U.S. Department of Transportation

Federal Aviation Administration

Memorandum

Subject: **INFORMATION**: Policy for Bird Strike, Lightning, and Centrifugal Load Testing for Composite Propeller Blades and Spinners

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From: Manager, Engine and Propeller Directorate, Aircraft Certification Service

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Manager, Propulsion Branch, ACE-118C
Manager, Wichita Aircraft Certification Office, ACE-115W
Manager, Systems and Propulsion Branch, ACE-116W
Manager, Anchorage Aircraft Certification Office, ACE-115N
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1. Purpose

Currently, part 35 of Title 14 of the Code of Federal Regulations (14 CFR part 35) does not have explicit safety standards for the substantiation of propellers with composite blades and spinners for bird strike, lightning strike, and centrifugal loads. Propeller blades constructed from composite materials have an unconventional feature of design, material, and construction. Therefore, the FAA has developed this policy to provide guidance for structurally substantiating propellers with composite blades and spinners for bird strike, lightning strike, and centrifugal loads. This guidance may be used for the development of special conditions that the Administrator considers necessary to establish a level of safety for composite blades and spinners equivalent to that established by the existing airworthiness standards for metal propeller blades and spinners.

2. Related Documents

a. Policy Statement Number ANE-2001-35.13-R0, "Policy for Propeller-Level Failure Effects," dated March 12, 2003.

b. AC 20-136, Protection of Aircraft Electrical/Electronic Systems Against the Indirect Effects of Lightning, dated March 5, 1990.

c. RTCA Document DO-160D, Environmental Conditions and Test Procedures for Airborne Equipment, dated July 29, 1997.

d. Report of SAE Committee AE4L-98-5, Aircraft Lightning Zoning Standard, dated May 1998.

e. Report of SAE Committee AE4L-97-4, Aircraft Lightning Environment and Related Test Waveforms Standard, dated July 1997.

f. Report of SAE Committee AE4L, Lightning Test Waveforms and Techniques for Aerospace Vehicles and Hardware, dated June 20, 1978.

g. Report of SAE Committee AE4L-87-3 Rev. C, Certification of Aircraft Electrical/Electronic Systems for the Indirect Effects of Lightning, Revision C, dated September 1996.

3. Discussion

The requirements of part 35 were established to address the airworthiness considerations associated with metal propeller blades and spinners. Blades and spinners constructed of composite material have fibers that are woven or aligned in specific directions to give the material directional strength properties. These properties depend on the type of fiber, the orientation and concentration of fiber, and the resin matrix material that binds the fibers together. Composite materials may introduce the following failure modes that are different from metallic materials:

- Damage due to the high impact forces associated with a bird strike;
- Damage due to the inability to safely conduct or dissipate the electrical current from a lightning strike; and
- Fractures in the structural transitions such as the bond between a composite blade and the metallic retention system.

Therefore, this policy provides guidance for substantiating composite propeller integrity following a bird strike, lightning strike, and operation at twice the centrifugal load.

4. Definitions

For the purpose of this policy the following terms, as defined in FAA Policy Statement Number ANE-2001-35.13-R0, apply to the propeller:

a. <u>Hazardous propeller effects</u>. The following are considered hazardous propeller effects:

(1) Significant overspeed of the propeller.

(2) Development of excessive drag.

(3) Significant thrust in the direction opposite to that commanded by the pilot.

(4) Release of the propeller or any major portion of the propeller.

(5) Failure that results in excessive unbalance.

(6) Unintended movement of the propeller blades below the established minimum in-flight low-pitch position.

b. Major propeller effects. The following are considered major propeller effects for variable pitch propellers:

(1) Inability to feather the propeller (for feathering propellers).

(2) Inability to change propeller pitch.

(3) Significant uncommanded change in pitch.

(4) Significant uncontrollable torque or speed fluctuation.

5. Bird Strike Substantiation

Using tests, analysis based on tests, or experience on similar designs, the applicant should demonstrate that the propeller with composite blades or spinner is capable of withstanding the impact of a four-pound bird at the critical location(s) and critical flight condition(s) of the intended aircraft without causing a major or hazardous propeller effect. The following paragraphs provide test guidance for substantiating the integrity of the propeller for a bird strike.

a. Composite Blade and Spinner Testing.

(1) Selection of critical operating conditions. The selection of critical operating conditions should be based on an evaluation of the intended use of the propeller, the operating conditions when the propeller would most likely encounter bird populations, and the impact geometry of the propeller. Typically, this condition occurs at takeoff and landing. Also, most bird impacts occur close to the ground; the bird population decreases with altitude.

(2) Selection of impact site.

(a) Blade. The field experience with bird impact shows that the entire span of the blade is capable of receiving bird strikes. Therefore, the applicant should choose an impact site that produces maximum blade retention loads. This site would show that the entire blade would not separate and at the same time would test for local structural integrity to show any local or tip blade damage. The dynamic impact force and the dynamic blade response are major contributors to both the resultant retention loads and local damage. Local structure may also play a role in the final determination of the impact site. Discontinuities in the structure such as ply drops in composite blades may factor into the critical impact location selection. Foreign object analyses should be used whenever possible to guide the selection of the impact site. Multiple impact tests may be needed to determine the critical impact site if other information is unavailable or insufficient.

(b) Spinner. The applicant should choose an impact site that produces maximum loads. This site would show that the entire spinner would not separate and at the same time would test for local structural integrity to show any local damage. This impact site would generally be at the center of the spinner.

(3) Selection of the bird. The test bird should weigh four pounds. The applicant may use natural or simulated birds for testing. The applicant should ensure that the bird or simulated bird has been stored properly, so that the physical characteristics are similar to those that exist in nature. Improper storage can change the density and fluid properties of the natural or simulated bird. The applicant should also ensure that the bird temperature is appropriate for the test, because temperature has an effect on the bird properties.

(4) Static or rotating testing. Either static or rotating testing is acceptable. The objective is to simulate a bird strike in a controlled manner to assess the resulting blade and spinner damage. When appropriate, blade hub, retention, and pitch change hardware should be included as part of the static test set-up for assessment of the effect of the bird strike on these components.

(5) Test set-up. The test set-up should include a method for verifying the bird impact velocity, geometry, and the blade response to the impact. These factors may be verified by high-speed cameras and instrumentation to record blade strain and load during and following the impact.

(6) Strike verification. The applicant should verify that the bird strike is successful.

(a) Blade. A successful strike should have no more than 10 percent of the bird sliced off by the leading edge and passing by the camber side of the blade. The bird should be oriented within 10 degrees off axis in any direction.

(b) Spinner. A successful strike should have a portion of the bird striking the center of the spinner, with an orientation within 10 degrees off axis in any direction.

6. Lightning Strike Substantiation

Using tests, analysis based on tests, or experience on similar designs, the applicant should demonstrate that a propeller with composite blades or spinner is capable of withstanding a lightning strike without causing a major or hazardous propeller effect. The following guidance provides an overview of test methodology used to determine the effect of a lightning strike on composite propeller blades and spinners. The documents referenced in paragraphs 2.b. through 2.g. of this policy provide detailed methods, test set-up information on voltage waveforms, current waveforms, data collection, and other general procedures for conducting a lightning strike test.

a. The applicant should consider all components of the propeller blade assembly that could be in the lightning path. These components include, but are not limited to, the following:

- Spinner;
- Blade;
- Hub;
- Blade bearings; and
- Possibly the pitch change mechanism.

Electrical or electronic components that could be influenced by the indirect effects should also be considered. These include propeller blade de-icing system components, as well as other propeller-mounted electrical or electronic components.

b. The damage caused by lightning is characterized into two categories: direct and indirect.

(1) The direct effect of lightning depends on the structural component involved, the attachment point, and the current path through the structure. The direct effect of lightning is physical damage. The damage caused by lightning depends on the strength of the strike and the construction of the propeller blade.

(2) The indirect effect of lightning is classified as damage to electrical equipment by the current or voltages, either by the associated electromagnetic field, surges, or current directly injected into the electrical wires. Testing for indirect effects determines the currents conducted, surge voltages, and induced voltages entering the aircraft electrical system through systems such as the propeller de-icing system. The testing involves measuring voltages at the terminals of the de-icing system or other electrical/electronic systems at their connection to the aircraft electrical system.

7. Centrifugal Load

a. Substantiation of Composite Blades. The applicant should demonstrate that composite blade features associated with transitions to the retention system (for example, a composite blade bonded to a metallic retention) are tested for a period of one hour to a load equivalent to twice the maximum centrifugal load, based on the maximum rated rotational speed. This test should account for environmental degradation expected in service without evidence of failure, malfunction, or permanent deformation that would result in a major or hazardous propeller effect. Environmental degradation may be accounted for by adjustment of the loads during the tests.

b. Substantiation of Composite Spinners and Components Attached to Composite Blades. The applicant should demonstrate that composite spinners and components attached to composite blades, such as erosion shields and de-ice boots, can withstand a load equivalent to 159 percent of the maximum centrifugal load, based on the maximum rated rotational speed, without evidence of failure, malfunction, or permanent deformation that would result in a major or hazardous propeller effect. This should be demonstrated either by test at the required load for a period of 30 minutes or analysis based on test.

c. Substantiation Guidance.

(1) The maximum centrifugal load is based on the maximum rated rpm declared in the type certificate data sheet (TCDS). Transient overspeed limits and overspeeds that would occur at the overspeed governor setting are not considered normal and do not constitute the maximum rpm to be used for establishing test conditions.

(2) The test may be conducted on an assembly, either by whirl testing or static testing, by applying the load to the assembled components to simulate the centrifugal load, as appropriate.

(3) This test does not have to include the complete blade. Stub blades, with weights to establish the correct centrifugal load during whirl tests, can be used. The stub blades should have the same blade retention as the full blade, to maintain similarity to the full blade retention.

(4) Blade features such as those associated with transitions from composite blade to the metallic retention can be tested during the hub and retention test required by §35.35 or with a separate component test. There may be other applicable configurations, such as the transition associated with a configuration in which the blade of any material construction is bonded or otherwise attached to the portion of the blade that is retained in the hub.

8. Assessment of Major or Hazardous Propeller Effects

The overall propeller should be evaluated to determine if primary or secondary composite blade or damage due to the bird strike, lightning strike, or centrifugal load application would result in a major or hazardous propeller effect.

a. The following are examples of damage that is considered a hazardous propeller effect:

(1) A release of any portion of a blade, blade component, or spinner with sufficient energy to penetrate a fuselage.

(2) The failure of a blade pitch change pin, resulting in the uncommanded pitch change of an individual blade.

b. The following are examples of damage that is considered a major propeller effect:

(1) A failure that would jam the pitch change actuation system and cause the propeller to pitch lock.

(2) A failure of the spinner that would interfere with pitch change linkages, causing pitch lock or preventing feathering.

c. FAA Policy Statement Number ANE-2001-35.13-R0 provides additional guidance on assessing major or hazardous propeller effects.

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