAA	Federal Aviation Administration
F&DT	Fatigue & Damage Tolerance (fixed wing)
ICA	Instructions for Continued Airworthiness
LL	Limit Load
NDI	Non Destructive Inspection
OSD	Operational Suitability Data
PSE	Principal Structural Element
SMS	Safety Management System
UL	Ultimate Load

1.4. Definitions

Adhesion Failure	A mode of failure associated with separation at the adhesive-adherend interface, usually the result of inadequate bonding.
Barely Detectable Impact Damage	Damage at the threshold of detectability for the approved inspection procedure. (rotorcraft)
Barely Visible Impact Damage	Damage at the threshold of visually detectable damage associated with a detailed visual inspection procedure. (fixed wing)
Co-bonded structure	Components bonded together during cure of one, or more, of the components, but not all components, e.g. bonding to metallic or a pre-cured component.
Co-cured Structure	Structure obtained by a single cure of uncured components
Critical Structure	A load bearing structure/element whose integrity is essential in maintaining the overall flight safety of the aircraft. (AMC 20-29)
Detectable Damage	Damage that can be reliably detected at scheduled inspection intervals
'Grandfathered'	Expression used to refer to the continued use of previously used technologies, design concepts etc. Such experience can reduce the extent of certification work necessary for a new design. However, although such an approach can improve certification efficiency when confidence has been developed with any particular applicant, the acceptable extent of credit for previous practice will be subject to 'engineering judgement' and agreement between the applicant and regulator. .
Monocoque	Thin shells which rely entirely upon the skins for the capacity to resist loads (Megson). Note: For the purposes of this CM a sandwich structure forming a shell comprising 2 skins and a core (e.g. fuselage or tail boom) is considered to be the 'thin shell', and thus described as a monocoque.
Principal Structural Element	Principal Structural Elements are structural elements that contribute significantly to carrying flight, ground, or pressurisation loads, and whose integrity is essential in maintaining the overall structural integrity of the aeroplane (AMC 25.571). Similarly, per AC29-2C Change 4, AC 29.573, a PSE is a structural element that contributes significantly to the carrying of flight or ground loads and whose failure can lead to catastrophic failure of the rotorcraft..
Telegraphing	Excessive undulation of the sandwich panel skin resulting from excessive overpressure during the autoclave process
Weak Bond	A bond line with mechanical properties lower than expected which cannot be reliably detected using non-destructive inspection (NDI) procedures currently applied to industry. Such situations may result from poor chemical bonding caused by contaminations of the surfaces including presence of peel ply material left within the structure during the cure (ref. AMC 20-29)

Witness Structure	A structure used in service which provides a defined indication of an event having occurred which may be correlated with other less evident damages in the structure of interest and which is related to, or is aggravated by, the same event. Such witness indications may be used to drive further airworthiness actions applicable to potentially damaged structure, e.g. initiate more detailed inspections, etc. The use of such witness structures requires particularly thorough substantiation and may be limited in scope of application. Note: the term 'Witness Structure' should not be confused with Process Control Specimens (PCS) used in the production process.

2. Background

2.1. General

Sandwich structures have been used successfully throughout the recent decades in many applications, e.g. in small, and large, fixed wing and rotorcraft structures, including many Primary structures, PSE structures and some monocoque structures. However, there have also been several significant incidents involving sandwich structures (of various configurations in various applications) which have presented a potential safety concern, as discussed at recent workshops and seminars, e.g. the European Bonded Structure Workshop EASA - June 2013, the EASA/FAA Sandwich Structure Workshop – October 2016, and at various CMH-17 Meetings .

There have also been a growing number of component development and certification test failures which exhibited unexpected or premature failure in terms of load level and/or damage mode and/or location. Although development tests have not typically been considered to form part of the formal certification process, they can contribute significantly towards understanding and gaining confidence in the final design. These failures have been associated with one or more of the potentially large number of competing damage modes possible in sandwich structures, e.g. ref. CMH-17 Volume 6, some of which are not readily detectable, either visually or by NDI. Therefore, it is considered appropriate to more explicitly emphasise the importance of strict manufacturing process controls and the use of a robust damage tolerance philosophy which includes identification of all likely damage modes.

Furthermore, it is also considered to be necessary to simulate likely undetectable damage (realistically or conservatively) during certification or engineering tests, in addition to the consideration of disbond or weak bonds, as is typically included in current design substantiation processes.

Failures in sandwich structures sometimes can be attributed to a combination of many factors, including deficiencies in design, production and/or continuing airworthiness activities. Therefore, it is considered appropriate to emphasise the importance of integrated involvement of all responsible organisations in the supply, design, production, and continuing airworthiness processes, i.e. in accordance with SMS and OSD processes, as appropriate to the product.

Although AMC 20-29 and AC 29 2C MG8 could be interpreted as excluding sandwich structures from the requirements associated with bonded structure, e.g. AC 29 2C MG8 cites sandwich structures as being examples of co-cured structures, this would seem to be inappropriate, particularly when considering PSE sandwich designs as addressed in this CM, because many sandwich structures comprise of metallic and/or pre-cured skins and/or cores. Unless individual elements of the monocoque sandwich shell, e.g. inner skin, outer skin, can be demonstrated to independently satisfy the requirements, then it would seem to be appropriate to address the bonding requirements (e.g. CS23.573(a)5) for such structure. These include the requirements for rigorous process control and for 'design features' intended to prevent catastrophic failure, typically considered to be discrete 'back-up' features or 'arrest' features. However, in the absence of discrete design features intended to avoid catastrophic failure, other mitigating actions may be acceptable subject to agreement with EASA.

Demonstration of the use of rigorous process control and good design practice is expected for PSEs in general and as described in existing rules and guidance materials, e.g.DOT/FAA/AR-99/49, DOT/FAA/AR-02/121 etc. Additional mitigating factors that may further justify the use of sandwich structures in monocoque PSE applications should be identified and agreed with the Agency*.

*Note: This CM is intended to be developed and revised as part of a broader sandwich structure focused activities and in conjunction with a broader ARAC Damage Tolerance task which will include consideration of monocoque structures within its scope of activity.

2.2. Related regulations

CS 2X.601 Design states the structure:

'(a) …may have no design features or details that experience has shown to be hazardous or unreliable.
(b) The suitability of each questionable design detail and part must be established by tests.'

CS 29.602 Critical Parts states for rotorcraft:

'(a) …A critical part is a part, the failure of which could have a catastrophic effect upon the rotorcraft, and for which critical characteristics have been identified which must be controlled to ensure the required level of integrity.

(b)…Procedures shall be established to define the critical design characteristics, identify processes that affect those characteristics, and identify the design change and process change controls necessary for showing compliance with the quality assurance requirements of Part 21.'

AMC 20-29 Composite Aircraft Structures/ACs 27/29.573 Damage Tolerance and Fatigue Evaluation of Composite Rotorcraft Structures

AMC 20-29 makes clear the expectations for all 'critical structures' regarding materials, design, production, and continued airworthiness. This includes identification of the need to use appropriate F&DT criteria and identifies the unacceptability of any defect remaining undetected such that UL cannot be maintained, e.g. AMC 20-29 Figure 4.

AMC 20-29 also refers to the need to observe linkage to basic strength and data reliability requirements, e.g. CS2X.305, 2X.307, 2X.603, and 2X.613 etc., and also the need to address bonded structure.

AMC 20-29 further identifies the need to consider the potential for disbonded structure, or 'weak bonds', which may remain undetected, and that adhesion failure is unacceptable.

AMC 20-29 refers to AC 21-26 "Quality Control for the Manufacture of Composite Structures"

Note: AMC 20-29 was partly developed from ACs 27/29.573 respectively to provide generic guidance for both fixed wing and rotorcraft. These ACs, and supporting references, provide further guidance specific to rotorcraft bonded/sandwich structures.

3. EASA Certification Policy

3.1. EASA Policy

EASA considers that PSEs utilising monocoque sandwich structures, including repairs to those structures should be treated with caution, paying particular attention to rigorous process and robust design practice, as may be expected for any sandwich structure PSE. However, particular attention should be paid to the points identified in the following text. Furthermore, additional mitigating factors should be clearly identified and substantiated in support of the use of such structures in PSE applications:

3.1.1. Qualification of the manufacturing process

The manufacturing process should be fully qualified and all production parts shown to comply prior to achieving Type Certification. Any supporting development data must be shown to be applicable and traceable.

The qualification is intended to demonstrate that the combination of material, tooling, equipment, procedures, and other controls, making up the process, will produce representative parts having consistent material properties that conform to design requirements.

As part of the process qualification, destructive tests, non-destructive inspections (NDI), and specimen level tests should be conducted to determine conformity to specified design requirements, paying particular attention to ensuring that the specifications are appropriate and that the following features remain within the specified and substantiated limits:

- Uniformity of the adhesive fillets between honeycomb core cell wall and skin, in particular the process should ensure that on both faces of the honeycomb core a regular shaped fillet (meniscus) be established.
- 'Telegraphing' effects and waviness on the skins of the sandwich panel
- Distortion of the core cells. This defect could be particularly critical for highly curved panels unless suitable precautions are taken during fabrication (e.g. core thermal conforming).
- Adhesive porosity or humidity.
- Disbonds between core and skin (facesheet)
- Minimising the risk of weak bonds by following rigorous established robust processes

3.1.2. Process specifications

Specifications covering fabrication procedures have to be established to ensure that repeatable and reliable structure can be manufactured.

The process specification should include all necessary instructions to manufacture, inspect, and test the produced parts in order to ensure that they consistently conform to the one that has been qualified (see point 3.1.1 above).

The process specification should typically include information required by AC 21-26, paying particular attention to:

- Procedures for accepting the in-coming material (skin, adhesive (when used) and core) and instructions for its handling and storing conditions.
- Instructions for material preparation and curing cycles.
- Inspection procedures and quality control tests.

3.1.3. Material strength and determination of design allowable

Sandwich panel strength, including stiffness, properties should be established in order to ensure that the probability of structural failure due to material and process variability is minimised. Consideration of stiffness is of particular importance for understanding local and global stability in sandwich structures.

Because of the specifics of sandwich panel configurations, the material properties should be established on specimens representative of the panel construction in terms of skin, adhesive (when used), core material and curing cycle.

Design features such as transition zones from solid laminate to core/skin should also be tested with representative specimens for determination of strength properties.

Typically (depending upon application), the following static strength (and associated stiffness) properties may need to be established according to the statistics required under CS 2X.613:

- Adhesive Shear Strength.
- Shear Core Strength (Ribbon and Transverse direction).
- Core Compression Strength.
- Flatwise Strength.
- Flexural Strength.
- Compressive Strength.
- Bearing Strength (for specimen representative of all the panel areas where fasteners are installed and subject to significant bearing stresses.)
- Fastener pull-out strength
- Panel pull-out strength (panel assemblies joined and inclined relative to one another)
- Core transverse tension strength
- Face to core tension strength

In determining the above properties, the effect due to humidity uptake, highest and lowest temperature expected in service, manufacturing defects up to limit of acceptability, and impact damage should be also considered.

The validity of engineering formulas used to establish analytical design allowables should always be verified by experimental data in order to assess the effects of the manufacturing process (e.g. curing pressure which is normally limited to the crush core strength) and environmental conditions on the allowable predicted by these formulas.

It is also expected that relevant specimen level fatigue testing of critical design features (e.g. fastened joints) and typical panel configurations be performed in order to assess the effects of the following on the fatigue strength:

- Material/Manufacturing Process variability.
- Environmental Condition.
- Allowable manufacturing defects.
- Impact damages.

3.1.4. Damage tolerance and residual strength

3.1.4.1. Threat survey and damage modes

As part of the showing of compliance with the applicable F&DT requirements, e.g. AMC 20-29, the applicant should clearly demonstrate that a robust structure has been produced by showing:

- That a thorough damage threat survey has been completed which identifies and defines all likely threats, including impacts, heat, moisture, etc. and the potential for interaction of these threats.
- That all potential damage modes have been identified for the configuration when subject to all likely threats, paying particular attention to all likely damage modes which might not be readily detected, e.g. including shear core failure etc., not only disbond.

  For example, to be confident regarding likely damage modes resulting from impact threats, it is considered to be appropriate to test throughout the threat impact energy range up to readily detectable damage using a range of appropriate impactor geometries, e.g. including sharp impactors and blunt impactors up to diameters agreed with EASA, e.g. for CS25, a range of impactors up to 4 inches diameter have been accepted, based upon typical protection device geometries carried by ground vehicles. Furthermore, it may be appropriate to consider a range of impactor stiffnesses, e.g. for hail, or ground vehicle rubber bumpers, such that all competing damage modes can be identified. Representative boundary conditions should be used in the substantiation test campaigns.

Note: Although not explicitly required by the regulations, the determination of governing damage modes following High Energy Wide Area Blunt Impacts (HEWABI) can further help to provide confidence regarding the performance of the structure, e.g. following Cat 5 events, and the relationship to the 'certifiable' damages as defined in AMC 20-29, such that appropriate inspection methods, and extents of inspection, ensure that the bounds of damage are correctly defined and appropriate repair action can be taken.

- That all potential damage modes determined by the threat assessment have been simulated in testing or are addressed by validated analysis.

- The possibility of interaction between threats, e.g. impact and heat, should be considered in the simulation and substantiation process.

Note: Witness structures, see 'Definitions', can be used in service, to initiate airworthiness actions, provided that a consistent and conservative correlation can be demonstrated to exist between the indications on the witness structure (which may be an existing part of the airframe structure) and the damage (all likely modes and extents) considered in the PSE structure of interest. For example, subject to appropriate substantiated correlation, hail damage to an existing thin metallic skin control surface structure could be used to determine the need, or otherwise, to initiate extensive NDI action for a composite structure which has the potential for non-visible damage modes etc.

Note: In some cases, it may be possible to conservatively bound many damage types, and thus reduce the detailed substantiation workload, by demonstrating a larger structural damage capability. However, this will require demonstration that all likely damage modes have been bounded by the structural damage capability assumption, e.g. a large penetration could be used to address all likely damage modes within the bounds of the penetration.

3.1.4.2. Residual strength

As is generally required for composites in the existing regulations, e.g. AMC 20-29, monocoque sandwich structure will be expected to demonstrate UL capability with damages at the limits of detectability resulting from fatigue, environmental degradation, accidental damages, e.g. BVID/DDID, and manufacturing defects, e.g. local disbonds, throughout, and at the end of, the product's life. However, noting that such structure has no alternative load paths available, and may not include discrete design features intended to avoid catastrophic failure, e.g. doublers, stringers etc., it is essential that damage and defects are more thoroughly understood, more so than would be expected for multi-load path structures.

Also, as required for composites, the applicant is to demonstrate that the monocoque sandwich PSEs can sustain no less than LL capability with detectable damage (e.g. Cat 2 per AMC 20-29, VID per AC 29 2C etc.), damage near LL capability with obviously detectable damage (e.g. Cat 3 per AMC 20-29, CVID per rotorcraft application), and 'continued safe flight and landing' with discrete source damage (e.g. Cat 4 per AMC 20-29) for all damage modes, particularly those which could be potentially catastrophic. However, unless the applicant can also demonstrate, to the satisfaction of the Agency, robust experience* using similar materials and processes in similar configurations at similar strain levels and in similar service environments, then any potentially catastrophic damage mode, which may not initially be readily detectable**, should be identified and addressed for growth up to readily detectable levels and/or should be demonstrated to exhibit 'no detrimental damage growth' under repeated loadings for the applicable duration. The intent is to ensure that the damaged structure demonstrates no-growth, or stable slow progressive growth (maintaining a predictable damage mode), i.e. it maintains a safe margin relative to the steep slope on the residual strength curve.

Furthermore, additional mitigating factors should be identified which may further justify the use of monocoque sandwich structures, in addition to rigorous processes and good design practices, as would typically be applied to multi-load path PSE sandwich structures, such as designing with very low strain levels, conservative use of notched data, structural damage capability beyond that necessary to address all likely damage modes and extents etc.

*Note: The application of 'grandfathered' technology (design and production aspects) should be treated with caution. A thorough and integrated design and production review should be completed, in conjunction with material suppliers, in order to ensure that any credit for the 'grandfathered' technology is appropriate for the new product. For example, recent sub-contractor changes in the existing project should be treated with particular caution because the 'grandfathered' credit may no longer be valid. Furthermore, extrapolation of data without appropriate substantiation should be avoided. Applicants are further reminded regarding the intent of CS2x.601. Furthermore, any corrective actions for previous problems also require thorough substantiation, as typically expected i.a.w. standard regulatory processes.

**Note: In order to ensure robust design of monocoque sandwich PSE structure applications, detectable damage should be considered to be associated with the larger damages (e.g. larger Cat 2 damages), not the smallest obviously detectable damage (e.g. BVID, BDID,VID). Sizing structure to the latter, e.g. a small, but readily detectable, hole in the skin, without addressing all other likely damage threats and potentially catastrophic damage modes, is unlikely to be considered to be an appropriate interpretation of AMC 20-29 or AC 27/29 that would result in a robust structure, particularly for monocoque sandwich PSEs.

3.1.5. SMS

Recognising that several structural failures have resulted from various combinations of design, production, and continued airworthiness deficiencies, EASA will expect the applicant to demonstrate that the structure has been subjected to the appropriate co-ordinated involvement of material suppliers, the design organisation (TC Holder), production organisations, and those with appropriate continued airworthiness experience throughout the supply, design, development, and certification processes.

The intent of such a co-ordinated effort should be the early identification of hazards and the assessment of potential risks relative to the recognised criticalities and design complexities, the manufacturing process, the envisaged production supply chain and environment, particularly with respect to continued airworthiness implications. Appropriate actions should then be developed and documented for risk mitigation, including the necessary organisational policies and procedures in order to ensure the integrity, efficiency and effectiveness of the action taken in addition to appropriately managing changes when occurring to the approved design and production.

3.1.6. ICA

The ICA must include clear instructions for both internal and external inspection:

- which address all load paths* following significant impact events, e.g. up to load transfer fittings, joints, other significant changes in stiffness and section. Consideration of such impact events include overload events, e.g. ground equipment impact, heavy landing, excessive gust etc.,
- for all structure regularly exposed to extreme temperatures, e.g. local to engine outlets and/or aircraft used extensively in hot climates, etc. Although inspection intervals should have been justified according to the level of detectability and residual strength capability during certification substantiation based upon a damage threat survey, experience has indicated that interaction between heat and damage can be difficult to simulate during certification and can be challenging.

*paying particular attention to:

- previously completed repairs and the surrounding repaired structures

- any existing ICA , e.g. existing Airworthiness Directives, etc., which could be affected by the event or damage.

The ICA must include adequate information on allowable damage limits, including identification of the NDI techniques and equipment necessary to inspect the structure, and the actions necessary to return the aircraft to an airworthy condition when damage is found.

3.2. Who this Certification Memorandum affects

This CM could affect applicants who need to show compliance with requirements identified in AMC 20-29, e.g. CS-2X.573, 2X.603, 2X.605, and 2X.613, etc. when using monocoque sandwich structure in PSEs, particularly paying attention to single load path applications.

Note: Although primarily addressing CS23 – commuter, CS25, CS27, and CS29, this CM includes content which may also be useful when addressing smaller CS23 and VLA aircraft.

4. Remarks

1. Suggestions for amendment(s) to this EASA Certification Memorandum should be referred to the Certification Policy and Safety Information Department, Certification Directorate, EASA. E-mail CM@easa.europa.eu.
2. For any question concerning the technical content of this EASA Certification Memorandum, please contact:

   Name, First Name: Waite, Simon

   Function: Senior Expert - Materials

   Phone: +49 (0)221 89990 4082

   E-mail: simon.waite@easa.europa.eu