Certification Memorandum

Bonded Repair Size Limits in accordance with CS-23, CS-25, CS-27, CS-29 and AMC 20-29

EASA CM No.: CM-S-005 Issue 01 issued 11 September 2015

Regulatory requirement(s): **CS-23, CS-25, CS-27, CS-29**

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Log of issues

Issue	Issue date	Change description
01	11.09.2015	First issue.

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1. Introduction

1.1. Purpose and scope

This Certification Memorandum (CM) provides guidance regarding the determination of Bonded Repair Size Limits for composite (typically polymeric) and metallic (monolithic and sandwich) critical structures (as classified by the TCHs) in accordance with CS 23, CS-25, CS-27, CS-29 and AMC 20-29.

This CM primarily addresses certification associated with continued airworthiness as appropriate to both TC holders and non-TC holders. However, AMC 20-29 also recognises that the engineering properties associated with composite material, and bonded structure in particular, can be very dependent upon sensitive materials and processes which may be completed in challenging service environments. Therefore, this CM also provides some background guidance to organisations engaged in repair activities regarding the possible reasons for some repair size limitations.

The content of this CM may be used to assist in the determination of repair classification and the policy, Section 3.1, is not intended for repairs finally determined to be minor repairs.

This CM applies to those projects with an application date that is on or after the effective date of the policy. If the date of application precedes the effective date of the policy and the methods of compliance have already been coordinated with and approved by the EASA, the applicant may choose to either follow the previously acceptable methods of compliance or follow the guidance contained in this policy.

Note: This CM policy text, Section 3.1, was harmonised with FAA and TCCA.

1.2. References

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

Reference	Title	Code	Issue	Date
AC 43-214	Repairs and Alterations to Composite and Bonded Aircraft Structures	---	---	---
AMC 20-29	Composite Aircraft Structure	---	---	---
AMC 145.A.42(c)	Acceptance of Components	---	---	---
CS 2x.571	Fatigue and Damage Tolerance	CS-23, CS-25, CS-27, CS-29	---	---
CS 2x.573	Fatigue and Damage Tolerance	CS-23, CS-27, CS-29	---	---
CMH-17	Composite Materials Handbook - 17	---	---	---
Part 21, Subpart J	Design Organisation Approval	---	---	---
Part 21, Subpart M	Repairs	---	---	---

1.3. Abbreviations

AC	Advisory Circular
AMC	Acceptable Means of Compliance
CM	Certification Memorandum

CAA	Civil Aviation Authority
CS	Certification Specification
DOA	Design Organisation Approval
EASA	European Aviation Safety Agency
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
PSE	Principle Structural Element
SRM	Structural Repair Manual
STC	Supplemental Type Certificate
TC	Type Certificate
TCH	Type Certificate Holder
TCCA	Transport Canada Civil Aviation
TD	Type Design

1.4. Definitions

Adherend	A body that is held to another body, usually by an adhesive. A detail or part prepared for bonding. (SAE AIR 4844)
Adhesion	The state in which two surfaces are held together by interphase forces. mechanical adhesion*, n*—adhesion between surfaces in which the adhesive holds the parts together by interlocking action. specific adhesion*, n*—adhesion between surfaces which are held together by intermolecular forces of a chemical or physical nature[1].(ASTM D 907-8b)
Adhesive	A substance capable of holding two materials together by surface attachment. Adhesive can be in film, liquid, or paste form. In this context, the term is used to denote structural adhesives, i.e., those which create attachments capable of transmitting significant structural loads. (SAE AIR 4844)
Adhesion Failure	Separation of the adhesive-adherend interface due to inadequate bonding.
Bond	The adhesion of one surface to another, with or without the use of an adhesive as a bonding agent.[2] (CMH-17, Vol. 1, Chapter 1 rev. F)

[1] Chemical adhesion is the primary goal for structural bonding discussed in this policy

[2] Uncured composite adherends may carry enough matrix material to complete adequate bonding when cured in place to form a bonded repair

Bonded Joint\Structure	See Structural Bonding (The term 'Bonded Joint\Structure' has typically been considered to mean Secondary Bonded structure. However, increasing diversity of material forms and processes has broadened the common meaning to include Co-bonding – see Figure 1)
Bonded Repair	A repair means elimination of damage and/or restoration to an airworthy condition following initial release into service by the manufacturer. For the purposes of this Policy, Bonded Repair refers to repairs using Co-bonding or Secondary Bonding, as described in these definitions. This includes repairs that use uncured skins bonded over sandwich core.
Co-bonded Structure	Components bonded together during cure of one of the components.
Co-cured Structure	Uncured components cured together.
Cohesion	The state in which the constituents of a mass of material are held together by chemical and physical forces. (ASTM 907-8b)
Cohesive Failure	Rupture of a bonded assembly in which the separation appears visually to be in the adhesive or the adherend. (ASTM D 907-8b)
Critical Structure	A load bearing structure/element whose integrity is essential in maintaining the overall flight safety of the aircraft.[3](AMC 20-29)
Critical Failure Mode	The failure mode most likely to compromise safety.
Cure	To develop the structural properties of an adhesive (or composite resin) by chemical reaction. (modified ASTM D 907-8b)
Debond	Same as disbond.[4] (AMC 20-29)
Disbond	An area within a bonded interface between two adherends in which an adhesion failure has occurred.[5] It may occur at any time during the life of the substructure and may arise from a wide variety of causes. Also, colloquially, an area of separation between two lamina in the finished laminate (in this case the term "delamination" is normally preferred). (AMC 20-29)
In-Production Repair	Repair completed before initial release of an aircraft or component from production for which design and substantiation has been appropriately supported by the design approval holder
In-service repair	Repair completed following initial aircraft release from production by TCH (or appropriately approved TCH original component subcontractors)

[3] This definition was adopted because there are differences in the definitions of primary structure, secondary structure, and principal structural elements (PSE) when considering the different categories of aircraft. For each product category, critical structure applies to those structures that must meet CS 2x.571/573. For example, critical structures for Large Aeroplanes are PSEs.

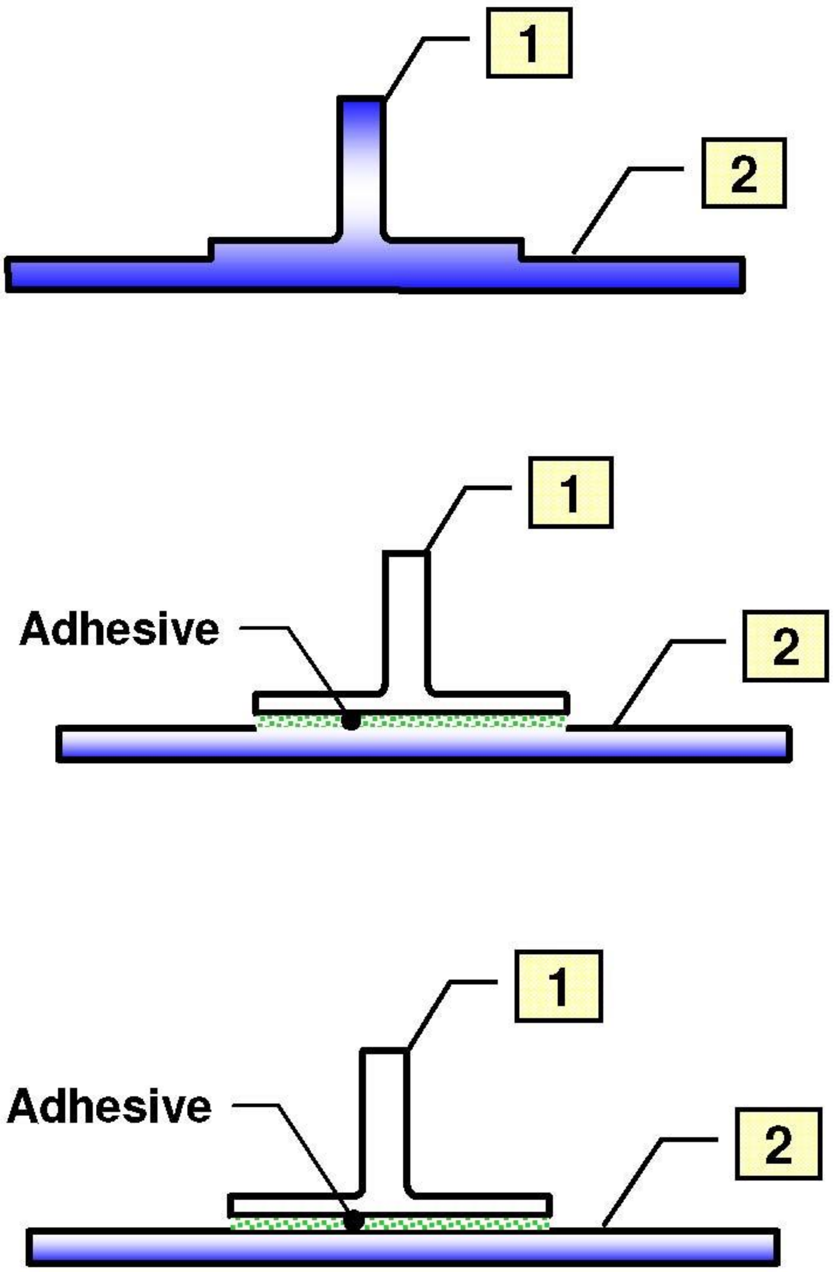
[4] "Debond" and "disbond" are used interchangeably throughout literature. The term "debond" may also apply to the process of deliberately separating joints, e.g., using heat guns, freezing etc., for the purposes of disassembly for access, repair etc.

[5] Disbond is usually unintended.

Primary Structure	The structure which carries flight, ground, or pressurization loads, and whose failure would reduce the structural integrity of the airplane. (AMC 20-29)
Principal Structural Element	Principal structural elements are those which contribute significantly to carrying flight, ground, and pressurisation loads, and whose failure could result in catastrophic failure of the aeroplane. Principal structural elements include all structure susceptible to fatigue cracking, which could contribute to a catastrophic failure (AMC 25.571 para.2)
Sandwich Constructions	Panels composed of a lightweight core material, such as honeycomb, foamed plastic, etc. to which two relatively thin, dense, high-strength or high-stiffness faces or skins are adherends. (See CMH-17 Volume 6) (SAE AIR 4844)
Secondary Bond	The joining together, by the process of adhesive bonding of two or more previously-cured composite parts or metal parts, during which the principal chemical or thermal reaction occurring is the curing of the adhesive itself.[6] (CMH-17 Vol. 1 Chapter 1 rev. F)
Structural Bonding	A structural joint created by the process of adhesive bonding, comprising of one or more previously-cured composite or metal parts (referred to as adherends). (AMC 20-29) Also, see the definition of “Co-cured Structure”.
Weak Bond	A bond line with mechanical properties lower than expected which cannot be detected reliably using non-destructive inspection (NDI) procedures currently applied by industry. Such situations result from poor chemical bonding.[7] (AMC 20-29)

[6] The word ‘Secondary’, historically used within the term ‘Secondary Bonding’, has been mistakenly considered to imply a lesser significance, e.g., in the sense of Secondary structure etc. For this reason, the intention of EASA and other CAAs is to avoid using this term in regulatory text. However, if used, the understanding of the term Secondary Bond should be clarified by the user.

[7] Poor chemical bonding could be due to several contributing factors (e.g., material incompatibility, pre-bond surface contamination, use of out-of-date materials, environmental degradation of the adherends).



<u>Co-Curing</u>:

Components cured together

- Component 1 uncured
- Component 2 uncured

(may include additional adhesive and/or continuous structural plies common to both Components 1 and 2)

<u>Co-Bonding</u>
(Structural Bonding):

Components bonded together during cure of one of the components

- Component 1 cured*
- Component 2 uncured

or
- Component 1 uncured
- Component 2 cured*

* or metal
(may not necessarily include additional adhesive)

<u>Secondary Bonding</u>
(Structural Bonding):

Components bonded together with separate bonding operation

- Component 1 cured*
- Component 2 cured*

* or metal

Figure 1. Bonded Structure – Definitions

(Airbus – Composites Workshop Tokyo 2009)

2. Background

The recent increased use of bonding as a principal means of fabricating *Critical Structures* on large aeroplanes (e.g., pressure hull and wing box structure) increases the likelihood of bonding being used as a viable repair option. In the past, bonded repairs have generally been limited to less critical structure, particularly in large aeroplane applications. Service experience shows that these repairs have not always been successful, resulting in unexpected bond failures. Without a reliable inspection technique to detect weak bonds or related bond failures, EASA has concluded that bonded repair of critical structure is a potential safety threat. Nonetheless, there have also been long established successes with bonded repairs and extensively bonded baseline structures, including many examples in the CS-22 gliding industry, small CS-23 aircraft industry, and the rotorcraft industry, the latter experience being recognized (in conjunction with some governing conditions) for safe utilization in critical joints, ref.AC29-2C MG8 para. 6.ii.C.3:

"*Critical bonded joints that have high static margins of safety (e.g. some rotor blades) may be acceptable, provided there is satisfactory service history of like or similar components.*".

Bonded repairs require careful design and strict processing control to ensure good quality for the specific materials and processes used for a given structure. Common processing errors such as high humidity, improper surface preparation, bondline contamination, insufficient control of cure temperature (either overheating or under-cure), loss of vacuum or pressure, and use of materials outside of time and temperature or calendar life limits can cause undetectable low bondline strengths. Currently, there are no reliable non-destructive inspection (NDI) techniques to ensure a bonded assembly has achieved full strength.

Further to addressing the adhesive, the baseline structure, and repair material surfaces, the bonded repair design and substantiation should also address the engineering properties of the baseline and repair materials. This includes consideration of the threats, those for metals being primarily fatigue and corrosion whilst the composite threat is primarily impact. Furthermore, the appropriate fatigue and damage tolerance philosophy should be adopted. For a mixed metal and composite configuration this may introduce hybrid structure issues, e.g. galvanic incompatibility and thermal expansion coefficient differences.

A bonded repair should be designed such that its failure does not become the critical failure mode for the baseline structure.

Once in service, a further problem associated with weak bonding is that environmental effects may continue to degrade the bond strength over time in an unpredictable manner. The effects of exposure to in-service loads and environmental aging should also be considered in the substantiation of repairs.

Good designs, qualified materials, proven processes, well-trained and experienced personnel, and existence of a structural substantiation database, iaw AMC 20-29 and other supporting documents, such as CMH-17, reduce the risk of disbonds or weak bonds.

Repair design substantiation following Part 21 procedures ensures the associated specific repair design data; including structural details, materials and process specifications, that must be followed when installing a repair provide a reasonable degree of confidence that the bondline will achieve full strength. Nonetheless, past experience has shown that there have been cases where critical structures with approved bonded repairs have contained undetected flaws that have resulted in inadequate strength of the bondline. Therefore, it is necessary to account for weak bonds in the design and substantiation of the repair and repaired structure. This results in the necessity to limit the size of bonded repairs such that the aircraft structure can sustain required regulatory loads in the event of a failed bonded repair. The substantiating data that supports proof of structure for the bonded repair should include the tests or analyses supported by tests that meet the applicable regulatory requirements for fatigue and damage tolerance, static and dynamic strength, material and fabrications specification, statistical material allowables, flutter behavior, and lightning protection.

The information developed for complete bonded repair substantiation is typically not readily available to the maintenance engineering community, unless supported by the TCH. Furthermore, significant investment in resources, testing and analyses are needed in demonstrating compliance with the appropriate rules for structural substantiation of a given structure. For these reasons, the non-TCH may be challenged when attempting to design a significant repair.

In-service bonded repairs are typically performed less frequently than production bonding activities and often occur in less stabilized service environments. As a result, an in-service bonded repair is more likely to have material property variation[8] , which may alter the basis for repair substantiation and result in less than Ultimate Load capability in the repaired condition. Therefore, in-service conditions and the availability of experts in bonded in-service repairs, should be considered in developing supporting maintenance documents. Such considerations may yield more conservative (smaller) repair size limits for repairs performed in the in-service environment than may be allowed with bonded factory repairs.

The bonded repair should not exceed substantiated size limits. The bonded repair design and fabrication instructions should also outline the facilities, tooling, equipment, and technician skills required to complete the repair. In-service repairs may need to be performed on the airplane using facilities, equipment, and tools adopted to mate with the assembled part. Special care should be taken to avoid contamination and to maintain the desired layup, bagging, and cure conditions.

The TCH Structural Repair Manual typically limits in-service bonded repair size, often as a function of part location, based on their internal databases and access to in-service experiences. A SRM may be approved as part of the type design. Bonded repairs performed per an aircraft SRM should comply with all the processing limits, details, and limitations. The bonded repair would otherwise require a specific approval substantiating deviations or new processes.

Reverse engineering practices, as often applied on metallic structure, or even when used to generate design data through conservative assumptions, will generally not equip the designer with a full understanding of the knowledge basis necessary to expand bonded repair size limits defined in the SRM. Therefore, it cannot be asserted that structural substantiation has been accomplished for the “reversed-engineered” design or that a safe product will result, unless additional data is generated to address the considerations documented in this policy.

In some cases, it has been argued that a part utilizing bonding can be ‘remanufactured’ well beyond published relevant bonded repair size limits using TCH specified materials, processes, tooling, and structural details without additional data since it is considered to be substantiated by the original type certification. The TCH documents design, specifications, procedures, tooling and substantiating data that proves the damaged structure can be repaired to its original type certified condition within the specified repair size limits. When expanding these size limits or using alternate materials, processes, tooling and/or inspection procedures, the larger or alternate repair will generally require additional data that qualifies bonded material and process compatibilities, demonstrates proof of structure, and establishes reliable inspection procedures. As one example of the proof of structure, both damage tolerance and residual strength data would be needed to expand the size limits for a given bonded repair to substantiate structural capability of the larger repair with impact damage and to ensure limit load capability still exists with a failed repair.

Additional considerations may be needed for some structures to ensure that the bonded repair size limit is properly defined. For example,

- comprehensive damage characterization is needed prior to repair to determine the full extent of damage, including consideration of the potential for significant areas of hidden damage, depending on the part configuration and the damaging event.

[8] Bonded Repair of Aircraft Composite Sandwich Structures, DOT/FAA/AR-03/74 (Fig.24)

- A bonded repair should be considered to include one or more repairs performed, at the same time and under similar processes, on a structural part. The potential for interaction between repairs could be of significance to residual strength.
- some repaired components may require a full fatigue and damage tolerance assessment. The effect of a failed bonded repair should be considered when evaluating the adjacent structure in a multi-load path design.
- for structural repairs subject to compartment pressurization loads where partial or complete failure of the repair could lead to pressure loss, rapid decompression should be considered within the structural evaluations.

Additional considerations may also need to be applied to structures not typically considered to be PSE or Primary Structure, but for which repair failure could result in a significant reduction in safety.

- bonded repairs to composite and metal engine structures should consider whether the failed repair can be ingested and damage engine parts.
- repairs to large fairings which may depart the aircraft, if failed, and impact downstream critical structure may require further consideration.
- repairs to fuel tanks which, if failed, could result in fuel leaks

Such evaluations will require engineering judgment. The EASA should be consulted early in the process whenever additional substantiation data is needed to extend existing repair size limits.

Note: This CM primarily addresses bonded repair to CS-23, CS-25, CS-27, and CS-29 structures, although issues addressed in this CM may also be applicable in part, or in full, to other CSs. However, when using this CM with other CSs, appropriate 'engineering judgement' should be exercised and early agreement with the Agency sought.

2.1. Existing requirements and AMC

Structure, including repairs, should satisfy the requirements. The following requirements are of particular relevance to the design of bonded repairs which are to be implemented in a service environment. This requires appropriate understanding by the DOA (TCH or non-TCH) regarding design and repair sizing. It also requires the understanding of the maintenance organisation executing the repairs as regards to limitations associated with the interpretation of Part 145 with respect to the scope of fabrication. The "x" in the requirement reference refers to CS-23, CS-25, CS-27 or CS-29 as appropriate.

2.1.1. CS 2x.603 Materials (For composite materials see AMC 20-29)

'The suitability and durability of materials used for parts, the failure of which could adversely affect safety, must -

…

(b) Conform to approved specifications, that ensure their having the strength and other properties assumed in the design data…

(c) Take into account the effects of environmental conditions, such as temperature and humidity, expected in service.'

2.1.2. AMC 20-29 'Composite Aircraft Structure'

AMC 20-29 develops discussion relating to the requirements, including the key requirements below, as applicable to composite structure. Para. 6.c. specifically introduces the subject of bonded structures and the developed use of CS 23.573(a)(5) for the other CSs.

Para. 10 addresses 'Continued Airworthiness' and states:

'The maintenance and repair of composite aircraft structure should meet all general, design and fabrication, static strength, fatigue/damage tolerance, flutter, and other considerations covered by this AMC as appropriate for the particular type of structure and its application.'

Para. 10.c.(1) makes clear that substantiation of the bonded repairs may require data beyond that of the baseline structure stating:

'…substantiation data will generally be needed for damage types and sizes not previously considered in design development'

and

'Bonded repair is subjected to the same structural bonding considerations as the base design

(refer to paragraph 6.c).'

Furthermore, Para. 8.a.(2)(c) states:

'For any damage size that reduces load capability below ultimate, the component is either

repaired to restore ultimate load capability or replaced.'

Note: Further relevant guidance regarding maintenance and repair of composite structure can be found in AC 43-214 (previously AC 145-6)

2.1.3. CS 2x.605 Fabrication Methods

*'(a) The methods of fabrication used must produce a consistently sound structure. If a fabrication process (**such as gluing**, spot welding, or heat treating) requires close control to reach this objective, the process must be performed under an approved process specification.*

(b) Each new aircraft fabrication method must be substantiated by a test programme.'

2.1.4. CS 2x.613 Material Strength Properties and Material design Values

'(a) Material strength properties must be based on enough tests of material meeting approved specifications to establish design values on a statistical basis.

(b) Material design values must be chosen to minimise the probability of structural failures due to material variability…'

2.1.5. PART 21 Subpart M, 21.A.433 Repair Design

'(a) The applicant for approval of a repair design shall:

1. demonstrate compliance with the type-certification basis…'

Noting that the Type Design consists, Part 21.A.31, of '*drawings and specifications*', including *'Information on materials and processes and on methods of manufacture and assembly of the product necessary to ensure the conformity of the product'*, then the potential for a bonded repair process to change the TD should be recognised. Therefore, demonstrating compliance with the TC basis, including all processes is important.

2.1.6. PART 21 GM 21.A.435(a) Classification of repairs

Although some 'engineering judgement' may be necessary when making a repair classification, it should be noted that several elements of repair design highlighted in GM 21.A.435(a) may be of particular relevance to bonded repairs:

'…a repair is classified as major if it needs extensive static, fatigue and damage tolerance strength justification and/or testing in its own right, or if it needs methods, techniques or practices that are unusual (i.e., unusual material selection, heat treatment, material processes, jigging diagrams, etc.)'

2.1.7. AMC 145.A.42(c) Acceptance of Components

This CM is focused on Primary Structures and PSEs. However, it also recognises that some structures not typically considered to satisfy the definitions of Primary Structures and PSEs could reduce the level of safety should a repair fail, e.g. large fairings which could separate and impact other structure or be ingested by engines. These may require further consideration. Therefore, AMC 145.A.42(c) is referenced in this CM in order to support the decision process regarding interpretation of para. 7, either within a Part 145 organisation or as part of a non-TC holder DOA process, e.g. Part 21 Subpart J & Subpart M etc.

'7. Examples of fabrication under the scope of an Part-145 approval can include but are not limited to the following:

…

b) Fabrication of secondary structural elements and skin panels.

…

Note: It is not acceptable to fabricate any item to pattern unless an engineering drawing of the item is produced which includes any necessary fabrication processes and which is acceptable to the competent authority.

8. Where a TC-holder or an approved production organisation is prepared to make available complete data which is not referred to in aircraft manuals or service bulletins but provides manufacturing drawings for items specified in parts lists, the fabrication of these items is not considered to be within the scope of an approval unless agreed otherwise by the competent authority in accordance with a procedure specified in the exposition.'

3. EASA Certification Policy

3.1. EASA Policy

Within the context of the 'Purpose and Scope' of this CM:

Bonded repairs should meet the appropriate airworthiness requirements for the structure they are designed to cover, including material and process qualification, static strength (Ultimate Load), and fatigue and damage tolerance. Bonded repairs to critical structure should also meet the conditions specified in this policy statement.

Bonded repairs may not require size limits for structure where there is no safety risk in the event of repair failure. In contrast, repair size limits may be restrictive for critical structures addressed by this policy.

The maximum size and other limits for a bonded repair depend on the limitations inherent in the design to be repaired. There may also be repair size limits or other constraints associated with the substantiating data used to meet the appropriate rules. These may include:

1. Repair processes that produce a consistently sound structure and critical fabrication processes which should be performed using qualified repair materials and process specifications intended to ensure structural behaviour governed by predictable and repeatable structural damage modes e.g. cohesive failure, not adhesion failure or 'weak bonds'. Repair designs should be approved in accordance with Part 21, and should be performed and inspected by properly trained/qualified individuals with suitable experience, supported and verified using process control specimens.

2. Repair designs should have structural substantiation based on tests or analyses supported by tests. The bonded repair should be shown to be capable of withstanding ultimate static loads and be shown to retain the required residual strength, as defined in the applicable requirements for the type, which include, but are not limited to;

- Fatigue and damage tolerance (CS 23.573, 25.571, 27.573 & 29.573)
- Static strength requirements, (CS 2x.305 & 2x.307)
- Material and fabrications specification requirements, (CS 2x,603 & 2x,605)
- Statistical material design values, (CS 2x.613)
- Flutter behavior (CS 2x.629)
- Lightning protection. (CS 2x.954 & 2x.981)

3. The data supporting the bonded repair should include inspections that are capable of detecting complete or partial failure (within damage arresting design features, e.g. fasteners that exist within the base structure or repair design) of the bond line. Inspection methods, thresholds, and intervals should be set considering the repeated load environment, likelihood of load excursions, the specific damage threats, criticality of the structure and the magnitude of the residual strength of the failed repair in accordance with AMC 20-29 (i.e., a failed repair which could result in a residual strength near Limit Load is recommended to be inspected with increased frequency).

All critical structure will have a repair size limit *no* larger than a size that allows Limit Load strength to be achieved with the repair failed or failed within constraints of the arresting design features (in the repair or base structure). This approach is needed to ensure Limit Load capability in the event of bonded repair failures such as “weak bonds”, which result from rare processing mistakes or other problems in combination with the service environment that cannot be ruled out through a threat assessment.

Bonded repairs to critical structure should be designed to be damage tolerant in order to preclude catastrophic failure due to fatigue, environmental, or accidental damage throughout the operational life of the aircraft. Manufacturing defects (i.e., porosity, disbonds and other anomalies), which cannot be detected or which are on the threshold of detectability with available inspection methods, should be controlled by process and included in the damage tolerance assessment as appropriate.

Per item one above, process specifications are used to ensure that non-detectable manufacturing defects, such as weak bonds, are rare. Regardless, the design of the repair still should account for these rare events and be considered in the damage tolerance evaluation. The regulatory considerations for accounting for these rare events may be addressed as follows:

- When complying with CS 23.573(a)(5)(i), all CS-23 critical structure should have a bonded repair size limit no larger than a size that allows limit load strength [per loads defined in 23.573 (a)(3)] to be achieved with the repair failed or failed within constraints of the arresting design features (in the repair or base structure).
- When complying with CS 25.571, 27.573 and 29.573, all structures subject to residual strength requirements have a minimum required residual strength of limit load (as defined in the regulations for each type of aircraft). Limiting the bonded repair size to sustain the minimum required loads with the bond failed or failed within constraints of the arresting design features (in the repair or base structure) is an acceptable approach to address potential weak bonds.

AMC 20-29 provides a further description of the bonded structure or repair qualification, quality controls and reliable procedures needed to ensure weak bonds are rare. The bonded repair size limits are first constrained by the data collected in establishing sound fabrication processes and substantiating the design. In addition, the bonded repair may be no larger than needed in demonstrating residual strength for a failed repair. All other approaches applied in establishing bonded repair size limits should have approved substantiating data, inspections or other procedures, as necessary, to prevent catastrophic failure.

Residual strength requirements with the repair failed should be shown by tests or analysis supported by tests. Some structure may be shown to have Limit Load capability, even with a very large failed repair. If significant changes in structural stiffness and/or geometry result from the failed repair, analysis for flutter and other aeroelastic instabilities should be performed to ensure the failed repair does not lead to other flight safety issues.

The size of the repair should be defined in the approved repair data. If it is an SRM (or equivalent document) repair addressing a range of potential repair sizes, then the maximum repair size limits for which the repair data is applicable should be provided. Documentation on all repairs performed in service should be added to the maintenance records for the specific part number. As bondline strength is only ensured by abiding to the substantiated processes and materials, the design approval holder should provide guidance on the criticality of, and need to demonstrate and record adherence to, specific material and process parameters that are provided in and controlled by the repair document design data**.**

This repair design and embodiment record documentation supports future maintenance damage disposition and repair activities performed on the same part. It also helps ensure the associated data, including repair design and process details, structural substantiation evidence, and inspection procedures, are available to those evaluating airworthiness.

Any failed bonded metal or composite repairs should be reported through the normal incident or accident reporting process (e.g., failure, malfunction, or defect reports required by Part 21.A.3 or service difficulty reports required by Part 145.A.60 or Part M.A.202).

The inspection of bonded repairs, including the specified inspection methods, interval and detection criteria, should be defined based on substantiating tests, analyses, trials, and other safety risk mitigation procedures.

Note: To accommodate special cases and advances in bond repair technology, alternate methods of repair substantiation may be acceptable and should be established in coordination with the Agency.

3.2. Who this Certification Memorandum Affects

This Certification Memorandum affects applicants for major bonded repair design approvals and Design Organisations conducting major bonded repair design approvals, initiated after the issue date of this CM in compliance with CS-23, CS-25, CS-27 or CS-29 or equivalent requirements. It is also of background interest to those showing compliance with Part 145, e.g., AMC 145.A.42 para.7.

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:

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