U.S. Department
of Transportation

**Federal Aviation
Administration**

Memorandum

Subject: Information: Rotorcraft Directorate Policy, Certification
Secondary Composite Structure

Date: OCT 28 1998

From: Manager, Rotorcraft Directorate,
Aircraft Certification Service, ASW-100

Reply to Attn. of:

To: See Distribution:

This Memorandum is provided to promote standardization among the Aircraft Certification Offices in the type certification of rotorcraft secondary composite structure. In the past, applicants have ignored or not fully considered the strength degradation effects of the environment, material variability, manufacturing variability, and impact damage on rotorcraft secondary composite structure. The following information is intended to provide a means to substantiate secondary rotorcraft composite structure without utilizing the complete phased approval (building block) composite materials certification process. The building block approach requires statistically valid strength and strain allowable development. It also relies on the use of analysis to predict internal loads and project the effects of material properties on structural capability. Applicants may use some or all of the following information in lieu of supplementing analysis with a more complete set of data using the building block approach.

For the purposes of this policy, secondary structure is defined as structure which does not carry primary aircraft loads, but structure which if failed may pose a catastrophic hazard to the rotorcraft or persons on the ground. Rotorcraft secondary structure usually includes such items as fairings and cowlings. Typical add ons such as camera mounts, night sun mounts, loud speaker mounts, and external fixture (water/spray) tanks may be considered as secondary structure.

Due to composite material components sensitivity to out of plane loads, the static notch sensitivity of composite materials, and the number of unanticipated certification static test failures to date, the FAA requires that secondary composite structure be statically tested to ultimate load or analyzed to ultimate load using methods which were substantiated from previous component and/or subcomponent tests. This static ultimate load substantiation must account for factors that affect the critical failure mode. These include the following:

* Environmental Accountability
* Material / Manufacturing Variability
* Nondetectable Impact Damage

It should be noted that the approach described in this document is thought to be conservative, particularly for those secondary structures which are critical in stiffness, stability, and minimum gage requirements. As a result, it may be desirable to apply some level of building block test and analysis substantiation to avoid cost and weight penalties. For example, subcomponent tests and supporting analyses which show panel stability limits far below strength cutoffs and show little effect due to the environment, can minimize the use of conservative load factors. In order to take advantage of this more rigorous approach, the applicant must also be able to predict the location and failure mode (e.g., Euler buckling, crippling, face sheet wrinkling, etc.) for ultimate load tests performed in ambient conditions. Analysis must also be used to show failure modes involving material strength would not drop below those for stability after considering the effects of environment and material variability.

ENVIRONMENTAL ACCOUNTABILITY

Environmental accountability may be approached by either testing within the environment (environmental conditioning) or using load enhancement factors. For simplicity, the load enhancement factor approach is typically preferred. It is general knowledge that moisture and temperature exposure degrade the matrix controlled mechanical properties of the composite. As a guideline for composite material system selection, the Wet-Glass Transition Temperature, Tg, should be 50° F higher than the maximum structural temperature. Unless otherwise substantiated using analysis and test from the building block method, a Hot-Wet (H-W) knockdown factor of 1.5 must be used.

MATERIAL/MANUFACTURING VARIABILITY

Material/Manufacturing variability can reduce the unflawed strength of a composite material system. Such flaws include but are not limited to bond efficiency, disbonds, delaminations, porosity, voids, wrinkles, marcels, and constituent inconsistency (resin content/fiber volume). Unless otherwise substantiated using the building block method, a Material/Manufacturing knockdown factor of 1.3 must be used.

LOAD ENHANCEMENT FACTORS

The above knockdown factors were established based on a search of the scientific literature and past experience in composite materials certification. The factors are conservative for all loading conditions. The factors were reviewed with and found acceptable by FAA National Resource Specialist for Advanced Composite Materials, Dr. Larry Ilcewicz.

Therefore, a typical Load Enhancement Factor calculation looks like the following:

DLL x 1.5 x 1.5 x 1.3 = Ultimate Test Load (Actual), where DLL = Design Limit Load

This Ultimate Test Load may be used for coupon, component, or full scale test.

Some examples of previously successful rotorcraft composite materials secondary structure projects which did not use the building block approach:

(1) Entry and Exit Steps: Full scale test using above mentioned knock down factors.

(2) Fuselage Fairing: Full scale test using above mentioned Ultimate Test Load.

(3) Fire Fighting Water Tank: The applicant chose to develop his own room temperature dry (RTD) allowable load by testing a statistically valid number of coupon specimens and then reducing the RTD allowable by 1.5 to account for the environment as follows:

* 5 batches x 6 specimens per batch x # of load conditions (tested to failure).
Note: Load conditions tested were 0° tension, 90° tension, 0° flexure, and in-plane shear.

* Statistical reduction for each load condition, 1-3σ or Mil-Hdbk 17 Weibull reduction preferred.

* 1.5 reduction for environment in lieu of testing for H-W.

* Showing a positive margin of safety for the tank membrane loads, MS = (allowable load/actual load) - 1.

- Similar allowables were developed by test for bolt bearing and bolt tension loads transferred to the composite tank through the fittings that attach the tank to the helicopter.

The Material/Manufacturing knockdown may be reduced to one in this case. Due to the large sample size the flaws are considered inherent in the specimens.

IMPACT DAMAGE

Impact Damage is critical and must always be considered for composite material Primary Structural Elements. Realistic Impact Damage up to the threshold of detectability for the inspection procedure used must not reduce the structural strength below ultimate load capability. Impact Damage is assumed for the life of the aircraft. Thin laminate impact damage is expected to be detected by the specified inspection procedure.

For rotorcraft secondary composite structure some judgment must be used. The probability of an impact may be considered. In general, the greatest causes of impact damage are hail, foreign object damage, and dropped tools. Engine cowlings have a higher risk than water/spray tanks for impact damage. Because of their location on the rotorcraft, impact damage on water/spray tanks is generally not considered because the probability of impact is low and the damage is detectable (thin laminate). The applicant must have an approved program to inspect for impact damage.

If impact damage is considered, the following procedure may be used:

(1) Conduct a one time static ultimate load test.
(2) The test specimen must contain realistic impact damage up to the threshold of detectability.
(3) The impact damage must be in the most critical location.
(4) The test must consider the worst probable environment; H-W.
(5) A full scale or component test is acceptable.

LIMIT DESIGN STRAIN LEVELS

Designing to limit strain levels no higher than those dependent on strength considerations is a preferred method of composite structure substantiation since these strain levels account for notch sensitivity, resin microcracking, impact damage, and long term environmental exposure. Experience and tests have shown that there is no growth of damage at these strain levels. Applicants must validate the structure with a strain survey.

Limit Design Strain Levels for Carbon/Epoxies are as follows:

Tension - 3200 to 3500 μ in/in

Compression - 2700 μ in/in

Shear - 5300 μ in/in

Limit Design Strain Levels for Fiberglass/Epoxies are as follows:

Tension - 8000 μ in/in

Compression - 5000 μ in/in

It should be noted that the above strain levels are based on strength considerations. It may not be possible to achieve such strain levels in designs dominated by stiffness and stability requirements.

Please pass this information to your structures engineers. If you have any questions, please contact Mr. Richard Monschke at (817) 222-5116.

For
Henry A. Armstrong

DISTRIBUTION:

ACE-110/ACE-115A/ACE-115C/ACE-115N/ACE-115W
AEU-100
AIR-110/AIR-200
ANE-110/ANE-150/ANE-170
ANM-110/ANM-100S/ANM-100D/ANM-100L
ASW-170
FTW-AEG