



Notice of Proposed Amendment 2022-01

in accordance with
Articles 6(3), 7 and 8 (Standard procedure: public consultation) of MB Decision
No 18-2015

Regular update of the Certification Specifications for Small Rotorcraft (CS-27), and Large Rotorcraft (CS-29)

RMT.0128

EXECUTIVE SUMMARY

The objective of this Notice of Proposed Amendment (NPA) is to:

- address three safety recommendations addressed to the European Union Aviation Safety Agency (EASA) related to the accident to an Airbus Helicopters EC 225 LP, registration LN-OJF, on 29 April 2016 in Norway:
 - by improving the existing provisions and procedures applicable to critical parts on helicopters in order to ensure that design assumptions are valid throughout their service life;
 - by amending the Acceptable Means of Compliance (AMC) to the Certification Specifications (CSs) for Large Rotorcraft (CS-29) in order to highlight the importance of different modes of component structural degradation and how these can affect crack initiation and propagation and ultimately fatigue life; and
 - by amending the corresponding CSs with regard to the instructions for continued airworthiness (ICA) for critical parts on helicopters in order to maintain their design integrity after being subject to any unusual event;
- harmonise CS-27 and CS-29 with the equivalent Federal Aviation Administration (FAA) regulations, thus reducing the validation effort; and
- reflect the state of the art for small and large rotorcraft certification, thus modernising the existing requirements and being in line with the current good practices.

The proposed amendments are expected to improve safety, have no social or environmental impacts, and provide economic benefits by streamlining the certification and validation processes.

Domain:	Design and production		
Related rules:	CS-27, CS-29		
Affected stakeholders:	DAHs; rotorcraft manufacturers and other design organisations dealing with supplemental type certificates (STCs), repairs or changes to rotorcraft		
Driver:	Safety, Efficiency/proportionality	Rulemaking group:	No
Impact assessment:	No	Rulemaking Procedure:	Standard

EASA rulemaking procedure milestones

Start Terms of Reference	Public consultation NPA 202X-XX	Decision Certification Specifications, Acceptable Means of Compliance, Guidance Material
28.9.2016	14.2.2022	2023/Q2



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1. About this NPA

1.1. How this NPA was developed

EASA developed this NPA in line with Regulation (EU) 2018/1139¹ (the ‘Basic Regulation’) and the Rulemaking Procedure². This rulemaking task (RMT).0128 is included in Volume II of the European Plan for Aviation Safety (EPAS) 2022–2026³. The scope and timescales of the task were defined in the related Terms of Reference (ToR)⁴.

The NPA is hereby submitted to all interested parties for consultation in accordance with Articles 6(3), 7 and 8 of the Rulemaking Procedure.

1.2. How to comment on this NPA

Please submit your comments using the automated **Comment-Response Tool (CRT)** available at <http://hub.easa.europa.eu/crt/>⁵.

The deadline for the submission of comments is **16 May 2022**.

1.3. The next steps

Following the closing of the public commenting period, EASA will review all the comments received.

In consideration of the comments received, EASA will develop and issue a decision to amend the CSs and AMC for Small Rotorcraft (CS-27) and for Large Rotorcraft (CS-29).

The individual comments received on this NPA and the EASA responses to them will be reflected in a comment-response document (CRD), which will be published on the EASA website⁶.

¹ Regulation (EU) 2018/1139 of the European Parliament and of the Council of 4 July 2018 on common rules in the field of civil aviation and establishing a European Union Aviation Safety Agency, and amending Regulations (EC) No 2111/2005, (EC) No 1008/2008, (EU) No 996/2010, (EU) No 376/2014 and Directives 2014/30/EU and 2014/53/EU of the European Parliament and of the Council, and repealing Regulations (EC) No 552/2004 and (EC) No 216/2008 of the European Parliament and of the Council and Council Regulation (EEC) No 3922/91 (OJ L 212, 22.8.2018, p. 1) (<https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1535612134845&uri=CELEX:32018R1139>).

² EASA is bound to follow a structured rulemaking process as required by Article 115(1) of Regulation (EU) 2018/1139. Such a process has been adopted by the EASA Management Board (MB) and is referred to as the ‘Rulemaking Procedure’. See MB Decision No 18-2015 of 15 December 2015 replacing Decision 01/2012 concerning the procedure to be applied by EASA for the issuing of opinions, certification specifications and guidance material (<http://www.easa.europa.eu/the-agency/management-board/decisions/easa-mb-decision-18-2015-rulemaking-procedure>).

³ <https://www.easa.europa.eu/document-library/general-publications/european-plan-aviation-safety-2022-2026>

⁴ [ToR RMT.0128 | EASA \(europa.eu\)](#)

⁵ In case of technical problems, please send an email to crt@easa.europa.eu with a short description.

⁶ <https://www.easa.europa.eu/document-library/comment-response-documents>

2. In summary — why and what

2.1. Why we need to amend the rules — issue/rationale

The aviation industry is complex and rapidly evolving. CSs, AMC and GM need to be updated regularly to ensure that they are fit for purpose, cost-effective, and can be implemented in practice.

Regular updates are issued when relevant data is available following an update of industry standards, feedback from certification activities, or minor issues raised by the stakeholders.

Lessons learnt from accident and incident investigations may also be addressed in regular updates when the topic is not complex and not controversial. This NPA proposes amendments following three safety recommendations addressed to EASA by the Accident Investigation Board of Norway after the investigation of the accident to an Airbus Helicopter EC 225 LP, registration LN-OJF, on 29 April 2016 in Norway.

This regular update is made up of 41 items. Each item is introduced below:

Item 1 (lightweight flight recorders): New requirements and associated guidance are needed to facilitate the approval of lightweight flight recorder installations on board of light rotorcraft, when a lightweight flight recorder may be required to be installed to meet Part-CAT, CAT.IDE.H.191 of Regulation (EU) No 965/2012⁷ (the Air OPS Regulation).

Item 2 (unusable fuel supply): Clarifications are needed on the acceptability of analyses and ground testing which could be used as means of compliance for the determination of the unusable fuel.

Item 3 (fragment containment): Guidance needs to be introduced to clarify what credit can be claimed from engine certification activities and from engine manufacturer data in case of an engine rotor failure generating small fragments and under which conditions.

Item 4 (fuel quantity indicator): The accuracy of the fuel quantity indication may be affected by the fuel quantity gauging system susceptibility to water-contaminated fuel. CS-27 and CS-29 requirements do not address specifically the need to demonstrate the integrity of the fuel quantity indication function under a situation of water-contaminated fuel; however, the design of the fuel quantity gauging system may be influenced by such a condition up to an extent that prevents the demonstration of compliance with CS 27.1337(b) and CS 29.1337(b) respectively.

Item 5 (fatigue evaluation of drive system components): To address Safety Recommendation NORW-2018-003, clarifications are needed on the fatigue tolerance evaluation of rotor drive system components subject to rolling contact fatigue.

Item 6 (critical parts): To address Safety Recommendation NORW-2018-008, the specifications and associated guidance on the 'Continued Integrity Verification Programme' already introduced in Certification Memorandum (CM)-S-007 need to be introduced. By doing so, the CM will be transposed into CS in order to make the specifications on the 'Continued Integrity Verification Programme' part of the certification basis.

⁷ Commission Regulation (EU) No 965/2012 of 5 October 2012 laying down technical requirements and administrative procedures related to air operations pursuant to Regulation (EC) No 216/2008 of the European Parliament and of the Council (OJ L 296, 25.10.2012, p. 1) (<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32012R0965&qid=1640079688754>).

Item 7 (30-minute power rating): A number of project-specific certification review items (CRIs) have been issued to address the use of a 30-minute power rating which is not considered in CS-27 and CS-29. The 30-minute power rating is defined by an extension in usage of the 5-minute power rating to 30 minutes for specific flight operations. The engine shall be certified for the usage of this 30-minute power rating. Other engine limitations are considered identical. In some instances, pending the engine certification, the number of cumulative usages of the 30-minute power rating may be limited.

Item 8 (variable rotor speed (NR)): The use of a variable rotor speed (NR) capability in modern helicopters requires some considerations as part of the drive system tests prescribed by CS 27.923, CS 29.923 and CS 29.927. These considerations were provided in project-specific CRIs. They are proposed to be transferred now in a dedicated AMC.

Item 9 (instructions for continued airworthiness): Clarifications are introduced addressing Safety Recommendation NORW-2018-002. In addition, the guidance currently provided in CM-RTS-002 regarding how to define and develop overhaul intervals of rotorcraft drive system gearboxes is transferred to AMC.

Item 10 (usable fuel capacity markings): Alignment with the equivalent proposed FAA requirements is needed (ref: NPRM 2017-23360). CS 27.1555(c)(1) and CS 29.1555(c)(1) are amended to allow more than one method to inform the pilot of the usable fuel system capacity. The existing CS requires marking the usable fuel capacity at the fuel quantity indicator. With modern display systems, the location of the fuel quantity indicator may change, rendering affixing a placard next to the display impractical. In addition, although the usable fuel capacity is commonly included in the rotorcraft flight manual, the proposed alternate method would clarify the requirements to address the lack of continuous display provided by a placard.

Item 11 (airspeed and powerplant instruments): Alignment with the equivalent proposed FAA requirements (ref: NPRM 2017-23360) is needed. CS 27.1549 and CS 29.1549 are amended to remove the restrictive requirement for some instrument markings to allow alternative means of compliance typically proposed on modern glass cockpits.

Item 12 (oil pressure indicator and warning independence): The relevant requirements need to be amended to transfer the consolidated interpretation already provided in EASA CM CM-PIFS-004 Issue 01 on the independence of engine oil pressure indication and low engine oil pressure warning into a CS. This will result in a reduced burden on applicants for the certification of new rotorcraft designs by reducing the need to refer to additional guidance material.

Item 13 (fuel tank tests): Clarifications on tests to be performed in showing compliance of fuel tanks with CS 27.965 and CS 29.965 are needed.

Item 14 (ignition switches): Amendments and related guidance are needed to address modern designs currently used in the rotorcraft industry. This will reduce the burden on applicants for the certification of new rotorcraft designs by eliminating the need for equivalent level of safety findings and additional MoC/Interpretative Material on common architectures with full authority digital engine control (FADEC) engines.

Item 15 (synthesised powerplant instruments): More generic wording needs to be introduced to allow the use of synthesised powerplant instruments and to align with the proposed FAA requirements (ref: NPRM 2017-23360, CS 27.1305 (e), (k), (n) and (o)).

Synthesised powerplant instruments combining different powerplant instruments in a single indicator of engine performance, generally presented as a percentage of the nearest engine limit, are today commonly used by CS-27 and CS-29 rotorcraft manufacturers. A more generic wording will allow the introduction of synthesised powerplant instruments without requiring an equivalent safety finding (ESF) to be granted.

Item 16 (Category A engine training mode): For Category A training purposes, several modern helicopter designs incorporate a feature to represent a simulated engine failure by reducing the power of all engines symmetrically without damaging the engines, the so-called OEI Training Mode.

Similarly, to the rule proposed by the FAA in the NPRM 2017-23360, CS 29.1305(b)(4) is introduced to permit manipulating the powerplant instruments to simulate one engine inoperative (OEI) conditions in a more standardised way and without the need for any ESF.

However, helicopters with OEI Training Mode would require additional annunciations to differentiate the OEI condition from that of an actual engine failure.

CS 27.1305 is not proposed for amendment because CS-27 Category A rotorcraft are approved under Appendix C to CS-27, which requires compliance with CS 29.1305 (b).

Item 17 (Single-engine restart capability): Discussions held in the framework of some validation projects revealed that the engine restart capability of a CS-27 single engine was only demonstrated on ground without considering the implications of the FADEC or electronic engine controller (EEC) (or similar equipment) installed on the new generation engines.

This equipment may influence the engine restart capability.

AMC1 27.903(d) and AMC1 29.903(e) are introduced to address the EASA expectations in case the engine restart capability is not going to be demonstrated in flight and recommends that, whenever the engine restart capability has not been demonstrated in flight, a clear indication should be included in the rotorcraft flight manual (RFM) Emergency Procedures Section. This would prevent crew misunderstandings on the demonstrated engine restart capability.

Item 18 (non-required equipment in the primary field of view): AMC1 27.1301 and AMC1 29.1301 are introduced to explain that the demonstration of compliance with CS 27.1301 and CS 29.1301 on 'function and installation' applies to both required and optional / non-required installed equipment, in particular to equipment providing information in the crew primary field of view. The reason behind this proposed AMC is that information provided to the crew by the optional / non-required equipment is likely to be used.

The installation of non-required equipment is also an item of the Safety Emphasis Items (SEIs) list. The purpose of the proposed change to the AMC is to clarify that any equipment installed in the cockpit needs to be evaluated for its intended function.

Item 19 (power-OFF_{NE}): The background behind the current requirement is that V_{NE} Power-OFF should be something easy to calculate for the crew starting from the V_{NE} Power-ON (either a constant V_{NE} Power-OFF was required or a constant difference from the V_{NE} Power-ON or a combination of the two approaches). This is to achieve the objective of reducing the crew mental effort. However, with the latest technology displays, this requirement may be unnecessary and cause an undue burden to applicants.

EASA has already faced several times the need to grant an ESF to modern designs of rotorcraft equipped with latest-generation avionics, where the V_{NE} Power-ON and Power-OFF are automatically calculated and displayed to the crew.

Hence, CS 27.1505(c)(2) and CS 29.1505(c)(2) are proposed for amendment and AMC1 27.1505 and AMC1 29.1505 are introduced to take into consideration that V_{NE} Power-ON and Power-OFF may be automatically calculated and displayed to the crew.

Item 20 (correction in CS 29-777): A correction to a typo is needed to provide the correct conversion between imperial units and SI units.

Note: CS 27.777 uses the same height range but without a typo.

Item 21 (unsymmetrical loads): Clarifications on the justifications intended in case of load distribution deviations are needed.

Item 22 (control systems): Guidance on design reaction loads for the flight control system, in particular to consider modern rotorcraft control system designs, is needed.

Item 23 (vibration): Clarifications are needed to provide guidance on the demonstration of compliance with the requirements with regard to resilience to vibration. The objective is to limit potential equipment detachment.

Item 24 (rotor drive): Corrections are needed to the guidance, introduced in CS-29 Amendment 5, on the demonstration of compliance with the requirements regarding loss of lubrication when compliance is achieved by means of an auxiliary lubrication system without a dedicated test that focuses on the complete loss of lubrication of the system.

Item 25 (emergency exit signs): Provisions and guidance need to be introduced for the use of so-called running man signs, for indicating the route to or location of emergency exits, as already accepted in some applications under an ESF.

Item 26 (proof of structure): Guidance is needed on the demonstration of compliance with the requirements on proof of structure, in particular regarding fairing substantiation and also for the demonstration of compliance by similarity with the static and fatigue requirements.

Item 27 (use of standard fasteners in critical installations): Guidance needs to be introduced on the demonstration of compliance of the fasteners with certification standards, in particular those fasteners used in critical installations.

Item 28 (lightning and static electricity protection): Guidance is needed to provide an acceptable means of compliance for rotorcraft components evaluation after lightning strike.

Item 29 (density effect on manoeuvring load factors): Amendments and related guidance are needed to ensure that the entire operational density envelope is considered when showing compliance with the structural requirements. Further guidance is needed on the demonstration of compliance with the requirements on limit manoeuvring load factor.

Item 30 (single 'non-smoking' and 'fasten seatbelt' placard): Guidance is needed on smoking possibilities and the need to fasten the seatbelt, in particular with respect to the use of a single placard.

Item 31 (compliance with requirements on flammability testing): Clarifications on the flammability requirements are needed and a link to relevant guidance needs to be provided.

Item 32 (use of composite sandwich panels): Guidance is needed on the use of composite sandwich panels (material strength properties and design value).

Item 33 (turbine engine induction systems): Guidance and means to comply with the requirements on induction system icing protection are needed.

Item 34 (seat adapter plates): Guidance and means to comply with the requirements on proof of structure are needed, in particular regarding the seat adapter plates.

Item 35 (protection of occupants): Guidance and means to comply to the requirements on protection of occupants in emergency conditions are needed.

Item 36 (development of assurance process): Guidance is introduced to provide means to comply with the requirements on development assurance process.

Item 37 (fuselage, landing gear and rotor pylon structures): For consistency purposes, a reference to a FAR paragraph needs to be added.

Item 38 (equipment, systems and network information): The requirement to protect rotorcraft equipment, systems and networks against information security threats needs to be clarified.

Item 39 (fuel quantity indicator and fuel low-level sensor independence (CS-27 and CS-29)): Amendments are needed to allow installation of fuel quantity and fuel low-level sensors on the same supporting structure under specific conditions without requiring an ESF (TBC) to be granted.

Item 40 (ditching): A correction to a typo is needed to provide the correct reference to the requirements that a rotorcraft must meet for certification with ditching provisions.

Item 41 (Model test method for flotation stability): A correction to a typo is needed to provide the correct reference to FAA AC paragraph.

2.2. What we want to achieve — objectives

The overall objectives of the EASA system are defined in Article 1 of the Basic Regulation. This proposal will contribute to the achievement of the overall objectives by addressing the issues outlined in Section 2.1.

The specific objective of this proposal is to amend CS-27 and CS-29 based on the above selection of non-complex, non-controversial and mature subjects, with the ultimate goal being to increase safety.

2.3. How we want to achieve it — overview of the proposals

Item 1: Lightweight flight recorders (CS-27)

CS 27.1458 is introduced to facilitate the approval of lightweight flight recorder installations on board light rotorcraft, when a lightweight flight recorder may be required to be installed to meet the Air OPS rules.

Item 2: Unusable fuel supply (CS-27 and CS-29)

AMC1 27.959 and AMC1 29.959 are introduced to provide clarification on the acceptability of analyses and ground testing which could be used as means of compliance if supported by actual flight test data.

Item 3: Fragment containment (CS-29)

AMC1 29.901(d)(1) is introduced to provide acceptable means to give credit to engine manufacturer data substantiating the capability of the engine to contain fragments in case of an engine rotor failure.

Item 4: Fuel quantity indicator (CS-27 and CS-29)

AMC1 27.1337(b) and AMC1 29.1337(b) are introduced to provide clarification regarding the susceptibility of the fuel quantity indication accuracy to water contamination.

Item 5: Fatigue evaluation of drive system components (CS-27 and CS-29)

AMC1 27.571 and AMC1 29.571 are introduced to provide means of compliance with CS 27.571 and CS 29.571 with regard to the fatigue tolerance evaluation of rotor drive system components subject to rolling contact fatigue.

Item 6: Critical parts (CS-27 and CS-29)

CS 27.602(c)/29.602(c) and AMC1 27.602/29.602 are introduced to clarify the need to develop a continued integrity verification programme.

Item 7: 30-minute power rating (CS-27 and CS-29)

AMC1 27.923 and AMC1 29.923 are introduced to provide means of compliance with CS 27.923 and CS 29.923 with regard to the testing of rotor drive systems including a 30-minute power rating .

AMC1 27.1045 and CS 29.1049 are updated in order to address the cooling capabilities when using the 30-minute power rating.

CS 27.1305(w) and CS 29.1305(a)(27) are introduced to require specific displays to support the usage of this extended power rating.

AMC1 27.1521 and AMC1 29.1521 are introduced to provide means of compliance on the time limit to be declared for the 30-minute power rating duration limit.

Item 8: Variable rotor speed (NR) (CS-27 and CS-29)

AMC1 27.927 and AMC1 29.927 are introduced to provide means of compliance with CS 27.927 and CS 29.927 with regard to the testing of the variable rotor speed function of a rotor drive system.

Item 9: Time between overhaul (TBO) development (CS-29)

AMC1 27.1529 and AMC1 29.1529 are introduced to provide means of compliance with CS 27.1529 and CS 29.1529 regarding the instructions for continued airworthiness addressing the overhaul interval definition and in-service development for rotor drive systems. In addition, guidance is also added that addresses abnormal events in operation, maintenance or during transportation of components.

Item 10: Usable fuel capacity markings (CS-27 and CS-29)

CS 27.1555(c)(1) and CS 29.1555(c)(1) are amended to align the requirements on usable fuel capacity marking with the equivalent FAA NPRM 2017-23360 proposed requirements.

Item 11: Airspeed and powerplant instruments (CS-27 and CS-29)

CS 27.1549 and CS 29.1549 are amended to align the requirements on airspeed and powerplant indicators with the equivalent FAA NPRM 2017-23360 proposed requirements.

Item 12: Oil pressure indicator and warning independence (CS-29)

CS 29.1305(b)(1) is amended to transfer the consolidated interpretation of this requirement already provided in EASA CM-PIFS-004 Issue 01 on the independence of engine oil pressure indication and low engine oil pressure warning into a CS.

Item 13: Fuel tank tests (CS-27 and CS-29)

AMC1 27.965 and AMC1 29.965 are introduced to provide means of compliance on the fuel tank tests (vibrations and slosh tests) to be performed in showing compliance with CS 27.965 and CS 29.965.

Item 14: Ignition switches (CS-29)

CS 29.1145(a) is amended, and AMC1 29.1145(a) is introduced, to allow architectures with a FADEC engine to be compliant without requiring an ESF to be granted.

Item 15: Synthetised powerplant instruments (CS-27 and CS-29)

To align with the rule proposed by the FAA in NPRM 2017-23360, the more generic wording 'A means' is introduced in sub-paragraphs (e) and (n) of CS 27.1305 and in sub-paragraphs (a)(5), (a)(11) and (a)(12) of CS 29.1305 allow the introduction of synthetised powerplant instruments without requiring an ESF to be granted.

Item 16: Category A engine training mode (CS-29)

For Category A training purposes, CS 29.1305(b)(4) is introduced to permit manipulating the powerplant instruments to simulate one engine inoperative (OEI) conditions, the so-called OEI Training Mode, in a more standardised way and without the need for any ESF.

Item 17: Single engine restart capability (CS-27 and CS-29)

AMC1 27.903(d) and AMC1 29.903(e) are introduced to provide means of compliance and to recommend that whenever the engine restart capability has not been demonstrated in flight, a clear indication should be included in the RFM Emergency Procedures Section.

Item 18: Non-required equipment in the primary field of view (CS-27 and CS-29)

AMC1 27.1301 and AMC1 29.1301 are introduced to provide means of compliance with CS 27.1301 and CS 29.1301.

Item 19: Power-OFF V_{NE} (CS-27 and CS-29)

CS 27.1505(c)(2) and CS 29.1505(c)(2) are proposed for amendment, and AMC1 27.1505 and AMC1 29.1505 are introduced to take into consideration that V_{NE} Power-OFF may be automatically calculated and displayed to the crew by modern rotorcraft designs.

Item 20: Correction to CS 29.777 (CS-29)

CS 29.777 is amended to correct the conversion of the height range between imperial and SI units.

Item 21: Unsymmetrical loads (CS-27 and CS-29)

AMC1 27.427 and AMC1 29.427 are introduced to provide guidance on the demonstration of load distribution.

Item 22: Control systems (CS-27 and CS-29)

AMC1 27.395 and AMC1 29.395 are introduced to provide means of compliance with the requirements on load design reaction loads for the flight control system, in particular to consider modern rotorcraft control system designs.

Item 23: Vibration (CS-27 and CS-29)

AMC1 27.251 and AMC1 29.251 are introduced to provide means of compliance with the requirements with regard to resilience to vibration. The objective is to contribute to limitation of potential equipment detachment.

Item 24: Rotor drive system design (CS-29)

AMC2 29.917 is amended to provide means of compliance with the requirements regarding loss of lubrication when compliance is achieved by means of an auxiliary lubrication system.

Item 25: Emergency exit signs

CS 29.811 is amended, and AMC1 29.811(d) is introduced, to provide means of compliance for the use of the so-called running man signs, for indicating the route to or location of emergency exits, as already accepted in some applications under an ESF.

Item 26: Proof of structure (CS-27 and CS-29)

AMC1 27.307 and AMC1 29.307 are introduced to provide means of compliance by similarity to the static and fatigue requirements. The AMC propose criteria for classification of structure (new, similar new, derivative/similar).

AMC2 27.307 and AMC2 29.307 are introduced to provide means of compliance with the requirements on proof of structure, in particular regarding fairing substantiation.

Item 27: Use of standard fasteners in critical installations (CS-27 and CS-29)

AMC1 27.607 and AMC1 29.607 are introduced to provide means of compliance of the fasteners with certification standards, in particular those fasteners used in critical installations.

Item 28: Lightning and static electricity protection (CS-27 and CS-29)

AMC1 27.610 and AMC1 29.610 are introduced to provide an acceptable means of compliance for rotorcraft components evaluation after lightning strike.

Item 29: Density effect on manoeuvring load factors (CS-27 and CS-29)

CS 27.309 and CS 29.309 are amended to ensure that the entire operational density envelope is considered when showing compliance with the structural requirements.

AMC1 27.337 and AMC1 29.337 are introduced to provide means of compliance with the requirements on the limit manoeuvring load factor.

Item 30: Single ‘non-smoking’ and ‘fasten seatbelt’ placard (CS-27 and CS-29)

AMC1 27.853(c), AMC1 29.853(c) and AMC1 29.1413(a) are introduced to provide means to comply with the requirements on smoking possibilities and the need to fasten the seatbelt, in particular with respect to the use of a single placard.

Item 31: Compliance with requirements on flammability testing (CS-29)

AMC1 29.853 is introduced to provide means to comply with the requirements on flammability testing.

Item 32: Use of composite sandwich panels (CS-27 and CS-29)

AMC1 27.613 and AMC1 29.613 are introduced to provide means to comply with the requirements on material strength properties and design values.

Item 33: Turbine engine induction systems certification in icing conditions (CS-27 and CS-29)

AMC1 27.1093(b)(1)(i) and AMC1 29.1093(b)(1)(i) are introduced to provide means to comply with the requirements on induction system icing protection.

Item 34: Seat adapter plates (CS-27 and CS-29)

AMC3 27.307 and AMC3 29.307 are introduced to provide means to comply with the requirements on proof of structure, in particular regarding the seat adapter plates.

Item 35: Protection of occupants (CS-27 and CS-29)

AMC1 27.561, AMC1 29.561, AMC1 27.787 and AMC1 29.787 are introduced to provide means to comply with the requirements on protection of occupants in emergency conditions.

Item 36: Development assurance process (CS-27 and CS-29)

AMC1 27.1309 and AMC1 29.1309 are introduced to provide means to comply with the requirements on development assurance process in CS 27.1309 and CS 29.1309.

Item 37: Fuselage, landing gear and rotor pylon structures

CS 27.547 and CS 27.549 are amended to add a missing reference.

Item 38: Equipment, systems and network information security protection

AMC1 29.1319 is amended to clarify that the requirement to protect rotorcraft equipment, systems and networks against information security threats is limited to those having a potential safety impact more than MAJOR.

Item 39: Fuel quantity indicator and fuel low-level sensors independence (CS-27 and CS-29)

CS 27.1305 (l)(2) and CS 29.1305 (a)(4)(ii) are amended to allow installation of fuel quantity and fuel low-level sensors on the same supporting structure under specific conditions without requiring an ESF (TBC) to be granted. In addition, related AMC are introduced.

Item 40: Ditching (CS-29)

CS 29.801(a) is amended to correct a reference to the requirements the rotorcraft must meet for certification with ditching provisions.

Item 41: Model test method for flotation stability

AMC to CS 27.801(e) and 27.802(c) is amended to correct a reference to an FAA AC paragraph.

AMC to CS 29.801(e) and 29.802(c) is amended to correct a reference to an FAA AC paragraph.

2.4. What are the expected benefits and drawbacks of the proposal

The proposed amendments reflect the state of the art of small and large rotorcraft certification. They will improve safety, while having no social or environmental impacts. The proposed amendments would provide economic benefits by streamlining the certification and validation processes. No adverse impacts are expected.



3. Proposed amendments and rationale in detail

The text of the amendment is arranged to show deleted, new or amended, and unchanged text as follows:

- deleted text is ~~struck through~~;
- new or amended text is highlighted in blue;
- an ellipsis '[...]' indicates that the rest of the text is unchanged.

3.1. Draft CS, AMC and GM to CS-27 / CS-29 (draft EASA decision)

Item 1: Lightweight flight recorders

CS 27.1458 Lightweight flight recorder

- (a) Each lightweight flight recorder required by Regulation (EU) No 965/2012 must be approved and must be installed so that:
- (1) there is an aural or visual means for pre-flight checking of the recorder for proper recording of data in the storage medium; and
 - (2) it complies with point (d) of CAT.IDE.H.191 and point (d) of SPO.IDE.H.146 of Regulation (EU) No 965/2012.
- (b) The recording medium container of the lightweight flight recorder in point (a) must be mounted and located in a place that reduces the risk of the container rupturing or the recording medium being destroyed as a result of impact with the Earth's surface and subsequent heat damage caused by a post-impact fire, to an acceptable level.
- (c) The recording medium container of the lightweight flight recorder in point (a) must:
- (1) have a high proportion of its outer surface area coloured in bright orange; and
 - (2) have dimensions that are adequate for visually locating it on an accident scene.
- (d) Each flight parameter to be recorded as required in Regulation (EU) No 965/2012 must be recorded as digital data or by means of images.
- (e) If the lightweight flight recorder in point (a) records a flight parameter as required in by Regulation (EU) No 965/2012 by means of images, the image source must be installed to provide images with a quality sufficient for reading the values of this flight parameter during all phases of the flight.
- (f) If the lightweight flight recorder in point (a) records images or audio of the flight crew area:
- (1) an 'erase function' must be provided, which can be operated by the commander and which modifies image and audio recordings made before the operation of that function, so that those recordings cannot be retrieved using normal replay or copying techniques; and

- (2) the probability of inadvertent operation of the erase function and the probability of actuation of that function during crash impact must be minimised.

AMC1 27.1458 Lightweight flight recorder

(a) General

The installation of a recorder by means of an ETSO authorisation against ETSO 2C197, ETSO C123b, ETSO C124b, ETSO C176 or ETSO C177 (or equivalent standards accepted by EASA) satisfies the approval requirement in CS 27.1458(a).

In showing compliance with CS 27.1458, the applicant should take into account EUROCAE Document ED-155 'MOPS for Lightweight Flight Recording Systems' or EUROCAE Document ED-112 'MOPS for Crash Protected Airborne Recorder Systems' or later revisions of these documents.

'Flight recorder system' refers to the lightweight flight recorder and its dedicated equipment. It may include the following items as appropriate to the rotorcraft:

- (1) The equipment necessary to:
 - (i) acquire and process sensor signals;
 - (ii) store the recorded data in a robust recording medium; and
 - (iii) when necessary, support dedicated sensors; and
- (2) Digital data buses and/or networks providing communications between elements of the system.

The lightweight flight recorder should receive its electric power from the bus that provides the maximum reliability for operation of the recorder without jeopardising service to essential or emergency loads.

The height, width and depth of the recording medium container of the lightweight flight recorder should be at least 4 cm (1.5 inches).

(b) Installation of the flight recorder system

The flight recorder system should be installed in accordance with the recommendations made in EUROCAE Document ED-155 Section 2-5.3.

The recording medium container should be located and mounted in accordance with the specifications given in EUROCAE Document ED-155 Sections 2-5.4 and 2-5.5.

(c) Evaluation of recordings

The following acceptable means of compliance with CS 27.1458 (a), (d) and (e) is provided to demonstrate that the performance of the installed flight recorder system is acceptable with regard to data recording. Inspections of the recordings that are part of the instructions for continued airworthiness are not within the scope of this paragraph.

- (1) A recording made during a flight should be evaluated to confirm that the recording of the data required by Regulation (EU) No 965/2012 is acceptable during all phases of flight

where this data should be recorded. In the case of image recordings, refer to Section III-6.4 of ED-155.

(2) The evaluation of the recordings from the flight should include:

- (i) checking the correct functioning of the automatic start-and-stop function of the flight recorder system; and
- (ii) checking for the presence of any fault in the memory of the built-in-test feature of the recorder, if installed.

(3) The evaluation of the recordings should be documented in an evaluation report; and

(4) The performance of the flight recorder system with regard to data recording should be considered to be acceptable only if points (c)(1) and (c)(2) of this AMC were satisfactorily addressed.

(5) It is accepted that by implementing emergency procedures (i.e. for smoke/fire isolation) the power supply to the lightweight recorder is cut-off.

(d) Image and audio recordings of the flight crew area

If there are no compartments to physically segregate the flight crew from the passengers, 'flight crew area' should be understood as the area including:

- the flight crew seat(s),
- windshield and windows used by the flight crew to get an external view while seated,
- aircraft instruments and controls, and
- circuit breakers accessible by the flight crew while seated.

(e) Instructions for continued airworthiness (ICA)

When developing the ICA for the flight recorder system, required by CS 27.1529 and Appendix A, the applicant should address all the failures that may affect the performance of the flight recorder system or the quality of the data required to be recorded by Regulation (EU) No 965/2012.

Examples of failures (indicative and non-exhaustive list):

- Loss of the recording function of the lightweight flight recorder;
- Any data required by Regulation (EU) No 965/2012 is missing, or is not correctly recorded;
- Failure of the automatic start-and-stop function.

The ICA should include the procedures to be followed for retrieving the data required to be recorded by the lightweight flight recorder when it is undamaged.

In addition, if the lightweight flight recorder records some required flight parameters as digital data, the ICA should include a document that presents the information necessary to retrieve the raw binary data of these flight parameters from a recording file and to convert this data into engineering units and textual interpretations. If the lightweight flight recorder records some required flight parameters by means of images, the ICA should include a document that

presents the information necessary to read the flight parameter values from the recorded images.

Item 2: Unusable fuel supply

AMC1 27.959 Unusable fuel supply

This AMC supplements FAA AC 27.959.

This AMC provides clarification on the acceptability of analyses and ground testing which could be used as means of compliance if supported by actual flight test data.

FAA AC 27-1B provides some guidance by focusing on a flight/test demonstration as being directly in line with the intent of the specification to validate ‘...any intended operations and flight manoeuvres...’, but also provides for acceptability of analyses and ground testing.

In order to accept a demonstration by laboratory test with partial flight test, the applicant should demonstrate the ground testing capability to simulate the effects offered normally by the flight-testing environment (pressure, venting, vibrations, acceleration/deceleration, attitude, attitude change rate, etc.), knowing that in any case those ground simulated conditions would need correlation with flight test data.

In case the full flight-testing environment cannot be accurately simulated, it is necessary to either:

- revert to compliance demonstration based on flight test; or
- apply some conservatism factors on the unusable fuel quantity value resulting from the laboratory testing to determine the final unusable fuel value. The conservatism factors should be agreed by EASA.

Any (steady or transitory) engine abnormal operation/malfunction has to be taken as an indication that the fuel in the tank is becoming unusable.

AMC1 29.959 Unusable fuel supply

This AMC provides clarification on the acceptability of analyses and ground testing which could be used as means of compliance if supported by actual flight test data.

FAA AC 29-2C, § AC 29.959 provides some guidance by focusing on a flight/test demonstration as being directly in line with the rule intent to validate ‘...any intended operations and flight manoeuvres...’, but also provides for acceptability of analyses and ground testing.

In order to accept a demonstration by laboratory test with partial flight test, the applicant shall demonstrate the ground testing capability to simulate the effects offered normally by the flight-testing environment (pressure, venting, vibrations, acceleration/deceleration, attitude, attitude change rate, etc.), knowing that in any case those ground simulated conditions would need correlation with flight test data.

In case the full flight-testing environment cannot be accurately simulated, it is necessary to either:

- revert to compliance demonstration based on flight test; or
- apply some conservatism factors on the unusable fuel quantity value resulting from the laboratory testing to determine the final unusable fuel value. The conservatism factors should be agreed by EASA.

Any (steady or transitory) engine abnormal operation/malfunction has to be taken as an indication that the fuel in the tank is becoming unusable.

Item 3: Fragment containment

AMC1 29.901(d)(1) Installation

FRAGMENT CONTAINMENT

This AMC supplements FAA AC 29.901 with regard to the credit that can be taken from engine manufacturer data substantiating the capability of the engine to contain fragments.

(a) Blade containment

Singe blade containment is a CS-E / CS-APU requirement. Full credit is given to engine certification for blade containment and no specific certification activity is required at helicopter level for blade failure. This approach is supported by the in-service experience.

(b) Small debris containment at engine level

Some engine designs feature the capability to retain small debris, featuring, for instance, a reinforced casing. This raises two issues:

- The containment capability is not required by CS-E and the corresponding data is not covered by the engine type certificate; the helicopter manufacturer should propose a mechanism to ensure that the data is valid, under their DOA or by validation through the engine type certificate.
- The engine uncontained model features a small debris over a $\pm 15^\circ$ spread angle. Small fragments can be a collateral effect of either large or intermediate fragment release, but are released over larger spread angles, typically $\pm 15^\circ$. Therefore, from a CS 29.903(d) point of view, no credit can be given to engine containment for small debris, which might however have other safety benefits.

(c) Rotor containment at engine or APU level

CS-APU has provisions to demonstrate rotor containment. For engines, while not required by CS-E, engine manufacturers might decide to design their engines featuring rotor containment systems, for all or specific rotating stages.

- For engines, the containment capability is not required by CS-E and the corresponding data is not covered by the engine type certificate; the helicopter manufacturer should propose a mechanism to ensure that the data is valid, under their DOA or by validation through the engine type certificate whereas for an APU, CS-ETSO requirements are in place, and it can be expected that the data is covered by the ETSO issuance).

- In-service experience has shown that such containment features successfully perform their intended purpose of retaining the biggest debris (large fragments). However, small debris can defeat the containment system, either by missing it or by exiting through damages caused by the large fragments. Rotor containment systems, as explained in paragraph f.(1) of AC 29.903C, still require some activity at helicopter level to ensure that the risks associated with uncontained engine or APU uncontained failure are adequately mitigated.

Note: For APUs, AMC 20.128A defines an acceptable model based upon debris exiting the containment system with a 1 % residual energy.

Item 4: Fuel quantity indicator

AMC1 27.1337(b) Powerplant instruments

FUEL QUANTITY INDICATOR

This AMC supplements FAA AC 27.1337 and relates to the susceptibility of the fuel quantity indication accuracy to water contamination.

As provided in CS-27, the fuel system shall be designed to resist to different nature and level of fuel contamination.

For water contamination, CS 27.951(c) assumes the presence of free water in fuel already saturated with water. To show compliance with CS 27.1337(b), the applicant should take into account the potential water contamination as specified in CS 27.951(c).

It is expected that the fuel quantity indication should not be affected by water contamination as specified in CS 27.951(c).

The fuel level sensors should be designed to prevent an accumulation of water that could lead to an erroneous indication of the fuel quantity.

AMC1 29.1337(b) Powerplant instruments

FUEL QUANTITY INDICATOR

This AMC supplements FAA AC 29.1337 by providing clarification regarding the susceptibility of the fuel quantity indication accuracy to water contamination.

The certification specifications in CS-29 assume different natures and levels of fuel contamination to which the fuel system shall be designed tolerant.

For water contamination, CS 29.951(c) assumes a free water presence on top of a water saturated fuel (in standard conditions).

When showing compliance with CS 29.1337(b), an applicant should take into account the potential water contamination as specified in CS 29.951(c).

It is expected that the fuel quantity indication should not be affected by a water contamination as specified in CS 29.951 (c).

The fuel level sensors should be designed to prevent an accumulation of water that could lead to an erroneous indication of the fuel quantity.

Item 5: Fatigue evaluation of drive system components

AMC1 27.571 Fatigue evaluation of flight structure

DRIVE SYSTEM COMPONENTS

This AMC supplements FAA AC 27-1B, § AC 27.571 and should be used in conjunction with that AC when demonstrating compliance with CS 27.571.

(a) Definitions

- (1) Rolling contact fatigue (RCF): a form of fatigue that occurs due to the cyclic strains arising from the loading present during rolling contact between two parts of an assembly, e.g. a bearing race and a rolling element.

Note: For the purposes of this AMC, it also includes combinations of rolling and sliding contact phenomena.

- (2) Integral race: a bearing race that is an integral part of the transmission structural component such as a gear or shaft.

(b) Explanation

Service experience has shown that RCF can initiate cracks in integral bearing races of rotor drive system structural elements that, in some cases, can propagate to a failure with catastrophic results.

The certification specifications in CS 27.571 require the identification and fatigue evaluation of the portions of the flight structure (including the rotor drive systems), the failure of which could be catastrophic. In order to complete this fatigue evaluation, one of or a combination of the methods proposed in sub-paragraphs (b), (c), (d) and (e) of CS 27.571 should be applied. However, specific characteristics of rotor drive systems gearbox internal components, such as the difficulty to visually inspect the operating nature of its elements which can lead to mechanical degradation and the impact of RCF, make the application of some of the methods challenging. It is often assumed that RCF leads first to non-critical failure modes such as micro-pitting and spalling that should be detected before more critical failure modes can develop. The procedures of this AMC ensure that the effects of RCF are adequately accounted for in the fatigue evaluations required by CS 27.571.

(c) Procedure

For rotor drive system components, the applicant should establish the list of components to be evaluated by assessing the failure of those that could result in catastrophic consequences for the rotorcraft. This should include consideration of RCF in integral bearing races and the possibility of this mechanism leading to a catastrophic failure due to cracking of the component.

The applicant should define the method of compliance that will be applied to demonstrate that a catastrophic failure as a result of fatigue failure is extremely remote. The methodology should take into consideration points (1) and (2) below.

- (1) The use of 'fail-safe evaluation' is recommended. This method ensures that, should fatigue cracks initiate, the remaining structure will withstand service loads without failure until the cracks are detected. This demonstration should include structural tests and/or analyses to substantiate that the fail-safe design objective has been achieved, including residual strength demonstration. The means of detection, including indirect means of detection such as chip detection systems, should be demonstrated to be capable of detecting the failed condition within an acceptable period of time.
- (2) In order to make use of other methods such as CS 27.571(b) 'Fatigue tolerance evaluation' and CS 27.571(c) 'Replacement time evaluation', the applicant should select safe design allowables for aspects such as contact pressures that industry standards and know-how confidently identify as safe and capable of ensuring good levels of reliability. The applicant should verify that the selected allowables are suitable to ensure the integrity of the rotor drive system components in the operating conditions (temperature, lubrication, etc.) applicable to their design. In addition, means of detecting any potential degradation of components that could alter the foreseeable operating conditions and fatigue performance of the parts evaluated in CS 27.571 should be provided and demonstrated to be effective.

AMC1 29.571 Fatigue tolerance evaluation of metallic structure

FATIGUE EVALUATION OF ROTOR DRIVE SYSTEM COMPONENTS

This AMC supplements FAA AC 29-2C, § AC 29.571 and should be used in conjunction with that AC when demonstrating compliance with CS 29.571.

(a) Definitions

- (1) Rolling contact fatigue (RCF): a form of fatigue that occurs due to the cyclic strains arising from the loading present during rolling contact between two parts of an assembly, e.g. a bearing race and a rolling element.

Note: For the purposes of this AMC, RCF also includes combinations of rolling and sliding contact phenomena.

- (2) Integral race: a bearing race that is an integral part of the transmission structural component such as a gear or shaft.

(b) Explanation

Service experience has shown that RCF can initiate cracks in integral bearing races of rotor drive system structural elements that, in some cases, can propagate to a failure with catastrophic results. It is often assumed that RCF leads first to failure modes such as micro-pitting and spalling that will be detected before more severe failure modes can develop. The procedures of

this AMC are intended to help ensure that the effects of RCF are accounted for in the fatigue tolerance evaluations required by CS 29.571.

(c) Procedure

The fatigue tolerance evaluation of rotor drive system principal structural elements (PSEs) should include, when applicable, the combined effect of RCF and other damage threats such as dents, scratches, corrosion, loss of pre-load in bearings or joints, surface and sub-surface material defects, etc., considering residual stress coming from surface treatments and other manufacturing processes and all other applicable loading conditions. Particular attention should be paid to evaluation of components with integral bearing races.

Steps should be taken to minimise the risk of crack initiation due to RCF in integrated races by minimising contact stresses, specifying high standards for surface finishes, ensuring good lubrication and maintaining oil quality regardless of the fatigue tolerance approach selected. Experience has demonstrated that it can be beneficial for bearings to be designed so that the reliability of the integrated race of the PSE is even higher than the less critical race of the bearing. In this way, degradation of the less critical race can lead to detection of the bearing failure before cracking initiates in the integrated race. The consequences of damage to the integrated race from the debris generated in such scenarios should be considered in the evaluation.

As it is difficult to totally preclude cracking initiated by RCF, a fail-safe approach is recommended wherever possible, such that failure or partial failure due to cracking of the rotor drive system structural element is detected prior to its residual strength capability falling below the required levels prescribed in CS 29.571(f). This method using analysis supported by test ensures that, should fatigue cracks initiate, the remaining structure will withstand service loads and limit loads without failure until the cracks are detected. Analysis, experience with similar designs and testing should be used to verify any assumptions related to the way the crack or cracks develop in the structure from potential surface and sub-surface origins and whether a through crack may develop and its relationship with other forms of damage including spalling. In addition, the continued safe operation of the gearbox should be ensured for this period considering the effect of the cracking on stiffness, dynamic behaviour, loads and functional performance.

The effectiveness and reliability of means of crack detection for the fail-safe approach, including indirect means of detection such as chip detection systems, and associated instructions for continued airworthiness should be evaluated to show that, if implemented as required, they will result in timely detection and repair or replacement of damaged components. In addition, the instructions for continued airworthiness, prescribing the maintenance actions leading up to and following detection of potential damage should be substantiated sufficiently to ensure timely repair or replacement of damaged components. The substantiation should consider aspects such as threshold criteria on indicators of means of detection for additional investigative actions and removal from service of the damaged parts, the overall clarity and practicality of the instructions for continued airworthiness and human factors aspects.

A continued integrity verification programme (CIVP), as prescribed in CS 29.602(c), should be implemented to monitor critical parts and may be extended to all PSEs (see AMC1 29.602)

subject to RCF to ensure assumptions supporting the compliance demonstration remain valid throughout the operational life of the component.

Item 6: Critical parts

CS 27.602 Critical parts

- (a) Critical part - 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) If the type design includes critical parts, a critical parts list ~~shall~~ **must** be established. Procedures ~~shall~~ **must** 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**. ~~Part 21~~.
- (c) As part of the process of compliance with this paragraph, a continued integrity verification programme (CIVP) **must** be developed. The CIVP should ensure the continued validity of assumptions made during certification that could affect the integrity of critical parts.

AMC1 27.602 Critical parts

This AMC supplements FAA AC 27-1B, § AC 27.602 and should be used in conjunction with that AC when demonstrating compliance with CS 27.602.

(a) Explanation

The continued integrity verification programme (CIVP) should address all critical parts. In addition, it may also include other parts the failure of which could have a catastrophic effect upon the rotorcraft and for which no critical characteristics have been identified at the time of certification. Actions arising from a finding in a CIVP could in the future change the certification approach for similar components or lead to a continued airworthiness action.

(b) Procedures

(1) The CIVP should assess the continued validity of assumptions made during certification regarding the condition and operation of critical parts in order to help ensure their continued integrity. This should include but not be limited to demonstration of the continuity of the effectiveness of design, maintenance and monitoring provisions (e.g. health monitoring, usage monitoring and safety devices) developed to comply with CS 27.571 and CS 27.573 through the life of the type design.

(2) The following data can be used to support the CIVP:

- (i) analysis of occurrence reports;
- (ii) analysis of unscheduled removal rates;

- (ii) results of scheduled maintenance;
 - (iv) strip reports / analysis at overhaul;
 - (v) post-TC development and maturity tests;
 - (vi) additional inspection (non-destructive and/or destructive) and testing on selected high time or rejected components;
 - (vii) feedback from lead customers.
 - (viii) audits of subcontractors and suppliers of critical parts;
 - (ix) statistical process control data of manufacturing processes affecting critical characteristics;
 - (x) review of concessions;
 - (xi) changes in utilisation and operating environment;
 - (xii) operator / applicant working group activities;
 - (xiii) health monitoring data; and
 - (xiv) usage monitoring data.
- (3) The assessments required by the CIVP, as described above, should be performed at suitable periods through the complete life of the subject component types, considering the types of operation, environment and ageing effects expected. To meet this objective, an evaluation will need to be performed on at least one sample of each component at each major inspection interval or overhaul, and at retirement time, as applicable. In addition, the applicant should consider scheduling early evaluation opportunities to confirm the suitability of the inspection intervals scheduled at entry into service. Consideration should be given to adding new samples and revising the CIVP when changes to the types of operation or environment occur. Where inspections and feedback from service need to be provided by operators or maintenance organisations, the information necessary should be clearly specified by the applicant within the continued integrity verification programme plan (CIVPP) and relevant maintenance instructions.
- (4) A CIVPP, defining the tasks and schedule of the CIVP should be agreed during certification. Reports stating the findings of the CIVP during service should be furnished to the Agency. The CIVPP may be revised during the life of the rotorcraft if considered appropriate by the applicant and agreed by the Agency. On conclusion of the CIVP, an assessment of all findings should be made by the applicant and reported in the continued integrity verification programme report (CIVPR). The applicant should consider the participation of an operator for review of the CIVPR.

CS 29.602 Critical parts

- (a) Critical part - 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) If the type design includes critical parts, a critical parts list ~~shall~~ **must** be established. Procedures ~~shall~~ **must** 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**. ~~Part 21~~.
- (c) As part of the process of compliance with this paragraph, a continued integrity verification programme (CIVP) shall be developed. The CIVP should ensure the continued validity of assumptions made during certification that could affect the integrity of Critical Parts.

AMC1 29.602 Critical parts

This AMC supplements FAA AC 29-2C, § AC 29.602 and should be used in conjunction with that AC when demonstrating compliance with CS 29.602.

(a) Explanation

The continued integrity verification programme (CIVP) should address all critical parts. In addition, it may also include other parts the failure of which could have a catastrophic effect upon the rotorcraft and for which no critical characteristics have been identified at the time of certification. Actions arising from a finding in a CIVP could in the future change the certification approach for similar components or lead to a continued airworthiness action.

(b) Procedures

- (1) The CIVP should assess the continued validity of assumptions made during certification regarding the condition and operation of critical parts in order to help ensure their continued integrity. This should include but not be limited to demonstration of the continuity of the effectiveness of design, maintenance and monitoring provisions (e.g. health monitoring, usage monitoring and safety devices) developed to comply with CS 29.547(b), CS 29.571, CS 29.573 and CS 29.917(b) through the life of the type design.
- (2) The following data can be used to support the CIVP:
 - (i) analysis of occurrence reports;
 - (ii) analysis of unscheduled removal rates;
 - (iii) results of scheduled maintenance;
 - (iv) strip reports / analysis at overhaul;
 - (v) post-TC development and maturity tests;
 - (vi) additional inspection (non-destructive and/or destructive) and testing on selected high time or rejected components;
 - (vii) feedback from lead customers;
 - (viii) audits of subcontractors and suppliers of critical parts;
 - (ix) statistical process control data of manufacturing processes affecting critical characteristics;
 - (x) review of concessions;

- (xi) changes in utilisation and operating environment;
 - (xii) operator / applicant working group activities;
 - (xiii) health monitoring data; and
 - (xiv) usage monitoring data.
- (3) The assessments required by the CIVP, as described above, should be performed at suitable periods through the complete life of the subject component types, considering the types of operation, environment and ageing effects expected. To meet this objective, an evaluation will need to be performed on at least one sample of each component at each major inspection interval or overhaul, and at retirement time, as applicable. In addition, the applicant should consider scheduling early evaluation opportunities to confirm the suitability of the inspection intervals scheduled at entry into service. Consideration should be given to adding new samples and revising the CIVP when changes to the types of operation or environment occur. Where inspections and feedback from service need to be provided by operators or maintenance organisations, the information necessary should be clearly specified by the applicant within the continued integrity verification programme plan (CIVPP) and relevant maintenance instructions.
- (4) A CIVPP, defining the tasks and schedule of the CIVP should be agreed during certification. Reports stating the findings of the CIVP during service should be furnished to the Agency. The CIVPP may be revised during the life of the rotorcraft if considered to be appropriate by the applicant and agreed by the Agency. On conclusion of the CIVP, an assessment of all findings should be made by the applicant and reported in the continued integrity verification programme report (CIVPR). The applicant should consider the participation of an operator for review of the CIVPR.
- (5) Additionally, the CIVP could be used to verify the continued validity of compensating provisions identified in the design assessments required by 29.547(b) and 29.917(b) and their associated assumptions.

Item 7: 30-minute power rating

AMC1 27.923 Rotor drive system and control mechanism tests

(a) Introduction

This AMC supplements FAA AC 27-1B, § AC 27.923 and should be used in conjunction with that AC when demonstrating compliance with CS 27.923.

(b) 30-minute power rating

(1) Explanation

The option to establish a 30-minute power rating for turbine engines for rotorcraft has been introduced in CS-E Amendment 5 (published on 14 December 2018) with the creation of CS-E 40(b)(4). Means to demonstrate compliance with this requirement are

provided in the associated AMC E 40(b)(3) and (b)(4) 30-Second OEI, 2-Minute OEI and 30-minute Power Ratings.

In particular, AMC E40(b)(3) and (b)(4) mentions that 'The 30-Minute Power rating may be set at any level between the Maximum Continuous up to and including the take-off rating, and may be used for multiple periods of up to 30 minutes each, at any time between the take-off and landing phases in any flight'. In addition, CS-E 740 (c)(2)(i) specifies additional running time for the endurance test for engines for rotorcraft for which approval with this rating is sought.

In comparison, the endurance test programme specified in CS 27.923 for rotorcraft rotor drive systems and control mechanisms:

- addresses the take-off power rating, which is 'limited in use to a continuous period of not more than 5 minutes' according to CS-Definitions, through the test runs specified in CS 27.923(b), and
- currently does not address the 30-minute power rating.

(2) Procedures

For applications including a 30-minute power rating, the applicant should consider that the approval of such rating should be supported by additional tests, as prescribed in CS 27.927(a), with the aim of determining that the rotor drive mechanism is safe considering the use of this specific power rating. In this context, the applicant may consider running additional test phases and/or extending the running time and/or increasing the minimum power conditions defined in CS 27.923 to include testing of this power rating.

AMC1 29.923 Rotor drive system and control mechanism tests

(a) Introduction

This AMC supplements FAA AC 29-2C, § AC 29.923 and should be used in conjunction with that AC when demonstrating compliance with CS 29.923.

(b) 30-minute power rating

(1) Explanation

The option to establish a 30-minute power rating for turbine engines for rotorcraft has been introduced in CS-E Amendment 5 (published on 14 December 2018) with the creation of CS-E 40(b)(4). Means to demonstrate compliance with this requirement are provided in the associated AMC E 40(b)(3) and (b)(4) 30-Second OEI, 2-Minute OEI and 30-minute Power Ratings).

In particular, AMC E 40(b)(3) and (b)(4) mentions that 'The 30-Minute Power rating may be set at any level between the Maximum Continuous up to and including the take-off rating, and may be used for multiple periods of up to 30 minutes each, at any time between the take-off and landing phases in any flight'. In addition, CS-E 740 (c)(2)(i)

specifies additional running time for the endurance test for engines for rotorcraft for which approval with this rating is sought.

In comparison, the endurance test programme specified in CS 29.923 for rotorcraft rotor drive systems and control mechanisms:

- addresses the take-off power rating, which is 'limited in use to a continuous period of not more than 5 minutes' according to CS-Definitions, through the test runs specified in CS 29.923(b), and
- currently does not address the 30-minute power rating.

(2) Procedures

For applications including a 30-minute power rating, the applicant should consider that the approval of such rating should be supported by additional tests, as prescribed in CS 29.927(a), with the aim of determining that the rotor drive mechanism is safe considering the use of this specific power rating. In this context, the applicant may consider running additional test phases and/or extending the running time and/or increasing the minimum power conditions defined in CS 29.923 to include testing of this power rating.

AMC1 27.1045 Cooling test procedures

(a) Introduction

This AMC supplements FAA AC 27-1B, § AC 27.1045A and should be used in conjunction with that AC when demonstrating compliance with CS 27.1045.

(b) 30-minute power rating

(1) Explanation

The usage of the 30-minute power rating supposes an extension of the duration at which the engine may deliver its maximum take-off power.

This use of this rating may affect the cooling capabilities of the rotorcraft. This potential impact should be evaluated during the certification.

(2) Procedure

In the case of usage of a 30-minute power rating, AC 27.1045A b) should be completed as such:

Procedures. All of the policy material pertaining to this section remains in effect except that the engine fluid temperatures do not have to stabilise. Paragraph AC 27.1045 currently lists three criteria for test completion: temperature stabilisation, flight test segment completion, or an operation limitation. With Amendment 27-23, a fourth criterion for test completion is:

- 5 minutes after the peak temperature is reached, the test can be considered to be complete, or

- the continuous time limit of the 30-minute power rating if the highest temperature recorded is not stabilised before.

CS 29.1049 Hovering cooling test procedures

For rotorcraft for which a 30-minute power rating is claimed, the hovering cooling provisions must be shown:

- (c) At maximum weight or at the greatest weight at which the rotorcraft can hover (if less), at sea level, with the power required to hover but not more than 30-minute power rating, in the ground effect in still air, until:
- at least 5 minutes after the occurrence of the highest temperature recorded, or
 - the continuous time limit of the 30-minute power rating if the highest temperature recorded is not stabilised before.
- (d) With 30-minute power rating, maximum weight, and at the altitude resulting in zero rate of climb for this configuration, until:
- at least 5 minutes after the occurrence of the highest temperature recorded, or
 - the continuous time limit of the 30-minute power rating if the highest temperature recorded is not stabilised before.

CS 27.1305 Powerplant instruments

(...)

- (w) For rotorcraft for which a 30-minute power rating is claimed, a means must be provided to alert the pilot when the engines are at the 30-minute power rating levels, when the event begins, when the time interval expires and, if a cumulative limit in one flight exists, when the cumulative time in one flight is reached.

CS 29.1305 ~~Power-plant~~ Powerplant instruments

(...)

- (a)(27) For rotorcraft for which a 30-minute power rating is claimed, a means must be provided to alert the pilot when the engines are at the 30-minute power rating levels, when the event begins, when the time interval expires and, if a cumulative limit in one flight exists, when the cumulative time in one flight is reached.

AMC1 27.1521 Powerplant limitations

(a) Introduction

This AMC supplements FAA AC 27-1B, § AC 27.1521 and should be used in conjunction with that AC when demonstrating compliance with CS 27.1521.

(b) 30-minute power rating

(1) Explanation

The usage of the 30-minute power rating supposes an extension of the duration at which the engine may deliver its maximum take-off power.

This rating is associated with some limitations which should be adequately established and declared.

(2) Procedure

CS 27.1521 (a) refers to the limits for which the engines are type certificated. This should include the 30-minute power rating usage and:

- the associated usage limit:
 - 30 minutes in one single shot;
 - cumulative limit in one flight; and
- any other limits associated with the usage of the 30-minute power rating declared in the installation and/or operating manual of the engine.

AMC1 29.1521 Powerplant limitations

(a) Introduction

This AMC supplements FAA AC 29-2C, § AC 29.1521 and should be used in conjunction with that AC when demonstrating compliance with CS 29.1521.

(b) 30-minute power rating

(1) Explanation

The usage of the 30-minute power rating supposes an extension of the duration at which the engine may deliver its maximum take-off power.

This rating is associated with some limitations which should be adequately established and declared.

(2) Procedure

CS 29.1521 (a) refers to the limits for which the engines are type certificated. This should include the 30-minute power rating usage and:

- the associated usage limit:

- 30 minutes in one single shot;
- cumulative limit in one flight; and
- any other limits associated with the usage of the 30-minute power rating declared in the installation and/or operating manual of the engine.

Item 8: Variable rotor speed (NR)

AMC1 27.927 Additional tests

(a) Introduction

This AMC supplements FAA AC 27-1B, § AC 27.927 and should be used in conjunction with that AC when demonstrating compliance with CS 27.927.

(b) Variable rotor speed (NR)

(1) Explanation

The variable rotor speed (NR) function allows running at different NR levels to achieve, for instance, lower noise levels and better rotorcraft performance.

In addition to the endurance test prescribed in CS 27.923, additional tests may be necessary to demonstrate that rotor drive systems of rotorcraft with a variable NR are safe.

(2) Procedure

In order to substantiate an acceptable vibration and dynamic behaviour of rotor drive systems when using the available range of rotor speeds within the variable NR function, the applicant should consider performing specific test investigations, as prescribed in CS 27.927(a). The need for representative test runs at the different torque and rotor speed combinations, covering steady states and transient conditions to be encountered in operation, should be evaluated by and agreed with the Agency.

AMC1 29.927 Additional tests

(a) Introduction

This AMC supplements FAA AC 29-2C, § AC 29.927 and should be used in conjunction with that AC when demonstrating compliance with CS 29.927

(b) Variable rotor speed (NR)

(1) Explanation

The variable rotor speed (NR) function allows running at different NR levels to achieve, for instance, lower noise levels and better rotorcraft performance.

In addition to the endurance test prescribed in CS 29.923, additional tests may be necessary to demonstrate that rotor drive systems of rotorcraft with a variable NR are safe.

(2) Procedure

In order to substantiate an acceptable vibration and dynamic behaviour of rotor drive systems when using the available range of rotor speeds within the variable NR function, the applicant should consider performing specific test investigations, as prescribed in CS 29.927(a). The need for representative test runs at the different torque and rotor speed combinations, covering steady states and transient conditions to be encountered in operation, should be evaluated by and agreed with the Agency.

Item 9: Instructions for continued airworthiness

AMC1 27.1529 Instructions for continued airworthiness

(a) Introduction

This AMC supplements FAA AC 27-1B, § AC 27.1529 and should be used in conjunction with that AC when demonstrating compliance with CS 27.1529.

(b) Abnormal events

The ICA should include instructions that ensure that operators conduct appropriate inspections or other actions following abnormal events in operation, maintenance or during transportation of components.

Abnormal events that should be considered include hard landings, severe turbulence encounters, lightning strike, exposure to high winds when parked and dropping components during maintenance or transport.

The instructions should consider the nature of the components, including but not limited to critical parts, and in particular the possibility of damage that can occur during impact or overload events that may not be detectable but could subsequently lead to premature failure in operation. In such cases, scrapping the component or parts of it may be the only appropriate action to take.

(c) Time between overhaul (TBO) development

(1) Explanation

The purpose of this AMC is to provide guidance for establishing an appropriate TBO for rotorcraft drive system gearboxes at type certificate approval and to increase it during the service life of the product.

A rotorcraft rotor drive system gearbox is usually a complex assembly composed of many parts of which a significant proportion are critical parts. Many are rotating parts which are subject to high torque and fatigue loads, such as bearings, shafts, gears, and free wheels with the primary function of transmitting power from the engine to the rotors.

Non-rotating components have other functions such as support, lubrication, load transfer or condition monitoring.

Most gearbox components are enclosed inside the housings, which prevents the possibility of detailed maintenance inspections without disassembly. As a result, to ensure the internal gearbox components remain in serviceable condition, periodic overhauls of the assembly are typically scheduled. Overhaul allows an in-depth and periodic inspection of gearbox components, controlling and limiting the development of degradation and build-up of debris, as well as checking for cracks and other damages that may be developing. In addition, the inspection findings can determine whether parts are sufficiently protected and whether they remain in serviceable condition. In summary, the overhaul of the gearbox is intended to verify the condition of its elements, restore them to a serviceable condition or replace them where needed, and ensure the gearbox will be safe for operation until the following overhaul. The TBO is the periodic interval between two overhauls and is traditionally defined in flight hours and calendar time.

During the type-certification process, rotorcraft drive system gearbox components are subject to various forms of analyses and tests, which assess their criticality, integrity and reliability. These assessments rely on a number of assumptions regarding the condition of the components during their service life and have an impact on aspects such as contact conditions between elements, fretting, wear, loads and environmental deterioration. The applicant should consider that the continued validity of these assumptions is typically linked to an appropriate TBO. As a result, the validation of these assumptions and the development of the TBO are processes that should be progressed in parallel after entry into service (EIS).

The final and mature TBO should normally be based on the results of investigations from in-service aircraft, overhauled gearboxes and data acquired during development, certification, and maturity tests substantiating the reliability of the parts and their capability to operate safely. However, until this data becomes available, the applicant should maintain a conservative TBO, extending it throughout the life of the product as positive supporting data from service becomes available.

(2) Guidance

For drive system gearboxes that are essential to drive the rotors, EASA considers that the initial TBO at EIS and the plan to increase it in service should be justified. For this purpose, the following should be considered by the applicant:

— Initial TBO (applicable at EIS)

At EIS, the available data supporting the justification of the TBO of a rotor drive system gearbox is typically limited. The applicant should, therefore, propose a conservative initial TBO supported by the data coming from:

- the endurance test,
- flight tests,
- other relevant tests, and

- experience on similar design having the same characteristics.

The applicant should take into account that, in general, only limited experience of the real operating environment and conditions for a new gearbox are available at EIS.

This initial TBO should ensure enough opportunities to verify the condition of internal gearbox components in order to validate the assumptions made at the time of certification, preventing that any compromised assumption may lead to an in-service catastrophic or hazardous failure.

— TBO step increase

The increase of a gearbox TBO in service should be accomplished in steps providing confidence progressively in the validity of the certification assumptions. Each TBO step increase should:

- only be proposed when the current TBO is supported by a sufficient number of gearbox overhaul inspection results;
- be based on a sufficient number of gearboxes from the fleet to be inspected, and take into account the representativeness of operational and environmental aspects of the selected samples to represent the full spectrum of gearbox usage;
- be based on technical justifications from overhauled gearboxes (e.g. condition of inspected parts, evidence from similar designs, etc.), maturity testing and in-service feedback (incidents, health and usage monitoring system (HUMS) data, etc.), and take into account the findings of the CIVP, where applicable; and
- be completed prior to formally increasing the TBO to verify acceptable behaviour and condition of the gearbox components prior to starting a new increase phase.

— Management of TBO steps

The process for managing the evolution of the TBO of drive system gearboxes should be documented in a TBO maturity plan. This should include:

- planned increase steps and target TBO, technical criteria for the validation of the steps planned and justification of the proposed plan (see note 1);
- definition of the number of gearboxes and selection criteria considering operation and environment (see note 1);
- definition of responsible parties for performing the TBO step increase validation inspections, activities involved and information to be reported;
- proposed analysis process of the inspection results, responsible parties and methods of analysis; and
- the TBO step increase validation process and associated deliverables (see note 2).

Any findings arising from the TBO development process which might bring into question the suitability of the current TBO or impair the capability of the gearbox to reach the planned increase in TBO should be reported to the Agency.

Finally, if a major change is introduced to or affecting a drive system gearbox, the applicant should evaluate the need to revise the TBO and incorporate additional steps in the gearbox TBO maturity plan.

Note 1: The TBO maturity plan and the associated TBO increase validation criteria should be defined by the applicant and provided to the Agency during the certification process. The results of the process of validation of each step might lead to revisions of the maturity plan.

Note 2: The acceptance of each individual step as well as the closure of the maturity plan should be formally endorsed by the applicant and duly documented.

AMC1 29.1529 Instructions for continued airworthiness

(a) Introduction

This AMC supplements FAA AC 29-2C, § AC 29.1529 and should be used in conjunction with that AC when demonstrating compliance with CS 29.1529.

(b) Abnormal events

The ICA should include instructions that ensure that operators conduct appropriate inspections or other actions following abnormal events in operation, maintenance or during transportation of components.

Abnormal events that should be considered include hard landings, severe turbulence encounters, lightning strike, exposure to high winds when parked and dropping components during maintenance or transport.

The instructions should consider the nature of the components, including but not limited to critical parts, and in particular the possibility of damage that can occur during impact or overload events that may not be detectable but could subsequently lead to premature failure in operation. In such cases, scrapping the component or parts of it may be the only appropriate action to take.

(c) Time between overhaul (TBO) development

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A rotorcraft rotor drive system gearbox is usually a complex assembly composed of many parts of which a significant proportion are critical parts. Many are rotating parts which are subject to high torque and fatigue loads, such as bearings, shafts, gears, and free

wheels with the primary function of transmitting power from the engine to the rotors. Non-rotating components have other functions such as support, lubrication, load transfer or condition monitoring.

Most gearbox components are enclosed inside the housings, which prevents the possibility of detailed maintenance inspections without disassembly. As a result, to ensure the internal gearbox components remain in serviceable condition, periodic overhauls of the assembly are typically scheduled. Overhaul allows an in-depth and periodic inspection of gearbox components, controlling and limiting the development of degradation and build-up of debris, as well as checking for cracks and other damages that may be developing. In addition, the inspection findings can determine whether parts are sufficiently protected and whether they remain in serviceable condition. In summary, the overhaul of the gearbox is intended to verify the condition of its elements, restore them to a serviceable condition or replace them where needed, and ensure the gearbox will be safe for operation until the following overhaul. The TBO, is the periodic interval between two overhauls and is traditionally defined in flight hours and calendar time.

During the type-certification process, rotorcraft drive system gearbox components are subject to various forms of analyses and tests, which assess their criticality, integrity and reliability. These assessments rely on a number of assumptions regarding the condition of the components during their service life and have an impact on aspects such as contact conditions between elements, fretting, wear, loads and environmental deterioration. The applicant should consider that the continued validity of these assumptions is typically linked to an appropriate TBO. As a result, the validation of these assumptions and the development of the TBO are processes that should be progressed in parallel after entry into service (EIS).

The final and mature TBO should normally be based on the results of investigations from in-service aircraft, overhauled gearboxes and data acquired during development, certification, and maturity tests substantiating the reliability of the parts and their capability to operate safely. However, until this data becomes available, the applicant should maintain a conservative TBO, extending it throughout the life of the product as positive supporting data from service becomes available.

(2) Guidance

For drive system gearboxes that are essential to drive the rotors, EASA considers that the initial TBO at EIS and the plan to increase it in service should be justified. For this purpose, the following should be considered by the applicant:

— Initial TBO (applicable at EIS)

At EIS, the available data supporting the justification of the TBO of a rotor drive system gearbox is typically limited. The applicant should, therefore, propose a conservative initial TBO supported by the data coming from:

- the endurance test,
- flight tests,
- other relevant tests, and

- experience on similar design having the same characteristics.

The applicant should take into account that, in general, only limited experience of the real operating environment and conditions for a new gearbox are available at EIS.

This initial TBO should ensure enough opportunities to verify the condition of internal gearbox components in order to validate the assumptions made at the time of certification, preventing that any compromised assumption may lead to an in-service catastrophic or hazardous failure.

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The increase of a gearbox TBO in service should be accomplished in steps providing confidence progressively in the validity of the certification assumptions. Each TBO step increase should:

- only be proposed when the current TBO is supported by a sufficient number of gearbox overhaul inspection results;
- be based on a sufficient number of gearboxes from the fleet to be inspected, and take into account the representativeness of operational and environmental aspects of the selected samples to represent the full spectrum of gearbox usage;
- be based on technical justifications from overhauled gearboxes (e.g. condition of inspected parts, evidence from similar designs, etc.), maturity testing and in-service feedback (incidents, health and usage monitoring system (HUMS) data, etc.), and take into account the findings of the CVP, where applicable; and
- be completed prior to formally increasing the TBO to verify acceptable behaviour and condition of the gearbox components prior to starting a new increase phase.

— Management of TBO steps

The process for managing the evolution of the TBO of drive system gearboxes should be documented in a TBO maturity plan. This should include:

- planned increase steps and target TBO, technical criteria for the validation of the steps planned and justification of the proposed plan (see note 1);
- definition of the number of gearboxes and selection criteria considering operation and environment (see note 1);
- definition of responsible parties for performing the TBO step increase validation inspections, activities involved and information to be reported;
- proposed analysis process of the inspection results, responsible parties and methods of analysis; and
- the TBO step increase validation process and associated deliverables (see note 2).

Any findings arising from the TBO development process which might bring into question the suitability of the current TBO or impair the capability of the gearbox to reach the planned increase in TBO should be reported to the Agency.

Finally, if a major change is introduced to or affecting a drive system gearbox, the applicant should evaluate the need to revise the TBO and incorporate additional steps in the gearbox TBO maturity plan.

Note 1: The TBO maturity plan and the associated TBO increase validation criteria should be defined by the applicant and provided to the Agency during the certification process. The results of the process of validation of each step might lead to revisions of the maturity plan.

Note 2: The acceptance of each individual step as well as the closure of the maturity plan should be formally endorsed by the applicant and duly documented.

Item 10: Usable fuel capacity markings

CS 27.1555 Control markings

- (a) Each cockpit control, other than primary flight controls or controls whose function is obvious, must be plainly marked as to its function and method of operation.
- (b) For powerplant fuel controls:
 - (1) Each fuel tank selector control must be marked to indicate the position corresponding to each tank and to each existing cross feed position;
 - (2) If safe operation requires the use of any tanks in a specific sequence, that sequence must be marked on, or adjacent to, the selector for those tanks; and
 - (3) Each valve control for any engine of a multi-engine rotorcraft must be marked to indicate the position corresponding to each engine controlled.
- (c) Usable fuel capacity must be marked as follows:
 - (1) For fuel systems having no selector controls, the usable fuel capacity of the system must be indicated at the fuel quantity indicator - unless it is:
 - (i) provided by another system or equipment readily accessible to the pilot; and
 - (ii) contained in the limitations section of the rotorcraft flight manual.
 - (2) For fuel systems having selector controls, the usable fuel capacity available at each selector control position must be indicated near the selector control.

[...]

CS 29.1555 Control marking

- (a) Each cockpit control, other than primary flight controls or controls whose function is obvious, must be plainly marked as to its function and method of operation.
- (b) For powerplant fuel controls:
 - (1) Each fuel tank selector valve control must be marked to indicate the position corresponding to each tank and to each existing cross feed position;
 - (2) If safe operation requires the use of any tanks in a specific sequence, that sequence must be marked on, or adjacent to, the selector for those tanks; and
 - (3) Each valve control for any engine of a multi-engine rotorcraft must be marked to indicate the position corresponding to each engine controlled.
- (c) Usable fuel capacity must be marked as follows:
 - (1) For fuel systems having no selector controls, the usable fuel capacity of the system must be indicated at the fuel quantity indicator, unless it is:
 - (i) provided by another system or equipment readily accessible to the pilot; and
 - (ii) contained in the limitations section of the rotorcraft flight manual.
 - (2) For fuel systems having selector controls, the usable fuel capacity available at each selector control position must be indicated near the selector control.

Item 11: Airspeed and powerplant instruments

CS 27.1549 Powerplant instruments

For each required powerplant instrument, as appropriate to the type of instrument:

- (a) Each maximum and, if applicable, minimum safe operating limit must be marked with ~~a red radial or~~ a red line;
- (b) Each normal operating range must be marked ~~with a green arc or green line, not extending beyond the maximum and minimum safe limits;~~ as a green or unmarked range;
- (c) Each take-off and precautionary range must be marked with a yellow range or yellow line;
- (d) Each engine or propeller range that is restricted because of excessive vibration stresses must be marked with red ranges or red lines; and
- (e) Each OEI limit or approved operating range must be marked to be clearly differentiated from the markings of sub-paragraphs (a) to (d) except that no marking is normally required for the 30-second OEI limit.

CS 29.1549 Powerplant instruments

For each required powerplant instrument, as appropriate to the type of instruments:

- (a) Each maximum and, if applicable, minimum safe operating limit must be marked with ~~a red radial or~~ a red line;
- (b) Each normal operating range must be marked ~~must be marked with a green arc or green line, not extending beyond the maximum and minimum safe limits~~ as a green or unmarked range;
- (c) Each take-off and precautionary range must be marked with a yellow ~~arc~~ range or yellow line;
- (d) Each engine or propeller range that is restricted because of excessive vibration stresses must be marked with red ~~arcs~~ ranges or red lines.
- (e) Each OEI limit or approved operating range must be marked to be clearly differentiated from the markings of sub-paragraphs (a) to (d) except that no marking is normally required for the 30-second OEI limit.

Item 12: Oil pressure indicator and warning independence

CS 29.1305 Powerplant ~~Power plant~~ instruments

The following are required ~~power plant~~ powerplant instruments:

[...]

- (b) For Category A rotorcraft:
 - (1) An individual oil pressure indicator for each engine, ~~and either an independent warning device for each engine or a master warning device for the engines with means for isolating the individual warning circuit from the master warning device~~ and either an oil pressure warning for each engine or a master warning device for all engines with means for identifying the individual circuit in case of master warning.
 - (2) An independent fuel pressure warning device for each engine or a master warning device for all engines with provision for isolating the individual warning device from the master warning device; and
 - (3) Fire warning indicators.

[...]

Item 13: Fuel tank tests**AMC1 27.965 Fuel tank tests**

This AMC supplements FAA AC 27.965.

(a) Tests to be performed

CS 27.965 (a), (b) and (c) deal with the fuel tank pressure testing as follows:

- Sub-paragraph (a) prescribes general testing conditions.
- Sub-paragraph (b) prescribes testing conditions for conventional metal tanks, integral tanks and for non-metallic tanks with walls that are not supported by the rotorcraft structure.
- Sub-paragraph (c) prescribes pressure testing for non-metallic tanks with walls supported by the rotorcraft structure.

CS 27.965 (d) deals with fuel tank vibration & slosh testing with large unsupported or unstiffened flat areas. A clear definition of 'large unsupported or unstiffened flat area' is provided in FAA AC 27-1B, § AC 27.965.

The intent of the tests required in sub-paragraphs (a), (b) or (c) does not cover the intent of the test required in sub-paragraph (d) and vice versa.

Therefore, pressure tests, as prescribed under (a), (b) or (c), and the vibration and slosh test, as prescribed under (d), should be performed.

(b) Use of MIL-T-6396

AC 27.965 (b)(2)(v) recognises the use of MIL-T-6396 to support the demonstration of compliance with CS 27.965. However, few clarifications are required to appropriately make use of this standard.

Combined tests

To be in line with the CS 27.965(d) requirement, the slosh and vibration test conditions shall be simultaneously applied to the test article.

Therefore, the use of MIL-T-6396 should be restricted to paragraph 4.6.6 'Simultaneous Slosh and Vibration test'. Individual/separate performance of paragraph 4.6.7 'Vibration test' and paragraph 4.6.8 'Slosh Test' of the referenced MIL Specification are not considered to be appropriate.

Application of the slosh effect during the test as specified in CS 27.965 (d)(5):

CS 27.965 (d)(5) prescribes the performance of the vibration test for 25h at 16 to 20 slosh cycles per minute (cpm).

MIL-T-6396 proposes two test durations in paragraph 4.6.6:

- Option 1: Vibrate for 25h at 16 to 20 slosh cpm, which is identical to the CS 27.965 (d)(5) requirement.

or

- Option 2: Vibrate for 25h at 10 to 16 slosh cpm with 15 hours of additional test at 10 to 16 slosh cpm.

While it is recognised that Option 2 is appropriate in terms of number of cycles to which the test article is finally submitted (extended testing duration to compensate for the reduction of rocking frequency), it potentially omits a major effect introduced by the higher rocking frequency which may induce more severe structural effects due to the fluid dynamics and subsequent shocks.

An applicant wishing to use Option 2 should demonstrate by analysis, test or a combination thereof, that the reduction of rocking frequency compared to Option 1 has no positive effect to the test results.

AMC1 29.965 Fuel tank tests

This AMC supplements FAA AC 29.965.

(a) Tests to be performed

CS 29.965 (a), (b) and (c) deal with the fuel tank pressure testing as follows:

- Sub-paragraph (a) prescribes general testing conditions.
- Sub-paragraph (b) prescribes testing conditions for conventional metal tanks, integral tanks and for non-metallic tanks with walls that are not supported by the rotorcraft structure.
- Sub-paragraph (c) prescribes pressure testing for non-metallic tanks with walls supported by the rotorcraft structure.

CS 29.965 (d) deals with fuel tank vibration & slosh testing with large unsupported or unstiffened flat areas. A clear definition of 'large unsupported or unstiffened flat area' is provided in FAA AC 29-2C, § AC 29.965.

The intent of the tests required in sub-paragraphs (a), (b) or (c) does not cover the intent of the test required in sub-paragraph (d) and vice versa.

Therefore pressure tests, as prescribed under (a), (b) or (c), and the vibration and slosh test, as prescribed under (d), should be performed.

(b) Use of MIL-T-6396

AC 29.965 (c)(6) recognises the use of MIL-T-6396 to support the demonstration of compliance with CS 29.965. However, few clarifications are required to appropriately make use of this standard.

Combined tests

To be in line with the CS 29.965(d) requirement, the slosh and vibration test conditions shall be simultaneously applied to the test article.

Therefore the use of MIL-T-6396 should be restricted to paragraph 4.6.6 'Simultaneous Slosh and Vibration test'. Individual/separate performance of paragraph 4.6.7 'Vibrations test' and paragraph 4.6.8 'Slosh Test' of the referenced MIL Specification are not considered to be appropriate.

Application of the slosh effect during the test as prescribed in CS 29.965 (d)(5):

CS 29.965 (d)(5) prescribes the performance of the vibration test for 25h at 16 to 20 slosh cycles per minute (cpm).

MIL-T-6396 proposes 2 test duration in paragraph 4.6.6:

— Option 1: Vibrate for 25h at 16 to 20 slosh cpm, which is identical to the CS 29.965 (d)(5) requirement.

or

— Option 2: Vibrate for 25h at 10 to 16 slosh cpm with 15 hours of additional test at 10 to 16 slosh cpm.

While it is recognised that Option 2 is appropriate in terms of number of cycles to which the test article is finally submitted (extended testing duration to compensate for the reduction of rocking frequency), it potentially omits a major effect introduced by the higher rocking frequency which may induce more severe structural effects due to the fluid dynamics and subsequent shocks.

An applicant wishing to use Option 2 should demonstrate by analysis, test or a combination thereof, that the reduction of rocking frequency compared to Option 1 has no positive effect to the test results.

Item 14: Ignition switches

CS 29.1145 Ignition switches

(a) ~~Ignition switches must control each ignition circuit on each engine.~~ For each engine, means must be provided in the cockpit so as to:

- (1) control, either by the crew or via a system, each ignition circuit;
- (2) readily allow the crew to conduct the flight and manage both ground start and in-flight restart and any other limitations;
- (3) check the health condition of each ignition circuit; and
- (4) maintain an isolation between each engine control.

(b) There must be means to quickly shut off all ignition by the grouping of switches or by a master ignition control.

(c) Each group of ignition switches, except ignition switches for turbine engines for which continuous ignition is not required, and each master ignition control, must have a means to prevent its inadvertent operation.

AMC1 29.1145(a) Ignition switches

Compliance with CS 29.1145(a) is considered to be demonstrated by providing for each engine one of the following design solutions:

- (a) Independent ignition controls should be provided for each ignition circuit, or
- (b) A single ignition control acting on two ignition switches should be provided to control each ignition circuit via a dual-channel FADEC.
 - (1) Each switch should be connected to one channel of the FADEC
 - (2) The FADEC should ensure the following functions:
 - (i) Ability to control automatically and independently each ignition circuit of the engine
 - (ii) Ability to perform a health monitoring of each ignition circuit at a frequency higher than the one required for the engine and the aircraft to meet the safety objectives of CS-E and CS-29

Item 15: Synthetised powerplant instrument

CS 27.1305 Powerplant instruments

The following are the required powerplant instruments:

[...]

- (e) Means to indicate the ~~A~~ manifold pressure ~~indicator~~, for each altitude engine.
- (f) An oil temperature warning device to indicate when the temperature exceeds a safe value in each main rotor drive gearbox (including any gearboxes essential to rotor phasing) having an oil system independent of the engine oil system.
- (g) An oil pressure warning device to indicate when the pressure falls below a safe value in each pressure-lubricated main rotor drive gearbox (including any gearboxes essential to rotor phasing) having an oil system independent of the engine oil system.
- (h) An oil pressure indicator for each engine.
- (i) An oil quantity indicator for each oil tank.
- (j) An oil temperature indicator for each engine.
- (k) At least one tachometer to indicate the rpm of each engine and, as applicable:
 - (1) The rpm of the single main rotor;
 - (2) The common rpm of any main rotors whose speeds cannot vary appreciably with respect to each other; or

- (3) The rpm of each main rotor whose speed can vary appreciably with respect to that of another main rotor.
 - (l) A low fuel warning device for each fuel tank which feeds an engine. This device must:
 - (1) Provide a warning to the flight crew when approximately 10 minutes of usable fuel remains in the tank; and
 - (2) [...]
 - (m) Means to indicate to the flight crew the failure of any fuel pump installed to show compliance with CS 27.955.
 - (n) Means to indicate the A gas temperature indicator for each turbine engine.
 - (o) Means to enable the pilot to determine the torque of each turboshaft turbine engine; if a torque limitation is established for that engine under in CS 27.1521 (e).
- [...]

CS 29.1305 Powerplant ~~power-plant~~ instruments

The following are required powerplant instruments:

- (a) For each rotorcraft:
 - (1) A carburettor air temperature indicator for each reciprocating engine;
 - (2) A cylinder head temperature indicator for each air-cooled reciprocating engine, and a coolant temperature indicator for each liquid-cooled reciprocating engine;
 - (3) A fuel quantity indicator for each fuel tank;
 - (4) A low fuel warning device for each fuel tank which feeds an engine. This device must:
 - (i) Provide a warning to the crew when approximately 10 minutes of usable fuel remains in the tank; and
 - (ii) [...]
 - (5) A means to indicate the manifold pressure indicator, for each reciprocating engine of the altitude type;
 - (6) An oil pressure indicator for each pressure-lubricated gearbox;
 - (7) An oil pressure warning device for each pressure-lubricated gearbox to indicate when the oil pressure falls below a safe value;
 - (8) An oil quantity indicator for each oil tank and each rotor drive gearbox, if lubricant is self-contained;
 - (9) An oil temperature indicator for each engine;
 - (10) An oil temperature warning device to indicate unsafe oil temperatures in each main rotor drive gearbox, including gearboxes necessary for rotor phasing;
 - (11) A means to indicate the gas temperature indicator for each turbine engine;
 - (12) A means to indicate the gas producer rotor tachometer speed for each turbine engine;
- [...]

Item 16: Category A engine training mode

CS 29.1305 Powerplant ~~power-plant~~ instruments

[...]

(b) For Category A rotorcraft:

- (1) [...]
- (2) An independent fuel pressure warning device for each engine or a master warning device for all engines with provision for isolating the individual warning device from the master warning device; ~~and~~
- (3) Fire warning indicators; ~~and~~
- (4) When the OEI Training Mode is prescribed, a means must be provided to indicate to the pilot the simulation of an engine failure, the annunciation of that simulation, and a representation of the OEI power being provided.

[...]

Item 17: Single-engine restart capability

AMC1 27.903(d) Engines**ENGINE RESTART CAPABILITY**

This AMC replaces FAA AC 27-1B, § AC 27.903B and should be used when showing compliance with CS 27.903(d).

(a) Explanation

CS 27.903(d) requires that any engine must have a restart capability that has been demonstrated throughout a flight envelope to be certificated for the rotorcraft.

(b) Procedures

Compliance is usually shown by conducting actual in-flight restarts during flight tests or other tests in accordance with an approved test plan. However, CS 27.903(d)(1) does not require in-flight demonstration of restart capability for single-engine rotorcraft or for all-engine shutdown of multi-engine rotorcraft. In the past, engine restart capability for single-engine rotorcraft has been demonstrated on the ground taking into account altitude effects, warm engine characteristics, depleted battery, etc. Restarts should be conducted at various altitudes, ambient temperatures, and fuel temperatures using the most critical fuel type unless the applicant can show that this parameter is not pertinent. Latest-technology engines embody electronic engine controls (EEC or FADEC) that may have sophisticated starting or restarting laws. For these designs the engine restart capability demonstrated on ground may not provide an appropriate level of representativeness and therefore applicants are encouraged to demonstrate the capability in flight.

The pilot station arrangement for flight controls and engine starting controls should be assessed in the context of an engine restart operation. It should be verified that the engine restart can



be accomplished without jeopardising continued safe operation of the rotorcraft. Pilot workload for a pre-existing one engine inoperative (OEI) situation, the location of the restart system controls, and the availability of a second pilot should be considered. The emergency and malfunction instruction sections of the RFM should present a detailed definition of the approved restart envelope and detailed instructions for the restart.

Eligible ambient atmospheric conditions, pre-start requirements (to allow for waste fuel drainage), starter duty cycle (if different from the ground start duty cycle), and pre-start situation analysis should be included. The pre-start situation analysis should consider the following questions:

- (1) Should a restart be attempted in view of the cause of the initial shutdown?
- (2) Is the inlet system ice ingestion a possibility?
- (3) Is re-ignition of fuel in the engine nacelle a possibility?
- (4) Is sufficient restart time available?
- (5) Is power available?
- (6) Is altitude sufficient to maintain terrain clearance?

Windmilling of the engine can be considered to be part of this restart capability; however, most rotorcraft airspeeds and engine locations do not support engine windmilling up to start speeds. Only electrical power requirements were considered for restarting; however, other factors that may affect this capability are permitted to be considered. Engine restart capability following an in-flight shutdown of all engines is the primary requirement, and the means of providing this capability is left to the applicant.

To minimise any potential height loss, the applicant should ensure that the engine restart can be initiated at the earliest opportunity. The engine certification should be checked to ensure that the flight manual procedures for in-flight restart are consistent with any specific engine restart requirements identified in the installation and/or operating manual of the engine.

AMC1 29.903(e) Engines

This AMC replaces FAA AC 29-2C, § AC 29.903B and should be used when showing compliance with CS 29.903(e).

(a) Explanations

CS 29.903(e) requires that any engine must have a restart capability that has been demonstrated throughout a flight envelope to be certificated for the rotorcraft.

(b) Procedures

Compliance is usually shown by conducting actual in-flight restarts during flight tests or other tests in accordance with an approved test plan. However, CS 29.903(e)(2) does not require in-flight demonstration of restart capability for single-engine rotorcraft or for all-engine shutdown of multi-engine rotorcraft. In the past, engine restart capability for single-engine

rotorcraft has been demonstrated on the ground taking into account altitude effects, warm engine characteristics, depleted battery, etc. However, latest-technology engines embody electronic engine controls (EEC or FADEC) that may have sophisticated starting or restarting laws. For these designs the engine restart capability demonstrated on ground may not provide the level of representativeness required and therefore applicants are encouraged to demonstrate the capability in flight. The minimum restart envelope for category A rotorcraft is discussed in AC 29.903A. The restart capability can consider windmilling of the engine as part of this restart capability; however, most rotorcraft airspeeds and the locations of the engines do not support engine windmilling up to start speeds. Only electrical power requirements were considered for restarting; however, other factors that may affect this capability are permitted to be considered. Engine restart capability following an in-flight shutdown of the engine in single-engine rotorcraft, or all engines in a multi-engine rotorcraft, is the primary requirement, and the means of providing this capability is left to the applicant. To minimise any potential height loss following the failure of one or more engines, engine restart should be available at the earliest opportunity. The engine certification should be checked to ensure that the flight manual instructions for in-flight restart are consistent with any specific engine restart requirements. If the procedure was only demonstrated on ground, this should be stated in the RFM.

Item 18: Non-required equipment in the primary field of view

AMC1 27.1301 Function and installation

This AMC replaces FAA AC 27-1B, § AC 27.1301 and should be used when showing compliance with CS 27.1301.

(a) Explanation

It should be emphasised that CS 27.1301 applies to each item of installed equipment including optional as well as required equipment.

(b) Procedures

- (1) Information regarding installation limitations and proper functioning is normally available from the equipment manufacturers in their installation and operations manuals. In addition, some other paragraphs in FAA AC 27-1B include criteria for evaluating proper functioning of particular systems — an example is § AC 27 MG 1 for avionics equipment.)
- (2) This general rule is quite specific in that it applies to each item of installed equipment. It should be emphasised, however, that even though a general rule is relevant, a rule that gives specific functional requirements for a particular system will prevail over a general rule. Therefore, if a rule exists that defines specific system functioning requirements, its provisions should be used to evaluate the acceptability of the installed system and not the provisions of this general rule. It should also be understood that an interpretation of a general rule should not be used to lessen or increase the requirements of a specific rule.

CS 27.1309 is another example of a general rule, and this discussion is appropriate when applying its provisions.

- (3) If optional equipment is installed, the crew may be expected to use it. This may be the case of navigation capabilities (as, for instance, LPV capability) installed on VFR rotorcraft. Therefore, the applicant should define the optional equipment and demonstrate that it complies with CS 27.1301 for its intended function. In addition, the applicant should ensure that the optional equipment does not interfere with the other systems that are required for safe operation of the rotorcraft and that its failure modes are acceptable and do not create any hazards.

AMC1 29.1301 Function and installation

This AMC replaces FAA AC 29-2C, § AC 29.1301 and should be used when showing compliance with CS 29.1301.

(a) Explanation

It should be emphasised that this rule applies to each item of installed equipment which includes optional equipment as well as required equipment.

(b) Procedures

- (1) Information regarding installation limitations and proper functioning is normally available from the equipment manufacturers in their installation and operation manuals. In addition, some other paragraphs in FAA AC 29-2C include criteria for evaluating proper functioning of particular systems — an example is § AC 29 MG 1 for avionics equipment.
- (2) This general rule is quite specific in that it applies to each item of installed equipment. It should be emphasised, however, that even though a general rule is relevant, a rule that gives specific functional requirements for a particular system will prevail over a general rule. Therefore, if a rule exists that defines specific system functioning requirements, its provisions should be used to evaluate the acceptability of the installed system and not the provisions of this general rule. It should also be understood that an interpretation of a general rule should not be used to lessen or increase the requirements of a specific rule. CS 29.1309 is another example of a general rule, and this discussion is appropriate when applying its provisions.
- (3) If optional equipment is installed, the crew may be expected to use it. This may be the case of navigation capabilities (as, for instance, LPV capability) installed on VFR rotorcraft. Therefore, the applicant should define the optional equipment and demonstrate that it complies with CS 29.1301 for its intended function. In addition, the applicant should ensure that the optional equipment does not interfere with the other systems that are required for safe operation of the rotorcraft and that its failure modes are acceptable and do not create any hazards.

Item 19: Power-OFF V_{NE} **CS 27.1505 Never-exceed speed**

[...]

- (c) For helicopters, a stabilised Power-OFF V_{NE} denoted as V_{NE} (Power-OFF) may be established at a speed less than V_{NE} established pursuant to sub-paragraph (a), if the following conditions are met:
- (1) V_{NE} (Power-OFF) is not less than a speed midway between the Power-ON V_{NE} and the speed used in meeting the requirements of:
 - (i) CS 27.65(b) for single-engine helicopters; and
 - (ii) CS 27.67 for multi-engine helicopters.
 - (2) Unless it is automatically displayed to the crew, the V_{NE} (Power-OFF) is:
 - (i) A constant airspeed; or
 - (ii) A constant amount less than Power-ON V_{NE} ; or
 - (iii) A constant airspeed for a portion of the altitude range for which certification is requested, and a constant amount less than Power-ON V_{NE} for the remainder of the altitude range.

CS 29.1505 Never-exceed speed

[...]

- (c) For helicopters, a stabilised Power-OFF V_{NE} denoted as V_{NE} (Power-OFF) may be established at a speed less than V_{NE} established pursuant to sub-paragraph (a), if the following conditions are met:
- (1) V_{NE} (Power-OFF) is not less than a speed midway between the Power-ON V_{NE} and the speed used in meeting the requirements of:
 - (i) CS 29.67(a)(3) for Category A helicopters;
 - (ii) CS 29.65(a) for Category B helicopters, except multi-engine helicopters meeting the requirements of CS 29.67(b); and
 - (iii) CS 29.67(b) for multi-engine Category B helicopters meeting the requirements of CS 29.67(b).
 - (2) Unless it is automatically displayed to the crew, the V_{NE} (Power-OFF) is:
 - (i) A constant airspeed; or
 - (ii) A constant amount less than Power-ON V_{NE} ; or

- (iii) A constant airspeed for a portion of the altitude range for which certification is requested, and a constant amount less than Power-ON V_{NE} for the remainder of the altitude range.

[...]

AMC1 27.1505 Never-exceed speed

This AMC replaces FAA AC27-1B, § AC 27.1505 and should be used when showing compliance with CS 27.1505.

(a) Explanation

(1) General

CS 27.1505 requires the never-exceed speed (V_{NE}) for both Power-ON and Power-OFF flight to be established as operating limitations. The rule specifies how to establish and substantiate these limits.

(2) Power-ON limit

- (i) The all-engines-operating V_{NE} is established by design and substantiated by flight tests. The V_{NE} limits are the most conservative value that demonstrates compliance with the structural requirements (§ 27.309), the manoeuvrability and controllability requirements (§ 27.143), the stability requirements (§§ 27.173 and 27.175), or the vibration requirements (§ 27.251). The Power-ON V_{NE} will normally decrease as density altitude or weight increases. A variation in rotor speed may also require a variation in the V_{NE} . The regulation restricts to two the number of variables that are used to determine the V_{NE} at any given time so that a single pilot can readily ascertain the correct V_{NE} for the flight condition with a minimum of mental effort. Helicopter manufacturers have typically presented never-exceed-speed limitation data as a function of pressure altitude and temperature. This information was placarded as well as contained in the flight manual. As the weight of some derivative models was increased, EASA and the FAA accepted altitude/temperature/ V_{NE} limitations that were categorised or contained within a weight range. Literal compliance with the regulation then required that the take-off weight be calculated and then the indicated, appropriate airspeed limitation chart or placard be used for the entire flight. However, V_{NE} charts or placards based on longitudinal centre of gravity have been found to be unacceptable, since the same chart would potentially not be used throughout the flight and the pilot would thus be dealing with more than two variables to determine the V_{NE} . Alternatively, rotorcraft that are equipped with modern avionics systems may be able to automatically calculate and display the V_{NE} in an unambiguous manner as a function of the different parameters upon which it depends. For these designs, the applicant is expected to appropriately address the criticality associated with the loss and misleading presentation of the V_{NE} when compliance of such systems with 27.1309 is carried out. These rotorcraft should also have a method for determining

the V_{NE} that complies with the regulation for all failure conditions or combinations of failure conditions that are not extremely improbable. This method is usually more conservative than the automatic system because of the limitation in the number of parameters that can be varied. A placard may be used or appropriate RFM instructions.

- (ii) To ensure compliance with the structural requirements (§ 27.309), vibration requirements (§ 27.251), and flutter requirements (§ 27.629), the all-engines-operating V_{NE} should be restricted so that the maximum demonstrated main rotor tip Mach number will not be exceeded at $1.11 V_{NE}$ for any approved combination of altitude and ambient temperature. Previous rotorcraft cold weather tests have shown that the rotor system may exhibit several undesirable and possibly hazardous characteristics due to compressibility effects at high advancing blade tip Mach numbers. As the centre of pressure of the advancing rotor blade moves aft near the blade tip due to the formation of localised upper surface shock waves, rotor system loads may increase, the rotor system may exhibit an aerodynamic instability such as rotor weave, rotorcraft vibration may increase substantially, and rotorcraft static or dynamic stability may be adversely affected. Which, if any, of these adverse characteristics are exhibited at high rotor tip Mach numbers is dependent on the design of each particular rotor system. EASA and the FAA experience with high advancing blade tip Mach number has shown that different types of rotor systems (articulated, semi-rigid, rigid, etc.) have various adverse characteristics. Therefore, it has been EASA and the FAA policy to establish V_{NE} so that it is not more than 0.9 times the maximum speed substantiated for advancing blade tip Mach number effects for the critical combination of altitude, approved Power-ON rotor speed, and ambient temperature conditions. This policy was incorporated as a specific regulatory requirement with Amendment 27-21 to § 27.1505. High main rotor tip Mach numbers obtained power off at higher-than-normal main rotor rotational speeds should not be used to establish the maximum Power-ON tip Mach number V_{NE} limit. In addition, since the onset of adverse conditions associated with high tip Mach numbers can occur with little or no warning and amplify very rapidly, no extrapolation of the maximum demonstrated main rotor tip Mach number V_{NE} limitation should be allowed.
- (iii) A maximum speed for use of power in excess of maximum continuous power (MCP) should be established unless structural requirements have been substantiated for the use of take-off power (TOP) at the maximum approved V_{NE} airspeed. TOP is intended for use during take-off and climb for not more than 5 minutes at relatively low airspeeds. However, EASA and the FAA experience has shown that pilots will not hesitate to use TOP at much higher than best-rate-of-climb airspeeds unless a specific limitation against TOP use above a specified airspeed is included in the RFM. Structural and fatigue substantiations have not normally included loads associated with the use of TOP at V_{NE} ; thus, a TOP airspeed limitation should be established from the structural substantiation data to preclude the accumulation of damaging rotor system and control mechanism loads through intentional use of the TOP rating at high airspeeds.

(iv) A one-engine-inoperative (OEI) V_{NE} is generally established through flight test and is usually near the V_H or V_{NE} of the rotorcraft. It is the highest speed at which the failure of the remaining engine must be demonstrated. For rotorcraft with more than two engines, the appropriate designation would be 'one-engine-operating' V_{NE} and would be that speed at which the last remaining engine could be failed with satisfactory handling qualities. It is possible, although believed improbable, that a rotorcraft with more than two engines could have different V_{NE} depending upon the number of engines still operating. It is recommended that the OEI V_{NE} not be significantly lower than the OEI best range airspeed. A multiengine rotorcraft may require an OEI V_{NE} if the handling qualities following the last remaining engine failure are not satisfactory or if the rotor speed decays below the Power-OFF transient limits at the all-engine-operating V_{NE} .

(3) Power-OFF limits

A Power-OFF V_{NE} may be established either by design or flight test and should be substantiated by flight tests. A Power-OFF V_{NE} is generally required if the handling qualities or stability characteristics at high speed in autorotation are not acceptable. A limitation of the Power-OFF V_{NE} may also be used if the rotorcraft has undesirable or objectionable flying qualities, such as large lateral-directional oscillations, at high autorotational airspeeds. The Power-OFF V_{NE} must meet the same criteria for control margins as the Power-ON V_{NE} . The regulation requires that the Power-OFF V_{NE} be no less than the speed midway between the Power-ON V_{NE} and the speed used to comply with the rate of climb requirements for the rotorcraft. When the regulation was written, rotorcraft V_{NE} speeds were significantly lower than those of recently certificated rotorcraft. The high V_{NE} speeds of current rotorcraft result in relatively high values for Power-OFF V_{NE} . Speeds lower than those specified in the regulation have been found acceptable through a finding of equivalent safety if the selected Power-OFF V_{NE} is equal to or greater than the Power-OFF speed for best range. In any case, the Power-OFF V_{NE} must be a high enough speed to be practical. A demonstration is required of the deceleration from the Power-ON V_{NE} or OEI V_{NE} to the Power-OFF V_{NE} . The transition must be made in a controlled manner with normal pilot reaction and skill. In addition to the minimum speed requirements for Power-OFF V_{NE} , the rule restricts the manner in which Power-OFF V_{NE} can be specified when it is not automatically calculated and displayed to the crew. To reduce the crew workload, in all the cases where the Power-OFF V_{NE} is not automatically calculated and displayed, the Power-OFF V_{NE} may be a constant airspeed which is less than Power-ON V_{NE} for all approved ambient conditions/gross weight combinations; a series of airspeeds varying with altitude, temperature or gross weight that is always a constant amount less than the Power-ON V_{NE} for the same ambient condition/gross weight combination; or some combination of a constant airspeed for a portion of the approved altitude range and a constant amount less than Power-ON V_{NE} for the remainder of the approved altitude range.

(b) Procedures

The tests to substantiate the different V_{NE} speeds are ordinarily conducted during the flight

characteristics flight tests. The flight test procedures are discussed for the various limiting areas in earlier paragraphs of this document. Static stability test techniques are covered in § AC 27.175 and the vibration test techniques in § AC 27.251.

AMC1 29.1505 Never-exceed speed

This AMC replaces FAA AC 29-2C, § AC 29.1505 and should be used when showing compliance with CS 29.1505.

(a) Explanation

(1) General

CS 29.1505 requires the never-exceed speed (V_{NE}) for both Power-ON and Power-OFF flight to be established as operating limitations. The rule specifies how to establish and substantiate these limits.

(2) Power-ON limits

(i) All engines operative (AEO)

(A) The all-engines-operating V_{NE} is established by design and substantiated by flight tests. The V_{NE} limits are the most conservative value that demonstrates compliance with the structural requirements (CS 29.309), the manoeuvrability and controllability requirements (CS 29.143), the stability requirements (CS 29.173 and CS 29.175), or the vibration requirements (CS 29.251). The Power-ON V_{NE} will normally decrease as density altitude or weight increases. A variation in rotor speed may also require a variation in the V_{NE} . The regulation restricts to two the number of variables that are used to determine the V_{NE} at any given time so that a single pilot can readily ascertain the correct V_{NE} for the flight condition with a minimum of mental effort. Helicopter manufacturers have typically presented never-exceed-speed limitation data as a function of pressure altitude and temperature. This information was placarded as well as contained in the flight manual. As the weight of some derivative models was increased, EASA and the FAA accepted altitude/temperature/ V_{NE} limitations that were categorised or contained within a weight range. Literal compliance with the regulation then required that the take-off weight be calculated and then the indicated, appropriate airspeed limitation chart or placard be used for the entire flight. However, V_{NE} charts or placards based on longitudinal centre of gravity have been found to be unacceptable, since the same chart would potentially not be used throughout the flight and the pilot would thus be dealing with more than two variables to determine the V_{NE} . Alternatively, rotorcraft that are equipped with modern avionics systems may be able to automatically calculate and display the V_{NE} in an unambiguous manner as a function of the different parameters upon which it depends. For these designs, the

applicant is expected to appropriately address the criticality associated with the loss and misleading presentation of the V_{NE} when compliance of such systems with CS 29.1309 is carried out. These rotorcraft should also have a method for determining the V_{NE} that complies with the regulation for all failure conditions or combinations of failure conditions that are not extremely improbable. This method is usually more conservative than the automatic system because of the limitation in the number of parameters that can be varied. A placard may be used or appropriate RFM instructions.

- (B) To ensure compliance with the structural requirements (CS 29.309), vibration requirements (CS 29.251), and flutter requirements (CS 29.629), the all-engines-operating V_{NE} should be restricted so that the maximum demonstrated main rotor tip Mach number will not be exceeded at $1.11 V_{NE}$ for any approved combination of altitude and ambient temperature. Previous rotorcraft cold weather tests have shown that the rotor system may exhibit several undesirable and possibly hazardous characteristics due to compressibility effects at high advancing blade tip Mach numbers. As the centre of pressure of the advancing rotor blade moves aft near the blade tip due to the formation of localised upper surface shock waves, rotor system loads may increase, the rotor system may exhibit an aerodynamic instability such as rotor weave, rotorcraft vibration may increase substantially, and rotorcraft static or dynamic stability may be adversely affected. Which, if any, of these adverse characteristics are exhibited at high rotor tip Mach numbers is dependent on the design of each particular rotor system. EASA and the FAA experience has shown that some adverse characteristics exist for all the types of rotor systems (articulated, semirigid, rigid, etc.) and the various rotor blade designs evaluated at high advancing blade tip Mach numbers during past certification programmes. Therefore, it has been EASA and the FAA policy to establish V_{NE} so that it is not more than 0.9 times the maximum speed substantiated for advancing blade tip Mach number effects for the critical combination of altitude, approved Power-ON rotor speed, and ambient temperature conditions. This policy was incorporated as a specific regulatory requirement with Amendment 29-24 to § 29.1505. High main rotor tip Mach numbers obtained power off at higher-than-normal main rotor rotational speeds should not be used to establish the maximum Power-ON tip Mach number V_{NE} limit. In addition, since the onset of adverse conditions associated with high tip Mach numbers can occur with little or no warning and amplify very rapidly, no extrapolation of the maximum demonstrated main rotor tip Mach number V_{NE} limitation should be allowed.
- (C) A maximum speed for use of power in excess of maximum continuous power (MCP) should be established unless structural requirements have been substantiated for the use of take-off power (TOP) at the maximum approved V_{NE} airspeed. TOP is intended for use during take-off and climb for not more than 5 minutes at relatively low airspeeds. However, EASA and the FAA experience has shown that pilots will not hesitate to use TOP at much higher

than best-rate-of-climb airspeeds unless a specific limitation against TOP use above a specified airspeed is included in the RFM. Structural and fatigue substantiations have not normally included loads associated with the use of TOP at V_{NE} . Thus, a TOP airspeed limitation should be established from the structural substantiation data to preclude the accumulation of damaging rotor system and control mechanism loads through intentional use of the TOP rating at high airspeeds.

- (ii) One engine inoperative (OEI). An OEI V_{NE} is generally established through flight test and is usually near the OEI V_H of the rotorcraft. It is the highest speed at which the failure of the remaining engine must be demonstrated. For rotorcraft with more than two engines, the appropriate designation would be 'one-engine-operating' V_{NE} and would be that speed at which the last remaining engine could be failed with satisfactory handling qualities. It is possible that a rotorcraft with more than two engines could have different V_{NE} speeds depending upon the number of engines still operating. It is recommended that the OEI V_{NE} not be significantly lower than the OEI best range airspeed. For the last remaining engine failure case, a multiengine rotorcraft may require an OEI V_{NE} if the handling qualities are not satisfactory, if the rotor speed decays below the Power-OFF transient limits, or if any other unacceptable characteristic is found at speeds below the all-engine-operating V_{NE} .

(3) Power-OFF limits

- (i) A Power-OFF V_{NE} may be established either by design or flight test and should be substantiated by flight tests. A Power-OFF V_{NE} that is less than the maximum Power-ON V_{NE} is generally required if the handling qualities or stability characteristics at high speed in autorotation are not acceptable. A limitation of the Power-OFF V_{NE} may also be used if the rotorcraft has undesirable or objectionable flying qualities, such as large lateral-directional oscillations, at high autorotational airspeeds. The Power-OFF V_{NE} must meet the same criteria for control margins as the Power-ON V_{NE} . The regulation requires that the Power-OFF V_{NE} be no less than the speed midway between the Power-ON V_{NE} and the speed used to comply with the rate of climb requirements for the rotorcraft. When the regulation was written, rotorcraft V_{NE} speeds were significantly lower than those of recently certificated rotorcraft. The high V_{NE} speeds of current rotorcraft result in relatively high values for the Power-OFF V_{NE} . Speeds lower than that specified in the regulation have been found acceptable through a finding of equivalent safety if the selected Power-OFF V_{NE} is equal to or greater than the Power-OFF speed for best range. In any case, the Power-OFF V_{NE} must be a high enough speed to be practical. A demonstration is required of the deceleration from the Power-ON V_{NE} for Category B rotorcraft, or OEI V_{NE} for transport rotorcraft with Category A engine isolation, to the Power-OFF V_{NE} . The transition must be made in a controlled manner with normal pilot reaction and skill.
- (ii) In addition to the minimum speed requirements for Power-OFF V_{NE} , the rule

restricts the manner in which Power-OFF V_{NE} can be specified when it is not automatically calculated and displayed to the crew. To reduce the crew workload, in all the cases where the Power-OFF V_{NE} is not automatically calculated, Power-OFF V_{NE} may be a constant airspeed which is less than Power-ON V_{NE} for all approved ambient conditions/gross weight combinations; a series of airspeeds varying with altitude, temperature or gross weight that is always a constant amount less than the Power-ON V_{NE} for the same ambient condition/gross weight combination; or some combination of a constant airspeed for a portion of the approved altitude range and a constant amount less than Power-ON V_{NE} for the remainder of the approved altituderange.

(b) Procedures

The tests to substantiate the different V_{NE} speeds are ordinarily conducted during the flight characteristics flight tests. The flight test procedures are discussed for the various limiting areas in earlier paragraphs of this AMC. The controllability test techniques are covered in § AC 29.143, static stability test techniques in § AC 29.175, and the vibration test techniques in § AC 29.251.

Item 20: Correction in CS 29-777

CS 29.777 Cockpit controls

Cockpit controls must be:

- (a) Located to provide convenient operation and to prevent confusion and inadvertent operation; and
- (b) Located and arranged with respect to the pilot's seats so that there is full and unrestricted movement of each control without interference from the cockpit structure or the pilot's clothing when pilots from 1.57 m (5 ft 2 inches) to 1.83 m (6 ft) in height are seated.

Item 21: Unsymmetrical loads

AMC1 27.427 Unsymmetrical loads

This AMC supplements FAA AC 27-1B, § AC 27.427 and should be used in conjunction with that AC when demonstrating compliance with CS 27.427.

In case of load distribution deviating from CS 27.427(b), the applicant should provide the rationale justifying that the selected load distribution conservatively addresses the limit flight load conditions of Subpart C. Dedicated flight load and/or wind tunnel measurements should be performed to confirm the suitability of the proposed criteria.

AMC1 29.427 Unsymmetrical loads

This AMC supplements FAA AC 29-2C, § AC 29.427 and should be used in conjunction with that AC when demonstrating compliance with CS 29.427.

In case of load distribution deviating from CS 29.427(b), the applicant should provide the rationale justifying that the selected load distribution conservatively addresses the limit flight load conditions of Subpart C. Dedicated flight load and/or wind tunnel measurements should be performed to confirm the suitability of the proposed criteria.

Item 22: Control systems

AMC1 27.395 Control system

This AMC supplements FAA AC 27-1B, § AC 27.395 and should be used in conjunction with that AC when demonstrating compliance with CS 27.395.

The design reaction loads prescribed in CS 27.395 for the flight control system should apply to the part of the control system from the pilot cockpit control sticks/pedals to the main/tail rotor servo-actuators. The remaining part of the flight control systems located between the attachment of the servo-actuators and the (main/tail) blades (i.e. rotating parts, servo-actuators and their attachments) should be substantiated to the highest of:

- maximum loads expected in service (limit loads) as per CS 27.301, CS 27.305 and CS 27.547 (nominal conditions);
- maximum loads for a single failure of the hydraulic system leading to an operating hydraulic overpressure;
- the maximum loads due to a jamming of the flight control system (rotating parts).

The maximum pilot loads from CS 27.397 to CS 27.399 should be added to these loads appropriately.

AMC1 29.395 Control system

This AMC supplements FAA AC 29-2C, § AC 29.395 and should be used in conjunction with that AC when demonstrating compliance with CS 29.395.

The design reaction loads prescribed in CS 29.395 for the flight control system should apply to the part of the control system from the pilot cockpit control sticks/pedals to the main/tail rotor servo-actuators. The remaining part of the flight control systems located between the attachment of the servo-actuators and the (main/tail) blades (i.e. rotating parts, servo-actuators and their attachments) should be substantiated to the highest of:

- maximum loads expected in service (limit loads) as per CS 29.301, CS 29.305 and CS 29.547 (nominal conditions);

- maximum loads for a single failure of the hydraulic system leading to an operating hydraulic overpressure;
- the maximum loads due to a jamming of the flight control system (rotating parts).

The maximum pilot loads from CS 29.397 to CS 29.399 should be added to these loads appropriately.

Item 23: Vibration

AMC1 27.251 Vibration

This AMC supplements FAA AC 27-1B, § AC 27.251 and should be used in conjunction with that AC when demonstrating compliance with CS 27.251.

The applicant should investigate each individual installation of the rotorcraft for compliance with CS 27.251. The absence of coupling with the rotor vibration frequencies should be demonstrated by a combination of analysis, vibration test and flight tests.

Qualitative and quantitative flight tests should be performed depending on the extent of the change. For any installation, the failure of which or its attachment would have a hazardous or catastrophic consequence, a fatigue evaluation should be performed when the vibrations are likely to affect the fatigue strength.

AMC1 29.251 Vibration

This AMC supplements FAA AC 29-2C, § AC 29.251 and should be used in conjunction with that AC when demonstrating compliance with CS 29.251.

The applicant should investigate each individual installation of the rotorcraft for compliance with CS 29.251. Absence of coupling with the rotors vibration frequencies has to be demonstrated by a combination of analysis, vibration test and flight tests.

Qualitative and quantitative flight tests should be performed depending on the extent of the change. For any installation, the failure of which or its attachment would have a hazardous or catastrophic consequence, a fatigue evaluation should be performed when the vibrations are likely to affect the fatigue strength.

Item 24: Rotor drive system design

AMC2 29.917 Drive ~~Rotor drive system design~~

LUBRICATION SYSTEMS — ROTOR DRIVE SYSTEM DESIGN

[...]

- (g) Use of an auxiliary lubrication system

The use of an auxiliary lubrication system may be an acceptable means of providing extended operating time after a loss of lubrication. The auxiliary lubrication system should be designed to provide sufficient independence from the normal-use lubrication system. Since the auxiliary lubrication system is by definition integral to the same gearbox as the normal-use lubrication system, it may be impractical for it to be completely independent. Therefore, designs should be conceived such that shared components or interfaces between the normal-use and auxiliary lubrication systems are minimised and comply with the design assessment provisions of CS 29.917(b). A failure of any common feature shared by both the normal-use and auxiliary lubrication systems that could result in the failure of both systems, and would consequently reduce the maximum period of operation following loss of lubrication, should be shown to be an extremely remote lubrication failure. If compliance with CS 29.927(c) is reliant on the functioning of an auxiliary lubrication system, then:

- (1) ~~in~~ for the unlikely event of a combined failure of both the normal-use lubrication system and the auxiliary lubrication system, the applicant should perform additional loss of lubrication tests simulating this condition. The aim is to substantiate additional RFM emergency procedures introduced in order to ensure that the severity of this event is commensurate with the probability of failure. These procedures should instruct the flight crew to 'Land immediately' unless the additional tests performed ~~testing~~ representing this failure mode ~~has been performed in order to substantiate~~ demonstrate that an increased duration is justified; and
- (2) a means of verifying that the auxiliary lubrication system is functioning properly should be provided during normal operation of the rotorcraft on either a periodic, pre-flight or continual basis. Following failure of the ~~normal-use lube~~ normal-use lubrication system and activation of an auxiliary lubrication system, the flight crew should be alerted in the event of any system malfunction.

[...]

Item 25: Emergency exit signs

CS 29.811 Emergency exit marking

[...]

- (d) Each passenger emergency exit marking and each locating sign must have white letters ~~25 mm (1 inch) high~~ on a red background ~~51 mm (2 inches) high~~, or a universal emergency exit symbol, of adequate size. These signs must be self or electrically illuminated, and have a minimum luminescence (brightness) of at least 0.51 candela/m² (160 microlamberts). The colours of a text-based sign may be reversed if this will increase the emergency illumination of the passenger compartment.

[...]

- (g) Exits marked as such, though in excess of the required number of exits, must meet the requirements for emergency exits of the particular type. Emergency exits need only be marked with the word 'Exit' or a universal emergency exit symbol.

[...]

AMC1 29.811(d) Emergency exit marking

EMERGENCY EXIT SIGNS

Emergency exit signs should consist of a consistent type throughout the rotorcraft. They may be letter-based or symbolic, as outlined below.

Letter-based emergency exit signs should use letters with a height to stroke width ratio of not more than 7:1 nor less than 6:1.

Symbolic emergency exit signs should be white and green in compliance with European Standard (EN) ISO 7010:2012, Graphical symbols, safety colours and safety signs, registered safety signs.

The green area of the sign should constitute at least half of the total area of the sign.

In the area determination of an emergency exit sign, no part of the sign outside of the white background (text signs) or green element (symbolic signs), for instance a surrounding contrasting border, should be included.

Minimum size

For each emergency exit sign required by CS 29.811(c), a sign using English letters of at least 25 mm (1 inch) height, or a white symbolic element (i.e. that part incorporating the green 'running man') of at least 40 mm (1.6 inches) height, with an overall area of at least 64.5 cm² (10 square inches) should be acceptable provided the centrelines of the forward most and rearward most emergency exits are no more than 6 m (19.8 feet) apart.

Example of an acceptable design of a symbolic exit sign



Direction of running man

There may be a reason to choose a particular movement direction of the 'running man'; for instance, where a sign required by CS 29.811(c) is placed to the left or right of the emergency exit. The 'running man' should not suggest movement away from the emergency exit.

Item 26: Proof of structure**AMC1 27.307 Proof of structure****GENERAL****(a) Purpose**

This AMC provides guidance and acceptable means of compliance with CS 27.307, which specifies the requirements for proof of structure.

(b) Related Certification Specifications

CS 27.303 'Factor of safety'

CS 27.305 'Strength and deformation'

Definitions

- (1) Detail: a structural element of a more complex structural member (e.g. joints, splices, stringers, stringer run-outs, or access holes).
- (2) Subcomponent: a major three-dimensional structure which can provide a complete structural representation of a section of the full structure (e.g. stub-box, section of a spar, wing panel, wing rib, body panel, or frames).
- (3) Component: a major section of the airframe structure (e.g. wing, body, fin, horizontal stabiliser) which can be tested as a complete unit to qualify the structure.
- (4) Full scale: dimensions of the test article are the same as design; fully representative test specimen (not necessarily complete airframe).
- (5) New structure: a structure for which the behaviour is not adequately predicted by analysis supported by previous test evidence. A structure that utilises significantly different structural design concepts such as details, geometry, structural arrangements, and load paths or materials from previously tested designs.
- (6) Similar new structure: a structure that utilises similar or comparable structural design concepts such as details, geometry, structural arrangements, and load path concepts and materials to an existing tested design.
- (7) Derivative/similar structure: a structure that uses structural design concepts such as details, geometry, structural arrangements, and load paths, stress levels and materials that are nearly identical to those on which the analytical methods have been validated.
- (8) Previous test evidence: testing of the original structure that is sufficient to verify the structural behaviour in accordance with CS 27.305.

(c) Introduction

As required by sub-paragraph (a) of CS 27.307, the structure must be shown to comply with the strength and deformation requirements of Subpart C of CS-27. This means that the structure must be able to support:

- (a) limit loads without detrimental permanent deformation; and
- (b) ultimate loads without failure.

This implies the need of a comprehensive assessment of the external loads (addressed by CS 27.301), the resulting internal strains and stresses, and the structural allowables.

CS 27.307 requires compliance for each critical loading condition. Compliance may be shown by analysis supported by previous test evidence, analysis supported by new test evidence or by test only. As compliance by test only is impractical in most cases, a large portion of the substantiating data will be based on analysis.

There are a number of standard engineering methods and formulas which are known to produce acceptable, often conservative, results especially for structures where load paths are well defined.

Those standard methods and formulas, applied with a good understanding of their limitations, are considered to be reliable analyses when showing compliance with CS 27.307. Conservative assumptions may be considered in assessing whether or not an analysis may be accepted without test substantiation.

The application of methods such as finite element method or engineering formulas to complex structures in modern aircraft is considered to be reliable only when validated by full-scale tests (ground and/or flight tests). Experience relevant to the product in the utilisation of such methods should be considered.

(d) Classification of structure

(a) The structure of the product should be classified into one of the following three categories:

- (1) new structure
- (2) similar new structure
- (3) derivative/similar structure

(b) Justifications should be provided for classifications other than new structure. Elements that should be considered are:

- (1) the accuracy/conservatism of the analytical methods; and
- (2) comparison of the structure under investigation with a previously tested structure.

Considerations should include but are not limited to the following:

- external loads (bending moment, shear, torque, etc.);
- internal loads (strains, stresses, etc.);
- structural design concepts such as details, geometry, structural arrangements, load paths;
- materials;
- test experience (load levels achieved, lessons learned);

- deflections;
- deformations;
- extent of extrapolation from test stress levels.

(e) Need and extent of testing

The following factors should be considered in deciding the need for and the extent of testing including the load levels to be achieved:

- (a) the classification of the structure (as above);
- (b) the consequence of the failure of the structure in terms of the overall integrity of the rotorcraft;
- (c) the consequence of the failure of interior items of mass and the supporting structure to the safety of the occupants.

Relevant service experience may be included in this evaluation.

(f) Certification approaches

The following certification approaches may be selected:

- (a) Analysis, supported by new strength testing of the structure to limit and ultimate load. This is typically the case for new structure.

Substantiation of the strength and deformation requirements up to limit and ultimate loads normally requires testing of subcomponents, full-scale components or full-scale tests of assembled components (such as a nearly complete airframe). The entire test programme should be considered in detail to assure the requirements for strength and deformation can be met up to limit load levels as well as ultimate load levels.

Sufficient limit load test conditions should be performed to verify that the structure meets the deformation requirements of CS 27.305(a) and to provide validation of internal load distribution and analysis predictions for all critical loading conditions.

Because ultimate load tests often result in significant permanent deformation, choices will have to be made with respect to the load conditions applied. This is usually based on the number of test specimens available, the analytical static strength margins of safety of the structure and the range of supporting detail or subcomponent tests. An envelope approach may be taken, where a combination of different load cases is applied, each one critical for a different section of the structure.

These limit and ultimate load tests may be supported by detail and subcomponent tests that verify the design allowables (tension, shear, compression) of the structure and often provide some degree of validation for ultimate strength.

- (b) Analysis validated by previous test evidence and supported with additional limited testing. This is typically the case for similar new structure.

The extent of additional limited testing (number of specimens, load levels, etc.) will depend upon the degree of change, relative to the elements of sub-paragraphs (e)(b)(1) and (2).

For example, if the changes to an existing design and analysis necessitate extensive changes to an existing test-validated finite element model (e.g. different rib spacing), additional testing may be needed. Previous test evidence can be relied upon whenever practical.

These additional limited tests may be further supported by detail and subcomponent tests that verify the design allowables (tension, shear, compression) of the structure and often provide some degree of validation for ultimate strength.

- (c) Analysis, supported by previous test evidence. This is typically the case for derivative/similar structure.

Justification should be provided for this approach by demonstrating how the previous static test evidence validates the analysis and supports showing compliance for the structure under investigation. Elements that need to be considered are those defined in sub-paragraphs (e)(b)(1) and (2).

For example, if the changes to the existing design and test-validated analysis are evaluated to assure that they are relatively minor, and the effects of the changes are well understood, the original tests may provide sufficient validation of the analysis and further testing may not be necessary. For example, if a weight increase results in higher loads along with a corresponding increase in some of the element thickness and fastener sizes, and materials and geometry (overall configuration, spacing of structural members, etc.) remain generally the same, the revised analysis could be considered to be reliable based on the previous validation.

- (d) Test only

Sometimes no reliable analytical method exists, and testing must be used to show compliance with the strength and deformation requirements. In other cases, it may be elected to show compliance solely by tests even if there are acceptable analytical methods. In either case, testing by itself can be used to show compliance with the strength and deformation requirements of CS-27 Subpart C. In such cases, the test load conditions should be selected to assure that all critical design loads are encompassed.

If tests only are used to show compliance with the strength and deformation requirements for a single load path structure which carries flight loads (including pressurisation loads), the test loads must be increased to account for variability in material properties, as required by CS 27.307(d). In lieu of a rational analysis, for metallic materials, a factor of 1.15 applied to the limit and ultimate flight loads may be used. If the structure has multiple load paths, no material correction factor is required.

- (g) Interpretation of data

The interpretation of the substantiation analysis and test data requires an extensive review of:

- the representativeness of the loading;
- the instrumentation data;
- comparisons with analytical methods;

- representativeness of the test article(s);
- test set-up (fixture, load introductions);
- load levels and conditions tested;
- test results.

Testing is used to validate analytical methods except when showing compliance by test only. If the test results do not correlate with the analysis, the reasons should be identified, and appropriate action taken.

This should be accomplished whether or not a test article fails below ultimate load.

Should a failure occur below ultimate load, an investigation should be conducted for the product to reveal the cause of this failure. This investigation should include a review of the test specimen and loads, analytical loads, and the structural analysis. This may lead to adjustment in analysis/modelling techniques and/or part redesign and may result in the need for additional testing. The need for additional testing to ensure ultimate load capability depends on the degree to which the failure is understood, and the analysis can be validated by the test.

The approach described above is valid for static justification. However, a similar approach can be extended for compliance with fatigue, dynamic and crashworthiness requirements. For these applications, the criteria and the classification have to be accepted and agreed with the Authority.

AMC2 27.307 Proof of structure

FAIRING SUBSTANTIATION

This AMC supplements FAA AC 27-1B, § AC 27.307 and should be used in conjunction with that AC when demonstrating compliance with CS 27.307.

Further to CS 27.301, the specified loads must be distributed appropriately or conservatively and significant changes in the distribution of the loads, as a result of deflection, must be taken into account. FAA AC 27-1B, § AC 27.307 refers to the need for flight test measurement in the scope of the fatigue and damage tolerance demonstration. Only further to AMC No. 2 to CS 25.301(b) the methods used to determine load intensities and distribution must be validated by flight load measurements unless the methods used for determining those loading conditions are shown to be reliable.

Each fairing, when appropriate, must be constructed and supported so that it can resist any vibration, inertia, and air load to which it may be subjected in operation. The vibrations level, the inertia and air loads must be validated by appropriately instrumented flight measurements as recommended in FAA AC 27-1B, § AC 27.307 and AMC No. 2 to CS 25.301(b).

For the fairings and the associated supporting structure, the loads can be shown unreliably predicted and require a measurement during flight tests. The condition for loads measurement should be defined in accordance with AMC No. 2 to CS 25.301(b) paragraph 5 Flight load measurements (5.1 Measurements, 5.2 Variation of parameters, 5.3 Conditions).

The loads derived from flight testing should be compared with those obtained from analytical methods as described in AMC No. 2 to CS 25.301(b) paragraph 6 Results of flight load measurements.

AMC1 29.307 Proof of structure

(a) Purpose

This AMC establishes methods of compliance with CS 29.307, which specifies the requirements for proof of structure.

(b) Related Certification Specifications

CS 29.303 'Factor of safety'

CS 29.305 'Strength and deformation'

(c) Definitions

- (1) Detail: a structural element of a more complex structural member (e.g. joints, splices, stringers, stringer run-outs, or access holes).
- (2) Subcomponent: a major three-dimensional structure which can provide a complete structural representation of a section of the full structure (e.g. stub-box, section of a spar, wing panel, wing rib, body panel, or frames).
- (3) Component: a major section of the airframe structure (e.g. wing, body, fin, horizontal stabiliser) which can be tested as a complete unit to qualify the structure.
- (4) Full scale: dimensions of test article are the same as design; fully representative test specimen (not necessarily complete airframe).
- (5) New structure: a structure for which the behaviour is not adequately predicted by analysis supported by previous test evidence. A structure that utilises significantly different structural design concepts such as details, geometry, structural arrangements, and load paths or materials from previously tested designs.
- (6) Similar new structure: a structure that utilises similar or comparable structural design concepts such as details, geometry, structural arrangements, and load path concepts and materials to an existing tested design.
- (7) Derivative/similar structure: a structure that uses structural design concepts such as details, geometry, structural arrangements, and load paths, stress levels and materials that are nearly identical to those on which the analytical methods have been validated.
- (8) Previous test evidence: testing of the original structure that is sufficient to verify the structural behaviour in accordance with CS 29.305.

(d) Introduction

As required by sub-paragraph (a) of CS 29.307, the structure must be shown to comply with the strength and deformation requirements of Subpart C of CS-29. This means that the structure must be able to support:

- (a) limit loads without detrimental permanent deformation, and
- (b) ultimate loads without failure.

This implies the need of a comprehensive assessment of the external loads (addressed by CS 29.301), the resulting internal strains and stresses, and the structural allowables.

CS 29.307 requires compliance for each critical loading condition. Compliance can be shown by analysis supported by previous test evidence, analysis supported by new test evidence or by test only. As compliance by test only is impractical in most cases, a large portion of the substantiating data will be based on analysis.

There are a number of standard engineering methods and formulas which are known to produce acceptable, often conservative, results especially for structures where load paths are well defined.

Those standard methods and formulas, applied with a good understanding of their limitations, are considered to be reliable analyses when showing compliance with CS 29.307. Conservative assumptions may be considered in assessing whether or not an analysis may be accepted without test substantiation.

The application of methods such as finite element method or engineering formulas to complex structures in modern aircraft is considered to be reliable only when validated by full-scale tests (ground and/or flight tests). Experience relevant to the product in the utilisation of such methods should be considered.

(e) Classification of structure

(a) The structure of the product should be classified into one of the following three categories:

- (1) new structure
- (2) similar new structure
- (3) derivative/similar structure

(b) Justifications should be provided for classifications other than new structure. Elements that should be considered are:

- (1) the accuracy/conservatism of the analytical methods; and
- (2) comparison of the structure under investigation with a previously tested structure.

Considerations should include but are not limited to the following:

- external loads (bending moment, shear, torque, etc.);
- internal loads (strains, stresses, etc.);
- structural design concepts such as details, geometry, structural arrangements, load paths;
- materials;
- test experience (load levels achieved, lessons learned);
- deflections;
- deformations;
- extent of extrapolation from test stress levels.

(f) Need and extent of testing

The following factors should be considered in deciding the need for and the extent of testing including the load levels to be achieved:

- (a) the classification of the structure (as above);
- (b) the consequence of the failure of the structure in terms of the overall integrity of the rotorcraft;
- (c) the consequence of the failure of interior items of mass and the supporting structure to the safety of the occupants.

Relevant service experience may be included in this evaluation.

(g) Certification approaches

The following certification approaches may be selected:

- (a) Analysis, supported by new strength testing of the structure to limit and ultimate load. This is typically the case for new structure.

Substantiation of the strength and deformation requirements up to limit and ultimate loads normally requires testing of subcomponents, full-scale components or full-scale tests of assembled components (such as a nearly complete airframe). The entire test programme should be considered in detail to assure the requirements for strength and deformation can be met up to limit load levels as well as ultimate load levels.

Sufficient limit load test conditions should be performed to verify that the structure meets the deformation requirements of CS 29.305(a) and to provide validation of internal load distribution and analysis predictions for all critical loading conditions.

Because ultimate load tests often result in significant permanent deformation, choices will have to be made with respect to the load conditions applied. This is usually based on the number of test specimens available, the analytical static strength margins of safety of the structure and the range of supporting detail or subcomponent tests. An envelope approach may be taken, where a combination of different load cases is applied, each one critical for a different section of the structure.

These limit and ultimate load tests may be supported by detail and subcomponent tests that verify the design allowables (tension, shear, compression) of the structure and often provide some degree of validation for ultimate strength.

- (b) Analysis validated by previous test evidence and supported with additional limited testing. This is typically the case for similar new structure.

The extent of additional limited testing (number of specimens, load levels, etc.) will depend upon the degree of change, relative to the elements of sub-paragraphs (e)(b)(1) and (2).

For example, if the changes to an existing design and analysis necessitate extensive changes to an existing test-validated finite element model (e.g. different rib spacing), additional testing may be needed. Previous test evidence can be relied upon whenever practical.

These additional limited tests may be further supported by detail and subcomponent tests that verify the design allowables (tension, shear, compression) of the structure and often provide some degree of validation for ultimate strength.

- (c) Analysis, supported by previous test evidence. This is typically the case for derivative/similar structure.

Justification should be provided for this approach by demonstrating how the previous static test evidence validates the analysis and supports showing compliance for the structure under investigation. Elements that need to be considered are those defined in paragraphs (e)(b)(1) and (2).

For example, if the changes to the existing design and test-validated analysis are evaluated to assure they are relatively minor, and the effects of the changes are well understood, the original tests may provide sufficient validation of the analysis and further testing may not be necessary. For example, if a weight increase results in higher loads along with a corresponding increase in some of the element thickness and fastener sizes, and materials and geometry (overall configuration, spacing of structural members, etc.) remain generally the same, the revised analysis could be considered to be reliable based on the previous validation.

- (d) Test only

Sometimes no reliable analytical method exists, and testing must be used to show compliance with the strength and deformation requirements. In other cases, it may be elected to show compliance solely by tests even if there are acceptable analytical methods. In either case, testing by itself can be used to show compliance with the strength and deformation requirements of CS-29 Subpart C. In such cases, the test load conditions should be selected to assure all critical design loads are encompassed.

If tests only are used to show compliance with the strength and deformation requirements for single load path structure which carries flight loads (including pressurisation loads), the test loads must be increased to account for variability in material properties, as required by CS 29.307(d). In lieu of a rational analysis, for metallic materials, a factor of 1.15 applied to the limit and ultimate flight loads may be used. If the structure has multiple load paths, no material correction factor is required.

(h) INTERPRETATION OF DATA

The interpretation of the substantiation analysis and test data requires an extensive review of:

- the representativeness of the loading;
- the instrumentation data;
- comparisons with analytical methods;
- representativeness of the test article(s);
- test set-up (fixture, load introductions);
- load levels and conditions tested;
- test results.

Testing is used to validate analytical methods except when showing compliance by test only. If the test results do not correlate with the analysis, the reasons should be identified, and appropriate action taken.

This should be accomplished whether or not a test article fails below ultimate load.

Should a failure occur below ultimate load, an investigation should be conducted for the product to reveal the cause of this failure. This investigation should include a review of the test specimen and loads, analytical loads, and the structural analysis. This may lead to adjustment in analysis/modelling techniques and/or part redesign and may result in the need for additional testing. The need for additional testing to ensure ultimate load capability depends on the degree to which the failure is understood, and the analysis can be validated by the test.

The approach described above is valid for static justification. However, a similar approach can be extended for compliance with fatigue, dynamic and crashworthiness requirements. For these applications, the criteria and the classification have to be accepted and agreed with the Authority.

AMC2 29.307 Proof of structure

FAIRING SUBSTANTIATION

This AMC supplements FAA AC 29-2C, § AC 29.307 and should be used in conjunction with that AC when demonstrating compliance with CS 29.307.

Further to CS 29.301, the specified loads must be distributed appropriately or conservatively and significant changes in the distribution of the loads, as a result of deflection, must be taken into account. FAA AC 29-2C, § AC 29.307 refers to the need for flight test measurement in the scope of the fatigue and damage tolerance demonstration. Only further to AMC No. 2 to CS 25.301(b) the methods used to determine load intensities and distribution must be validated by flight load measurements unless the methods used for determining those loading conditions are shown to be reliable.

Each fairing, when appropriate, must be constructed and supported so that it can resist any vibration, inertia, and air load to which it may be subjected in operation. The vibrations level, the inertia and air loads must be validated by appropriately instrumented flight measurements as recommended in FAA AC 29-2C, § AC 29.307 and AMC No. 2 to CS 25.301(b).

For the fairings and the associated supporting structure, the loads can be shown unreliably predicted and require a measurement during flight tests. The condition for loads measurement must be defined in accordance with AMC No. 2 to CS 25.301(b) paragraph 5 Flight load measurements (5.1 Measurements, 5.2 Variation of parameters, 5.3 Conditions).

The loads derived from flight testing should be compared with those obtained from analytical methods as described in AMC No. 2 to CS 25.301(b) paragraph 6 Results of flight load measurements.

Item 27: Use of standard fasteners in critical installations**AMC1 27.607 Fasteners**

This AMC supplements FAA AC 27-1B, § AC 27.607 and should be used in conjunction with that AC when demonstrating compliance with CS 27.607.

(a) Explanation

Designers should consistently take into account the limitations of the standards, including the applicable fastener manufacturing processes and quality controls, to ensure that when a standard part or qualified standard part is selected, its properties and associated level of reliability will meet the applicable certification requirements for the design.

The intent of this AMC is to give further guidance to the design approval holders (DAHs) and applicants for design approvals to help ensure that appropriate measures are considered for initial certification, including associated continued airworthiness aspects, to minimise the risk that the use of standard fasteners might compromise the intended level of safety.

(b) Definitions

- (1) Standard fastener: a fastener that is a standard part. Fasteners (nuts and bolts) being produced according to a certain standard which is not directly approved by the Agency. They fall within the category of standard parts as defined in point 21.A.303(c) of Annex I (Part 21) to Commission Regulation (EU) No 748/2012.
- (2) Qualified standard fastener: a standard fastener that requires additional verification of compliance with specification and/or control of their source, by methods defined by the DAH.
- (3) Critical installation: a structural/mechanical assembly which may include fasteners the failure of which (single or multiple due to common cause) is classified as hazardous or catastrophic.

(c) Procedures

Failures of standard fasteners may have severe consequences at the aircraft level when used in critical installations.

Once demonstrated, conformance to a standard provides a certain level of reliability under known loading and environmental conditions. The reliability of a standard part or any other part specified in the design needs to be assessed and shown to be compatible with the design objectives to be met. Designers should take care to ensure that they select appropriate fasteners to meet the certification objectives for continued function and reliability, taking into account the limitations of the applicable standards including the associated manufacturing processes and applicable quality controls.

This AMC is therefore addressed to DAHs, to provide them with guidance on appropriate actions to ensure appropriate utilisation of standard fasteners in their designs, to help them to instruct production organisations and maintenance organisations as necessary to ensure continued

airworthiness and to provide means by which unsafe conditions related to the use in design of standard fasteners can be prevented.

In order to reduce the risk of critical installations failing, through the inadvertent use of defective standard fasteners or due to the inappropriate selection of standards, the Agency recommends that all applicants for type certificates and design changes perform a design review to ensure that the risk posed by the use of standard parts is mitigated by:

- (1) ensuring that fasteners (nuts and bolts) used in the design will meet the certification requirements, taking into account any limitations of the selected standards, the associated fastener manufacturing processes and quality controls, and relevant service experience;

[Note: The degree to which the standard ensures relevant characteristics such as locking functions, static strength and fatigue strength should be evaluated as far as is necessary based on the criticality of the intended use and operating environment of the parts. Consideration should be given to stress levels arising from manufacture, installation requirements, external loading and temperature effects. Particular attention should be paid to standard parts that utilise high-strength alloys in combination with plating or other processes that may increase the risk of hydrogen embrittlement or deformation processes that are not closely specified.]

- (2) ensuring that the design standard and associated procedures met for the production of the aircraft is maintained throughout the operational life of the aircraft, e.g. through the use of the ICA controlling maintenance of critical installations;
- (3) creating, when standard fasteners (nuts and bolts) are selected, a list of critical installations where only qualified standard fasteners (nuts and bolts) may be used. Redundancy of fasteners alone may not negate the need to qualify the fasteners as all the fasteners on a joint could originate from a common defective batch. Similarly, required double locking functions on fasteners may also need consideration of qualified standard fasteners to ensure that the fail-safe design philosophy is maintained when common cause failure of both locking functions is possible;
- (4) defining how the standard fastener is qualified wherever necessary;
- (5) clearly defining any necessary additional conformity checks as part of the type design standard, specifying requirements for approved suppliers and any other criteria necessary for acceptance, storage and installation of standard fasteners that are appropriate for use in the design;
- (6) ensuring through maintenance instructions that qualified standard fasteners are only replaced by other qualified standard fasteners; and
- (7) considering introducing a DAH part numbering system for qualified standard fasteners, at which point they would become aviation parts. (Note: If such part numbering is implemented and further part marking is not feasible due to the part's size or for other reasons, other means such as regular appropriate batch controls should be established, and documentation provided according to point 21.A.804(b) of Part 21.)

In addition, DAHs are reminded that certain existing Certification Specifications and regulations specifically address critical parts. Typically standard parts are not appropriate for use as critical parts. All critical parts are subject to a critical parts plan that controls their critical characteristics during production and service.

AMC1 29.607 Fasteners

This AMC supplements FAA AC 29-2C, § AC 29.607 and should be used in conjunction with that AC when demonstrating compliance with CS 29.607.

(a) Explanation

Designers should consistently take into account the limitations of the standards, including the applicable fastener manufacturing processes and quality controls, to ensure that when a standard part or qualified standard part is selected, its properties and associated level of reliability will meet the applicable certification requirements for the design.

The intent of this AMC is to give further guidance to the design approval holders (DAHs) and applicants for design approvals to help ensure that appropriate measures are considered for initial certification, including associated continued airworthiness aspects, to minimise the risk that the use of standard fasteners might compromise the intended level of safety.

(b) Definitions

- (1) Standard fastener: a fastener that is a standard part. Fasteners (nuts and bolts) being produced according to a certain standard which is not directly approved by the Agency. They fall within the category of standard parts as defined in point 21.A.303(c) of Annex I (Part 21) to Commission Regulation (EU) No 748/2012.
- (2) Qualified standard fastener: a standard fastener that requires additional verification of compliance with specification and/or control of their source, by methods defined by the DAH.
- (3) Critical installation: a structural/mechanical assembly which may include fasteners the failure of which (single or multiple due to common cause) is classified as hazardous or catastrophic.

(c) Procedures

Failures of standard fasteners may have severe consequences at the aircraft level when used in critical installations.

Once demonstrated, conformance to a standard provides a certain level of reliability under known loading and environmental conditions. The reliability of a standard part or any other part specified in the design needs to be assessed and shown to be compatible with the design objectives to be met. Designers should take care to ensure that they select appropriate fasteners to meet the certification objectives for continued function and reliability, taking into account the limitations of the applicable standards including the associated manufacturing processes and applicable quality controls.

This AMC is therefore addressed to DAHs, to provide them with guidance on appropriate actions to ensure appropriate utilisation of standard fasteners in their designs, to help them to instruct production organisations and maintenance organisations as necessary to ensure continued airworthiness and to provide means by which unsafe conditions related to the use in design of standard fasteners can be prevented.

In order to reduce the risk of critical installations failing, through the inadvertent use of defective standard fasteners or due to the inappropriate selection of standards, the Agency recommends that all applicants for type certificates and design changes perform a design review to ensure that the risk posed by the use of standard parts is mitigated by:

(8) ensuring that fasteners (nuts and bolts) used in the design will meet the certification requirements, taking into account any limitations of the selected standards, the associated fastener manufacturing processes and quality controls, and relevant service experience;

[Note: The degree to which the standard ensures relevant characteristics such as locking functions, static strength and fatigue strength should be evaluated as far as is necessary based on the criticality of the intended use and operating environment of the parts. Consideration should be given to stress levels arising from manufacture, installation requirements, external loading and temperature effects. Particular attention should be paid to standard parts that utilise high-strength alloys in combination with plating or other processes that may increase the risk of hydrogen embrittlement or deformation processes that are not closely specified.]

(9) ensuring that the design standard and associated procedures met for the production of the aircraft is maintained throughout the operational life of the aircraft, e.g. through the use of the ICA controlling maintenance of critical installations;

(10) creating, when standard fasteners (nuts and bolts) are selected, a list of critical installations where only qualified standard fasteners (nuts and bolts) may be used. Redundancy of fasteners alone may not negate the need to qualify the fasteners as all the fasteners on a joint could originate from a common defective batch. Similarly, required double locking functions on fasteners may also need consideration of qualified standard fasteners to ensure that the fail-safe design philosophy is maintained when common cause failure of both locking functions is possible;

(11) defining how the standard fastener is qualified wherever necessary;

(12) clearly defining any necessary additional conformity checks as part of the type design standard, specifying requirements for approved suppliers and any other criteria necessary for acceptance, storage and installation of standard fasteners that are appropriate for use in the design;

(13) ensuring through maintenance instructions that qualified standard fasteners are only replaced by other qualified standard fasteners; and

(14) considering introducing a DAH part numbering system for qualified standard fasteners, at which point they would become aviation parts. (Note: If such part numbering is implemented and further part marking is not feasible due to the part's size or for other

reasons, other means such as regular appropriate batch controls should be established, and documentation provided according to point 21.A.804(b) of Part 21.)

In addition, DAHs are reminded that certain existing Certification Specifications and regulations specifically address critical parts. Typically standard parts are not appropriate for use as critical parts. All critical parts are subject to a critical parts plan that controls their critical characteristics during production and service.

Item 28: Lightning and static electricity protection

AMC1 27.610 Lightning and static electricity protection

(a) Purpose

This AMC provides an acceptable means of compliance for evaluation of rotorcraft components after lightning strike.

(b) Related Certification Specifications

CS 27.610 'Lightning and static electricity protection'

CS 27.571 'Fatigue evaluation of flight structure'

CS 27.573 'Damage tolerance and fatigue evaluation of composite structures'

CS 27.1529 'Instructions for Continued Airworthiness'

(c) Explanation

CS 27.610 requires the protection of rotorcraft structural components, propulsion system, gearboxes, mechanical and hydraulic control systems from lightning effects that could result in catastrophic failures.

However, damage, failure or departure of any rotorcraft component which could endanger the rotorcraft or its occupants should be part of the evaluation.

This AMC provides detailed guidance on damage tolerance evaluation, including residual strength criteria after lightning strike to ensure continuous safe flight and landing.

Each part the failure which implies potential catastrophic consequences and that is exposed to damage under lightning conditions, should be subject to further evaluation which includes:

- (1) the nature and extent of the lightning damage (threat assessment, damage detectability, etc.);
- (2) a static residual strength capability supported by analysis and/or test;
- (3) when found necessary, a fatigue evaluation of a part with lightning damage for the demonstration of the exposure time before detection.

The airworthiness instruction requested after lightning strike (flight manual and maintenance instructions, etc.) should be consistent with the static and fatigue evaluation of the damage (considered to be a partial failure).

A similar approach should be considered for non-metallic components (for composite, see AMC 20-29 (11c) guidance).

The above approach is also considered to be applicable for parts departure which could preclude continued safe flight and landing.

For non-structural components (e.g. radomes, panels), only static residual strength is requested for part detachment which could preclude continued safe flight and landing.

AMC1 29.610 Lightning and static electricity protection

(a) Purpose

This AMC provides an acceptable means of compliance for rotorcraft components evaluation after lightning strike.

(b) Related Certification Specifications

CS 29.610 'Lightning and static electricity protection'

CS 29.571 'Fatigue tolerance evaluation of metallic structure'

CS 29.573 'Damage tolerance and fatigue evaluation of composite structures'

CS 29.1529 'Instructions for Continued Airworthiness'

(c) Explanation

CS 29.610 requires the protection of rotorcraft structural components, propulsion system, gearboxes, mechanical and hydraulic control systems from lightning damage that could result in catastrophic failures.

However, damage, failure or departure of any rotorcraft component which could endanger the rotorcraft or its occupants must be part of the evaluation.

This AMC provides detailed guidance on damage tolerance evaluation, including residual strength criteria after lightning strike to ensure continuous safe flight and landing.

Each part the failure which implies potential catastrophic consequences and that is exposed to damage under lightning conditions, should be subject to further evaluation which includes:

- (1) the nature and extent of the lightning damage (threat assessment, damage detectability, etc.);
- (2) a static residual strength capability supported by analysis and/or test;
- (3) when found necessary, a fatigue evaluation of a part with lightning damage for the demonstration of the exposure time before detection.

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A similar approach should be considered for non-metallic components (for composite, see AMC 20-29 (11c) guidance).

The above approach is also considered to be applicable for parts departure which could preclude continued safe flight and landing.

For non-structural components (e.g. radomes, panels), only static residual strength is requested for part detachment which could preclude continued safe flight and landing.

Item 29: Density effect on manoeuvring load factors

CS 27.309 Design limitations

The following values and limitations must be established to show compliance with the structural requirements of this Subpart:

- (a) The design maximum and design minimum weights.
- (b) The main rotor rpm ranges power on and power off.
- (c) The maximum forward speeds for each main rotor rpm within the ranges determined in subparagraph (b).
- (d) The maximum rearward and sideward flight speeds.
- (e) The centre of gravity limits corresponding to the limitations determined under sub-paragraphs (b), (c), and (d).
- (f) The rotational speed ratios between each powerplant and each connected rotating component.
- (g) The positive and negative limit manoeuvring load factors.
- (h) The maximum and minimum density altitude and temperatures.

AMC1 27.337 Limit manoeuvring load factor

This AMC supplements FAA AC 27-1B, § AC 27.337 and should be used in conjunction with that AC when demonstrating compliance with CS 27.337.

In accordance with CS 27.337, the rotorcraft may be substantiated to a maximum positive load factor less than +3.5 (but not less than 2.0) provided that the probability of being exceeded is shown to be extremely remote. Whenever this option is selected, the maximum available rotor lift with both power on and power off rotor speed ranges throughout the entire operational density envelope should be considered.

AC 27-1B, § AC 27.337(b)(1) provides some guidance as to the necessary considerations when substantiating manoeuvre load factors less than the specified values. Further clarification should be provided in this paragraph to specify that the entire operational envelope should be considered when determining the maximum available rotor lift.

The guidance should be read as follows:

§ AC 27.337(b)(1) The applicant may elect to substantiate the rotorcraft for a design manoeuvring load factor less than +3.5 and more than -1.0. Whenever this option is used, an analytical study and flight demonstration are required. Maximum available rotor lift with both power on and power off throughout the entire operational density envelope should be considered when substantiating manoeuvre load factors less than the specified values.

CS 29.309 Design limitations

The following values and limitations must be established to show compliance with the structural requirements of this Subpart:

- (a) The design maximum and design minimum weights.
- (b) The main rotor rpm ranges, power on and power off.
- (c) The maximum forward speeds for each main rotor rpm within the ranges determined under sub-paragraph (b).
- (d) The maximum rearward and sideward flight speeds.
- (e) The centre of gravity limits corresponding to the limitations determined under sub-paragraphs (b), (c) and (d).
- (f) The rotational speed ratios between each powerplant and each connected rotating component.
- (g) The positive and negative limit manoeuvring load factors.
- (h) The maximum and minimum density altitude and temperatures.

AMC1 29.337 Limit manoeuvring load factor

This AMC supplements FAA AC 29-2C, § AC 29.337 and should be used in conjunction with that AC when demonstrating compliance with CS 29.337.

In accordance with CS 29.337, the rotorcraft may be substantiated to a maximum positive load factor less than +3.5 (but not less than 2.0) provided that the probability of being exceeded is shown to be extremely remote. Whenever this option is selected, the maximum available rotor lift with both power on and power off rotor speed ranges throughout the entire operational density envelope should be considered.

AC 29-2C, § AC 29.337(b)(1) provides some guidance as to the necessary considerations when substantiating manoeuvre load factors less than the specified values. Further clarification should be provided in this paragraph to specify that the entire operational envelope should be considered when determining the maximum available rotor lift.

There, the guidance should be read as follows:

§ AC 29.337(b)(1) The applicant may elect to substantiate the rotorcraft for a design manoeuvring load factor less than +3.5 and more than -1.0. Whenever this option is used, an analytical study and flight demonstration are required. Maximum available rotor lift with both power on and power off

throughout the entire operational density envelope should be considered when substantiating manoeuvre load factors less than the specified values.

Item 30: Single 'non-smoking' and 'fasten seatbelt' placard

AMC1 27.853(c) Compartment interiors

PROHIBITION OF SMOKING

CS 27.853(c) requires that if smoking is to be prohibited, a placard so stating must be installed.

A single placard, installed such that it is clearly visible to all passengers whilst seated, is an acceptable means of compliance. Alternatively, more than one placard may be installed, in locations such that at least one placard is clearly visible to each passenger when seated.

A placard may have a text-based design, or may utilise symbols that clearly express the intent.

AMC1 29.853(c) Compartment interiors

PROHIBITION OF SMOKING

CS 29.853(c) requires that if smoking is to be prohibited, a placard so stating must be installed.

A single placard, installed such that it is clearly visible to all passengers whilst seated, is an acceptable means of compliance. Alternatively, more than one placard may be installed, in locations such that at least one placard is clearly visible to each passenger when seated.

A placard may have a text-based design, or may utilise symbols that clearly express the intent.

AMC1 29.1413(a) Safety belts: passenger warning device

INDICATION OF WHEN SEAT BELTS SHOULD BE FASTENED

If a means to indicate to the passengers when safety belts should be fastened is provided, it should consist of an illuminated sign or signs. At least one sign should be clearly visible to each passenger, when seated.

Item 31: Compliance with requirements on flammability testing

AMC1 29.853 Compartment interiors

CS 29.853 (a) and (b) refer directly to CS-25 flammability requirements. Furthermore, CS 29.853(d) sets a fire containment requirement for waste containers that is essentially the same as that set by CS 25.853(h).

Accordingly, the relevant guidance for complying with CS-25 flammability requirements that is found in AC 25-17A and PS-ANM-25.853-R2 may be used when showing compliance with the requirement of CS 29.853

Item 32: Use of composite sandwich panels

AMC1 27.613 Material strength properties and design values

COMPOSITE SANDWICH PANEL

(a) Qualification of the manufacturing process

The conditions outlined in the guidance standard AC 21-26, 'Quality Control for the Manufacture of Composite Materials' are considered to be relevant to composite sandwich PSE structure.

The qualification is 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 and non-destructive inspection (NDI) should be conducted to determine conformity to specified design requirements and check the suitability of the resulting product by assessing features such as:

- 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;
- absence of '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 performing);
- Presence in the adhesive of unacceptable levels of porosity or humidity;
- disbonds between core and cells; and
- weak bonds.

(b) Material strength and determination of design allowables

The strength properties of the sandwich panels should be established in order to ensure that the probability of structural failure due to material and process variability be minimised.

Because of the peculiarity of the sandwich panel construction, the material properties should be established on a specimen that is fully representative of the panel construction in terms of skin, core material and curing cycle.

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

It is expected that at least the following static allowables be established according to the statistics required in CS 27.613:



- Adhesive shear strength;
- shear core strength (ribbon and transverse direction);
- Core compression strength;
- Flatwise strength;
- Flexural strength;
- Compressive strength; and
- bearing strength (for a specimen representative of all the panel areas where fasteners are installed and subject to significant bearing stresses).

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, impact damages should be also considered.

The validity of the engineering formula used to establish analytical design allowables should be always verified by dedicated experimental activity 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 allowables predicted by these formulas.

(c) Damage tolerance and residual strength

(1) Threat survey and damage modes

Further to good processing, and when meeting the damage tolerance and fatigue evaluation of composite rotorcraft structures requirements of CS 27.573, 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 threats, including impacts, heat, moisture, etc. and the potential for interaction of these threats is addressed;
- that all 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.

For impact threats, this requires testing throughout the threat impact energy ranges up to a readily detectable damage using a range of appropriate impactor geometries, including blunt impactors up to 4 inches diameter⁽¹⁾, and a range of impactor stiffnesses, e.g. for hail threat damage (if appropriate), such that all competing damage modes can be identified. Representative boundary conditions should be used in the substantiating test campaigns; and

- that all potentially undetectable damage modes (not only disbonds and weak bonds) have been simulated in testing (up to appropriate dimensions such that detection becomes possible, and the dimension of such damage has been quantified such that ultimate load (UL) can be maintained up to this level). The possibility of interaction between threats, e.g. impact and heat, should be considered in the simulation and substantiation process.

Note: Witness structures can be used in service, provided that a consistent and conservative correlation can be demonstrated to exist between the witness indications on the witness structure and the damage (all likely modes and extents) considered in the critical structure.

The recommendations for threat assessment and blunt impact evaluation are also addressed in AC 27.573.

⁽¹⁾ An alternative impactor diameter may be proposed by the applicant, based on the results of the damage threat survey.

(2) Residual strength after extensive damage or degradation

The part should be sized to sustain limit load (LL) with extensive damage or degradation of the most critical skin to core bond between available arrestment features. Such damage or degradation should be readily detectable to assure damage tolerance for bond failures which experience has shown not to be extremely improbable.

It is also expected that relevant fatigue testing at specimen level, representative of design point (e.g. fastened joint) and typical panel configuration, be performed in order to assess the effects of:

- material/manufacturing process variability;
- environmental condition;
- allowable manufacturing defects; and
- impact damages.

(d) Instructions for continued airworthiness (ICA)

The ICA include clear instructions to inspect⁽²⁾ (and repair), both internally and externally:

- all load paths, e.g. up to load transfer fittings, joints, and other significant changes in stiffness and section, for damage following an overload event, e.g. impact, heavy landing, excessive gust, etc.;
- all structure regularly exposed to extreme temperatures, e.g. local to engine outlets for aircraft used extensively in hot climates, etc. Although inspections 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 the potential for interaction between heat and damage can be problematic.

⁽²⁾ paying particular attention to:

- repaired structures; and
- any existing, and potentially related, ICA, e.g. existing Ads, etc.

AMC1 29.613 Material strength properties and design values

COMPOSITE SANDWICH PANEL

(a) Qualification of the manufacturing process

The conditions outlined in the guidance standard AC 21-26, 'Quality Control for the Manufacture of Composite Materials' are considered to be relevant to composite sandwich PSE structure.

The qualification is 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 and non-destructive inspection (NDI) should be conducted to determine conformity to specified design requirements and check the suitability of the resulting product by assessing features such as:

- 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;
- absence of '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 performing);
- presence in the adhesive of unacceptable levels of porosity or humidity;
- disbonds between core and cells; and
- weak bonds.

(b) Material strength and determination of design allowables

The strength properties of the sandwich panels should be established in order to ensure that the probability of structural failure due to material and process variability be minimised.

Because of the peculiarity of the sandwich panel construction, the material properties should be established on a specimen that is fully representative of the panel construction in terms of skin, core material and curing cycle.

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

It is expected that at least the following static allowables be established according to the statistics required in CS 29.613:

- Adhesive shear strength ;
- Shear core strength (ribbon and transverse direction);
- Core compression strength;
- Flatwise strength;

- Flexural strength;
- Compressive strength; and
- Bearing strength (for a specimen representative of all the panel areas where fasteners are installed and subject to significant bearing stresses).

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, impact damages should be also considered.

The validity of the engineering formula used to establish analytical design allowables should be always verified by dedicated experimental activity 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 allowables predicted by these formulas.

(c) Damage tolerance and residual strength

(1) Threat survey and damage modes

Further to good processing, and when meeting the damage tolerance and fatigue evaluation of composite rotorcraft structures requirements of CS 27.573, 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 threats, including impacts, heat, moisture, etc. and the potential for interaction of these threats is addressed;
- that all 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.

For impact threats, this requires testing throughout the threat impact energy ranges up to a readily detectable damage using a range of appropriate impactor geometries, including blunt impactors up to 4 inches diameter⁽¹⁾, and a range of impactor stiffnesses, e.g. for hail threat damage (if appropriate), such that all competing damage modes can be identified. Representative boundary conditions should be used in the substantiating test campaigns; and

- that all potentially undetectable damage modes (not only disbonds and weak bonds) have been simulated in testing (up to appropriate dimensions such that detection becomes possible, and the dimension of such damage has been quantified such that ultimate load (UL) can be maintained up to this level). The possibility of interaction between threats, e.g. impact and heat, should be considered in the simulation and substantiation process.

Note: Witness structures can be used in service, provided that a consistent and conservative correlation can be demonstrated to exist between the witness indications on the witness structure and the damage (all likely modes and extents) considered in the critical structure.

The recommendations for threat assessment and blunt impact evaluation are also addressed in AC 27.573.

⁽¹⁾ An alternative impactor diameter may be proposed by the applicant, based on the results of the damage threat survey.

(2) Residual strength after extensive damage or degradation

The part should be sized to sustain limit load (LL) with extensive damage or degradation of the most critical skin to core bond between available arrestment features. Such damage or degradation should be readily detectable to assure damage tolerance for bond failures which experience has shown not to be extremely improbable.

It is also expected that relevant fatigue testing at specimen level, representative of design point (e.g. fastened joint) and typical panel configuration, be performed in order to assess the effects of on the fatigue strength of:

- material/manufacturing process variability;
- environmental condition;
- allowables manufacturing defects; and
- impact damages.

(d) Instructions for Continued Airworthiness (ICA)

The ICA include clear instructions to inspect⁽²⁾ (and repair), both internally and externally:

- all load paths, e.g. up to load transfer fittings, joints, and other significant changes in stiffness and section, for damage following an overload event, e.g. impact, heavy landing, excessive gust, etc.;
- all structure regularly exposed to extreme temperatures, e.g. local to engine outlets for aircraft used extensively in hot climates, etc. Although inspections 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 the potential for interaction between heat and damage can be problematic.

⁽²⁾ paying particular attention to:

- repaired structures; and
- any existing, and potentially related, ICA, e.g. existing Ads, etc.

Item 33: Turbine engine induction systems certification in icing conditions

AMC1 27.1093(b)(1)(i) Induction system icing protection

This AMC is applicable to rotorcraft equipped with air intake external screens and has been developed based on in-service experience.

In icing conditions, as defined in CS 29 Appendix C, when the outside air temperature (OAT) is quite cold, typically below -5°C, the water droplets freeze at the helicopter air intake external screen that, once clogged, acts as passive protection by preventing subsequent super-cooled droplets to enter the

engine duct and plenum. The air, then, enters the engine intake through screen areas where water droplets do not accrete, or through an air intake by-pass, if necessary.

For warmer temperatures, typically between -5°C and 0°C , a critical temperature can exist at which the water droplets do not freeze completely and immediately on the external screen and therefore icing conditions may exist downstream in the engine air intake ducts or engine internal screen.

Furthermore, ice accretions behind the air intake screen can then be released during an engine acceleration or a rotorcraft descent in a warmer atmosphere and thus may lead to engine damage, surge or in-flight shutdown.

In the case where the engine is also protected by its own screen, then the engine screen can then become clogged by ice. This may also lead to high pressure drop or distortion across the engine screen, resulting into engine surge, engine damage or engine shutdown.

The purpose of this AMC is to provide specific and complementary guidance for showing compliance with CS 27.1093 (b)(1)(i) in the determination of this critical temperature, but does not provide any other guidance to demonstrate full compliance with CS 27.1093 (b)(1)(i) to cope with icing conditions as detailed in Appendix C to CS-29.

Analysis only should not be considered in the determination of the critical temperature due to the level of accuracy required for such an assessment. Its determination should be validated during combined rotorcraft (air intake / engine) icing tests in a wind tunnel or a similar test facility where the temperature can be controlled accurately showing whether icing conditions downstream the air intake screen are an issue or not. Typically, an accuracy of 0.5°C could be envisaged.

If the above-mentioned testing is done without the engine, it should be first demonstrated that the engine flow is correctly simulated, and the engine thermal impact adequately considered and validated on air intake. In a second step, the repercussion of any ice accretion should be assessed at engine level both in terms of airflow distortion and engine ingestion and duly validated by appropriate means. It has to be noted that this alternative approach without the engine may lead to difficulties in interpreting the results at engine level.

During these tests, the engine should be run at critical power regarding the feared events in the icing conditions defined in CS-29 Appendix C depending on the claimed certification (inadvertent icing encounter or full icing certification).

To determine the temperature at which the water does not freeze on the external screen, the test temperature may be decreased by accurate steps (typically a value of 0.5°C is suggested) from 0°C until accretion downstream the external air intake screen, if any, is maximised. If no ice is observed after 15 minutes of water injection, the test point is believed to be performed at a too warm temperature and can be stopped.

When decreasing the temperature step by step, if no ice accretion is observed downstream the helicopter external screen — typically for temperatures below -5°C the external screen catches the majority of the super-cooled droplets — it means that the above-described phenomenon does not occur.

Some other method can be proposed to reduce the test point number.

The test should demonstrate, that at the determined critical temperature, the maximum potential ice accretions downstream the rotorcraft screen do not have an adverse effect on the engine both in the

full range of claimed operation and when the rotorcraft then descends in an atmosphere with a positive OAT.

As an example, the following test procedure may be considered:

- A 1st run: at the end of the test (in fact, when reaching the highest measured pressure drop in the air intake), perform three consecutive engine quick decelerations (from maximum power to idle) / accelerations (idle to maximum power).
- A 2nd run: at the end of the test (in fact, when reaching the highest measured pressure drop in the air intake), simulate a quick descent in atmosphere with a positive OAT considering a tunnel warm-up procedure.

As specified in CS 27.1093 (b)(1)(i), these tests shall demonstrate that the engine operation is not adversely affected by icing conditions.

For rotorcraft certified in full icing conditions, in order to determine the rotorcraft performance in icing conditions, this test point should be used to identify the engine installation losses for flight into known icing conditions, in particular if the engine is also equipped with its own screen.

AMC1 29.1093(b)(1)(i) Induction system icing protection

This AMC is applicable to rotorcraft equipped with air intake external screens and has been developed based on in-service experience.

In icing conditions, as defined in CS 29 Appendix C, when the outside air temperature (OAT) is quite cold, typically below -5°C , the water droplets freeze at the helicopter air intake external screen that, once clogged, acts as passive protection by preventing subsequent super-cooled droplets to enter the engine duct and plenum. The air, then, enters the engine intake through screen areas where water droplets do not accrete, or through an air intake by-pass, if necessary.

For warmer temperatures, typically between -5°C and 0°C , a critical temperature can exist at which the water droplets do not freeze completely and immediately on the external screen and therefore icing conditions may exist downstream in the engine air intake ducts or engine internal screen.

Furthermore, ice accretions behind the air intake screen can then be released during an engine acceleration or a rotorcraft descent in a warmer atmosphere and thus may lead to engine damage, surge or in-flight shutdown.

In the case where the engine is also protected by its own screen, then the engine screen can then become clogged by ice. This may also lead to high pressure drop or distortion across the engine screen, resulting into engine surge, engine damage or engine shutdown.

The purpose of this AMC is to provide specific and complementary guidance for showing compliance with CS 29.1093 (b)(1)(i) in the determination of this critical temperature, but does not provide any other guidance to demonstrate full compliance with CS 29.1093 (b)(1)(i) to cope with icing conditions as detailed in Appendix C to CS-29.

Analysis only should not be considered in the determination of the critical temperature due to the level of accuracy required for such an assessment. Its determination should be validated during

combined rotorcraft (air intake / engine) icing tests in a wind tunnel or a similar test facility where the temperature can be controlled accurately showing whether icing conditions downstream the air intake screen are an issue or not. Typically, an accuracy of 0.5°C could be envisaged.

If the above-mentioned testing is done without the engine, it should be first demonstrated that the engine flow is correctly simulated, and the engine thermal impact adequately considered and validated on air intake. In a second step, the repercussion of any ice accretion should be assessed at engine level both in terms of airflow distortion and engine ingestion and duly validated by appropriate means. It has to be noted that this alternative approach without the engine may lead to difficulties in interpreting the results at engine level.

During these tests, the engine should be run at critical power regarding the feared events in the icing conditions defined in CS-29 Appendix C depending on the claimed certification (inadvertent icing encounter or full icing certification).

To determine the temperature at which the water does not freeze on the external screen, the test temperature may be decreased by accurate steps (typically a value of 0.5°C is suggested) from 0°C until accretion downstream the external air intake screen, if any, is maximised. If no ice is observed after 15 minutes of water injection, the test point is believed to be performed at a too warm temperature and can be stopped.

When decreasing the temperature step by step, if no ice accretion is observed downstream the helicopter external screen — typically for temperatures below -5°C the external screen catches the majority of the super-cooled droplets — it means that the above-described phenomenon does not occur.

Some other method can be proposed to reduce the test point number.

The test should demonstrate, that at the determined critical temperature, the maximum potential ice accretions downstream the rotorcraft screen do not have an adverse effect on the engine both in the full range of claimed operation and when the rotorcraft then descends in an atmosphere with a positive OAT.

As an example, the following test procedure may be considered:

- A 1st run: at the end of the test (in fact, when reaching the highest measured pressure drop in the air intake), perform three consecutive engine quick decelerations (from maximum power to idle) / accelerations (idle to maximum power).
- a 2nd run: at the end of the test (in fact, when reaching the highest measured pressure drop in the air intake), simulate a quick descent in atmosphere with a positive OAT considering a tunnel warm-up procedure.

As specified in CS 27.1093 (b)(1)(i), these tests shall demonstrate that the engine operation is not adversely affected by icing conditions.

For rotorcraft certified in full icing conditions, in order to determine the rotorcraft performance in icing conditions, this test point should be used to identify the engine installation losses for flight into known icing conditions, in particular if the engine is also equipped with its own screen.

Item 34: Seat adapter plates**AMC3 27.307 Proof of structure****SEAT ADAPTER PLATES****(a) Purpose**

This AMC provides an acceptable means of compliance for seat adapter plates. The seat adapter plate includes any other forms of new interface structure installed between the seat and the rotorcraft floor.

(b) Related Certification Specifications

- CS 27.307 'Proof of structure'
- CS 27.561 'General'
- CS 27.785 'Seats, berths, safety belts, and harnesses'

(c) Explanation

The requirements for seats under emergency landing dynamic conditions have been developed to prevent detachment of the seat under floor deformation and for the seat to help absorb the energy developed in crash conditions. This dynamic condition has been addressed with the 10° roll and 10° pitch deformation required by CS 27.562 (b)(3) to ensure that the seat and the floor attachments will be designed to accommodate deformation. This objective should be maintained when the seat adapter plate is installed between the seat and the floor.

Introducing an adapter plate can move the problems created by floor deformation from the seat-to-track interface to the adapter-to-floor interface. The same level of safety is appropriate for the occupant of the seat whether it is installed in the rotorcraft with or without an adapter plate. The floor structure itself is not subject to the dynamic requirements of CS 27.562, therefore when additional structure such as an adapter plate is introduced to fix the seat to the floor, it is very important to determine whether that structure should be considered to be part of the seat or part of the floor. The installation of any interface between the existing floor and the seat should not create a weak element between the seat and the existing airframe. This has successfully been assured by testing the adapter with the seat according to the requirements of CS 27.562.

This AMC provides further guidance and acceptable means of compliance for classification of seat adapters as plinths or pallets and supplements FAA AC 25.562.

Plinths are subject to CS 27.562 compliance whereas pallets (traditionally defined as large adapters) are not, except for the attachment of the seat to the pallet.

FAA Policy Memo PS-ANM100-2000-00123 (applicable to CS-25 and that can be extended to CS-27) suggests that it may also be possible to classify some smaller adapters as an integral part of the floor as follows:

'Generally speaking, adapters of the size that contain a single row of seats (whether they are individual seat places or a common assembly), and mount into seat tracks, should be treated as part of the seat for purposes of certification in accordance with § 27/29.562. Larger, or more

integrally mounted adapters, should be assessed to determine whether they should be treated as part of the floor for purposes of certification in accordance with § 27/29.561.¹

To treat an adapter or other new interface structure as part of the floor when it does not appear to be similar to conventional floor structure, the applicant must substantiate that the adapter plate or any other structure installed between the existing floor and the seat attachment will not constitute a weak element under minor crash conditions. The issue is whether the critical interface is between the seat and the adapter or between the adapter and the rotorcraft. No further detailed guidance is available to assist with the assessment required to make the classification of an adapter as part of the floor.

Where the proposed floor design utilises a plate above the existing floor or otherwise significantly differs in concept from the type design's existing methods of floor construction, geometries and utilisation of load paths, it is not adequate to rely on compliance with CS 27.561 alone, to determine whether the adapter plate may be considered to be part of the floor. This guidance does not intend to request a complete crash scenario evaluation, but asks for evidence that the adapter plate and associated new under floor structure will not degrade the level of protection compared to that offered by the seat if it were installed directly on the helicopter existing floor seat track and floor construction. For the adapter plate to be considered sufficiently integrated to be part of the floor, the adapter plate should be capable of accommodating floor deformation and be able to safely react and distribute the seat loads into the rotorcraft.

(d) Seat adapter plate definition and classification

(1) Definitions

The definitions of plinth and pallet that are available in AC 25.562(b) are valid.

In general, swivelling seat adapter plate systems are by definition considered to be plinth.

(2) Classification

There are three possible options for the seat-to-floor interface with corresponding means of compliance. In each case, the applicant is requested to show that any interface between the existing floor and the seat will not create a weaker element between the seat and the existing airframe than that that would exist for a CS 27.562-compliant seat attached directly to the standard floor, e.g. seat track.

Acceptable means of assessing seat installations using adapter plates:

Option 1

- The adapter is classified as a plinth following AC 25.562-1B.
- Compliance with CS 27.561 and CS 27.562 must be shown.
- The plinth must be tested as part of the seat according to CS 27.562 (b)(1) and (b)(2) unless alternative compliance is agreed as per CS 27.562 (d).
- The guidance of AC 25.562-1B and AMC 27.307 may be used to reduce the number of tests based on design similarity.

Option 2

- The adapter is classified as a pallet due to its size following AC 25.562-1B.
- The seat and its attachments to the pallet only are tested according to CS 27.562 and CS 27.561.
- The pallet is justified against CS 27.561 only.

Option 3

- If Option 1 or 2 does not clearly apply, seat-to-floor interface structure may be proposed to be classified as an integral part of the floor based on one of the methods described below.
- If classification as part of the floor is agreed with the Agency, the seat and its attachments to the structure are tested according to CS 27.562 and compliance with CS 27.561 is shown for the whole installation.

Acceptable methods to be used in support of Option 3, allowing classification of new seat-to-floor interface structure as an integral part of the floor structure:

Method 1

A design review showing the floor design for seat installation uses the same or equivalent design principle as the current floor provided in the type design. If the pre-existing floor design used seats directly attached to seat track independently of the floor panel, then the introduction of a structural floor panel to which a seat is attached would represent a change in design philosophy, and a different method (e.g. Method 2) would need to be used to support Option 3.

Method 2

A detailed design review showing the level of integration of the plate to the floor, including the redundancy and strength of the attachments, that is acceptable to the Agency based on the experience of the applicant and the Agency with similar designs.

Any other alternative methods have to be agreed with the Agency.

Note:

When assessing the design, the following points should be considered by the applicant and the Agency, in particular for design change certification:

- The modified structure may be evaluated using AMC1 27.307 to categorise the structural elements as new, similar-new or similar. Comparison can be made with the existing type floor design (Method 1) or with designs that the applicant has previously substantiated according to Method 2.
- An adequate number of appropriately distributed attachments between the adapter plate and the rotorcraft floor structure should be provided to assure that the additional structure behaves as an integral part of the rotorcraft floor. The appropriate number, strength and degree of redundancy of the attachments will depend on the design of the adapter plate and positioning of the seats on the plate.
- A considerable degree of engineering judgement is required when making the classification of the structure; when there is any doubt about the capability of the

proposed adapter design to act as an integral part of the floor, it will be classified as a plinth under Option1.

AMC3 29.307 Proof of structure

SEAT ADAPTER PLATES

(a) Purpose

This AMC provides an acceptable means of compliance for seat adapter plates. The seat adapter plate includes any other forms of new interface structure installed between the seat and the rotorcraft floor.

(b) Related Certification Specifications

- CS 29.307 'Proof of structure'
- CS 29.561 'General'
- CS 29.785 'Seats, berths, safety belts, and harnesses'

(c) Explanation

The requirements for seats under emergency landing dynamic conditions have been developed to prevent detachment of the seat under floor deformation and for the seats to help absorb the energy developed in crash conditions. This dynamic condition has been addressed with the 10° roll and 10° pitch deformation required by CS 29.562 (b)(3) to ensure that the seat and the floor attachments will be designed to accommodate deformation. This objective should be maintained when the seat adapter plate is installed between the seat and the floor.

Introducing an adapter plate can move the problems created by floor deformation from the seat-to-track interface to the adapter-to-floor interface. The same level of safety is appropriate for the occupant of the seat whether it is installed in the rotorcraft with or without an adapter plate. The floor structure itself is not subject to the dynamic requirements of CS 29.562, therefore when additional structure such as an adapter plate is introduced to fix the seat to the floor, it is very important to determine whether that structure should be considered to be part of the seat or part of the floor. The installation of any interface between the existing floor and the seat should not create a weak element between the seat and the existing airframe. This has successfully been assured by testing the adapter with the seat according to the requirements of CS 29.562.

This AMC provides further guidance and acceptable means of compliance for classification of seat adapters as plinths or pallets and supplements FAA § AC 25.562.

Plinths are subject to CS 29.562 compliance whereas pallets (traditionally defined as large adapters) are not, except for the attachment of the seat to the pallet.

FAA Policy Memo PS-ANM100-2000-00123 (applicable to CS-25 and that can be extended to CS-29) suggests that it may also be possible to classify some smaller adapters as an integral part of the floor as follows:

'Generally speaking, adapters of the size that contain a single row of seats (whether they are individual seat places or a common assembly), and mount into seat tracks, should be treated as

part of the seat for purposes of certification in accordance with § 27/29.562. Larger, or more integrally mounted adapters, should be assessed to determine whether they should be treated as part of the floor for purposes of certification in accordance with § 27/29.561.'

To treat an adapter or other new interface structure as part of the floor when it does not appear to be similar to conventional floor structure, the applicant must substantiate that the adapter plate or any other structure installed between the existing floor and the seat attachment will not constitute a weak element under minor crash conditions. The issue is whether the critical interface is between the seat and the adapter or between the adapter and the rotorcraft. No further detailed guidance is available to assist with the assessment required to make the classification of an adapter as part of the floor.

Where the proposed floor design utilises a plate above the existing floor or otherwise significantly differs in concept from the type design's existing methods of floor construction, geometries and utilisation of load paths, it is not adequate to rely on compliance with CS 29.561 alone, to determine whether the adapter plate may be considered to be part of the floor. This guidance does not intend to request a complete crash scenario evaluation, but asks for evidence that the adapter plate and associated new under floor structure will not degrade the level of protection compared to that offered by the seat if it were installed directly on the helicopter existing floor seat track and floor construction. For the adapter plate to be considered sufficiently integrated to be part of the floor, the adapter plate should be capable of accommodating floor deformation and be able to safely react and distribute the seat loads into the rotorcraft.

(d) Seat adapter plate definition and classification

(1) Definition

The definition of plinth and pallet available in AC25.562(b) is valid.

In general, swivelling seat adapter plate systems are by definition considered to be plinth.

(2) Classification

There are three possible options for the seat-to-floor interface with corresponding means of compliance. In each case, the applicant is requested to show that any interface between the existing floor and the seat will not create a weaker element between the seat and the existing airframe than that that would exist for a CS 29.562-compliant seat attached directly to the standard floor e.g. seat track.

Acceptable means of assessing seat installations using adapter plates:

Option 1

- The adapter is classified as a plinth following AC 25.562-1B.
- Compliance with CS 29.561 and CS 29.562 must be shown.
- The plinth must be tested as part of the seat according to CS 29.562 (b)(1) and (b)(2) unless alternative compliance is agreed as per CS 29.562 (d).
- The guidance of AC 25.562-1B and AMC 29.307 may be used to reduce the number of tests based on design similarity.

Option 2

- The adapter is classified as a pallet due to its size following AC 25.562-1B.
- The seat and its attachments to the pallet only are tested according to CS 29.562 and CS 29.561.
- The pallet is justified against CS 29.561 only.

Option 3

- If Option 1 or 2 does not clearly apply, seat-to-floor interface structure is proposed to be classified as an integral part of the floor based on one of the methods described below.
- If classification as part of the floor is agreed with the Agency, the seat and its attachments to the structure are tested according to CS 29.562 and compliance with CS 29.561 is shown for the whole installation.

Acceptable methods to be used in support of Option 3, allowing classification of new seat-to-floor interface structure as an integral part of the floor structure:

Method 1

A design review showing the floor design for seat installation uses the same or equivalent design principle as the current floor provided in the type design. If the pre-existing floor design used seats directly attached to seat track independently of the floor panel, then the introduction of a structural floor panel to which a seat is attached would represent a change in design philosophy, and a different method (e.g. Method 2) would need to be used to support Option 3.

Method 2

A detailed design review showing the level of integration of the plate to the floor, including the redundancy and strength of the attachments, that is acceptable to the Agency based on the experience of the applicant and the Agency with similar designs.

Any other alternative methods have to be agreed with the Agency.

Note:

When assessing the design, the following points should be considered by the applicant and the Agency, in particular for design change certification:

- The modified structure may be evaluated using AMC1 29.307 to categorise the structural elements as new, similar-new or similar. Comparison can be made with the existing type floor design (Method 1) or to designs that the applicant has previously substantiated according to Method 2.
- An adequate number of appropriately distributed attachments between the adapter plate and the rotorcraft floor structure must be provided to assure that the additional structure behaves as an integral part of the rotorcraft floor. The appropriate number, strength and degree of redundancy of the attachments will depend on the design of the adapter plate and positioning of the seats on the plate.

- A considerable degree of engineering judgement is required when making the classification of the structure; when there is any doubt about the capability of the proposed adapter design to act as an integral part of the floor, it will be classified as a plinth under Option 1.

Item 35: Protection of occupants

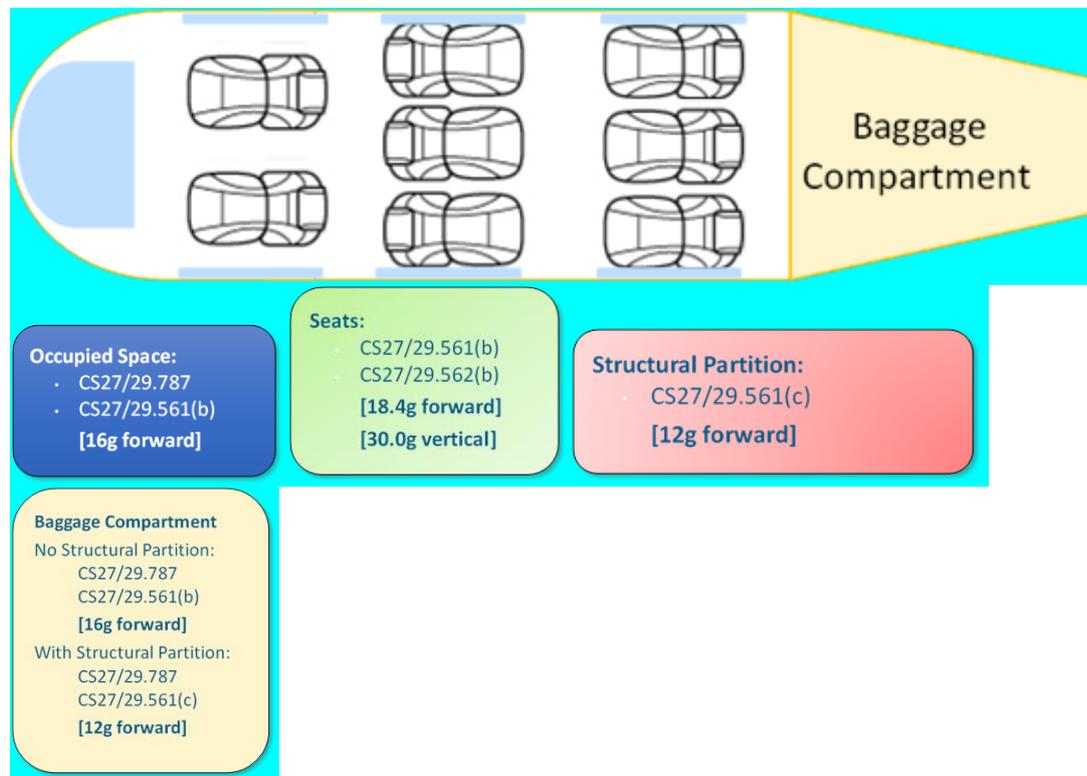
AMC1 27.561 General

EMERGENCY LANDING CONDITIONS

The CS-27 objective is to protect the occupant within the cabin from forces up to 16g. The seats are treated in CS 27.561 (b)(3), CS 27.562 and CS 27.785.

In the stowage compartment, if separated with a partition, it is anticipated as per the CS 27.787 requirement that items (luggage, cargo, etc.) will be restrained up to 12g. If the cabin is adjacent to the baggage compartment, the protection of the occupants within the cabin is ensured by the installation of a structural partition (bulkhead) sized to 12g for the maximum allowed baggage or cargo weight, regardless of the instructions to restrain the baggage.

Conditions to be considered:

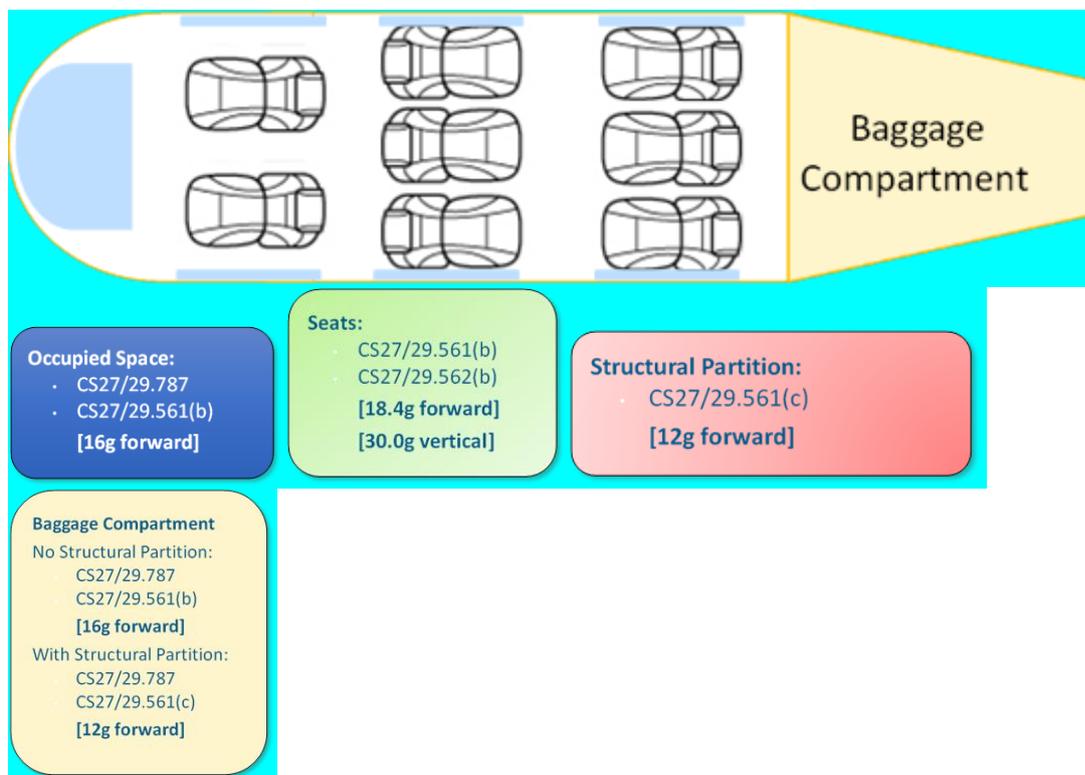


AMC1 27.787 Cargo and baggage compartments

PROTECTION OF OCCUPANTS IN THE CABIN

In the stowage compartment, if separated with a partition, it is anticipated as per the CS 27.787 requirement that items (luggage, cargo, etc.) will be restrained up to 12g. If the cabin is adjacent to the baggage compartment, the protection of the occupants within the cabin is ensured by the installation of a structural partition (bulkhead) sized to 12g for the maximum allowed baggage or cargo weight, regardless of the instructions to restrain the baggage.

Conditions to be considered:



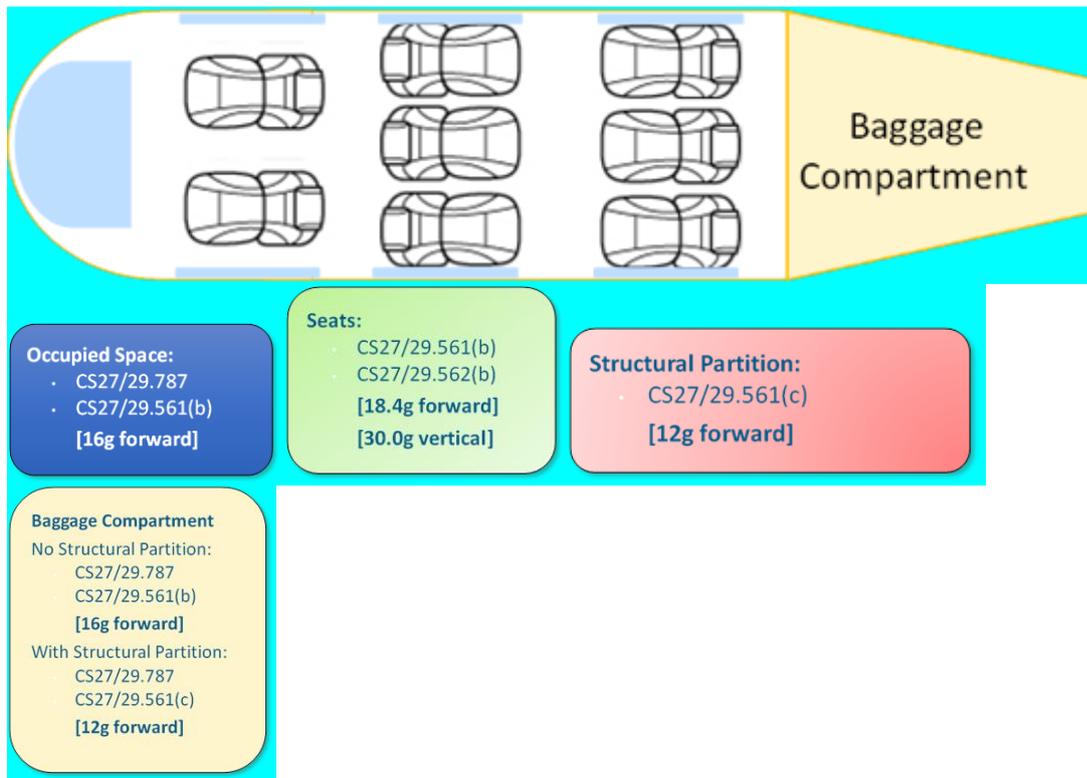
AMC1 29.561 General

EMERGENCY LANDING CONDITIONS

The CS-29 objective is to protect the occupant within the cabin from forces up to 16g. The seats are treated in CS 29.561 (b)(3), CS 29.562 and CS 29.785.

In the stowage compartment, if separated with a partition, it is anticipated as per the CS 29.787 requirement that items (luggage, cargo, etc.) will be restrained up to 12g. If the cabin is adjacent to the baggage compartment, the protection of the occupants within the cabin is ensured by the installation of a structural partition (bulkhead) sized to 12g for the maximum allowed baggage or cargo weight, regardless of the instructions to restrain the baggage.

Conditions to be considered:

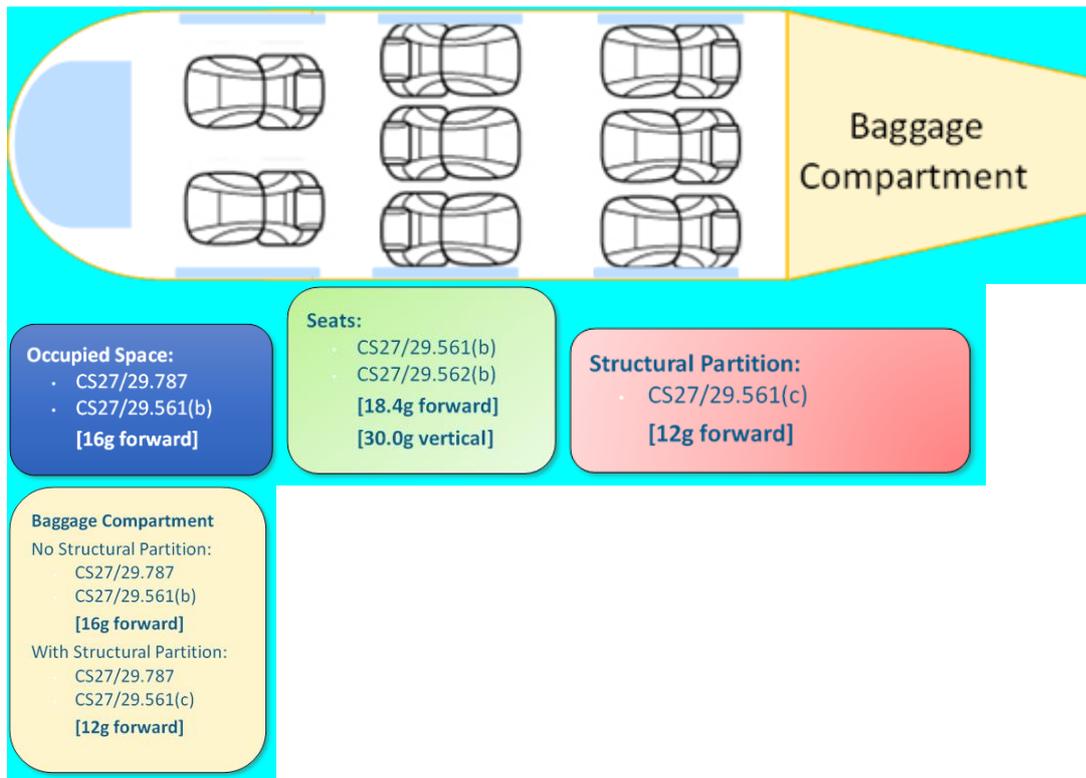


AMC1 29.787 Cargo and baggage compartments

PROTECTION OF OCCUPANTS IN THE CABIN

In the stowage compartment, if separated with a partition, it is anticipated as per the CS 29.787 requirement that items (luggage, cargo, etc.) will be restrained up to 12g. If the cabin is adjacent to the baggage compartment, the protection of the occupants within the cabin is ensured by the installation of a structural partition (bulkhead) sized to 12g for the maximum allowed baggage or cargo weight, regardless of the instructions to restrain the baggage.

Conditions to be considered:



Item 36: Development of assurance process

AMC1 27.1309 Equipment, systems, and installations

As stated in AMC 27, the AMC to CS-27 consists generally of FAA AC 27-1B Change 7, dated 4 February 2016. This AMC supplements AC 27-1B, § AC 27.1309 and should be used in conjunction with that AC when demonstrating compliance with CS 27.1309.

Development assurance process

Any analysis necessary to show compliance with CS 27.1309(b) should consider the possibility of development errors and should focus on minimising the likelihood of those errors.

Errors made during the development of systems have traditionally been detected and corrected by exhaustive tests conducted on the system and its components, by direct inspection, and by other direct verification methods capable of completely characterising the performance of the system.

These tests and direct verification methods may be appropriate for systems containing non-complex items (i.e. items that are fully assured by a combination of testing and analysis) that perform a limited number of functions and that are not highly integrated with other rotorcraft systems. For more complex or integrated systems, exhaustive testing may either be impossible because not all system states can be determined or be impractical because of the number of tests that must be accomplished. For these types of systems, compliance may be demonstrated using development assurance.

The system development assurance may also be used for modifications to previously certificated aircraft.

The extent of application of development assurance standards to substantiate development assurance activities depends on the complexity of the systems and on their level of interaction with other systems.

(a) Software development assurance

This AMC recognises AMC 20-115 as an acceptable means of compliance with the requirements in CS 27.1309 (a) and (b).

(b) Airborne electronic hardware (AEH) development assurance

This AMC recognises AMC 20-152 as an acceptable means of compliance with the requirement in CS 27.1309 (a) and (b).

(c) Open problem report management

This AMC recognises AMC 20-189 as an acceptable means of compliance for establishing an open problem report management process for the system, software and AEH domains.

AMC1 29.1309 Equipment, systems, and installations

As stated in AMC 29, the AMC to CS-29 consists generally of FAA AC 29-2C Change 7, dated 4 February 2016. This AMC supplements AC 29-2C, § AC 29.1309 and should be used in conjunction with that AC when demonstrating compliance with CS 29.1309.

Development assurance process

Any analysis necessary to show compliance with CS 29.1309(b) should consider the possibility of development errors and should focus on minimising the likelihood of those errors.

Errors made during the development of systems have traditionally been detected and corrected by exhaustive tests conducted on the system and its components, by direct inspection, and by other direct verification methods capable of completely characterising the performance of the system.

These tests and direct verification methods may be appropriate for systems containing non-complex items (i.e. items that are fully assured by a combination of testing and analysis) that perform a limited number of functions and that are not highly integrated with other rotorcraft systems. For more complex or integrated systems, exhaustive testing may either be impossible because not all system states can be determined or impractical because of the number of tests that must be accomplished. For these types of systems, compliance may be demonstrated using development assurance.

The applicability of system development assurance should also be considered for modifications to previously certificated aircraft.

ED-79A/ARP4754A is recognised as providing acceptable guidelines for establishing a development assurance process from aircraft and systems levels down to the level where software/airborne electronic hardware (AEH) development assurance is applied.

The extent of application of ED-79A/ARP4754A to substantiate development assurance activities depends on the complexity of the systems and on their level of interaction with other systems.

(a) Software development assurance

This AMC recognises AMC 20-115 as an accepted means of compliance with CS 29.1309 (a) and (b).

(b) AEH development assurance

This AMC recognises AMC 20-152 as an acceptable means of compliance with the requirements in CS 29.1309 (a) and (b).

(c) Open problem report management

This AMC recognises AMC 20-189 as an acceptable means of compliance for establishing an open problem report management process for the system, software and AEH domains.

Item 37: Fuselage, landing gear, and rotor pylon structures

CS 27.547 Main rotor structure

[...]

(b) The main rotor structure must be designed to withstand the following loads prescribed in CS 27.337 to 27.341 and CS 27.351:

- (1) Critical flight loads.
- (2) Limit loads occurring under normal conditions of autorotation. For this condition, the rotor rpm must be selected to include the effects of altitude.

[...]

CS 27.549 Fuselage, landing gear, and rotor pylon structures

[...]

(b) Each structure must be designed to withstand:

- (1) The critical loads prescribed in CS 27.337 to 27.341 and CS 27.351;
- (2) The applicable ground loads prescribed in CS 27.235, 27.471 to 27.485, CS 27.493, 27.497, 27.501, 27.505, and 27.521; and
- (3) The loads prescribed in CS 27.547 (c)(2) and (d).

[...]

Item 38: Equipment, systems and network information security protection**AMC1 29.1319 Equipment, systems and network information security protection**

In showing compliance with CS 29.1319, the applicant may consider AMC 20-42, which provides acceptable means, guidance and methods to perform security risk assessments and mitigation for aircraft information systems.

The term 'adverse effects on the safety of the rotorcraft' should be understood in the context of information security as catastrophic or hazardous.

The term 'mitigated as necessary' clarifies that the applicant has the discretion to establish appropriate means of mitigation against security risks.

Item 39: Fuel quantity indicator and fuel low-level sensors independence (CS-27 and CS-29)**CS 27.1305 Powerplant instruments**

The following are the required powerplant instruments:

[...]

- (i) An oil quantity indicator for each oil tank.
- (j) An oil temperature indicator for each engine.
- (k) At least one tachometer to indicate the rpm of each engine and, as applicable:
 - (1) The rpm of the single main rotor;
 - (2) The common rpm of any main rotors whose speeds cannot vary appreciably with respect to each other; or
 - (3) The rpm of each main rotor whose speed can vary appreciably with respect to that of another main rotor.
- (l) A low-fuel warning device for each fuel tank which feeds an engine. This device must:
 - (1) Provide a warning to the flight crew when approximately 10 minutes of usable fuel remains in the tank; and
 - (2) Be independent of the normal fuel quantity indicating system or be designed and constructed to meet the minimum safety objectives compatible with the most severe hazard induced by the combination of any failures of the fuel quantity indicating system and the low-fuel level warning device.
- (m) Means to indicate to the flight crew the failure of any fuel pump installed to show compliance with CS 27.955.

[...]

CS 29.1305 Powerplant instruments

The following are the required powerplant instruments:

- (a) For each rotorcraft:
- (1) A carburettor air temperature indicator for each reciprocating engine;
 - (2) A cylinder head temperature indicator for each air-cooled reciprocating engine, and a coolant temperature indicator for each liquid-cooled reciprocating engine;
 - (3) A fuel quantity indicator for each fuel tank;
 - (4) A low-fuel warning device for each fuel tank which feeds an engine. This device must:
 - (i) Provide a warning to the crew when approximately 10 minutes of usable fuel remains in the tank; and
 - (ii) Be independent of the normal fuel quantity indicating system or be designed and constructed so as to meet the minimum safety objectives compatible with the most severe hazard induced by the combination of any failures of the fuel quantity indicator device and the low-fuel level warning device.

[...]

AMC1 27.1305(I)(2) Powerplant instruments

FUEL QUANTITY INDICATOR AND LOW-FUEL LEVEL WARNING

This AMC provides guidance in the case where the fuel quantity indicator and the low-fuel warning device are not fully independent.

AC 27.1305 provides guidance that supports the use of specific instruments that do not meet the principle of independence (integrated avionics, ECAS, etc.). However, it does not provide guidance regarding the independence between the fuel quantity sensor and the fuel low-level sensor.

The fuel quantity sensor and the fuel low-level sensor should be independent. However, it is considered to be acceptable to place them on the same supporting structure providing that the following design precautions are ensured:

- (a) They are electrically independent. Each sensor should be connected to the aircraft systems via a dedicated connector and a dedicated harness;
- (b) A pre-flight test capability is provided for each sensor to preclude an associated latent failure; and
- (c) It is demonstrated by tests such as equipment qualification tests, slosh and vibration tests as requested in CS 27.965, analysis (such as safety analysis, particular risk analysis, zonal safety

analysis, comparison with a fully independent design), or a combination thereof that no common modes can lead to the most severe hazard determined in CS 27.1305(l)(2).

AMC1 29.1305(a)(4) Powerplant instruments

FUEL QUANTITY INDICATOR AND LOW FUEL LEVEL WARNING

This AMC provides guidance in the case where the fuel quantity indicator and the low-fuel warning device are not fully independent.

AC 29.1305 provides guidance that supports the use of specific instruments that do not meet the principle of independence (integrated avionics, ECAS, etc.). However, it does not provide guidance regarding the independence between the fuel quantity sensor and the fuel low-level sensor.

The fuel quantity sensor and fuel the low-level sensor should be independent. However, it is considered to be acceptable to place them on the same supporting structure providing that the following design precautions are ensured:

- (a) They are electrically independent. Each sensor should be connected to the aircraft systems via a dedicated connector and a dedicated harness;
- (b) A pre-flight test capability is provided for each sensor to preclude an associated latent failure; and
- (c) It is demonstrated by tests such as equipment qualification tests, slosh and vibration tests as requested in CS 29.965, analysis (such as safety analysis, particular risk analysis, zonal safety analysis, comparison with a fully independent design), or a combination thereof that no common modes can lead to the most severe hazard determined in CS 29.1305(a)(4)(ii).

Item 40: Ditching (CS-29)

CS 29.801 Ditching

- (a) If certification with ditching provisions is requested by the applicant, the rotorcraft must meet the requirements of this CS and CS 29.563, CS 29.783(h), CS 29.803(c), CS 29.805(c), CS 29.807(d), CS 29.809(j), CS 29.811(h), CS 29.813(d), CS 29.1411, CS 29.1415, CS 29.1470, CS 29.1555(d)~~(3)~~ and CS 29.1561.

[...]

Item 41: Model test method for flotation stability (CS-27 and CS-29)**AMC1 to CS 27.801(e) and 27.802(c) Model test method for flotation stability**

This AMC should be used when showing compliance with CS 27.801(e) or CS 27.802(c) as introduced at Amendment 5.

(a) Explanation

[...]

(3) Target probability of capsizing

Target probabilities of capsizing have been derived from a risk assessment. The target probabilities to be applied are stated in CS 27.801(e) and 27.802(c), as applicable.

For ditching, the intact flotation system probability of capsizing of 3 % is derived from a historic ditching rate of 3.32×10^{-6} per flight hour and an ~~AMC~~ 27.1309 consequence of hazardous, which implies a frequency of capsizing of less than 10^{-7} per flight hour.

[...]

AMC1 to CS 29.801(e) and 29.802(c) Model test method for flotation stability

This AMC should be used when showing compliance with CS 29.801(e) or CS 29.802(c) as introduced at Amendment 5.

(a) Explanation

[...]

(3) Target probability of capsizing

Target probabilities of capsizing have been derived from a risk assessment. The target probabilities to be applied are stated in CS 29.801(e) and 29.802(c), as applicable.

For ditching, the intact flotation system probability of capsizing of 3 % is derived from a historic ditching rate of 3.32×10^{-6} per flight hour and an ~~AMC~~ 29.1309 consequence of hazardous, which implies a frequency of capsizing of less than 10^{-7} per flight hour.

[...]

4. Impact assessment (IA)

The proposed amendments to CS-27 and CS-29 address safety recommendations and reflect the state of the art of small and large rotorcraft certification. Overall, they will improve safety as well as harmonisation with the FAA, will have no social or environmental impacts, and will provide economic benefits by streamlining the certification process. No need to develop a detailed regulatory impact assessment (RIA) was identified.



5. Proposed actions to support implementation

N/A



6. References

6.1. Related regulations

N/A

6.2. Related decisions

- Decision No. 2003/15/RM of the Executive Director of the Agency of 14 November 2003 on certification specifications for small rotorcraft (« CS-27 »)
- Decision No. 2003/16/RM of the Executive Director of the Agency of 14 November 2003 on certification specifications for large rotorcraft (« CS-29 »)

6.3. Other reference documents

- FAA Advisory Circular – Certification of Transport Category Rotorcraft (FAA AC 29-2C)
- FAA Advisory Circular – Certification of Transport Category Rotorcraft (FAA AC 27-1B)
- Report SL 2018/04 — REPORT ON THE AIR ACCIDENT NEAR TURØY, ØYGARDEN MUNICIPALITY, HORDALAND COUNTY, NORWAY 29 APRIL 2016 WITH AIRBUS HELICOPTERS EC 225 LP, LN-OJF, OPERATED BY CHC HELIKOPTER SERVICE AS
 - Safety Recommendation NORW-2018-002
 - Safety Recommendation NORW-2018-003
 - Safety Recommendation NORW-2018-008

7. Appendix

N/A



8. Quality of the NPA

To continuously improve the quality of its documents, EASA welcomes your feedback on the quality of this NPA with regard to the following aspects:

8.1. The regulatory proposal is of technically good/high quality

Please choose one of the options below and place it as a comment in CRT; if you disagree or strongly disagree, please provide a brief justification.

Fully agree / Agree / Neutral / Disagree / Strongly disagree

8.2. The text is clear, readable and understandable

Please choose one of the options below and place it as a comment in CRT; if you disagree or strongly disagree, please provide a brief justification.

Fully agree / Agree / Neutral / Disagree / Strongly disagree

8.3. The regulatory proposal is well substantiated

Please choose one of the options below and place it as a comment in CRT; if you disagree or strongly disagree, please provide a brief justification.

Fully agree / Agree / Neutral / Disagree / Strongly disagree

8.4. The regulatory proposal is fit for purpose (capable of achieving the objectives set)

Please choose one of the options below and place it as a comment in CRT; if you disagree or strongly disagree, please provide a brief justification.

Fully agree / Agree / Neutral / Disagree / Strongly disagree

8.5. The impact assessment (IA), as well as its qualitative and quantitative data, is of high quality

Please choose one of the options below and place it as a comment in CRT; if you disagree or strongly disagree, please provide a brief justification.

Fully agree / Agree / Neutral / Disagree / Strongly disagree

8.6. The regulatory proposal applies the 'better regulation' principles^[1]

Please choose one of the options below and place it as a comment in CRT; if you disagree or strongly disagree, please provide a brief justification.

Fully agree / Agree / Neutral / Disagree / Strongly disagree

8.7. Any other comments on the quality of this NPA (please specify)

Note: Your comments on Chapter 8 will be considered for internal quality assurance and management purposes only and will not be published in the related CRD.

^[1] For information and guidance, see:

- https://ec.europa.eu/info/law/law-making-process/planning-and-proposing-law/better-regulation-why-and-how_en
- https://ec.europa.eu/info/law/law-making-process/planning-and-proposing-law/better-regulation-why-and-how/better-regulation-guidelines-and-toolbox_en
- https://ec.europa.eu/info/law/law-making-process/planning-and-proposing-law/better-regulation-why-and-how/better-regulation-guidelines-and-toolbox/better-regulation-toolbox_en