CRD Special Condition for Small Jet Engine to be operated in Powered Sailplanes EASA

Commentator:	**CAA-UK, Safety Regulation Group**
Page No: 01	

Paragraph No: CS 19

Comment: The factors used in the "Cycling" section of SC 19 appear reasonable for a Hazardous engine effect. Since this is the first time such an installation has been considered for a sailplane, is it clear that "Hazardous" is the correct classification in this case for this class of aircraft? *(i.e. can the sailplane be designed such that critical part failure is not catastrophic?)* If a higher classification was justified, then it is proposed that the 1/3 factor on declared life should be further reduced.

Justification:

Proposed Text (*if applicable*):

EASA Response	**Noted.** As agreed with General Aviation Aircraft Certification a critical part failure is not considered leading to a catastrophic effect to the sailplane, and the classification of hazardous effect would be appropriate for sailplane installations. This is not the first time such an installation has been considered for a sailplane, the difference to the already approved Special Condition is only the treatment of the high energy rotating parts.

Commentator:	**CAA-UK, Safety Regulation Group**
Page No: 02	

Paragraph No: CS 22.1823

Comment: It is stated in the Discussion section of the Special Condition that the above paragraph 1823 is retained by this Special Condition. Special condition SC16 does however amend part of this paragraph.

While SC16 makes reference to the need to consider seizure and blade off loads, there appears to be no guidance on how much of the blade needs to be considered in doing the assessment, concerning the speed to be considered for blade release or seizure time to be considered.

Justification: Significant loads can be introduced by the failure of an aerofoil or part of an aerofoil in a gas turbine design. It is presumably the design intent to ensure that if such a failure occurs the loads introduced into the airframe by out of balance and engine/airframe resonant response do not exceed those cleared by structural considerations. While the SC makes it clear that blade out and seizure needs to be considered the conditions assumed for the failure should be specified (*release height, release rotational position, speed, seizure time, etc*) to allow the assessment to be performed. Alternatively, SC5 dealing with vibration could be modified to provide the blade out guidance.

Proposed Text (*if applicable*): Indication in the discussion that paragraph 22.1823(b) is amended. Additional text either in this paragraph or under SC5 (*Vibration*) to indicate what proportion of blade release needs to be considered.

EASA Response	**Partially accepted** *Reference to SC16 to expand CS.1823 is added in SC19.* *Special Condition 16 is not in the scope of the discussion because it's already agreed to in the original version.* *It is included here for reference only and to have a complete overview.*

Commentator:	**CAA-UK, Safety Regulation Group**
Page No: 03	

Paragraph No: SC 17

Comment: Extremely remote is defined in this SC as 1E-05 per engine hour. This is significantly higher than has historically been permitted in engine codes. It is suggested that gas turbine hazardous effects should occur at a much reduced rate than indicated here, in line with other engine codes, since the consequences at the aircraft level will be at least as severe as those for other types of aircraft.

Justification:

Proposed Text (*if applicable*):

EASA Response	**Not Accepted** The definition of Extremely Remote as 1E-05 is already accepted in the certification basis in a previous, similar project, after public consultation. It is considered appropriate in relation to the potential consequences in case of failure to the critical part. Because there is no definition of Extremely Remote within CS-22H, or CS-23, the definition as used in FAA AC23.1309-1D is accepted by EASA general aviation aircraft certification. The definition of Extremely Remote as 1E-05 per engine hour, is in line with the FAA AC 23.1309-1D. For a Class 1 airplane (*Single Reciprocating Engine*), this Advisory Circular defines a probability of < 1E-05 per engine Flight hour for a hazardous failure condition as Extremely Remote. AC 23.1309-1D, also explains a turbine engine airplane with a stall speed under 61 knots with simple systems and with otherwise similar characteristics to a traditional single-engine reciprocating airplane can be treated as a Class 1 airplane. These probability standards are based on historical accident data, system analyses and engineering judgement for each class of airplane. While the consequence at the aircraft level may be as severe as those for other types of aircraft, the overall safety target for powered sailplanes is considerably less than for other types of aircraft that are larger and capable of transporting higher number of passengers.

Commentator:	**Draline b.v.**
Page No: 04	

Paragraph No: **Special Condition 19**

Comment:
This paragraph seems to be more about notches than about cracks.

1. The notch size and geometry should be defined by the applicant.
2. The notch size and geometry should depend on the component size.
3. The stress amplification resulting from the notch should be set in relation to expected stress amplifications resulting from material and manufacturing imperfections (e.g. casting defects not covered by NDT capabilities).
4. The overall amount of stress amplification should be known in order to determine the degree of over testing.

Justification: -

Proposed Text (*if applicable*):

EASA Response	***Not accepted.*** *The initial anomaly size of the pre-prepared "engineering-crack" must be representative for a "real" crack. The special condition does not talk about notches, but about the dimensions and shape of a representative crack. The given anomaly size is accepted for this purposes in previous projects to be considered as a representative size and shape.* *The relation between component size and crack dimensions is not relevant in this case for crack development, so will not be taken into account.* *SC 19 is not about stress amplifications caused by notches, but about potential crack development. Therefore an approved life is taken highly conservative by approving a cycle life by means of a full engine test, without burst or significant crack growth, with a pre-damaged rotor by means of the engineering crack as specified in Special Condition 19.*

Commentator:	**Draline b.v.**
Page No: 05	

Paragraph No: **Special Condition 19**

Comment:

1. The test definition should be based on worst case conditions with regard to mechanical and (*cyclic*) thermal loads acting on the component.
2. The equivalent between tested 'start-stop' cycles and engine 'start-stop' cycles should be known. If necessary also engine sub-cycles have to be considered.
3. The number of components to be tested should be defined by the applicant.
4. The 'cycle reduction factor' and its justification should be provided by the applicant.
5. The 'cycle reduction factor' should be based on the degree of over testing, the number of tested components and a statistical evaluation.
6. The cycle reduction factor should take (*non-linear*) low cycle fatigue phenomena and material characteristics (*e.g. of casting*) into account.
7. The number of components to be tested should be based on the necessary statistical significance.

Justification: -

Proposed Text (*if applicable*):

EASA Response	**Partially accepted** 1. Noted, worst case conditions are taking into account by performing a real engine test. 2. Noted, the tested cycles will represent the expected flight profile. 3. Noted, this will be defined by the applicant in the certification test plan. 4. Agreed, Changed text: SC19, Cycling; (b) To establish a conservative and acceptable cycle life, the engine test can be performed with a real engine on a bench. The approved life should be very conservative *by means of an appropriate reduction factor (RF) of the cycles shown in the test without burst, or significant crack growth. An appropriate reduction factor (RF) based on number of test specimens and consideration of the differences between reference flight cycle and test cycle has to be determined by the applicant.* Only one rotor/shaft assembly can be used for the test (*one set of Compressor, Turbine and Shaft*). If during the test other parts fail (*like bearings*), they can be changed in between.

	(c) Cycling Test o The applicant to define a suitable test with representative start-stop cycles considering the operating envelope and typical flight usage profile of the engine. o Run the engine for x-cycles o Inspect => no cracks o Release RF of x ⇨ y o y= Approved Life Limit 5. Agreed, see text change item 4. 6. Different to the typical approach applied for CS-E engines, a full engine test at most adverse conditions will be performed with rotors having been prepared with an engineering crack. The mandatory life limit will be determined on a basis that either no burst has occurred and no significant crack growth has developed. <u>In addition</u>, an appropriate reduction factor (RF) will be applied to take variations in material characteristics into account. 7. The applied reduction factor will also reflect the number of engines being subject of the cyclic testing.

Commentator:	**Draline b.v.**
Page No: 06	
Paragraph No: Special Condition 19 **Comment:** Does compliance with 'Special Condition 19' result in engine designs without any containment? **Justification: -** **Proposed Changed text (*if applicable*): -**	
EASA Response	**Noted** *The engine does not feature specific containment features.* *It should also be noted, these engines already incorporate design features which provide a certain degree of containment, however no credit will be taken in the safety assessment.* *The design of the Critical Parts has to show no hazardous failure mode existing within its approved and mandatory life limit.*