EASA European Union Aviation Safety Agency	**Consultation paper** **Equivalent Safety Finding**	Doc. No.: CPTS-0000358 Issue : 1 Date : 22 JAN 2024 Proposed ☒ Final ☐ Deadline for comments: 15 MAR 2024

SUBJECT	:	Use of laboratory test rigs for the rotor drive system and control mechanism tests
REQUIREMENTS incl. Amdt.	:	CS 29.923(a)(2) and CS 29.923(a)(3)(ii) from CS-29 Initial issue
ASSOCIATED IM/MoC	:	Yes☐ / No ☒
ADVISORY MATERIAL	:	FAA AC 29-2C Change 8 (AC 29.923A)

Table of Content for Public Consultation

INTRODUCTORY NOTE:

The following Equivalent Safety Finding (ESF) has been classified as important and as such is subject to public consultation in accordance with EASA Management Board decision 12/2007 dated 11 September 2007, Article 3 (2.) which states:

"*2. Deviations from the applicable airworthiness codes, environmental protection certification specifications and/or acceptable means of compliance with Part 21, as well as important special conditions and equivalent safety findings, shall be submitted to the panel of experts and be subject to a public consultation of at least 3 weeks, except if they have been previously agreed and published in the Official Publication of the Agency. The final decision shall be published in the Official Publication of the Agency.*"

ABBREVIATIONS:

GAMA	General Aviation Manufacturers Association
TC	Type Certificate

IDENTIFICATION OF ISSUE:

EASA has received requests for an Equivalent Safety Finding to CS 29.923(a)(2) and CS 29.923(a)(3)(ii) for design changes affecting the rotor drive system and/or rotor control mechanism of large rotorcraft. In addition, EASA has received from GAMA the Industry White Paper on Drive System Endurance testing (GAMA 22-49), requesting the approach described in this ESF to be considered as acceptable to meet CS 29.923.

The endurance tests prescribed in CS 29.923 require testing each rotor drive system and rotor control mechanism with the aim of demonstrating that they are capable of normal operation within the limitations proposed, without hazard of failure from excessive wear or deterioration due to mechanical loads.

In particular, the following requirements in CS 29.923 'Rotor drive system and control mechanism tests' are applicable:

- CS 29.923(a) states: "[…] each rotor drive system and rotor control mechanism must be tested, as prescribed in sub-paragraphs […]"
- CS 29.923(a)(2) states: "The tests must be conducted on the rotorcraft."
- CS 29.923(a)(3)(ii) states: [The test torque and rotational speed must be] "Absorbed by the rotors to be approved for the rotorcraft."

Therefore, these tests should be performed on the rotorcraft, with the rotorcraft engines and the rotors respectively providing and absorbing power.

In this context, the parts constituting each rotor drive system and rotor control mechanism should be considered as parts under test.

FAA AC 29.923A, which is accepted by EASA as means of compliance with CS 29.923 when complented by EASA AMC1 29.923 for applications including a 30-min power rating, states:

"This section [29.923(a)] *also requires the test to be conducted 'on the rotorcraft'. This means a rotorcraft that is in conformity to the type design for which approval is requested. However, many nonconforming features, such as doors, some cowling and instrumentation, fuel tanks (alternate external fuel supply may be utilized), interior features, fire detectors, extinguishers, inlet ducts, exhaust baffles, etc., may be acceptable provided each item is technically considered and found to have no impact on the test results."*

In the context of AC 29.923A, the applicant may propose *nonconforming features* in the test, limited to elements of the rotorcraft type design that would not impact the test conditions for the parts under test. In these cases, a direct compliance demonstration to CS 29.923 is expected without an ESF.

However, for design changes to an existing rotor drive system and control mechanism, direct compliance with CS 29.923 would require having a complete rotorcraft in conformity to the type design available to perform the endurance tests. Typically, several design changes are planned and introduced along the life of a type and in some cases, such availability may not be possible. In this case, the applicant may propose to perform the endurance tests using laboratory test rigs (e.g. gearbox test rigs).

EASA considers that using laboratory test rigs as endurance test means cannot be simply considered as a non-conforming feaure of the prescribed rotorcraft and must be considered as an alternative test means. This alternative tests means should be adequately demonstrated not to impact the test results to substantiate an Equivalent Level of Safety to CS 29.923(a)(2) and CS 29.923(a)(3)(ii).

Considering all the above, the following Equivalent Safety Finding is proposed:

M-TS-0000358

Equivalent Safety Finding

CS 29.923(a)(2) and 29.923(a)(3)(ii) - Use of laboratory test rigs for the rotor drive system and control mechanism tests

1. APPLICABILITY

This ESF is applicable to large rotorcraft for design changes which do not consist in a substantial modification to the rotor drive system and/or rotor control mechanism.

A design change is deemed not to constitute a substantial modification to rotor drive system and/or rotor control mechanism, when it is:

a) A physical design change and/or extension of permitted operating conditions impacting parts of the rotor drive system and/or rotor control mechanism for which an extensive return of experience is available.
b) A limited and local physical design change to the rotor drive system and/or rotor control mechanism for which only limited or no return of experience from service exists, such as the local re-design of parts shortly following their initial certification.

In the first case, the applicant should have enough return of experience on the affected parts' behaviour and mechanical solicitations to justify that the alternative test means will result in testing conditions that would closely simulate the ones from a complete rotorcraft. In the second case, due to the limited and local impacts, the effects of the design change(s) to be evaluated are associated to a limited number of parts, for which the use of one or several laboratory test rigs may be sufficient and appropriate.

1.1 AFFECTED CS

CS 29.923(a)(2) and 29.923(a)(3)(ii) from CS-29 Initial issue onward (or identical requirements from FAR-29 and JAR-29).

2. STATEMENT OF EQUIVALENT SAFETY FINDING

According to CS 29.923(a)(2) and (3)(ii), the endurance tests must be performed on the rotorcraft with the rotorcraft engines and rotors respectively providing and absorbing power. The parts constituting each rotor drive system and rotor control mechanism should be considered as parts under test.

In lieu of direct compliance with the CS identified in chapter 1.1, and provided that the below compensating factors are complied with, the test means may consist in representative laboratory test rig(s) allowing to closely simulate the conditions that would exist for the parts under test during the endurance tests on the rotorcraft.

3. COMPENSATING FACTORS

The applicant must demonstrate that the test means used for the endurance tests allow to closely simulate the rotorcraft configuration. For this purpose, the following compensating factors must be

considered. To substantiate these compensating factors, different approaches including analysis and/or test results comparison may be proposed.

a) The scope of parts under test may be reduced and limited to the ones affected by the modification. For this purpose, the applicant must formally identify the parts that are affected by the modification and intended to be endurance-tested and provide associated justifications.

b) The applicant must demonstrate that the proposed test rig and specimens adequately fulfil the objectives of the endurance test for the identified parts under test.

c) When assessing the representativeness of a laboratory test rig, used as an alternative means to the rotorcraft for the endurance tests, the applicant must demonstrate the following:

1) Representative interfaces and boundary conditions:

i) The applicant must ensure that the interfaces between the parts under test and their surrounding elements are representative of the rotorcraft configuration.

ii) Any potential degradations, such as wear or fretting, that could appear during the endurance tests, must be demonstrated to be similar to those that would occur by testing on the rotorcraft.

iii) The interface properties to be considered must include: materials, surface treatments, dimensions (e.g. shape, contact areas, surface roughness), fitting conditions (e.g. means of attachments, tightening loads) and lubrication conditions (e.g. quantity and type of lubricants used for fasteners).

2) Representative environmental conditions: The applicant must ensure that rotorcraft environmental conditions are representatively introduced for the parts under test (e.g., oil flow and temperature for lubricated gears and bearings).

3) Representative loading conditions:

i) The applicant must ensure that the loading conditions of the parts under test are representative of the rotorcraft configuration.

ii) All sources of mechanical loads and their respective paths must be closely simulated on the parts under test.

iii) These loads must include rotor loads, rotor control loads, engine loads, accessory loads, rotor brake loads, reaction loads from the airframe, reaction loads from the engine(s), imposed deformations, displacements, rotational movements, and/or misalignments.

iv) The applicant must also pay particular attention to the fact that these loads may oscillate around their nominal values, even during stabilized manoeuvres, when evaluated on the rotorcraft. It is possible that alternative means to engines and rotors used to introduce and absorb torques and loads during the endurance tests will lead to less severe torque and rotor load oscillations compared to what would be observed in the rotorcraft.

A. For conventional helicopters using conventional turboshaft engines, the engine torques and rotor hub loads (i.e. thrust, bending and shear) oscillations are relatively low compared to their nominal values. A compensating measure that is considered as acceptable is to increase the nominal torque and load values on the

test rig(s) in order to ensure that the maximum torques and loads, including loads oscillations from the test rig(s), are at least as high as the rotorcraft ones.

B. As an alternative to A. directly above, the applicant may demonstrate that load oscillations different from those in the rotorcraft have no effect on the test results.

v) The applicant must ensure that the static and dynamic displacements and rotational movements applied on parts under test are at least as severe as the ones that would be observed on the rotorcraft configuration. This is particularly important for elements such as soft couplings, gimbal joints, spline couplings, bearings, or gear teeth. Displacements and/or rotational movements of these parts could impact their contact pressures, wear and fretting .

vi) When rotor(s) and/or engine(s) and/or rotor-brake(s) from the rotorcraft type design are replaced by alternative means:

A. the applicant must demonstrate that the accelerations and decelerations performed using a test rig are closely simulating the ones in the rotorcraft for the parts under test.

B. by derogation from a. above the applicant may demonstrate that accelerations and decelerations different from those in the rotorcraft have no effect on the test results.

C. the applicant shall consider the impact from variations of the accelerations and decelerations due to using a test rig instead of the rotorcraft configuration in particular on clutch(es), freewheel(s) and brake(s) engagements and disengagements and could, therefore, affect the endurance test conclusions for these elements.

d) When the test means are found to be not fully representative of the rotorcraft configuration for some of the parts under test and/or for some test phases, the applicant must:

1) address those parts and test phases by means of additional tests (potentially ground and/or flight tests on the rotorcraft),

2) maintain the parts under test unchanged for all the tests,

3) limit the assembly/disassembly phases to the minimum required to transfer the parts between the different test facilities, and

4) only perform maintenance, including assembly/disassembly phases, ensuring the test results will not be impacted.

In particular, using a Closed-Loop Test Rig[1] as an alternative test means may not allow to closely simulate the required accelerations and decelerations for the freewheel(s) engagements and disengagements and/or may not allow the operation of a rotor brake. In such cases, a compensating measure that is considered acceptable is to perform complementary ground and/or flight tests for

[1] A closed-loop test rig is defined for the purpose of this ESF as a test rig based on a mechanical closed power loop where drive motor(s) is(are) required to supply only the power needed to cover the mechanical losses generated during running by the test rig and the parts under test.

the evaluation of the parts under test that may be affected by the required engagements/disengagements of freewheel(s) and operation of a rotor brake.