Proposed Special Condition SC-VLA.901-01 for CS-VLA Aeroplanes with propeller drive shaft

Introductory Note:

The hereby presented Special condition has been classified as an important Special Condition and as such shall be 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.*"

Statement of Issue

The Certification specifications CS-VLA are applicable for single engine aeroplanes. Conventionally single engine aeroplanes are in tractor configuration, with the propeller directly attached to the engine. The case of the propeller driven by a shaft is not completely covered by the CS-VLA requirements.

Justification

The configuration where the engine and the propeller are connected through a drive shaft poses additional hazards that need to be addressed via specific requirements. Considering the above, the following Special condition is proposed:

SPECIAL CONDITION SC-VLA.901-01

CS-VLA Aeroplanes with a propeller drive shaft

Design

SC-VLA.901-01-1 propeller drive shaft

The propeller drive shaft includes any part necessary to transmit power from the engine to the propeller. This may include couplings, universal joints, drive shafts, supporting bearings for shafts, brake assemblies, clutches, transmissions, any attached accessory pads or drives, and any cooling fans that are attached to, or part of the propeller drive shaft.

The following aspects shall be considered:

a) joints (e.g. Universal joints) have to be selected and arranged/installed in the drive shaft such to avoid unsteadiness of rotation;
b) The drive shaft design should consider the effects of loads or deformations on the drive shaft. Such loads and deformations shall consider (but not be limited to):
    i. propeller thrust, lateral loads and gyroscopic moments;
    ii. Dissimilar expansion/deformation between structural and powerplant parts;
    iii. Deformation of the fuselage and tail surfaces under Flight and ground loads;
c) When the aeroplane airframe is deformed under the limit loads required by CS-VLA it has to be shown that the drive shaft is free to rotate without friction and without exceeding the design limitations (angular/radial) of the joints.
d) The above should consider degradation of the parts (if any) due to environmental effects;
e) If mass balances are necessary, the structural strength of their installation must be substantiated and maintenance procedures shall be established.
f) Wrapping guidance, protective covers and all other structural members must have such a distance to rotating parts that under deformation due to flight or ground loads a radial or

longitudinal distance of at least 13 mm (0.5 in) shall be kept, except that lower values may be acceptable upon justification by the applicant and agreement by the Agency.

AMC SC-VLA.901-01-1 b,i)

In case the loads and deformations references in b,i are transferred to the airframe load carrying structure in the shortest possible way, without acting on the drive shaft, their effects need not to be considered for the strength of the drive shaft.

SC-VLA.901-01-2 propeller drive shaft torque limit

If the drive shaft is torque limited, a means to prevent exceeding the torque limit must be provided unless it is shown by design and analysis or test that the torque limit cannot be exceeded.

SC-VLA.901-01-3 Lubrication

Each part of the propeller drive shaft whose lubrication is necessary for operation must have provisions for lubrication.

Structure (Strength and integrity)

The propeller drive shaft shall meet the structural requirements of CS-VLA. In addition, the following specific aspects shall be considered.

SC-VLA.901-01-3 strength

a) The stress acting on the propeller drive shaft, within its range of operation, shall be determined under the conditions established in this special condition. This shall include also the combined stress induced by flight loads (e.g. inertia loads or deformation induced loads). The resulting stress should be determined, either by flight test, or ground test or analysis supported by tests (or a combination of these methods).
b) The resulting peak stresses must not exceed the fatigue limit of the material the drive shaft is made of.

SC-VLA.901-01-4 Tests

Test shall be conducted as described below:

a) The drive shaft shall be subjected to endurance tests;
b) Any additional dynamic, operational test and vibratory investigation necessary to determine that the drive shaft installation is safe, shall be performed.

The tests above shall include also the engine and the propeller and shall be performed on the aeroplane, except that bench test may be accepted if it is shown that the installation is representative in conservative way. After these tests have been completed, the drive assembly shall be disassembled and inspected. No essential component may show rupture, cracks or excessive wear. Each part tested must be in a serviceable condition.

c) It has to be shown, that the flailing rests of a broken transmission shaft still driven by the engine, do not directly endanger occupants (if applicable) and do not prevent a continued safe flight and landing. The effect of dynamic loads resulting from such failure on the rest of the propulsion system and the whole aeroplane shall be evaluated. Compliance has to be sought in a test under the assumption that the shaft is broken at a point most critical for compliance and at the most critical RPM.

AMC to SC-VLA.901-01-4 a)

An endurance test of 50 hours of operation consisting of the following cycles is acceptable:

Sequence	Duration (Minutes)	Operating Conditions
1	5	Starting – Idle
2	5	Take-off power
3	5	Cooling run (Idle)
4	5	Take-off power
5	5	Cooling run (Idle)
6	5	Take-off power
7	5	Cooling run (Idle)
8	15	75% of maximum continuous power
9	5	Cooling run (Idle)
10	60	Maximum continuous power
11	5	Cooling run and stop
Total:	120	

SC-VLA.901-01- 5 Fatigue

a) The drive shaft shall be evaluated for fatigue according CS-VLA 572 b) for all areas with high stress level in the drive shaft.
b) The effects of probable damages and/or defects introduced by the manufacturing process and of damages that can be expected during operation shall be accounted for.

AMC to SC-VLA.901-01- 5 Fatigue

High static safety margins (low stress levels), in conjunction with good design practice to eliminate Stress concentration can provide adequate fatigue performances, if substantiated by the applicant and accepted by the Agency.

SC-VLA.901-01- 6 critical speed

a) The critical speeds of the transmission must be determined by test, except that analytical methods may be used if reliable methods of analysis are proven to be available for the particular design. When determining the critical speed, the influences of the maximum imbalance to be expected from the manufacturing process as well as the bending of the shaft under load factors or residual bending (if any) due to the fuselage deformation shall be considered.
b) If any critical speed lies within, or close to, the operating ranges of the engine, the stresses occurring at that speed must be evaluated. This shall be shown by tests.
c) If analytical methods are used to show that no critical speed lies within the permissible operating ranges, adequate margins between the calculated critical speeds and the limits of the allowable operating ranges must be ensured.

AMC to SC-VLA.901-01-6

The critical RPM of the transmission may be 1.5 the maximum RPM.

Fire protection

SC-VLA.901-01- 7 Parts of the drive shaft located in a designated fire zone shall be made of fire proof material, unless these parts are protected with fire proof material. Fire resistant material is acceptable if it is shown (by tests or analysis if found acceptable by the Agency) that failure of the shaft due to fire does not directly endanger occupants (if applicable) and does not prevent a continued safe flight and landing.

Limitations

SC-VLA.901-01- 8

The powerplant limitations required by CS-VLA 1521 shall include all limitations needed for the safe functioning of the drive shaft, as defined in the above requirements.