certificate or amended type certificate for that aircraft model (i.e. the as-delivered-aeroplane model configuration).

(2) Fatigue critical structure is generally a subset of principal structural elements, specifically those elements that are susceptible to fatigue damage. The exception may be a DDP that is susceptible to fatigue and, although not part of a PSE, could result in catastrophic failure if it were to fail (e.g. an undercarriage door hinge has been categorised by some TCHs as a DDP and FCS, when its failure would lead to loss of the door and the door could impact the aircraft with catastrophic results. In this case the door was not classified as a PSE because the TCH had not considered the door to contribute significantly to carrying flight, ground or pressurisation loads. Considering further aspects of the PSE definition now adopted, it might be claimed that the door is not essential to maintain the overall integrity of the aircraft, i.e. the aircraft may be safe without it. However, due to the need to identify all detail design points and FCS whose failure could cause catastrophic failure of the aircraft it is in any case subject to the fatigue and damage tolerance requirements.)

(d) Detail design points (DDP)

'Detail design point' is an area of structure that contributes to the susceptibility of the structure to fatigue cracking or degradation such that the structure cannot maintain its load carrying capability, which could lead to a catastrophic failure.

(e) Widespread fatigue damage (WFD)-susceptible structure

(1) 'Widespread fatigue damage (WFD)' is the simultaneous presence of cracks at multiple structural locations, which are of sufficient size and density such that the structure no longer meets the residual strength requirements of CS 25.571(b).

(2) 'Multiple site damage (MSD)' and 'Multiple element damage (MED)' are conditions that, with no intervention, can lead to WFD. The term 'WFD-susceptible structure' refers to areas of structure that, under normal circumstances, could be expected to eventually develop MSD and/or MED cracks, which could lead to WFD.

(3) Although not explicitly stated, structure susceptible to WFD cannot be inspected reliably to preclude WFD. Unless a flight cycles and/or flight hours limit is placed on an aeroplane, modifications may be needed to preclude WFD. Structure susceptible to WFD is a subset of FCS.

[Amdt 25/19]

LIGHTNING PROTECTION

CS 25.581 Lightning protection

ED Decision 2016/010/R

(See AMC 25.581)

(a) The aeroplane must be protected against catastrophic effects from lightning. (See CS 25.899 and AMC 25.581.)

(b) For metallic components, compliance with sub-paragraph (a) of this paragraph may be shown by –

(1) Bonding the components properly to the airframe; or

(2) Designing the components so that a strike will not endanger the aeroplane.

(c) For non-metallic components, compliance with sub-paragraph (a) of this paragraph may be shown by –

(1) Designing the components to minimise the effect of a strike; or

(2) Incorporating acceptable means of diverting the resulting electrical current so as not to endanger the aeroplane.

[Amdt 25/18]

AMC 25.581 Lightning protection

ED Decision 2020/024/R

1 INDUSTRY STANDARDS

The following documents may be used when showing compliance with CS 25.581:

— EUROCAE document ED-84A dated July 2013 (Aircraft Lightning Environment and Related Test Waveforms) or the equivalent SAE ARP5412B.

— EUROCAE document ED-91A (Aircraft Lightning Zoning) or the equivalent SAE ARP5414B.

— EUROCAE document ED-105A (Aircraft Lightning Test Methods) or the equivalent SAE ARP 5416A.

— EUROCAE document ED-113 (Aircraft Lightning Direct Effects Certification) or the equivalent SAE ARP 5577.

2 EXTERNAL METAL PARTS

2.1 External metal parts should either be –

a. Electrically bonded to the main earth system by primary bonding paths, or

b. So designed and/or protected that a lightning discharge to the part (e.g. a radio aerial) will cause only local damage which will not endanger the aeroplane or its occupants.

2.2 In addition, where internal linkages are connected to external parts (e.g. control surfaces), the linkages should be bonded to main earth or airframe by primary bonding paths as close to the external part as possible.

2.3 Where a primary conductor provides or supplements the primary bonding path across an operating jack (e.g. on control surfaces or nose droop) it should be of such an impedance and so designed as to limit to a safe value the passage of current through the jack.

2.4 In considering external metal parts, consideration should be given to all flight configurations (e.g. lowering of landing gear and wing-flaps) and also the possibility of damage to the aeroplane electrical system due to surges caused by strikes to protuberances (such as pitot heads) which have connections into the electrical system.

3 EXTERNAL NON-METALLIC PARTS

3.1 External non-metallic parts should be so designed and installed that –

a. They are provided with effective lightning diverters which will safely carry the lightning discharges described in EUROCAE document ED-84A dated July 2013 titled: Aircraft Lightning Environment and Related Test Waveforms, or the equivalent SAE ARP5412B document.

b. Damage to them by lightning discharges will not endanger the aeroplane or its occupants, or

c. A lightning strike on the insulated portion is improbable because of the shielding afforded by other portions of the aeroplane.

Where lightning diverters are used the surge carrying capacity and mechanical robustness of associated conductors should be at least equal to that required for primary conductors.

3.2 Where unprotected non-metallic parts are fitted externally to the aeroplane in situations where they may be exposed to lightning discharges (e.g. radomes) the risks include the following:

a. The disruption of the materials because of rapid expansion of gases within them (e.g. water vapour),

b. The rapid build-up of pressure in the enclosures provided by the parts, resulting in mechanical disruption of the parts themselves or of the structure enclosed by them,

c. Fire caused by the ignition of the materials themselves or of the materials contained within the enclosures, and

d. Holes in the non-metallic part which may present a hazard at high speeds.

3.3 The materials used should not absorb water and should be of high dielectric strength in order to encourage surface flash-over rather than puncture. Laminates made entirely from solid material are preferable to those incorporating laminations of cellular material.

3.4 Those external non-metallic part which is not classified as primary structure should be protected by primary conductors.

3.5 Where damage to an external non-metallic part which is not classified as primary structure may endanger the aeroplane, the part should be protected by adequate lightning diverters.

3.6 Confirmatory tests may be required to check the adequacy of the lightning protection provided (e.g. to confirm the adequacy of the location and size of bonding strips on a large radome.)

[Amdt 25/26]

SUBPART D – DESIGN AND CONSTRUCTION

GENERAL

CS 25.601 General

ED Decision 2003/2/RM

The aeroplane may not have design features or details that experience has shown to be hazardous or unreliable. The suitability of each questionable design detail and part must be established by tests.

CS 25.603 Materials

ED Decision 2021/015/R

(See AMC 25.603; for composite materials, see AMC 20-29; for use of glass in passenger cabins, see AMC No 2 to CS 25.603(a))

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

(a) be established on the basis of experience or tests; (see AMC No°1 to CS 25.603(a));

(b) conform to approved specifications that ensure their having the strength and other properties assumed in the design data (see AMC 25.603(b)); and

(c) take into account the effects of environmental conditions, e.g. temperature and humidity, expected in service.

[Amdt 25/9]
[Amdt 25/18]
[Amdt 25/19]
[Amdt 25/27]

AMC 25.603 Suitability and durability of materials

ED Decision 2021/015/R

The term 'material' is differently interpreted, ranging from raw feedstock material to the material state in a final complex part configuration that may have undergone various processes. CS 25.603, CS 25.605, CS 25.613, and AMC 25.613 should therefore be considered together to ensure the coherent and safe design and production of parts and thus maintain occupant and aeroplane safety throughout the aeroplane's operational life. This is of growing importance as more and more production methods allow the design of complex part configurations for which the characteristics of the materials are defined close to completion of the part production, e.g. castings, composite resin transfer methods, bonding, or additive manufacturing methods. The applicants should therefore discuss with EASA, at an early stage of the certification project, potential details supporting the means of compliance with CS 25.603, CS 25.605, and CS 25.613.

Note: organisations engaged in the design and certification of modifications or repairs should also comply with these CSs and consider the related AMC.

Appropriately defined tests and analysis pyramids (e.g. as outlined in AMC 20-29 for composite materials) should support the certification of materials, processes, and/or fabrication methods, including the development of the associated design values in more complex part configurations and assemblies.

[Amdt No: 25/27]

AMC No 1 to CS 25.603(a) Suitability and durability of materials — Experience or tests

ED Decision 2021/015/R

To show compliance with CS 25.603 and CS 25.605, applicants may use previous applicable experience and/or tests together with material specifications and material process specifications. Applicants should therefore carefully consider the controls on materials and material processing that are appropriate to the design data to be used for any part (e.g. controls on additive manufacturing powder material handling processes). However, as material strength and other properties may result from the process limitations that are specific to the configuration of some complex parts, the applicability of previous experience to new part configurations may be limited.

Shared databases: when the material strength and other properties that are used in the design data are not only influenced by the constituent materials and/or material processes, but also by the manufacturing and assembly processes, demonstrating controls on constituent materials and material processes may assist applicants in developing the final design data. For example, if an applicant successfully demonstrates data equivalence with established and accepted databases, this may create confidence in the applicant's production processes, if not providing existing design values.

[Amdt No: 25/27]

AMC No 2 to CS 25.603(a) Suitability and durability of materials — Large glass items

ED Decision 2021/015/R

1. General

   This AMC defines acceptable minimum performance standards for the specific case of large glass items used as an interior material in passenger cabin installations whereby the glass items carry no other loads than those resulting from the mass of the glass itself, rapid depressurisation, or abuse loading.

   Large glass items should be shown not to be a hazard during events such as an emergency landing and cabin depressurisation.

   1.1. A large glass item is defined as:

      (a) a glass item with a dimension that exceeds 51 cm (20 in.);

      (b) a glass panel with a surface area on one side that exceeds 0.12 m² (200 in.²); or

      (c) a glass item with a mass exceeding 4 kg.

      In case of multiple items in close proximity, the accumulated surface area of glass as well as the total mass should be considered (i.e. effects such as tiling should be considered).

1.2. A large glass item should meet the following requirements whenever installed in compartments that may be occupied during taxiing, take-off, and landing, or may be traversed during an emergency evacuation:

(a) The glass item should be subjected to, and pass, ball impact testing (see paragraph 2 below).

(b) The glass item should be subjected to, and pass, abuse load testing (see paragraph 3 below).

(c) The glass item should meet the requirements outlined in CS 25.561(b)(3), (c) and (d). A safety factor of 2.0 should be applied to glass items to account for variability in the production of the material and for long-term degradation.

(d) Cracking of glass should not produce a condition where the material may become hazardous to the occupants (e.g. sharp edges, splinters or separated pieces). This requires destructive testing. If any of the test conditions defined below (see paragraphs 2 and 3 below) do not result in a significant failure of the glass item, testing at a higher impact energy (ball impact test) or load (abuse load test) should be performed until destruction, or until an impact energy of 80 J or double the specified abuse load is reached.

Tests should be performed for worst-case conditions (e.g. the largest glass item should be tested with the maximum engraving). Similarity justification may then be used for other items.

These tests do not need to be performed for glass items that have traditionally been installed in large aeroplanes, provided that their installation method, location, etc. are not unusual (e.g. standard lavatory mirrors, light bulbs, light tubes, galley equipment).

The instructions for continued airworthiness should reflect the fastening method used and should ensure the reliability of all methods used (e.g. life limit of adhesives, or scheduled check for security of a clamp connection). For example, inspection methods and intervals for an adhesive-based design should be defined in accordance with adhesion data from the manufacturer of the adhesive, or actual adhesion test data, as necessary.

2. Ball Impact Tests

The test procedure(s) and pass/fail criteria of the Underwriters Laboratories standard UL 61965, Mechanical safety for cathode ray tubes, Edition 2, 27 July 2004, or former UL 1418, Standard for safety cathode ray tubes, Edition 5, 31 December 1992, or other equivalent approved method are the basis of the ball impact strength and no-hole tests described in this paragraph, combined with the impact energy in Section 5.12.2 of ANSI/SAE Z26.1, Safety glazing materials for glazing motor vehicles and motor vehicle equipment operating on land highways — safety standard, 1 December 1997.

The glass samples should be installed in a test fixture representative of the actual installation in the cabin.

2.1. Strength Test

The large glass item should be subjected to a single impact applied in accordance with the test conditions of paragraph 2.3 below. The impact energy should be 21 J, caused by a 51-mm diameter ball or, alternatively, by a 40-mm diameter ball, as specified in paragraph 2.3.2 below.

The test is passed if the expulsion of glass within a 1-min period after the initial impact satisfies the following criteria:

(a) there is no glass particle (a single piece of glass having a mass greater than 0.025 g) between the 0.90 and 1.50-m barriers (see paragraph 2.3.1) on either side (if appropriate);

(b) the total mass of all pieces of glass between the 0.90 and 1.50-m barriers (see paragraph 2.3.1) does not exceed 0.1 g on either side (if appropriate); and

(c) there is no glass expelled beyond the 1.50-m barrier (see paragraph 2.3.1) on either side (if appropriate).

2.2 No-Hole Test

The large glass item should be subjected to a single impact applied in accordance with the test conditions of paragraph 2.3 below. The impact energy should be 3.5 J, caused by a 51-mm diameter ball as specified in paragraph 2.3.2 below.

The test is passed if the large glass item does not develop any opening that may allow a 3 mm diameter rod to enter.

Note: If the large glass item does not develop any opening that would allow a 3 mm rod to enter when subjected to the strength test defined in paragraph 2.1 above, the no-hole test defined in this paragraph does not need to be performed.

2.3 Test Conditions

2.3.1 Test Apparatus and Setup

The large glass item should be mounted in a way representative of the aeroplane installation.

The centre of the large glass item should be 1.00 ± 0.05 m above the floor.

For the strength test (see paragraph 2.1 above), two barriers, each one made of material 10–20 mm thick, 250 mm high, and 2.00 m long, should be placed on the floor in front of the test item (or on both sides in case of a glass partition) at the specified location, measured horizontally from the front surface of the large glass item to the near surface of the barrier. The barriers may be less than 2.00 m long, provided that they extend to the walls of the test room. A non-skid surface such as a blanket or rug may be placed on the floor.

A solid, smooth, steel ball of the size specified in paragraph 2.3.2 below should be suspended by suitable means such as a fine wire or chain and allowed to fall freely as a pendulum and strike the large glass item with the specified impact energy. The large glass item should be placed in a way that its surface is vertical and in the same vertical plane as the suspension point of the pendulum. A single impact should be applied to any point on the surface of the large glass item at a distance of at least 25 mm from the edge of the surface.

2.3.2 Impact Objects

The 51-mm diameter steel ball, used as an impact object, should have a mass of approximately 0.5 kg and a minimum Scale C Rockwell Hardness of 60.

The 40-mm diameter steel ball, used as an impact object, should have a mass of approximately 0.23 kg and a minimum Scale C Rockwell Hardness of 60.

3. Abuse Loads Tests

The large glass item should withstand the abuse loads defined in paragraph 3.2 below when subjected to the test conditions defined in paragraph 3.1. The panel should remain attached to the fixture, and any failure should be shown to be non-hazardous (e.g. no sharp edges, no separation of pieces).

3.1 Test conditions

Abuse loads should be applied:

(a) at the points that would create the most critical loading conditions; and

(b) at least at the geometrical centre, and at one point located along the perimeter.

For the above-mentioned load applications, it is acceptable to use any loading pad with a shape and dimensions that fit into a 15.24-cm (6-in.) diameter circle.

For all tests, the glass item should be mounted in a test fixture representative of the actual installation in the cabin.

3.2 Loads to be applied

Abuse loads should be considered as ultimate loads, therefore, no additional factors (e.g. fitting factors, casting factors, etc.) need to be applied for abuse load analysis/testing.

Unless it is justified that one or more abuse load cases are not applicable due to the shape/size/location of the glass item making it unlikely or impossible for persons to apply loads in the direction(s) concerned, the following abuse loads should be considered (see also Figure 1 below):

3.2.1 Pushing loads

Pushing loads are 133 daN (300 lbf) from 0–1.5 m (60 in.) above the floor, reducing linearly to 44 daN (100 lbf) at 2 m (80 in.) above the floor level (see (1) in Figure 1 below).

3.2.2 Pulling loads

One-hand pull loads (where it is not possible to grab with two hands) are 66 daN (150 lbf) from 0–1.5 m (60 in.) above the floor, reducing linearly to 22 daN (50 lbf) at 2 m (80 in.) above the floor level (see (3) in Figure 1 below).

Two-hands pull loads are 133 daN (300 lbf) from 0–1.5 m (60 in.) above the floor, reducing linearly to 44 daN (100 lbf) at 2 m (80 in.) above the floor level (see (1) in Figure 1 below).

3.2.3 Up loads

Up loads are 66 daN (150 lbf) from 0–1.5 m (60 in.) above the floor, reducing linearly to 22 daN (50 lbf) at 2 m (80 in.) above the floor level (see (2) in Figure 1 below).

3.2.4 Downloads

Downloads are 133 daN (300 lbf) from 0-1.5 m (60 in.) above the floor, reducing linearly to 44 daN (100 lbf) at 2 m (80 in.) above the floor level (see (1) in Figure 1 below).

3.2.5 Stepping, Seating loads

In the case of large glass items which may be stepped or sat on, a load of 222 daN (500 lbf) should be used. This load is to be applied at the most critical point, and on any relevant surface up to 1 m (38 in.) above the floor level (see (4) in Figure 1 below).

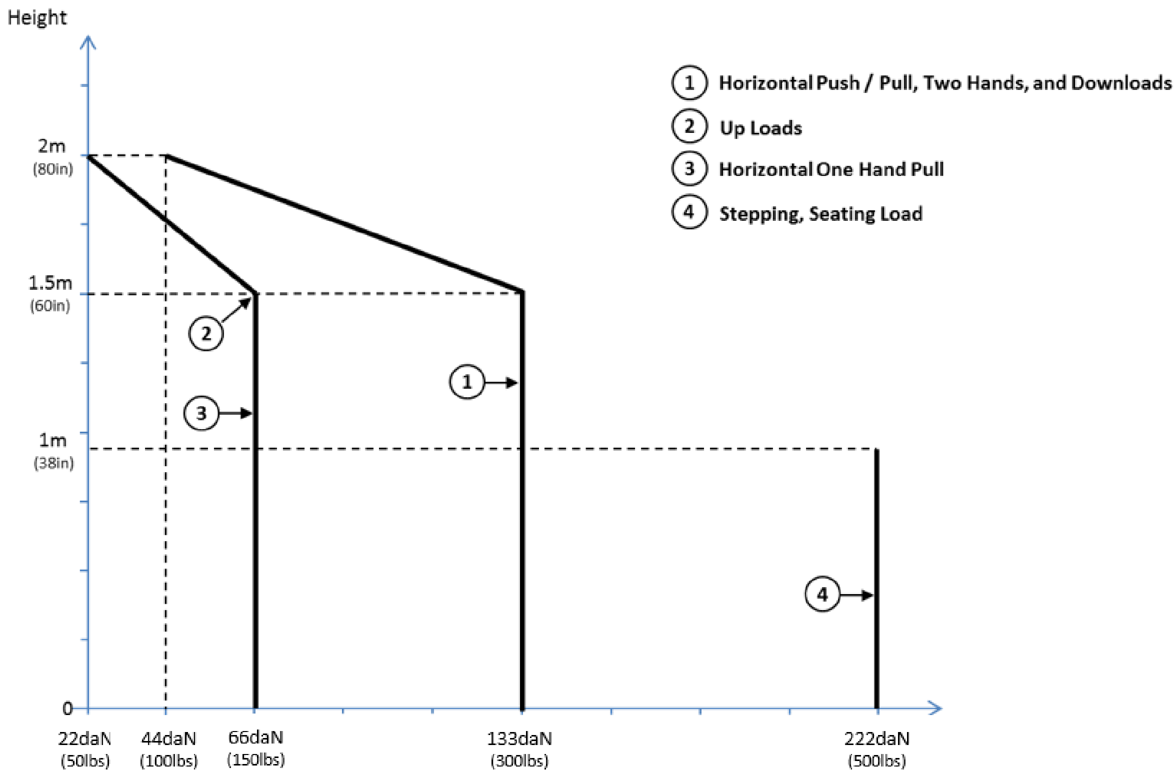

Figure 1

[Amdt No: 25/19]
[Amdt No: 25/27]

AMC 25.603(b) Suitability and durability of materials — Approved material specifications and material process specifications

ED Decision 2021/015/R

The approved material specifications and material process specifications should:

— be suitable for the application;

— define material and material process controls;

— include requirements to assist the applicant in managing raw/feedstock/unfinished materials, as appropriate to the technology (e.g. the feedstock powder used in additive manufacturing, or matrix systems used in pre-impregnated composites).

The material strength and other properties that are used in design data (including fatigue and damage tolerance characteristics, when applicable) are governed by, and can be significantly sensitive to, the related variables of the material production process (including raw-material considerations). Furthermore, these properties may also be influenced by other higher-level fabrication processes (manufacturing and assembly), including other post-processing activities (e.g. adhesive material and bonding properties produced in a bonded joint of a complex part may not be the same as those produced in a test coupon).

The material specifications, material process specifications, and/or production drawings should identify key characteristics and parameters to be monitored by in-process quality control, including the acceptable limits to the characteristics of materials and processes (e.g. acceptable anomalies or flaws), and should address anisotropy, when applicable. This information may also help applicants identify other defect types and damage modes than the anomalies and flaws that are accepted under the specifications, including those that may occur in service. Such data may be used to help applicants show compliance with other specifications, e.g. CS 25.571. However, showing compliance with CS 25.571 does not relieve from the requirement for material process controls.

Note: approved material specifications and approved material process specifications can be, for example, industry or military specifications, or European Technical Standard Orders (ETSOs).

[Amdt No: 25/27]

CS 25.605 Fabrication methods

ED Decision 2021/015/R

(See AMC 25.605)

(a) The fabrication methods used (i.e. the manufacturing and assembly methods, including consideration of the materials and material processes) must produce the strength and other properties necessary to ensure a consistently safe part. If a fabrication method includes processes that require close control to reach this objective, then those processes must be performed under representative approved fabrication process specifications, supported by appropriately approved material specifications (including considering the raw/feedstock/unfinished material specifications) with appropriate controls for the design data.

(b) Each new fabrication method must be substantiated by a test programme that is representative of the application.

[Amdt No: 25/27]

AMC 25.605(a) Fabrication methods — Approved process specifications

ED Decision 2021/015/R

Examples of fabrication method processes that may require close control to consistently produce safe parts include the following:

— castings,

— composite resin transfer methods,

— bonding,

— welding,