Memorandum

U.S. Department
of Transportation

**Federal Aviation
Administration**

Subject: **INFORMATION**: Substantiation of Secondary Composite Structures; PS-ACE100-2004-10030

Date: April 19, 2005

From: Manager, Small Airplane Directorate, ACE-100

Reply to Attn. of: Lester Cheng; 316-946-4111

To: See Distribution

1.0 Introduction

1.1 Purpose

This policy statement provides general guidance on some technical issues to address when certifying secondary structures fabricated from composite materials. We expect several differences from the major efforts applied in substantiating primary structures. However, experience shows there are some inconsistencies between programs, particularly in dealing with issues such as material and process qualification/control, structural substantiation, flammability, and overall quality assurance. This policy outlines some guidelines to use in composite applications that range from secondary structures to non-structural parts such as interiors. This policy applies to Title 14 of the Code of Federal Regulations (14 CFR), part 23 airplanes.

1.2 Definitions

Secondary structures are those that are not primary load carrying members, and their failure would not reduce the structural integrity of the airframe or prevent the airplane from continuing safe flight and landing. This is the same definition used in AC 23-19, issued by the Small Airplane Directorate. For clarification, the secondary structure definition implies that a hazard assessment of the partial or complete failure of the structure has been performed and there is no reasonable threat to safety of flight or landing. Such an assessment should include consideration for flight stability and control. Also consider subsequent failures that are the logical result of the initial failure.

Secondary structures must be designed, fabricated, and maintained such that they will not depart the aircraft and/or cause other safety hazards. Those exterior components that meet the definition of secondary structures may include fairings, cowlings, and radomes. Non-structural components, including many interior parts, whose failure would be inconsequential, may also fit the definition of secondary structures. Clearly, engineering judgment, based on the location, design, and function of a particular secondary structure, will help determine the level of material and process evaluation needed in type certification and subsequent production controls.

Ambiguity also exists between secondary and primary structures. For differentiation purposes, we define primary structure in this policy as, "The structure that carries flight, ground, crash or pressurization loads, and whose failure would reduce the structural integrity of the airplane or may result in injury or death to passengers or crew." Interior structures that carry crash loads, as required by 14 CFR part 23, §§ 23.561 and 23.562, are primary structure. Some structures may not satisfy the definitions of secondary or primary structure as provided in this policy. This may include structure that does not carry primary loads, but its failure may impact primary structure and prevent the continued safe flight of the airplane. Further coordination with the certification engineer may be required for these structures.

Composites may be susceptible to lightning damage. Lightning protection may be needed for secondary composite structure, such as engine cowls, where the effect of strike may be detrimental to engine operation. Demonstrate that the composite structure can dissipate P-static electrical charges, provides electromagnetic protection where required, and provides an acceptable means of diverting the lightning electrical current so as not to endanger the aircraft. Consider possible deterioration and undetected damage to the lighting protection system.

Flammability and fire protection requirements also need to be substantiated for aircraft components. The use of composite structures/components should not decrease the level of safety prescribed by the existing requirements for flammability and fire protection. These components may include some of the composite airframe structures and non-structural interior components. For certification convenience, divide the latter into two classifications: (1) non-structural components/parts that are not subject to compartment interior fire protection requirements (e.g., knobs, handles, pulleys, etc.), and (2) non-structural components/parts that are subject to compartment interior fire protection requirements.

In this policy, consider the term "manufacturer" as "the original equipment manufacturer (OEM) or qualified vendor, or other FAA production approval holder that fabricated or processed the components/parts." Also, consider the term "material supplier" as "the source from which the manufacturer receives material." The manufacturer is responsible for all flow down of quality assurance requirements that apply to the material supplier.

2.0 Related Regulatory and Guidance Materials

2.1 Federal Regulations

The regulations directly related to this policy include:

14 CFR, Part 23, Subpart C – Structure

Section 23.305	Strength and deformation
Section 23.307	Proof of structure

14 CFR, Part 23, Subpart D - Design and Construction

Section 23.601	General
Section 23.603	Materials and workmanship
Section 23.605	Fabrication methods
Section 23.609	Protection of structure
Section 23.613	Material strength properties and design values
Section 23.853	Passenger and crew compartment interiors
Section 23.867	Electrical bonding and protection against lightning and static electricity

14 CFR, Appendix F to Part 23 - Test Procedure

2.2 Advisory Circulars

The following advisory circulars (ACs) are related to this policy statement. These documents are available on the Internet at www.faa.gov or you may request a copy *at no cost* from the U.S. Department of Transportation, Subsequent Distribution Office, Ardmore East Business Center, 3341 Q 75th Avenue, Landover, MD 20785.

AC 20-107A	Composite Aircraft Structure (Apr/84)
AC 21-26	Quality Control for the Manufacture of Composite Structures (Jun/89)
AC 21-31	Quality Control for the Manufacture of Non-metallic Compartment Interior Components (Nov/91)
AC 23-2	Flammability Tests (Aug/84)
AC 23-20	Acceptance Guidance on Material Procurement and Process Specifications for Polymer Matrix Composite Systems" (Sep/03)

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AC 23-17A	Systems and Equipment Guide for Certification of Part 23 Airplanes (Jun/02)
AC 23-19	Airframe Guide for Certification of Part 23 Airplanes (Jan/03)

2.3 Policy Statements

The following policy statements relate closely to this policy:

> "Material Qualification and Equivalency for Polymer Matrix Composite Material Systems" [PS-ACE100-2002-006, Sep/03]
>
> "Static Strength Substantiation of Composite Airplane Structure" [PS-ACE100-2001-006, Dec/01]

The policy statements are available on line at www.faa.gov or you may request a copy from the Small Airplane Directorate at 901 Locust, Room 301, Kansas City, MO 64106.

In 1998, the Rotorcraft Directorate issued a policy statement on certifying secondary composite structure titled "Rotorcraft Directorate Policy: Certification Secondary Composite Structure (10/28/98)." This policy defines secondary structures differently from the definition presented by the Small Airplane Directorate as referenced in AC 23-19. However, the discussions contained in it are complementary to the current policy, as related to type design development and structural substantiation.

3.0 Substantiation Considerations

The first step in substantiation is to determine whether the particular component or part in question meets the definition for secondary structure given in this policy. In addition, determine whether failure of the component or an inability to perform its function could lead to an unacceptable safety hazard to people outside the aircraft (for example, departure from the aircraft). Most of the guidance in this policy applies to cases where failure of the secondary structure poses a safety threat to persons outside the aircraft. This policy also provides some guidance for non-structural components whose failure is inconsequential.

In general, the procedures to qualify and substantiate materials, processes, and designs are expected to be less stringent for secondary structure than for primary structure. Some flexibility may be permitted for the approach proposed by an applicant in substantiating the specific secondary structures. Such flexibility is made possible by evaluating all aspects of the proposed approach and by applying engineering judgment. The load and performance requirements for secondary structures may also present some relaxation in selecting the design/process.

In some situations, the design of a particular secondary structure may lead to ample structural capacity, which allows further simplification of the certification process (for example, reduced testing). Nevertheless, many of the same technical issues as primary structure must be considered for secondary structure. When applying engineering judgment, the potential failure and loss of function for a specific secondary structure should still be assessed and minimized.

3.1 Material and Process Qualification

In general, composite materials and processes used in the manufacturing of aircraft secondary structure must be qualified to help ensure control of these materials and processes. This includes the qualification of prepregs, adhesives, cores, cure processes, bonding, etc. It also includes constituents such as fiber, resin, etc. Finally, it includes expendable materials that may alter the process results or next-step processes, such as peel plies, tackifiers, storage medium, etc. Material strength values and other basic material properties must be based on enough tests to establish a statistical basis. Fewer tests, which will typically reduce the allowed strength value, may be acceptable for secondary structures with adequate design margin.

The first qualification of the material and processes may determine a representative data population for key properties and characteristics to use as a benchmark for subsequent material and process control. If the materials or processes selected have been previously qualified, then equivalency sampling needs to demonstrate material and process control. The level of qualification and equivalency performed (FAA test plan approvals and associated conformities) should be commensurate with the particular secondary structure and any threat it poses. Previous policy outlined in PS-ACE100-2002-006 provides minimum requirements for primary structures. For non-structural components, the manufacturer may rely on the supplier's material qualification data. Flammability tests must still be conducted when appropriate. The supplier is controlled by the manufacturer's quality assurance system (reference Section 3.8).

3.2 Environmental Resistance and Fluid Sensitivity

Composite materials and processes should be selected to ensure the resulting structure can perform its intended function in the service environment. This function includes resistance to all fluids to which the structure is likely to be exposed. Fluids, moisture, and temperature exposure degrade the matrix controlled mechanical properties of the composite. Some guidelines for screening tests exist to help select the appropriate composite material system (for example, Wet-Glass Transition Temperature, Tg, should have a sufficient margin above the maximum structural temperature). Environmental effects need to be considered in the material qualification and allowables testing.

3.3 Materials and Process Control

The aircraft part manufacturer plays an important role in advancing raw composite materials to a cured state needed for structural applications. As a result, the fabrication processes will directly affect the material properties and allowables of the final part. It is essential to develop material specifications and process specifications that are sufficient to ensure that critical parameters in the fabrication process are controlled. Some guidance for specifications developed for use with pre-impregnated composite materials for primary structures exist in AC 23-20. Engineering judgment may be applied in determining what differences may exist in the specifications used to control materials and processes for secondary composite parts.

Manufacturing procedures need to be in place for monitoring the temperature, vacuum, and pressure throughout the cure cycle of the part. Improper curing can lead to degraded mechanical

properties and part geometry that is out of tolerance. A procedure must be in place describing the cure cycle of parts and the method used to monitor that the curing process is under control.

Part geometry and quality depends on several tool issues, as well as the part lay-up and bagging procedures. Fabrication steps performed in lay-up and bagging can also affect the ply orientation, part thickness, and wrinkling. Procedures must be in place to ensure consistent and repeatable lay-up procedures.

If the manufacturer is receiving secondary composite parts from a supplier, then the supplier may have their own process specifications that need to be identified on the engineering drawing of the part. These specifications will also include notes and references to the supplier's specifications that identify the key characteristics of the part, such as strength values. The manufacturer still needs to document procedures to accept the composite parts from the supplier. The aircraft manufacturer is responsible for the structural integrity of the supplied part.

3.4 Bonding Issues

The control of structural bonding processes requires special attention. Substrate surface preparation plays a critical role in bonded structure. Inadequate surface roughening, pre-bond moisture, chemical contamination, anti-ice fluids, and other factors, both mechanical and chemical, can prevent adhesives from bonding properly to composites. One result of poor surface preparation is interfacial failures, which are an unacceptable failure mode. Traditional inspection procedures (for example, ultrasonic methods) used for quality control cannot reliably detect weak bonds caused by poor surface preparation; therefore, strict manufacturing procedures must be qualified to define quality controls that ensure proper surface preparation.

Another process and design consideration that is important to bonded structure is bondline thickness. Bondlines that are thick, or with widely variable thickness, generally lead to lower strength. A procedure must be in place to control bondline thickness to meet type design requirements where strength is an issue. The design details and data for structural substantiation should recognize the bonding process issues. Some non-structural items, such as interior panels, may not require attention to bondline thickness.

3.5 Drawing Requirements

Drawings should exist to define the type design of secondary structures. The drawing should identify the type of materials used in the part and show details that define key composite characteristics (for example, part lay-up sequence, orientation of each ply and dimensions). The drawing should also list the material acceptance requirements or reference the specification defining such requirements.

When the OEM is receiving secondary composite parts or materials from other sources (such as an approved vendor or material supplier), other proprietary process specifications may be involved. In such cases, the proprietary specifications need to be identified on the engineering drawing of that part and made available to the FAA when requested. The drawing should also include notes and references to the specifications that define the acceptance values determined

by qualification testing and any other special requirements. For secondary structure where strength is not a consideration, such as for interior decorative items, it is not necessary to list proprietary vendor specifications on the OEM drawing. The important parameter is burn properties, and an acceptable burn test may be submitted for certification (reference Section 3.7).

3.6 Structural Substantiation

Secondary composite structure should either be statically tested to ultimate load for all critical load cases or analyzed to substantiate limit and ultimate load requirements for all critical load cases using methods that have previously been shown to be reliable. For example, analysis methods that were validated in structural tests of primary components that use similar materials and processes may be applied for substantiation of secondary structures. Some point-design element testing of attachment details or other unique features of the secondary structures may also support simplified analysis of secondary structures. The static strength test or analysis substantiation must account for the effects of environment, and material and manufacturing variability. Non-detectable manufacturing defects or service damage should also be considered where strength is an issue. Non-structural components/parts, such as interior panels, need not consider non-detectable manufacturing defects.

Secondary composite structure is not required to comply with the damage tolerance requirements of 14 CFR, part 23, § 23.573.

Consider developing service information on the effects of service damage and repair, which will help disposition and avoid removal of structure found damaged in service. Even though secondary structures are lightly loaded, they are often fragile, and can easily be damaged by impact events such as hail, runway debris, and other foreign object damage. Service inspection requirements and procedures should be considered in the design process to support disposition of damage. Special inspection equipment and procedures should be identified in the Instructions for Continued Airworthiness. Repair procedures are often needed to seal the secondary composite part where damage has occurred and eliminate the potential for further degradation due to the environment.

3.7 Flammability Issues

Flammability tests need to be conducted for parts that are designed to minimize the hazard to the occupants. Compliance must be shown by test. Rational analysis may be used to select critical configurations (for example, core thickness or face sheet thickness) for testing. The results of flammability testing of composite parts depend on the design and process detail; therefore, the test coupons must be in the “as installed” configuration representative of the type design.

3.8 Quality Assurance

A quality control (QC) system established for composite fabrication of secondary structure is similar to any other QC system that has been established to meet the requirements of 14 CFR, part 21. The QC system should include procedures that ensure the quality of incoming materials, in-process control of manufacturing methods, and inspections of the end product conformity to

type design requirements. The QC system should also include standards for destructive and nondestructive tests, visual inspections during the fabrication process, and product final acceptance. There also should be procedures for the disposition of defects and other QC discrepancies.

A statement of conformance to the engineering drawing should accompany each shipment of parts or materials. The material batch or lot used to fabricate the part should be identified. The identification of the lot/batch and acceptance data must come from the manufacturer or supplier and be traceable to the basic material lot or batch formulation operation. There must be verification that the material used to manufacture the supplied part meets acceptance requirements provided by the manufacturer, including verification that the part has met the flammability requirements when appropriate.

4.0 Summary

This policy addresses some technical issues when certifying secondary composite structures. We identified these issues from the recent certification programs for part 23 airplanes: (1) material and process qualification, (2) environmental resistance and fluid sensitivity, (3) materials and process control, (4) bonding issues, (5) drawing requirements, (6) structural substantiation, (7) flammability issues, and (8) quality assurance.

This policy recaptures the lessons learned and promotes/supports standardization for future part 23 certification programs. You may use the guidance contained in this document for composite applications that range from secondary structures to non-structural parts (such as interiors).

Effect of Policy

The general policy stated in this document does not constitute a new regulation or create what the courts refer to as a "binding norm." The office that implements policy should follow this policy when applicable to the specific project. Whenever an applicant's proposed method of compliance is outside this established policy, it must be coordinated with the policy issuing office, for example, through the issue paper process or equivalent. Similarly, if the implementing office becomes aware of reasons that an applicant's proposal that meets this policy should not be approved, the office must coordinate its response with the policy issuing office.

Applicants should expect certificating officials to consider this information when making findings of compliance relevant to new certificate actions. Also, as with all advisory material, this policy statement identifies one means, but not the only means, of compliance.

If you have any questions or comments, please contact Mr. Lester Cheng, Regulations and Policy Branch, at 316-946-4111.

s/

Patrick R. Mullen
Acting Manager, Small Airplane Directorate
Aircraft Certification Service