Available online at www.sciencedirect.com

ScienceDirect

Procedia Engineering 80 (2014) 101 – 109

Procedia Engineering

www.elsevier.com/locate/procedia

3rd International Symposium on Aircraft Airworthiness, ISAA 2013

# Analysis of the technical issues and certification considerations in the airworthiness work of boned structures

Meng BAI[a*], Yan LI[a], Youdan LIU[a], Ning YUE[a]

[a]*Airworthiness Technology Research and Management Center, China Aero-polytechnology Establishment, AVIC Jingshun Rd. 7, Chaoyang District, Beijing 100028, China*

**Abstract**

The adverse properties of composite bond structure, such as complex process and environmental sensitivity, are complex and challenge the airworthiness work of it. Based on the advanced technical research in bonded structures and the successful engineering practices employed in the industry, the technical issues and certification considerations in the bonded structures' airworthiness work are analyzed so as to provide information considered as guidelines or recommendations for the airworthiness work of boned structures. The key technical issues in bonded structures' airworthiness work include: (1) material and process qualification and control, (2) design development and structural substantiation, (3) manufacturing implementation, (4) repair implementation, (5) service experience. The certification considerations in bonded structures' airworthiness work include: (1) design and construction, (2) structural substantiation, (3) production, (4) continued airworthiness, (5) other elements.



Selection and peer-review under responsibility of Airworthiness Technologies Research Center, Beihang University/NLAA.

*Keywords:* airworthiness; composite; bonded structure; technical issue; certification consideration

## 1. Introduction

The advantages of bonded structures over conventional mechanically fastened structures are well known, and this technology is widely used in both aircraft manufacturing and maintenance [1]. However, with the more widespread use of bonded structures for civilian aircraft, more and more technical issues emerge such as complex process and environmental sensitivity, which challenge the airworthiness work of boned structures. The complicity of bonding technical issues requires the government agencies and the

* Corresponding author, Engineer. Tel.:+86 15210808954; fax: +86 01064682871.
*E-mail address*: baimeng_2008@126.com


Selection and peer-review under responsibility of Airworthiness Technologies Research Center, Beihang University/NLAA.
doi:10.1016/j.proeng.2014.09.066

aircraft industry combine their adhesive bonding experiences and technical insights to gain mutual safety benefits. In 1999, the Federal Aviation Administration (FAA) cooperate with industry, government agencies and academia, and established the Composite Safety and Certification Initiatives (CS&CI) program for work to update certification guidance materials (such as “Static Strength Substantiation”, “Materials Qualification and Equivalency”) and support standardized composite engineering practices. In 2004, the FAA conducted a survey and two workshops to benchmark industry practices for structural bonding.

Based on the advanced technical research in bonded structures and the successful engineering practices employed in the industry, this paper analyzes the technical issues and certification considerations in the bonded structures’ airworthiness work so as to provide information considered as guidance or recommendations for the airworthiness work of boned structures.

## 2. Technical issues in the airworthiness work of bonded structures

Key technical issues for bonded structures depend on many factors because of the complicity [2]. So, successful applications rely on coordinated engineering work, which crosses several disciplines including material, process, design, analysis, manufacturing and repair. The bonded interface between substrate and adhesive materials contributes to the complexity. In addition, controls have been developed for all the material or process used in aircraft structure so as to yield a bond with reliable and repeatable performance.

The structural integrity and long-term durability of materials and processes used in bonding should be demonstrated so that they can meet the qualification standards. Once qualified, the use of material and process controls can ensure these standards are met in subsequent production and maintenance activities. Except the factors of manufacturing, tooling and maintenance considerations, the design of bonded joints, attachments or repair details also needs to consider the load paths and local stress distribution. The implementation of bonding procedures, process controls, documentation, and training in either manufacturing or repair, or both, ensure the reliable production of the proven structural concept.

### *2.1. Structure Material and Process Qualification and Control*

In qualification, the stiffness, strength, durability and reliability of bond materials and processes for aircraft applications are demonstrated. Such efforts begin with defining bonding processes and selecting compatible substrate, adhesive, and ancillary materials.

Evaluate structural performance, environmental effects and long-term durability in qualification tests. Also, it is important to establish processing tolerances, material handling and storage limits, and key characteristics and process parameters to monitor in quality control [3]. Most bond failures and problems in service are due to invalid qualifications or insufficient quality control of production processes.

The bonded joint design configuration, loading requirements, environmental conditions and chemical resistance to fluids found in service should be considered when choosing adhesive and substrate material. Reduction in strength properties at the maximum operating temperature (MOT) should be known for each application.

Define the bond fabrication procedures and perform the trials that demonstrate compatibility between the substrates, adhesive, and processes. Some of the most important process steps relate to substrate storage, handling, and surface preparation. Reliable adhesive bonding depends on a surface free of contamination, a chemically active surface, and a surface resistant to hydration.

The storage, handling, and surface preparation procedures depend on the specific substrate and adhesive materials.