



AEROSPACE RECOMMENDED PRACTICE

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Design, Manufacturing, and Performance Standard
for Composite Materials Used on Aircraft Seat Structures

RATIONALE

There has been interest in the use of composite (e.g., carbon fiber or glass-reinforced plastics) structures in seating systems. Historically, the design, fabrication, inspection, and maintenance of aircraft seats has centered on the use of metallic structures. The development and certification of metallic aircraft seats has also benefitted from long term in-service use. The use of composite materials requires additional standards to maintain the current level of aircraft seat safety and performance.

INTRODUCTION

Composite materials have begun to replace metallic materials in aircraft seat structures. Historically, composite materials have been used in applications such as seat backs, seat pans, and arm rests, but they are now expanding to portions of the seat primary load path structure that carry static and dynamic loads.

Different composite material forms are used to fabricate composite components. Monolithic structure is comprised of only reinforcements (e.g., fibers) and resin, and is referred to as laminates. Sandwich structure is comprised of laminate “skins” that cover a layer of core material. Other material forms, such as braided three-dimensional fabrics, and reinforcements, may also be used. The materials may be processed in many different ways, including resin infusion, pre-impregnated ply (prepreg) layup, wet layup, automated tape layup, etc., which may be cured at elevated temperature and pressure in an oven or autoclave.

Composite materials typically do not have industry standardized material properties like that of metallic materials. The final material properties of a composite part rely extensively on the manufacturing processes used to create that part. Therefore, the part manufacturer is responsible for developing material properties based on both the raw materials and their manufacturing processes used to create the part.

Another key difference with composite materials is the potential for undetectable nature of service damage. In traditional metallic components, service damage can be visually seen as cracks or dents, and dispositioned per appropriate maintenance and inspection instructions. Composite components may be subjected to service damage, such as impacts, that cause internal damage to the structure, but are not visually apparent on the surface. Such damage may not be detected until a dedicated maintenance action, which could result in a period of service with a seat that has reduced structural integrity.

Furthermore damage and failure in composite parts may not be as visually apparent as they are in metallic seat structures. In addition to visual inspection methods, this document defines methods to ensure that a continuous load path remains between the occupant and the seat attachments after the application of load cases per AS8049.

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TABLE OF CONTENTS

1.	SCOPE.....	3
1.1	General.....	3
1.2	Applicability	3
2.	REFERENCES.....	4
2.1	Applicable Documents	4
2.1.1	SAE Publications.....	4
2.1.2	ASTM Publications	4
2.1.3	Code of Federal Regulation (CFR) Publications	5
2.1.4	European Union Publications.....	5
2.1.5	FAA Publications	5
2.1.6	Industry Publications	6
2.1.7	RTCA.....	6
2.2	Definitions	6
2.3	Acronyms	8
3.	MATERIAL AND PROCESS REQUIREMENTS.....	9
3.1	Material Specification	9
3.2	Manufacturing Process Specification.....	10
3.3	Design Values	11
3.4	Additional Factors	11
3.4.1	Environmental Factors	12
3.4.2	Material Variability Factors.....	12
4.	QUALIFICATION TESTING CRITERIA.....	13
4.1	Damage Threat Assessment and Substantiation	13
4.1.1	Step 1 - Damage Threat Assessment.....	13
4.1.2	Step 2 - Substantiation of Damage	13
4.1.3	Substantiation of Damage for Dynamic Test Conditions	14
4.2	Static and Dynamic Substantiation	15
4.3	Load Path Integrity Evaluation	15
5.	ELECTRICAL PROPERTIES.....	17
6.	VALIDATION OF ENVIRONMENTAL REQUIREMENTS	17
6.1	Fluids Susceptibility.....	17
6.2	Waterproofness	17
7.	MAINTENANCE AND REPAIR PROCEDURES	18
8.	NOTES	18
8.1	Revision Indicator.....	18
APPENDIX A	Change of Composite Material and/or Process	19
Figure 1	Process flow for composite seat part development	9
Table 1	Seat type categories	3
Table 2	LPIE dynamic test pulse requirement	16
Table 3	DO-160 - environmental validation schedule	17
Table 4	Fluid susceptibility testing list.....	17

1. SCOPE

1.1 General

This SAE Aerospace Recommended Practice (ARP) defines additional documentation, environmental considerations, in-service damage limits, test and evaluation criteria necessary to support certification of aircraft seats manufactured using composite materials, in addition to requirements in AS8049 and ARP5526. This document is limited to aircraft seat composite parts in the seat primary load path from the occupant to the attachments of the seat to the aircraft.

The term “composite” is inclusive of any fiber-reinforced polymer matrix materials such as carbon fiber-reinforced plastics, sandwich panels and bonded structure.

1.2 Applicability

The applicability of this document is limited to the following seat types categories shown in [Table 1](#).

Table 1 - Seat type categories

Seat Type	Aircraft Category	Applicable Federal Regulations
A-T	Transport Airplane	14 CFR 25
C-N	General Aviation Aircraft - Normal	14 CFR 23
C-U	General Aviation Aircraft - Utility	14 CFR 23
C-A	General Aviation Aircraft - Acrobatic	14 CFR 23
C-C	General Aviation Aircraft - Commuter	14 CFR 23

The aircraft seat composite parts in the seat primary load path from the occupant to the attachments of the seat to the aircraft shall meet all requirements of this document.

Some manufacturers may have experience manufacturing composite components in the seat primary load path. In that case, past certification practices and in-service experience may be substituted for the requirements in [3.3](#) through [4.3](#) for only those components. All stake holders must accept the use of service experience. The service experience must be documented and rationale must be provided on how these requirements are being met. However, in the absence of an appropriate reference database, manufacturers must follow the requirements in this document and support new products (i.e., those associated with new composite materials, processes, configurations, or produced by new organizations) by collecting service history to establish a database.

In the special case of thin laminate that do not carry restraint system loads, or are not seat backs on aft facing seats, the requirements of [3.3](#) to [4.3](#) can be met as follows:

- Environmental factor ([3.4.1](#)): These are generally negligible for commercial aircraft cabins if a robust material system is used. This can be demonstrated with a glass transition temperature (T_g) that is at least 50 °F (28 °C) above the maximum operating or maximum storage temperature (whichever is greater).
- Material variability factor ([3.4.2](#)): If a robust material system and process is used, a material variability factor (MVF) of 1.15 instead of 1.33 specified in [3.4.2](#) for thin laminates is adequate and MVF does not need to be developed.
- Manufacturing defects ([4.1](#)): If a robust process specification that allows minimal manufacturing defects is used, visual inspection is adequate.
- In-service damage ([4.1](#)): With thin laminates, in-service damage would be visible to the operator. The additional damage threat requirements of [4.1](#) are not required.

- Load path integrity evaluation (4.3): With thin laminates, post dynamic test damage would be in the form of visible cracks and delamination. The existing dynamic test pass/fail criteria in AS8049 5.4.1 for minor cracks and delamination are adequate.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

ARP5526 Aircraft Seat Design Guidance and Clarifications

AS8049 Performance Standard for Seats in Civil Rotorcraft, Transport Aircraft, and General Aviation Aircraft

2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D5766/D5766M Standard Test Method for Open-Hole Tensile Strength of Polymer Matrix Composite Laminates

ASTM D6264/D6264M Test Method for Measuring the Damage Resistance of a Fiber-Reinforced Polymer-Matrix Composite to a Concentrated Quasi-Static Indentation Force

ASTM D6272 Standard Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials by Four-Point Bending

ASTM D6484/D6484M Standard Test Method for Open-Hole Compressive Strength of Polymer Matrix Composite Laminates

ASTM D6742/D6742M Standard Practice for Filled-Hole Tension and Compression Testing of Polymer Matrix Composite Laminates

ASTM D7136/D7136M Standard Test Method for Measuring the Damage Resistance of a Fiber-Reinforced Polymer Matrix Composite to a Drop-Weight Impact Event

ASTM D7137/D7137M Test Method for Compressive Residual Strength Properties of Damaged Polymer Matrix Composite Plates

ASTM D7249/D7249M Standard Test Method for Facesheet Properties of Sandwich Constructions by Long Beam Flexure

ASTM D7264/D7264M Standard Test Method for Flexural Properties of Polymer Matrix Composite Materials

ASTM D7766/D7766M Standard Practice for Damage Resistance Testing of Sandwich Constructions

2.1.3 Code of Federal Regulation (CFR) Publications

Available from the United States Government Printing Office, 732 North Capitol Street, NW, Washington, DC 20401, Tel: 202-512-1800, www.gpo.gov.

14 CFR Part 21	Certification Procedures for Products and Parts
14 CFR Part 23	Airworthiness Standards: Normal, Utility, Acrobatic, and Commuter Category Airplanes.
14 CFR Part 25	Airworthiness Standards: Transport Category Airplanes

2.1.4 European Union Publications

Available from European Aviation Safety Agency, Postfach 10 12 53, D-50452 Cologne, Germany, Tel: +49-221-8999-000, www.easa.eu.int.

AMC 20-29	Composite Aircraft Structure - General Guidance And recommendations for Design and Certification of Composite Structures
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2.1.5 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

AC 20-107B CHG 1	Composite Aircraft Structure - General Guidance and Recommendations for Design and Certification of Composite Structures
AC 21-31A	Quality Control for the Manufacture of Non-Metallic Compartment Interior Components
AC 25.562-1B CHG 1	Dynamic Evaluation of Seat Restraint Systems and Occupant Protection on Transport Airplanes
DOT/FAA/AR-02/109	Guidelines and Recommended Criteria for the Development of a Material Specification for Carbon Fiber/Epoxy Unidirectional Prepregs
DOT/FAA/AR-02/110	Guidelines for the Development of Process Specifications, Instructions, and Controls for the Fabrication of Fiber-Reinforced Polymer Composites
DOT/FAA/AR-03/19	Material Qualification and Equivalency for Polymer Matrix Composite Material Systems: Updated Procedure (supersedes DOT/FAA/AR-00/47)
DOT/FAA/AR-06/10	Guidelines and Recommended Criteria for the Development of a Material Specification for Carbon Fiber/Epoxy Fabric Prepregs
DOT/FAA/AR-06/25	Preliminary Guidelines and Recommendations for the Development of Material and Process Specifications for Carbon Fiber-Reinforced Liquid Resin Molded Materials
DOT/FAA/AR-06/53	Laminate Statistical Allowable Generation for Fiber-Reinforced Composite Materials: Lamina Variability Method

2.1.6 Industry Publications

CMH-17 Composite Material Handbook 17, <https://www.cmh17.org/>

NSP 100 NCAMP Standard Operating Procedures (SOP), <http://www.niar.wichita.edu/coe/ncampsops.asp>

2.1.7 RTCA

Available from RTCA, Inc., 1150 18th Street, NW, Suite 910, Washington, DC 20036, Tel: 202-833-9339, www.rtca.org.

DO-160 Environmental Conditions and Test Procedures for Airborne Equipment

2.2 Definitions

A-BASIS: A statistically based material property; a 95% lower confidence bound on the first percentile of a specified population of measurements. Also, a 95% lower tolerance bound for the upper 99% of a specified population.

BARELY VISIBLE IMPACT DAMAGE (BVID): The maximum damage size that is on the threshold of detectability for the selected inspection method. The inspection method is often defined as general visual where the damage would be visible within arms' length under normal lighting conditions, with the damage being at the threshold of detectability.

BATCH: One (continuous) impregnation run from a standard or extended roll(s) of the same type of cloth joined together and run through the same resin mix solution.

B-BASIS: A statistically based material property; a 95% lower confidence bound on the tenth percentile of a specified population of measurements. Also, a 95% lower tolerance bound for the upper 90% of a specified population.

BUILDING BLOCK: A synergistic analysis/test approach to conduct analysis and associated tests at various levels of structural complexity, often beginning with small specimens and progressing through structural elements and details, subcomponents, components, and finally the complete full-scale product. Each level builds on knowledge gained at previous, less complex levels. This substantiation process, using both testing and analysis in a program of increasingly complex levels, has become known as the "building block" approach.

COMPOSITE: Materials made from two or more constituent materials with significantly different physical or chemical properties that, when combined, produce a material with characteristics different from the individual components.

ENVIRONMENTAL FACTOR: If material allowable at ambient condition is F_o and changed allowable at extreme condition is F_e , then the environmental factor will be F_o/F_e .

EQUIVALENCY: The process by which material properties that are normalized in the original qualification should be compared with normalized properties of the follow-on material for statistical testing purposes. A successful material equivalency demonstration does not imply that the follow-on material or follow-on process will also yield equal properties at laminate, element, and subcomponent levels, because the manufacturing complexity of a particular application may result in different properties.

GLASS TRANSITION TEMPERATURE: The approximate midpoint of the temperature range over which the glass transition takes place.

GLASS TRANSITION: The reversible change in an amorphous polymer or in amorphous regions of a partially crystalline polymer from (or to) a viscous or rubbery condition to (or from) a hard and relatively brittle one.

LOAD PATH INTEGRITY EVALUATION: Evaluation methods to verify continuity of load path following dynamic testing defined by the methods detailed in [4.3](#).

MANUFACTURING DEFECT: An anomaly or flaw occurring during manufacturing that can cause varying levels of degradation in structural strength, stiffness, and dimensional stability.

MATERIAL SYSTEM: A specific composite material made from specifically identified constituents in specific geometric proportions and arrangements and possessed of numerically defined properties (e.g., in-plane tension, in-plane compression).

MATERIAL VARIABILITY FACTOR: A source of variability due to the spatial and consistency variation of the material itself and due to variations in processing (e.g., the inherent microstructure, defect population, cross-link density, etc.). Components of material variability can be any combination of fixed effects, random effects, and random error.

NONDESTRUCTIVE INSPECTION: A process or procedure for determining the quality or characteristics of a material, part, or assembly without permanently altering the subject or its properties. Refer to AC 21-26A Section 11(c) or CMH 17-3 Section 6.3.2 for commonly used techniques.

NONDESTRUCTIVE TESTING: Broadly considered synonymous with nondestructive inspection.

OVERLOAD FACTOR: A multiplication factor applied to design loads to account environmental factors, material and process variabilities, and in-service damage to the seat structure.

PREPREG: A fabric or tape which has been saturated with an uncured resin and stored below the resin cure temperature. Woven fabric or unidirectional tape impregnated with a matrix and suitably processed (e.g., B-staged) for storage, handling purposes, and curing by heat and pressure without further additives.

PROCESS CONTROL DOCUMENT: A document that describes the raw materials, manufacturing processes, in-process testing, and alternate test methods used to document and to control variation of a supplier's product. The seat manufacturer should coordinate with the material supplier to establish that the process control document (PCD) meets their requirements such as content of the PCD, what PCD changes must be reported/approved, and who approves (in writing) the PCD.

QUALIFICATION: Also material qualification. The process of evaluating a material, using a prescribed series of tests, to establish its characteristics as produced by the baseline manufacturing process, and of either comparing the evaluation results to existing material specification requirements or using the evaluation results to define new material specification requirements.

RESIN CONTENT: The amount of resin in a laminate expressed as either a fraction or percentage of the total weight or volume.

RESIN RICH AREAS: An area whose resin content is above the maximum allowable resin content by the specification.

RESIN STARVED AREAS: An area with less than the minimum allowable resin content, sometimes causing delamination or separation between plies due to poor bonding.

ROLL: Any section of the batch furnished as a continuous strip of rolled goods onto a cylindrical mandrel for transportation and storage. The material is typically specified by a roll width and lineal length for ease of transportation and handling.

SEAT PRIMARY LOAD PATH: The components within the seat that carry the load from the occupant to the attachments of the seat to the aircraft.

SELVAGE: The woven edge portion of a fabric parallel to the warp; usually has an increased number of ends/inch.

STORAGE LIFE: That period which the material may be kept so that it retains the properties within the limits of this specification.

STRUCTURAL INTEGRITY: Load-carrying capacity of a component or member within a structure, or of the structure itself.

TAP TEST: Sometimes referred to as audio, sonic, or coin tap, this technique makes use of frequencies in the audible range (10 to 20 Hz). The tap testing is a common technique used for the detection of delamination and/or disbond. The method is accomplished by tapping the inspection area with a solid round disk or lightweight hammer-like device and listening to the response of the structure to the hammer. A clear, sharp, ringing sound is indicative of a well-bonded solid structure, while a dull or thud-like sound indicates a discrepant area.