



AEROSPACE INFORMATION REPORT

AIR6827™

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Design Considerations for Composite Secondary Structure on Landing Gear

RATIONALE

There is a need for a document that provides considerations for the design and use of composite components that is specific to landing gear secondary structure applications. This document meets that need.

FOREWORD

The regulatory certification effort for composite secondary structures on landing gears is proportionate to criticality (also complexity and novelty to the industry and/or applicant). In the absence of broader industry guidance, related criticality and proportionate certification effort guidelines are being developed concerning additive manufacturing, which could be used to support such assessments (as appropriate), e.g.,

ASTM 3572-22 Standard Practices for Additive Manufacturing – General Principles – Part Classifications for Additive Manufactured Parts Used in Aviation

EASA CM-S-008 Additive Manufacturing

NOTE 1: This SAE Aerospace Information Report (AIR) is considered to be appropriate to support new design, repair, and “repair by replacement” following established regulatory processes. However, it should be noted that repair and “repair by replacement” for composite applications of any safety criticality is not considered to be adequately mature to be progressed without the original design organization support.

NOTE 2: All appropriate regulations, e.g., per AC 20-107B/AMC 20-29, should be addressed proportionately to safety criticality.

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1. SCOPE

This AIR provides commonly used design considerations for using composite component parts as secondary structures in landing gear applications.

NOTE: Secondary structure refers to structures which lie outside of primary load paths, and whose failure does not impact continued safe flight and landing or reduce the structural integrity of the airframe and landing gear. Examples of landing gear and general secondary structure are listed in Section 4.

1.1 Purpose

The purpose of this AIR is to provide general guidance for typical practices in the design of composite landing gear secondary structures where the use of composites may enable enhanced performance with cost and/or weight savings. Compliance with this report is not considered approval for installation on any category aircraft or helicopter.

NOTE 1: The Certifying Authority for the platform for which the equipment is intended should be consulted for concurrence with the approaches proposed herein as an acceptable qualification demonstration for composite landing gear components.

NOTE 2: It is important that the correct safety criticality classification has been established for the application (supported by appropriate threat and safety assessments, which extend beyond basic functionality, e.g., also considering the potential for debris impact, system jams, runway debris, etc.).

1.2 Application

This AIR applies to the design of secondary structure composite landing gear components in strength, fatigue, and endurance (if applicable). The current version of this document focuses on the use of Polymer Matrix Composites but might also apply to other composite materials such as Metal Matrix Composites although they are not explicitly discussed herein.

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.

AIR5552 Development and Qualification of Composite Landing Gears

AS1241 Fire Resistant Phosphate Ester Hydraulic Fluid for Aircraft

R-424 Composite Materials Handbook Volume 3 - Revision G

2.1.2 Code of Federal Regulations (CFR) Publications

Copies of these documents are available online at <https://www.ecfr.gov>.

14 CFR Part 25 Airworthiness Standards: Transport Category Airplanes

2.1.3 EASA Publications

Available from European Union Aviation Safety Agency, Konrad-Adenauer-Ufer 3 D-50668 Cologne, Germany, Tel: +49 221 8999 000, www.easa.europa.eu.

AMC 20-29 Composite Aircraft Structure

CS-25 Large Aeroplanes

2.1.4 FAA Publications

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

AC 20-107B Composite Aircraft Structure

AC 23-19A Airframe Guide for Certification of Part 23 Airplanes

DOT/FAA/AR-03/19 Material Qualification and Equivalency for Polymer Matrix Composite Material Systems

2.1.5 RTCA Publications

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

RTCA DO-160 Environmental Conditions and Test Procedures for Airborne Equipment

2.1.6 U.S. Government Publications

Copies of these documents are available online at <https://quicksearch.dla.mil>.

MIL-PRF-5606 Hydraulic Fluid, Petroleum Base; Aircraft, Missile, and Ordnance

MIL-PRF-83282 Hydraulic Fluid, Fire Resistant, Synthetic Hydrocarbon Base, NATO Code Number H-537

MIL-PRF-87257 Hydraulic Fluid, Fire Resistant; Low Temperature, Synthetic Hydrocarbon Base, Aircraft and Missile

MIL-STD-810 Environmental Engineering Considerations and Laboratory Tests

2.2 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.2.1 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.

AIR5914 Landing Gear Fatigue Spectrum Development For Part 25 Aircraft

ARP1311 Landing Gear Structures and Mechanisms

ARP5644 Landing Gear Shock Absorption Testing of Civil Aircraft

3. APPROACH

3.1 Pyramid or Building Block Testing

To define the strength and fatigue capabilities of composite components, their properties must be determined by structural analysis and/or test. Typically for primary structural components, a pyramid or building block approach is employed where analyses are combined with tests at various levels of structural complexity. Going up this pyramid, the number of test specimens decreases, while the test complexity increases.

During a program, these building block levels are linked with supporting technologies and design considerations. This is depicted in Figure 1.

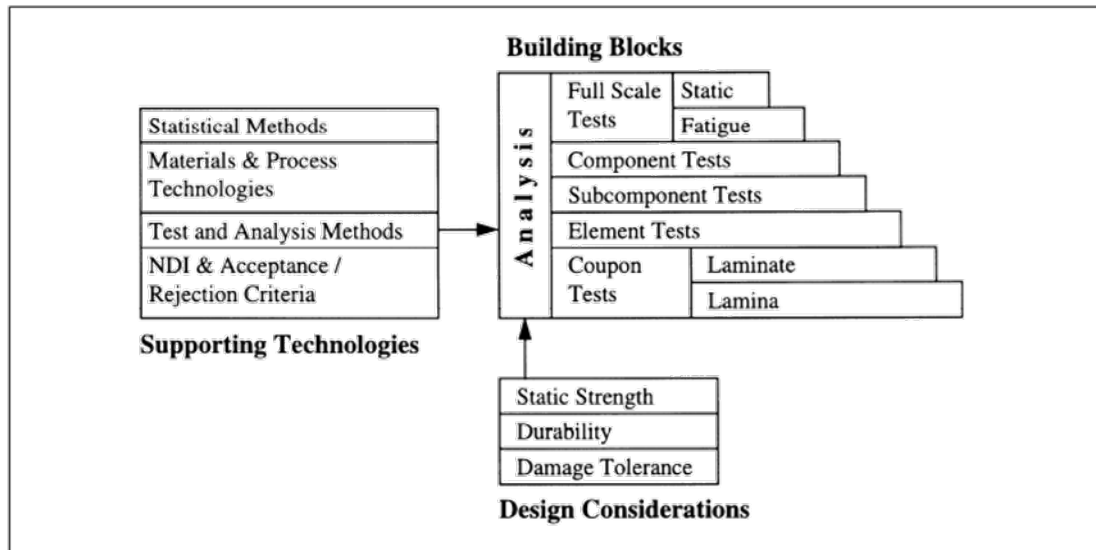


Figure 1 - Building block approach from R-424
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Simple coupons or specimens are tested at the lowest level to statistically determine the material strength and stiffness allowables. Once the simple coupon values are determined, more complex multi-directional coupon properties are developed by test until ultimately the component level properties are defined. The building block approach would include the critical service environmental conditions in deriving the material properties and allowables. There should be enough tests selected to ensure statistically significant results.

Because of the complex, anisotropic mechanical response of composite materials, modifying factors as traditionally used in metal components, like stress concentration factors found in handbooks, cannot be used. Instead, the properties of critical details are normally substantiated by using structural element or sub-component tests representing local composite architecture and design details. Also, scaling of structural elements as seen in metal design solutions is generally not possible in composite designs, and extensive testing and analyzing is necessary.

Although the building block approach is widely acknowledged, details are not universal and may be program and component specific. For more information on the building block approach, refer to R-424.