



AEROSPACE INFORMATION REPORT

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(R) Teaching Points for a Class on
"Critical Issues in Composite Maintenance, Repair and Overhaul"

RATIONALE

This document provides a list of learning objectives and teaching points which can be used to establish and/or evaluate a course or training in the areas of maintenance, modification and repair of composites.

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1. SCOPE

This document is to be used as a checklist by curriculum developers to create courses or training for critical composite repair, maintenance, and overhaul issues. This document will not take the place of courses or training requirements for specific job roles of a composite repair technician, inspector or engineer.

1.1 Purpose

The purpose of this AIR is to establish a standard teaching checklist for a course covering the critical technical issues associated with the maintenance, repair, and overhaul of composite aircraft structures. This document describes Terminal Course Objectives (TCO) and teaching points, which in combination serve as a course checklist for organizations developing a course or training.

1.2 Field of Application

This AIR can be used to develop a course or training for employees working in Maintenance, Repair and Overhaul organizations (MROs), Original Equipment Manufacturing (OEM), and operators. It also can be used to create a course for inspectors for regulation agencies, for example. It is intended to address critical composite structural safety and certification issues related to safety, but not provide training for specific skills for inspectors, technicians and engineers. Skill-building training is outside the scope of this document.

1.3 Form

This document provides an outline of topics, TCOs which indicate student learning expectations for each section of a course, and teaching points that should be covered within each TCO for Sections 4 through 7. TCOs are typically listed at the second numbering sequence (e.g., 4.1) in this document, with the exception of Section 3 which lists TCOs at the third numbering sequence (e.g., 3.1.1). Section 3 (Base Knowledge) only refers to the expected learning outcomes, or TCOs, in preparation for the subsequent sections which focus on specific teaching points in conjunction with TCOs.

2. 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 the referenced documents takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

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.

AIR4844	Composites and Metal Bonding Glossary
AIR4938	Composite and Bonded Structure Technician/Specialist Training Document
AIR5278	Composite and Bonded Structure Engineers: Training Document
AIR5279	Composite and Bonded Structure Inspector: Training Document
AIR5367	Machining of Composite Materials, Components and Structures
AIR5431	Repair Tooling
ARP4916	Masking and Cleaning of Epoxy and Polyester Matrix Thermosetting Composite Materials
ARP4977	Drying of Thermosetting Composite Materials

ARP4991	Core Restoration of Thermosetting Composite Components
ARP5089	Composite Repair NDT/NDI Handbook
ARP5143	Vacuum Bagging of Thermosetting Composite and Metalbond Repairs
ARP5144	Heat Application for Thermosetting Resin Curing
ARP5256	Mixing Resins, Adhesives and Potting Compounds
ARP5319	Impregnation of Dry Fabric and Ply Lay-Up
AE-27	Design of Durable, Repairable, and Maintainable Aircraft Composites

2.2 Other Industry Publications

AC 43-214	Repair Stations for Composite and Bonded Aircraft Structure
14 CFR	Part 147 Aviation Technician Schools
CMH-17	Composite Material Handbook 17

3. BASIC KNOWLEDGE

Basic knowledge in the technology of composite materials is provided to those students having limited understanding of composite materials technology. Prior to the exposure to critical and more advanced issues involved with the maintenance and repair of composite materials in commercial aerospace applications (Section 4 and subsequent sections), the student must understand the fundamentals of the technology as a basis for follow-on learning. This subject will provide an overview of maintenance and repair, to be later reinforced in the main course outlined in Section 4 and subsequent sections. Included in base knowledge are: (1) a description of basic materials technology and terms, (2) an introduction to maintenance and repair, (3) descriptions of other critical elements, such as coatings and selection criteria for bolted and bonded repairs, and (4) developments in materials research relating to composite maintenance and repair. Due to the overview nature of the base knowledge in Section 3, only TCOs and subordinate objectives are listed.

3.1 Basics of Composite Materials

The student will understand the basics of composite materials technology. This material is intended to provide fundamental concepts and terminologies to the student who has had minimal exposure to composites' technology. Terminologies, material applications, processing, and properties are covered at a summary level. For students requiring this level of knowledge, this content is best taught initially in the awareness course in preparation for more advanced learning in later topics.

- 3.1.1 The student will describe the different properties and uses of adhesives, resins, fibers, and core.
- 3.1.2 The student will describe how pressure, temperature and time at cure can have positive or negative effects on the strength of a composite part. The student will also explain how cleanliness can affect the quality of bonding.
- 3.1.3 The student will describe composite material properties and general failure modes.
- 3.1.4 The student will describe finishing requirements that include environmental effects and electrical conductivity.
- 3.1.5 The student will differentiate between solid laminate and sandwich core structure.
- 3.1.6 The student will identify sources that define the terms used in metal-bond and composite structures (such as AIR4844, CMH17 or OEM structural repair manuals (SRM)).

3.2 Basics of Composite Materials Safety Issues, Maintenance and Repair

The student will understand the basics of composite materials maintenance and repair. This material is an introduction to composite materials maintenance and repair. It previews the fundamental maintenance procedures which will be considered in more depth later in the course, and includes processing materials, tooling and equipment. This content is best taught following the composites materials technology summary presentation, and prepares the student for later teaching materials which focus on safety issues, maintenance and repair processes.

- 3.2.1 The student will list the basic repair process from damage detection through repair completion for a simple composite repair.
- 3.2.2 The student will list key composite and expendable materials needed for simple composite structure repair including storage requirements.
- 3.2.3 The student will list the necessary tooling and equipment to accomplish a simple composite structure repair.
- 3.2.4 The student will explain personal and equipment safety requirements.
- 3.2.5 The student will describe the differences between repairing composite and metal structures, including discussions on the special issues related to composite and metal bonding.
- 3.2.6 The student will describe the basic repair process of metal bonding.
- 3.2.7 The student will describe the sources of approved repair instructions and the importance of using approved data, methods and procedures.
- 3.2.8 The student will describe the implications of physical and geometrical differences when choosing between a bonded repair and a bolted repair.
- 3.2.9 The student will discuss the importance of special coating restoration for electrical conductivity, lightning protection and key measures for corrosion prevention during the repair process.
- 3.2.10 The student will describe typical paint and surface layer removal techniques for finished composite parts.
- 3.2.11 The student will describe the proper disposal of wastes from the composite repair process.
- 3.2.12 The student will describe personnel repair skill limits and the sources for assistance when the repair is beyond a skill limit.
- 3.2.13 The student will describe the importance of documenting and sharing information about damage scenarios discovered in service between OEMs, MROs and regulators.

3.3 Research and Industry Developments

At the end of this unit the student will be aware of composite maintenance research and industry developments. As a relatively new technology, composite material development and practice continues to evolve. This unit will provide an overview of some of the key advances and stimulate further research into these advances.

- 3.3.1 The student will explain the general lack of standards available for composite engineering practices with the perspective that composite maintenance and repair require special acquired skills.
- 3.3.2 The student will discuss emerging advances in repair process technologies that may appear for bonded and bolted repair and quality control. The need for industry to properly substantiate emerging repair process technology before it can be applied to certify products will be introduced.
- 3.3.3 The student will discuss emerging damage and repair inspection technologies, such as bond testing, moisture meters, and interferometer (3D characterization). The need for industry to properly substantiate emerging inspection process technology before it can be applied to certify products will be introduced.

3.3.4 The student will discuss advances in composite repair analysis and design, which may be used by engineers to develop a repair for aircraft structure.

4. TEAMWORK AND DISPOSITION

This section highlights the importance of teamwork to assure safety through the entire repair process which includes identification, inspection, repair design/implementation and post repair assessment. Each member of the team must have training for the specific tasks to be performed. Trained engineers, inspectors and technicians will work as a team from the time of damage detection until an approved repair is properly completed. An approved repair design and process for composite structures requires an interface with organizations having the necessary skills and data to substantiate structural integrity of the repair per local regulatory agency rules.

4.1 Skills, Roles and Responsibilities of Team Members

The student will identify skills, roles and responsibilities of the team members, including engineers, inspectors and technicians. The linkage between team members and personnel that report possible damage, such as pilots, operations and line/ramp maintenance personnel, is included. The content introduces several subjects covered in greater depth by other sections, such as an overall view of composite inspection, damage disposition and repair process, and documents used to guide the team on approved repair processes.

4.1.1 Structures Engineer

The structures engineer is responsible for defining damage assessment, repair design and implementation, process planning, repair documentation, post repair assessment and required approvals.

4.1.1.1 Education and Skills

The structures engineer at the OEM, operator or MRO should have the equivalent of a Bachelor of Science engineering degree from an accredited academic institution, with some formal training in composite aircraft structural analysis. Also required is a detailed knowledge of the specific aircraft structural components, source and regulatory documents.

4.1.1.2 Damage Assessment

The structures engineer will have knowledge and training to identify type and extent of damage, interpret inspection results and exercise engineering judgment related to overall damage assessment and structure criticality.

4.1.1.3 Repair Design

- Approved and/or acceptable data must be used to design repairs.
- Repairs to structure that are critical to safety of flight are subject to the same regulatory requirements as the original design, such as flammability, fatigue and damage tolerance.
- Repairs to moveable control surfaces must consider the effects on the overall part stiffness, weight, balance and flutter characteristics.
- Maintenance records must be reviewed for previous repairs and/or allowed damage.
- Regulatory procedures for repair design, process planning, and approval must be followed in the event an SRM or equivalent approved repair does not exist.
- Repair category A, B or C must be identified.
 - o Category A – Permanent Repair – No additional inspections
 - o Category B – Permanent Repair – Supplemental inspections
 - o Category C – Time Limited

4.1.1.4 Process Planning

Adhering to materials and process specifications and maintaining proper process control is critical for assuring that an approved repair is completed.

4.1.1.5 Repair Documentation

Repair design and process instructions in approved documentation must be in accordance with regulatory and OEM requirements. Repair designs and processes in approved documents must not be extended to components or zones other than those specified.

4.1.1.6 Post Repair Assessment

Post repair inspections and frequency of inspections, damage tolerance and durability must be determined.

4.1.2 Inspector

The inspector is responsible for damage characterization, repair implementation, repair documentation, post repair assessment and required approvals.

4.1.2.1 Education and Skills

The inspector should have formal training inspecting composite structures by using various techniques. The inspector shall have good eyesight and hearing; this may be corrected or uncorrected. Inspectors trained for nondestructive inspection (NDI) may need different levels of certification and/or training to become competent in certain methods. Familiarity with OEM drawing systems, and the approved documentation, and detailed knowledge of aircraft structure is needed.

4.1.2.2 Damage Characterization

Detailed knowledge of specific aircraft structural components and approved documentation such as the OEM SRM and NDI documentation is required. Considerations include the limitations of each NDI technique and the best way to characterize and map damage. Maintenance records must be reviewed for previous repairs and/or previously allowed damage.

4.1.2.3 Repair Implementation and Documentation

Repair design and process instructions in approved documentation must be strictly followed and properly documented. Approved workmanship and process controls must be assured to be in accordance with approved repair design.

4.1.2.4 Post Repair Assessment

Final repair must be assessed through inspection in accordance with approved repair design. Maintenance records must be updated for future repairs or allowed damage.

4.1.3 Technician

The technician is responsible for damage removal, repair implementation and documentation.

4.1.3.1 Education and Skills

The repair technician should have formal training in composite repair processing and in the use of repair equipment. The repair technician must have good manual dexterity and possess the high level of skills and experience needed for properly completing an approved composite repair. In addition, the technician should have a familiarity with OEM drawing systems, and approved documentation, and detailed knowledge of the specific aircraft structural components.

4.1.3.2 Damage Removal, Repair Implementation and Documentation

Repair design and process instructions in approved documentation must be strictly followed and properly documented. Repair designs and processes in approved documentation must not be extended to components or zones other than those specified.

4.2 Source Documentation

The student will identify and describe information contained in source documentation. Documentation includes composite maintenance and repair approved and acceptable data and/or procedures, in addition to field disposition procedures and the associated regulatory rules that must be followed. Source documents for specified structural components outline the inspection procedures and the repair design and process details, which had been previously substantiated to meet regulations. Limits on the damage and repairs covered by such documents are needed to control field disposition. Knowledge of the regulatory rules and the test data and analysis needed for structural substantiation provides a basis in gaining approval for repairs outside the limits.

4.2.1 Material and Process Specifications

All composite materials and processes used in aircraft structural fabrication and repair must meet accepted specifications. Material and process specifications include:

4.2.1.1 Quality control requirements, specimen fabrication, test methods, inspection procedures and acceptance criteria.

4.2.1.2 Reference process documents needed for fabrication of specimens used in quality control.

4.2.1.3 Shipping and handling requirements used to ensure the material storage and working life.

4.2.2 Approved Repair Information

All composite repair designs and processes must be approved and substantiated by proven analysis and/or test data demonstrating that the repair meets the appropriate structural requirements and regulations.

4.2.2.1 Structural design drawings provide details needed to perform composite damage inspection, disposition and repair.

4.2.2.2 The OEM's SRM or other authorized source documentation provides:

4.2.2.2.1 Detection and inspection procedures needed to disposition damage.

4.2.2.2.2 Allowable damage and repair size limits.

4.2.2.2.3 Acceptable repair designs and processes for the specified damage sizes and locations described for a given structure.

4.2.2.2.4 Design and process details for time limited and permanent composite repairs, including specified limits for their use.

4.2.2.3 Damage that requires inspection and repair outside the limits of source documents must be reported to inspectors and engineers that can gain the necessary regulatory approvals for proper damage disposition and repair. Alternatively, the part may be replaced following approved procedures.

4.2.3 Supporting Documentation

Other documentation which provides information in support of approved repairs may include the following but not limited to:

4.2.3.1 Specifications and other processing documents which are used for detailed repair process planning, step by step instructions and quality control (in-process and post-process inspection).

4.2.3.2 Maintenance planning documents and manuals which provide specific inspection procedures, overhaul instructions, repair designs and processes and other maintenance requirements for a specific aircraft.

4.2.3.3 Service bulletins and newsletters which are based on field history may be used to supplement previous maintenance and documented repair information.

4.2.4 Regulatory Documentation

Documentation is issued by regulatory authorities with jurisdiction for continued airworthiness of civil aircraft.

4.2.4.1 Regulatory Authority Responsibilities

Aircraft operating to or within foreign jurisdictions must meet the regulatory requirements of the country in which the aircraft will be operating. Many countries have bilateral agreements, for example the Bilateral Aviation Safety Agreement (BASA) with U.S., to minimize duplication in the certification process. Bilateral agreements facilitate the reciprocal and initial airworthiness certification of civil aeronautical products imported and/or exported between two signatory countries. An overview of regulatory authorities and the respective regulations/advisory circulars within United States, Canada and Europe is described in Section 7 of this AIR and may be used as a checklist.

4.3 Structural Substantiation

The student will describe the importance of structural substantiation. All composite inspection and repair design, materials and processes must be substantiated to meet airworthiness regulations. Composite inspection and repair design, materials and processes not previously approved must follow the regulatory processes for structural substantiation. Important regulations for the structural substantiation of a composite repair may include strength and deformation, proof of structure, inspections and other procedures, materials and workmanship, fabrication methods, protection of structure, accessibility provisions, material strength properties and design values, damage tolerance and fatigue evaluation of structure, flutter (aero elastic stability), fire protection of flight controls, engine mounts, and other flight structure, acoustical protection and restoration, corrosion and durability protective features, flammability, electrical bonding and protection against lightning and static electricity and instructions for continued airworthiness.

4.4 Damage Disposition and Repair Process – Overview of Teamwork and Sequence of Events

The student will describe the damage disposition and repair process, and be able to recognize individual skill limits in practice and where to find assistance. All aspects of composite maintenance and repair are interlinked such that each member of a repair team should understand individual roles and complete needed training to properly complete their tasks. The student will describe critical steps necessary for making damage dispositions, including inspection and how to compose a quality control repair plan.

4.4.1 Multi-functional team members, including inspectors, technicians and engineers, assure the existence of process accountability in order to achieve proper damage disposition and repair integrity.

4.4.2 When damage to a composite aircraft component structure is first discovered, the extent of damage must be assessed by personnel qualified in the appropriate inspection techniques. The damage must first be assessed, and the extent of the damage mapped per the approved maintenance and repair documentation. Repair designs and processes must be approved by the appropriate authority, or be in compliance with approved repair documentation. Documentation must be reviewed for repair designs, processes and quality controls for specified damage.

4.4.2.1 When damage is detected during routine inspections in the maintenance depot, the instructions within the maintenance planning data (MPD) document and source documentation, such as an SRM, must be strictly followed, and maintenance records must be reviewed for previous repairs and allowed damage.

4.4.2.2 The approved repair documentation, such as the SRM, must be consulted for allowable damage limits (ADL) and repair designs. An assessment of the full extent of composite damage must be made by qualified inspectors using appropriate inspection techniques as specified in maintenance source documentation. Any available documentation must be reviewed for approved inspection techniques using, for example, NDI methods in the OEM's SRM or other approved repair instructions.

4.4.2.3 When damage is found during normal operations, it must be reported to a qualified inspector or maintenance engineer for evaluation.

4.4.2.3.1 Damage visually detected during flight operations, heavy maintenance, or directed inspection may require a more thorough inspection with methods capable of detecting non-visible damage.