APPENDIX E: CERTIFICATION SPECIFICATIONS FOR LARGE ROTORCRAFT CS-29 (SELECTED EXTRACT)

SUBPART C – STRENGTH REQUIREMENTS

FATIGUE EVALUATION

CS 29.571 Fatigue tolerance evaluation of metallic structure

(a) A fatigue tolerance evaluation of each Principal Structural Element (PSE) must be performed, and appropriate inspections and retirement time or approved equivalent means must be established to avoid Catastrophic Failure during the operational life of the rotorcraft.

(b) Reserved

(c) Reserved

(d) Each PSE must be identified. Structure to be considered must include the rotors, rotor drive systems between the engines and rotor hubs, controls, fuselage, fixed and movable control surfaces, engine and transmission mountings, landing gear, and their related primary attachments.

(e) Each fatigue tolerance evaluation must include:

(1) In-flight measurements to determine the fatigue loads or stresses for the PSEs identified in sub-paragraph (d) in all critical conditions throughout the range of design limitations required in CS 29.309 (including altitude effects), except that manoeuvring load factors need not exceed the maximum values expected in operations.

(2) The loading spectra as severe as those expected in operations based on loads or stresses determined under sub-paragraph (e)(1), including external load operations, if applicable, and other high frequency powercycle operations.

(3) Take-off, landing, and taxi loads when evaluating the landing gear (including skis and floats) and other affected PSEs.

(4) For each PSE identified in subparagraph (d), a threat assessment, which includes a determination of the probable locations, types, and sizes of damage taking into account fatigue, environmental effects, intrinsic and discrete flaws, or accidental damage that may occur during manufacture or operation.

(5) A determination of the fatigue tolerance characteristics for the PSE with the damage identified in sub-paragraph (e)(4) that supports the inspection and retirement times, or other approved equivalent means.

(6) Analyses supported by test evidence and, if available, service experience.

(f) A residual strength determination is required that substantiates the maximum damage size assumed in the fatigue tolerance evaluation. In determining inspection intervals based on damage growth, the residual strength evaluation must show that the remaining structure, after damage growth, is able to withstand design limit loads without failure.

(g) The effect of damage on stiffness, dynamic behaviour, loads and functional performance must be considered.

(h) The inspection and retirement times or approved equivalent means established under this paragraph must be included in the Airworthiness Limitation Section of the Instructions for Continued Airworthiness required by CS 29.1529 and paragraph A29.4 of Appendix A.

(i) If inspections for any of the damage types identified in sub-paragraph (e)(4) cannot be established within the limitations of geometry, inspectability, or good design practice, then supplemental procedures, in conjunction with the PSE retirement time, must be established to minimize the risk of occurrence of these types of damage that could result in a catastrophic failure during the operational life of the rotorcraft.

[Amdt 29/3]

The following is cited from Advisory Circular (AC) 29-2C Change 4 dated 1 May 2014:

> *The unique performance capabilities of rotorcraft and their typical operational environment make fatigue tolerance evaluations both complex and critically important. Due to the many rotating elements inherent in their design, rotorcraft structures are potentially subject to damaging cyclic stresses in practically every regime of flight. The complexity of the fatigue loading is compounded by the fact that rotorcraft are highly maneuverable and are utilized for many widely varying roles. Corrosion and other environmental damages are not uncommon in rotorcraft operations; neither are inadvertent damages from maintenance that is typically frequent and intensive. For these reasons, special attention should be focused on the fatigue tolerance evaluation of rotorcraft structure.*

The initial 2003 issue[1] of CS 29.571 *Fatigue evaluation of structure* stated in section (a) *General* that the catastrophic failure of principal structural elements (PSE) within the rotor drive train due to the presence of fatigue must be avoided. Section (b) stated that inspection methods must be sufficiently robust to detect the deterioration of a critical component before the ability of the component to carry its design load is compromised. However, if under specific circumstance linked to inspectability (i.e. case of element located inside the gearbox) the sub-paragraph (b) (1) or (2) could not be applied, and the safe-life evaluation of sub-paragraph (b) (3) *Safe-life evaluation* is required. Safe-life is the number of events, such as flight hours or landings, for a structural component during which there is low probability that the strength will degrade below its design ultimate value due to fatigue damage initiating cracks.

Advances in the understanding of fatigue tolerance[2] evaluation led to the formation of a joint working group between the Joint Aviation Authority (JAA, predecessor to EASA), the Federal Aviation Administration (FAA), the rotorcraft industry and the Technical Oversight Group for Ageing Aircraft (TOGAA) in 2000. The working group evaluated proposals from the industry, TOGAA recommendations, and the continuing activities and results of rotorcraft damage tolerance[3] research and development. As a result of this review, the working group recommended changes to the fatigue evaluation requirements for CS 29.571. This resulted in the publication of EASA Notice of Proposed Amendment (NPA) 2010-06, published on 27 May 2010, which proposes to introduce

[1] ED Decision no. 2003/16/RM of 14 November 2003 on Certification Specifications for Large Rotorcraft (CS-29).
[2] Fatigue tolerance is the ability of a structure, either in an as-manufactured or damaged condition, to tolerate specified operational loading for a given period of use without initiating cracks, and assuming they initiate, tolerate their growth, without failure, under specified residual strength loads. Ref. FAA AC 29-2C.
[3] Damage tolerance is the attribute to the condition of the structure or assembly. In the AC 29-2C it is used as a generic term to describe all types of flaws including those caused by environmental effects and accidental damage arising in manufacture, maintenance or operation. Ref. FAA AC 29-2C.

improvements in the ability to avoid catastrophic failures of primary structure, including rotor transmission components.

On 11 December 2012 EASA published[4] CS-29 / Amendment 3 with the current CS 29.571 *Fatigue tolerance evaluation of metallic structure*. The objective of fatigue tolerance evaluation is to prevent catastrophic failure of the structure by mitigation of the effects of damage in combination with fatigue throughout the life of the rotorcraft. The fatigue evaluation should establish both retirement times and inspection intervals, or approved equivalent means, to prevent any catastrophic failures.

For all PSE's a fatigue tolerance evaluation is required, and a threat assessment needs to be performed to identify potential threats to component fatigue strength. If EASA is in agreement with this assessment, then the fatigue strength evaluation will be performed assuming damage consistent with the identified threats.

According to AC 29-2C Change 4 the following considerations will assist the successful design of a fatigue tolerant structure:

(A) Use multiple-element and multiple load path construction with provisions for crack stoppers that can limit (arrest) the growth of cracks while maintaining adequate residual strength.

(B) Select materials and stress levels that preclude crack growth or crack initiation from flaws or that provide a controlled slow rate of crack propagation combined with residual strength after initiation of cracks.

(C) Design for detection of damage (i.e. cracks and flaws) and retirement or repair.

(D) Provide provisions that limit the occurrence of damage and the probability of concurrent damage, particularly after long service.

SUBPART D – DESIGN AND CONSTRUCTION

GENERAL

CS 29.601 Design

(a) The rotorcraft may have no design features or details that experience has shown to be hazardous or *unreliable*.

b) The *suitability* of each questionable design detail and part must be established by tests.

CS 29.602 Critical parts

CS 29.602 requires the Part 21 organisation to define the design and the manufacturing process of a Critical part (the second stage planet gear):

(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 be established. Procedures shall be established to define the critical design characteristics, identify processes that affect

[4] ED Decision 2012/022/R amending ED Decision 2003/16/RM on Certification Specifications for Large Rotorcraft (CS-29).

those characteristics, and identify the design change and process change controls necessary for showing compliance with the quality assurance requirements of Part-21.

In other words, paragraph b) requires the manufacturer to establish a Critical Parts Plan that identifies and controls the critical characteristics and help to ensure that the condition of the part remains as envisaged by the designer throughout its life cycle.

AC 29-2C, Chg 2, para b. (2) states:

> *Documentation draws the attention of the personnel involved in the design, manufacture, maintenance, inspection, and overhaul of a critical part to the special nature of the part and details the relevant special instructions. For example all drawings, work sheets, inspection documents, etc., could be prominently annotated with the words "Critical Part" or equivalent and the Instructions for Continued Airworthiness and Overhaul Manuals (if applicable) should clearly identify critical parts and include the needed maintenance and overhaul instructions. The documentation should:*
>
> *(i) Contain comprehensive instructions for the maintenance, inspection and overhaul of critical parts and emphasize the importance of these special procedures;*
>
> *(ii) Indicate to operators and overhaulers that unauthorized repairs or modifications to critical parts may have hazardous consequences;*
>
> *(iii) Emphasize the need for careful handling and protection against damage or corrosion during maintenance, overhaul, storage, and transportation and accurate recording and control of service life (if applicable);*
>
> *(iv) Require notification of the manufacturer of any unusual wear or deterioration of critical parts and the return of affected parts for investigation when appropriate;*

EASA’s Certification memorandum[5] CM-S-007 Issue 01, issued 19 August 2015, supplements the existing guidance for compliance with CS 27/29.602 – Critical Parts, detailing the need for post certification actions to verify the continued integrity of Critical Parts. As part of the process of compliance with CS 27/29.602 the applicant should develop and perform a “Continued Integrity Verification Programme” (CIVP). The CM describes the data which can be used to support the CIVP.

SUBPART E - POWERPLANT

ROTOR DRIVE SYSTEM

The rotor drive system includes the gearbox and any part necessary to transmit power from the engines to the rotor hubs. It contains many critical parts which are subject to fatigue loading.

CS 29.917 Design

(a) General. The rotor drive system includes any part necessary to transmit power from the engines to the rotor hubs. This includes gearboxes, shafting, universal joints, couplings, rotor brake assemblies, clutches, supporting bearings for shafting, any attendant accessory pads or drives, and any cooling fans that are a part of, attached to, or mounted on the rotor drive system.

[5] EASA Certification Memoranda (CM) clarify the Agency’s general course of action on specific certification items. They are intended to provide guidance on a particular subject and, as non-binding material, may provide complementary information and guidance for compliance demonstration with current standards. CM do not constitute any legal obligation.

(b) Design assessment. A design assessment must be performed to ensure that the rotor drive system functions safely over the full range of conditions for which certification is sought. The design assessment must include a detailed failure analysis to identify all failures that will prevent continued safe flight or safe landing, and must identify the means to minimise the likelihood of their occurrence.

(c) Arrangement. Rotor drive systems must be arranged as follows:

(1) Each rotor drive system of multiengine rotorcraft must be arranged so that each rotor necessary for operation and control will continue to be driven by the remaining engines if any engine fails.

(2) For single-engine rotorcraft, each rotor drive system must be so arranged that each rotor necessary for control in autorotation will continue to be driven by the main rotors after disengagement of the engine from the main and auxiliary rotors.

(3) Each rotor drive system must incorporate a unit for each engine to automatically disengage that engine from the main and auxiliary rotors if that engine fails.

(4) If a torque limiting device is used in the rotor drive system, it must be located so as to allow continued control of the rotorcraft when the device is operating.

(5) If the rotors must be phased for intermeshing, each system must provide constant and positive phase relationship under any operating condition.

(6) If a rotor dephasing device is incorporated, there must be means to keep the rotors locked in proper phase before operation.

Compensating provisions are either design, maintenance or monitoring, where they are considered to be both technically feasible and economically justified. The CS 29.917 (b) AC material does not define what substantiation is necessary for each compensating provision, but according to EASA often experience on similar designs would be considered acceptable. If a failure mode exists for which no effective means of monitoring damage is physically possible, then it is considered acceptable to rely on the integrity of the part between inspections.

AMC 29.917 was introduced with CS-29 Amendment 3 of 11 December 2012. It deals with Vibration Health Monitoring if used as compensation provision for compliance to CS 29.917; in such case the VHM system will have to comply with CS 29.1465.

CS 29.923 Rotor drive system and control mechanism tests

(a) Endurance tests, general. Each rotor drive system and rotor control mechanism must be tested, as prescribed in sub-paragraphs (b) to (n) and (p), for at least 200 hours plus the time required to meet the requirements of subparagraphs (b)(2), (b)(3) and (k). These tests must be conducted as follows:

(1) Ten-hour test cycles must be used, except that the test cycle must be extended to include the OEI test of sub-paragraphs (b)(2) and (k), if OEI ratings are requested.

(2) The tests must be conducted on the rotorcraft.

(3) The test torque and rotational speed must be:

(i) Determined by the powerplant limitations; and

(ii) Absorbed by the rotors to be approved for the rotorcraft.

(b) Endurance tests, take-off run. The takeoff run must be conducted as follows:

(1) Except as prescribed in subparagraphs (b)(2) and (b)(3), the take-off torque run must consist of 1 hour of alternate runs of 5 minutes at take-off torque and the maximum speed for use with take-off torque, and 5 minutes at as low an engine idle speed as practicable. The engine must be declutched from the rotor drive system, and the rotor brake, if furnished and so intended, must be applied during the first minute of the idle run. During the remaining 4 minutes of the idle run, the clutch must be engaged so that the engine drives the rotors at the minimum practical rpm. The engine and the rotor drive system must be accelerated at the maximum rate. When declutching the engine, it must be decelerated rapidly enough to allow the operation of the overrunning clutch.

(2) For helicopters for which the use of a 2½-minute OEI rating is requested, the takeoff run must be conducted as prescribed in subparagraph (b)(1), except for the third and sixth runs for which the take-off torque and the maximum speed for use with take-off torque are prescribed in that paragraph. For these runs, the following apply:

(i) Each run must consist of at least one period of 2½ minutes with takeoff torque and the maximum speed for use with take-off torque on all engines.

(ii) Each run must consist of at least one period, for each engine in sequence, during which that engine simulates a power failure and the remaining engines are run at the 2½- minutes OEI torque and the maximum speed for use with 2½-minute OEI torque for 2½ minutes.

(3) For multi-engine, turbine-powered rotorcraft for which the use of 30-second/2- minute OEI power is requested, the take-off run must be conducted as prescribed in subparagraph (b)(1) except for the following:

(i) Immediately following any one 5-minute power-on run required by subparagraph (b)(1), simulate a failure, for each power source in turn, and apply the maximum torque and the maximum speed for use with the 30-second OEI power to the remaining affected drive system power inputs for not less than 30 seconds. Each application of 30-second OEI power must be followed by two applications of the maximum torque and the maximum speed for use with the 2 minute OEI power for not less than 2 minutes each; the second application must follow a period at stabilised continuous or 30-minute OEI power (whichever is requested by the applicant.) At least one run sequence must be conducted from a simulated 'flight idle' condition. When conducted on a bench test, the test sequence must be conducted following stabilisation at take-off power.

(ii) For the purpose of this paragraph, an affected power input includes all parts of the rotor drive system which can be adversely affected by the application of higher or asymmetric torque and speed prescribed by the test.

(iii) This test may be conducted on a representative bench test facility when engine limitations either preclude repeated use of this power or would result in premature engine removals during the test. The loads, the vibration frequency, and the methods of application to the affected rotor drive system components must be representative of rotorcraft conditions. Test components must be those used to show compliance with the remainder of this paragraph.

(c) Endurance tests, maximum continuous run. Three hours of continuous operation at maximum continuous torque and the maximum speed for use with maximum continuous torque must be conducted as follows:

(1) The main rotor controls must be operated at a minimum of 15 times each hour through the main rotor pitch positions of maximum vertical thrust, maximum forward thrust component, maximum aft thrust component, maximum left thrust component, and maximum right thrust component, except that the control movements need not produce loads or blade flapping motion exceeding the maximum loads of motions encountered in flight.

(2) The directional controls must be operated at a minimum of 15 times each hour through the control extremes of maximum right turning torque, neutral torque as required by the power applied to the main rotor, and maximum left turning torque.

(3) Each maximum control position must be held for at least 10 seconds, and the rate of change of control position must be at least as rapid as that for normal operation.

(d) Endurance tests: 90% of maximum continuous run. One hour of continuous operation at 90% of maximum continuous torque and the maximum speed for use with 90% of maximum continuous torque must be conducted.

(e) Endurance tests; 80% of maximum continuous run. One hour of continuous operation at 80% of maximum continuous torque and the minimum speed for use with 80% of maximum continuous torque must be conducted.

(f) Endurance tests; 60% of maximum continuous run. Two hours or, for helicopters for which the use of either 30-minute OEI power or continuous OEI power is requested, 1 hour of continuous operation at 60% of maximum continuous torque and the minimum speed for use with 60% of maximum continuous torque must be conducted.

(g) Endurance tests: engine malfunctioning run. It must be determined whether malfunctioning of components, such as the engine fuel or ignition systems, or whether unequal engine power can cause dynamic conditions detrimental to the drive system. If so, a suitable number of hours of operation must be accomplished under those conditions, 1 hour of which must be included in each cycle, and the remaining hours of which must be accomplished at the end of the 20 cycles. If no detrimental condition results, an additional hour of operation in compliance with sub-paragraph (b) must be conducted in accordance with the run schedule of sub-paragraph (b)(1) without consideration of sub-paragraph (b)(2).

(h) Endurance tests; overspeed run. One hour of continuous operation must be conducted at maximum continuous torque and the maximum power-on overspeed expected in service, assuming that speed and torque limiting devices, if any, function properly.

(i) Endurance tests: rotor control positions. When the rotor controls are not being cycled during the endurance tests, the rotor must be operated, using the procedures prescribed in subparagraph (c), to produce each of the maximum thrust positions for the following percentages of test time (except that the control positions need not produce loads or blade flapping motion exceeding the maximum loads or motions encountered in flight):

(1) For full vertical thrust, 20%.

(2) For the forward thrust component, 50%

(3) For the right thrust component, 10%.

(4) For the left thrust component, 10%.

(5) For the aft thrust component, 10%.

(j) Endurance tests, clutch and brake engagements. A total of at least 400 clutch and brake engagements, including the engagements of sub-paragraph (b), must be made during the takeoff torque runs and, if necessary, at each change of torque and speed throughout the test. In each clutch engagement, the shaft on the driven side of the clutch must be accelerated from rest. The clutch engagements must be accomplished at the speed and by the method prescribed by the applicant. During deceleration after each clutch engagement, the engines must be stopped rapidly enough to allow the engines to be automatically disengaged from the rotors and rotor drives. If a rotor brake is installed for stopping the rotor, the clutch, during brake engagements, must be disengaged above 40% of maximum continuous rotor speed and the rotors allowed to decelerate to 40% of maximum continuous rotor speed, at which time the rotor brake must be applied. If the clutch design does not allow stopping the rotors with the engine running, or if no clutch is provided, the engine must be stopped before each application of the rotor brake, and then immediately be started after the rotors stop.

(k) Endurance tests, OEI power run.

(1) 30-minute OEI power run. For rotorcraft for which the use of 30-minute OEI power is requested, a run at 30-minute OEI torque and the maximum speed for use with 30-minute OEI torque must be conducted as follows. For each engine, in sequence, that engine must be inoperative and the remaining engines must be run for a 30-minute period.

(2) Continuous OEI power run. For rotorcraft for which the use of continuous OEI power is requested, a run at continuous OEI torque and the maximum speed for use with continuous OEI torque must be conducted as follows. For each engine, in sequence, that engine must be inoperative and the remaining engines must be run for 1 hour.

(3) The number of periods prescribed in sub-paragraph (k)(1) or (k)(2) may not be less than the number of engines, nor may it be less than two.

(1) Reserved.

(m) Any components that are affected by manoeuvring and gust loads must be investigated for the same flight conditions as are the main rotors, and their service lives must be determined by fatigue tests or by other acceptable methods. In addition, a level of safety equal to that of the main rotors must be provided for:

(1) Each component in the rotor drive system whose failure would cause an uncontrolled landing;

(2) Each component essential to the phasing of rotors on multi-rotor rotorcraft, or that furnishes a driving link for the essential control of rotors in autorotation; and

(3) Each component common to two or more engines on multi-engine rotorcraft.

(n) Special tests. Each rotor drive system designed to operate at two or more gear ratios must be subjected to special testing for durations necessary to substantiate the safety of the rotor drive system.

(o) Each part tested as prescribed in this paragraph must be in a serviceable condition at the end of the tests. No intervening disassembly which might affect test results may be conducted.

(p) Endurance tests; operating lubricants. To be approved for use in rotor drive and control systems, lubricants must meet the specifications of lubricants used during the tests prescribed by this paragraph. Additional or alternate lubricants may be qualified by equivalent testing or

by comparative analysis of lubricant specifications and rotor drive and control system characteristics. In addition:

(1) At least three 10-hour cycles required by this paragraph must be conducted with transmission and gearbox lubricant temperatures, at the location prescribed for measurement, not lower than the maximum operating temperature for which approval is requested;

(2) For pressure lubricated systems, at least three 10-hour cycles required by this paragraph must be conducted with the lubricant pressure, at the location prescribed for measurement, not higher than the minimum operating pressure for which approval is requested; and

(3) The test conditions of sub-paragraphs (p)(1) and (p)(2) must be applied simultaneously and must be extended to include operation at any one-engine-inoperative rating for which approval is requested.

CS 29.927 Additional tests

(a) Any additional dynamic, endurance, and operational tests, and vibratory investigations necessary to determine that the rotor drive mechanism is safe, must be performed.

(b) If turbine engine torque output to the transmission can exceed the highest engine or transmission torque limit, and that output is not directly controlled by the pilot under normal operating conditions (such as where the primary engine power control is accomplished through the flight control), the following test must be made:

(1) Under conditions associated with all engines operating, make 200 applications, for 10 seconds each, of torque that is at least equal to the lesser of:

(i) The maximum torque used in meeting CS 29.923 plus 10%; or

(ii) The maximum torque attainable under probable operating conditions, assuming that torque limiting devices, if any, function properly.

(2) For multi-engine rotorcraft under conditions associated with each engine, in turn, becoming inoperative, apply to the remaining transmission torque inputs the maximum torque attainable under probable operating conditions, assuming that torque limiting devices, if any, function properly. Each transmission input must be tested at this maximum torque for at least 15 minutes.

(c) Lubrication system failure. For lubrication systems required for proper operation of rotor drive systems, the following apply:

(1) Category A. Unless such failures are extremely remote, it must be shown by test that any failure which results in loss of lubricant in any normal use lubrication system will not prevent continued safe operation, although not necessarily without damage, at a torque and rotational speed prescribed by the applicant for continued flight, for at least 30 minutes after perception by the flight crew of the lubrication system failure or loss of lubricant.

(2) Category B. The requirements of Category A apply except that the rotor drive system need only be capable of operating under autorotative conditions for at least 15 minutes.

(d) Overspeed test. The rotor drive system must be subjected to 50 overspeed runs, each 30 ± 3 seconds in duration, at not less than either the higher of the rotational speed to be expected from an engine control device failure or 105% of the maximum rotational speed, including transients, to be expected in service. If speed and torque limiting devices are installed, are

independent of the normal engine control, and are shown to be reliable, their rotational speed limits need not be exceeded. These runs must be conducted as follows:

(1) Overspeed runs must be alternated with stabilising runs of from 1 to 5 minutes duration each at 60 to 80% of maximum continuous speed.

(2) Acceleration and deceleration must be accomplished in a period not longer than 10 seconds (except where maximum engine acceleration rate will require more than 10 seconds), and the time for changing speeds may not be deducted from the specified time for the overspeed runs.

(3) Overspeed runs must be made with the rotors in the flattest pitch for smooth operation.

(e) The tests prescribed in sub-paragraphs (b) and (d) must be conducted on the rotorcraft and the torque must be absorbed by the rotors to be installed, except that other ground or flight test facilities with other appropriate methods of torque absorption may be used if the conditions of support and vibration closely simulate the conditions that would exist during a test on the rotorcraft.

(f) Each test prescribed by this paragraph must be conducted without intervening disassembly and, except for the lubrication system failure test required by sub-paragraph (c) , each part tested must be in a serviceable condition at the conclusion of the test.

SUBPART F – EQUIPMENT

GENERAL

CS 29.1301 Function and installation

Each item of installed equipment must:

(a) Be of a kind and design appropriate to its intended function;

(b) Be labelled as to its identification, function, or operating limitations, or any applicable combination of these factors;

(c) Be installed according to limitations specified for that equipment; and

(d) Function properly when installed.

CS 29.1309 Equipment, systems and installations

(a) The equipment, systems, and installations whose functioning is required by this CS–29 must be designed and installed to ensure that they perform their intended functions under any foreseeable operating condition.

(b) The rotorcraft systems and associated components, considered separately and in relation to other systems, must be designed so that –

(1) For Category B rotorcraft, the equipment, systems, and installations must be designed to prevent hazards to the rotorcraft if they malfunction or fail; or

(2) For Category A rotorcraft:

(i) The occurrence of any failure condition which would prevent the continued safe flight and landing of the rotorcraft is extremely improbable; and

(ii) The occurrence of any other failure conditions which would reduce the capability of the rotorcraft or the ability of the crew to cope with adverse operating conditions is improbable.

(c) Warning information must be provided to alert the crew to unsafe system operating conditions and to enable them to take appropriate corrective action. Systems, controls, and associated monitoring and warning means must be designed to minimise crew errors which could create additional hazards.

(d) Compliance with the requirements of subparagraph (b)(2) must be shown by analysis and, where necessary, by appropriate ground, flight, or simulator tests. The analysis must consider:

(1) Possible modes of failure, including malfunctions and damage from external sources;

(2) The probability of multiple failures and undetected failures;

(3) The resulting effects on the rotorcraft and occupants, considering the stage of flight and operating conditions; and

(4) The crew warning cues, corrective action required, and the capability of detecting faults.

(e) For Category A rotorcraft, each installation whose functioning is required by this CS–29 and which requires a power supply is an 'essential load' on the power supply. The power sources and the system must be able to supply the following power loads in probable operating combinations and for probable durations:

(1) Loads connected to the system with the system functioning normally.

(2) Essential loads, after failure of any one prime mover, power converter, or energy storage device.

(3) Essential loads, after failure of:

(i) Any one engine, on rotorcraft with two engines; and

(ii) Any two engines, on rotorcraft with three or more engines.

(f) In determining compliance with subparagraphs (e)(2) and (3), the power loads may be assumed to be reduced under a monitoring procedure consistent with safety in the kinds of operations authorised. Loads not required for controlled flight need not be considered for the two-engine-inoperative condition on rotorcraft with three or more engines.

(g) In showing compliance with subparagraphs (a) and (b) with regard to the electrical system and to equipment design and installation, critical environmental conditions must be considered. For electrical generation, distribution and utilisation equipment required by or used in complying with this CS–29, except equipment covered by European Technical Standard Orders containing environmental test procedures, the ability to provide continuous, safe service under foreseeable environmental conditions may be shown by environmental tests, design analysis, or reference to previous comparable service experience on other aircraft.

[Amdt 29/4]

INSTRUMENTS: INSTALLATION

CS 29.1337 Powerplant instruments

(a) Instruments and instrument lines

(1) Each powerplant and auxiliary power unit instrument line must meet the requirements of CS 29.993 and 29.1183.

(2) Each line carrying flammable fluids under pressure must:

(i) Have restricting orifices or other safety devices at the source of pressure to prevent the escape of excessive fluid if the line fails; and

(ii) Be installed and located so that the escape of fluids would not create a hazard.

(3) Each power plant and auxiliary power unit instrument that utilises flammable fluids must be installed and located so that the escape of fluid would not create a hazard.

(b) Fuel quantity indicator. There must be means to indicate to the flight-crew members the quantity, in US-gallons or equivalent units, of usable fuel in each tank during flight. In addition:

(1) Each fuel quantity indicator must be calibrated to read 'zero' during level flight when the quantity of fuel remaining in the tank is equal to the unusable fuel supply determined under CS 29.959;

(2) When two or more tanks are closely interconnected by a gravity feed system and vented, and when it is impossible to feed from each tank separately, at least one fuel quantity indicator must be installed; Annex to ED Decision 2016/025/R A

(3) Tanks with interconnected outlets and airspaces may be treated as one tank and need not have separate indicators; and

(4) Each exposed sight gauge used as a fuel quantity indicator must be protected against damage.

(c) Fuel flowmeter system. If a fuel flowmeter system is installed, each metering component must have a means for bypassing the fuel supply if malfunction of that component severely restricts fuel flow.

(d) Oil quantity indicator. There must be a stick gauge or equivalent means to indicate the quantity of oil:

(1) In each tank; and

(2) In each transmission gearbox.

(e) Rotor drive system transmissions and gearboxes utilizing ferromagnetic materials must be equipped with chip detectors designed to indicate the presence of ferromagnetic particles resulting from damage or excessive wear within the transmission or gearbox. Each chip detector must:

(1) Be designed to provide a signal to the indicator required by CS 29.1305 (a)(23); and

(2) Be provided with means to allow crew members to check, in flight, the function of each detector electrical circuit and signal.

MISCELLANEOUS EQUIPMENT

CS 29.1465 Vibration health monitoring

VHM is not mandatory for large rotorcraft, but if certification of a rotorcraft with VHM or if VHM is required by the applicable operating rules (such as operations in the North Sea) the system will have to comply with this paragraph.

(a) If certification of a rotorcraft with vibration health monitoring of the rotors and/or rotor drive systems is requested by the applicant, then the design and performance of an installed system must provide a reliable means of early detection for the identified failure modes being monitored.

(b) If a vibration health monitoring system of the rotors and/or rotor drive systems is required by the applicable operating rules, then the design and performance of the vibration health monitoring system must, in addition, meet the requirements of this paragraph.

(1) A safety analysis must be used to identify all component failure modes that could prevent continued safe flight or safe landing, for which vibration health monitoring could provide a reliable means of early detection;

(2) All typical VHM indicators and signal processing techniques should be considered in the VHM System design;

(3) Vibration health monitoring must be provided as identified in subparagraph (1) and (2), unless other means of health monitoring can be substantiated.

[Amdt 29/3]

SUBPART G – OPERATING LIMITATIONS AND INFORMATION

OPERATING LIMITATIONS

CS 29.1529 Instructions for Continued Airworthiness

Instructions for continued airworthiness in accordance with Appendix A to CS–29 must be prepared.

APPENDICES

Appendix A Instructions For Continued Airworthiness

A29.1 General

(a) This appendix specifies requirements for the preparation of instructions for continued airworthiness as required by CS 29.1529.

(b) The instructions for continued airworthiness for each rotorcraft must include the instructions for continued airworthiness for each engine and rotor (hereinafter designated 'products'), for each appliance required by any applicable CS or operating rule, and any required information relating to the interface of those appliances and products with the rotorcraft. If instructions for continued airworthiness are not supplied by the manufacturer of an appliance or product installed in the rotorcraft, the instructions for continued airworthiness for the rotorcraft must include the information essential to the continued airworthiness of the rotorcraft.

A29.2 Format

(a) The instructions for continued airworthiness must be in the form of a manual or manuals as appropriate for the quantity of data to be provided.

(b) The format of the manual or manuals must provide for a practical arrangement.

A29.3 Content

The contents of the manual or manuals must be prepared in a language acceptable to the Agency. The instructions for continued airworthiness must contain the following manuals or sections, as appropriate, and information:

(a) Rotorcraft maintenance manual or section.

(1) Introduction information that includes an explanation of the rotorcraft's features and data to the extent necessary for maintenance or preventive maintenance. (2) A description of the rotorcraft and its systems and installations including its engines, rotors, and appliances. (3) Basic control and operation information describing how the rotorcraft components and systems are controlled and how they operate, including any special procedures and limitations that apply. (4) Servicing information that covers details regarding servicing points, capacities of tanks, reservoirs, types of fluids to be used, pressures applicable to the various systems, location of access panels for inspection and servicing, locations of lubrication points, the lubricants to be used, equipment required for servicing, tow instructions and limitations, mooring, jacking, and levelling information.

(b) Maintenance Instructions.

(1) Scheduling information for each part of the rotorcraft and its engines, auxiliary power units, rotors, accessories, instruments, and equipment that provides the recommended periods at which they should be cleaned, inspected, adjusted, tested, and lubricated, and the degree of inspection, the applicable wear tolerances, and work recommended at these periods. However, it is allowed to refer to an accessory, instrument, or equipment manufacturer as the source of this information if it is shown that the item has an exceptionally high degree of complexity requiring specialised maintenance techniques, test equipment, or expertise. The recommended overhaul periods and necessary cross references to the airworthiness limitations section of the manual must also be included. In addition, an inspection program that includes the frequency and extent of the inspections necessary to provide for the continued airworthiness of the rotorcraft must be included.

(2) Trouble-shooting information describing probable malfunctions, how to recognise those malfunctions, and the remedial action for those malfunctions.

(3) Information describing the order and method of removing and replacing products and parts with any necessary precautions to be taken.

(4) Other general procedural instructions including procedures for system testing during ground running, symmetry checks, weighing and determining the centre of gravity, lifting and shoring, and storage limitations.

(c) Diagrams of structural access plates and information needed to gain access for inspections when access plates are not provided.

(d) Details for the application of special inspection techniques including radiographic and ultrasonic testing where such processes are specified.

(e) Information needed to apply protective treatments to the structure after inspection.

(f) All data relative to structural fasteners such as identification, discard recommendations, and torque values.

(g) A list of special tools needed.

[Amdt 29/2]

A29.4 Airworthiness Limitations Section

The instructions for continued airworthiness must contain a section titled airworthiness limitations that is segregated and clearly distinguishable from the rest of the document. This section must set forth each mandatory replacement time, structural inspection interval, and related structural inspection procedure required for type-certification. If the instructions for continued airworthiness consist of multiple documents, the section required by this paragraph must be included in the principal manual. This section must contain a legible statement in a prominent location that reads – 'The airworthiness limitations section is approved and variations must also be approved'.

[Amdt 29/3]