SAE AIR4938 PART 2

COMPOSITE

Training

ACRATS

DETAILED COURSE OUTLINE ATS2072

COMMERCIAL AIRCRAFT COMPOSITE STRUCTURE REPAIR (SAE AIR4938 PART 2)

Course Title
Commercial Aircraft Composite Structure Repair (SAE AIR4938 Part 2)

Course Tag
SAE AIR4938 Composites Level 2

Course ID
ATS2072

Course Duration
10 Working Days

Prerequisites
General Composite Structure Repair (SAE AIR4938 Part 1)

Learning Hours
Classroom: 17 Hours
Practical 58 Hours

Highest Standards
Meets EASA, FAA and OEM SRM Standards and is fully compliant with SAE AIR 4938

Scope and Purpose

The ACRATS Level 2 Composites Training Program builds upon the foundational knowledge and skills acquired in Level 1. This curriculum, in conjunction with the Part 1 curriculum, is intended to meet the formal training requirement for individuals who intend to become certified as aircraft composite repair technicians. Participants who successfully complete this aircraft structural repair training program are considered able to perform composite bonded repairs to aircraft structures in compliance with the manufacturers' repair documentation or other acceptable or approved repair data. Participants will gain advanced knowledge and practical expertise in various aspects of composite materials, repair processes, and inspection techniques, preparing them for more complex repair tasks in the aviation industry.

Course Module Overview

- Introduction to Aircraft Composite Structure
- Composite Structure Classification and Repair Categories and Repair Team Roles and Responsibilities
- Aircraft-Specific Repair Material Requirements
- Matrix Systems
- Safety and Environment
- Adhesives Review
- Aircraft Design Considerations
- Heat Transfer and Cure Cycle Management
- Source Documents Review
- Bonded Repair Design Considerations
- Inspection Techniques
- Damage Assessment
- Hands-on Exercises

Selection of the Learning Goals

Upon successful completion of this training, the student will be able to:

- Describe composite materials and their applications in aircraft structures;
- Identify team member skills, roles, and responsibilities in composite repair processes;
- Verify that repair materials match the specifications called for in the repair documentation;
- Understand the differences between thermoplastic and thermosetting matrix materials, and describe their roles, limitations, and handling requirements;
- State the personal hazards of working with polymeric materials and select the recommended personal protection equipment (PPE);
- Explain the properties and applications of adhesives, and identify the adhesive materials required per the repair documentation;
- Describe the design considerations for aircraft structures, including benefits and limitations of sandwich structures, solid laminates, and joint types;
- Operate and control heat application equipment to meet repair cure cycle requirements;
- Describe common OEM manuals used for composite structure repairs and understand the limitations of these manuals;
- Explain the differences between prepreg repairs, wet lay-up repairs, and bolted repairs, and calculate ply overlap dimensions;
- List various Non-Destructive Inspection (NDI) techniques and perform visual, tap test, and low-skill instrumented inspections;
- Assess damage to composite structures and map the limits of damage using appropriate inspection methods;
- Perform hands-on repairs to fiber-reinforced structures using wet lay-up and prepreg materials, vacuum bagging techniques, and hot bond equipment;
- Complete a practical assessment to demonstrate the ability to perform the entire repair process, from damage assessment to post-repair inspection, ensuring quality and compliance with repair documentation.

	Topic	Teaching Level	Classroom Hours	Practical Hours
1	Introduction to Aircraft Composite Structure	1	1	
2	Composite Structure Classification, Repair Categories and Repair Team Roles and Responsibilities	1	1	
3	Aircraft-Specific Repair Material Requirements	1	1	
4	Matrix Systems	2	1	
5	Safety and Environment	1	0,5	
6	Adhesives Review	1	0,5	
7	Aircraft Design Considerations	1	2	
8	Heat Transfer and Cure Cycle Management	3	2	
9	Source Documents Review	2	2	
10	Bonded Repair Design Considerations	2	1	
11	Inspection Techniques	2	2	
12	Damage Assessment	3	2	
13	Hands-on Exercises and Assessment Criteria	3		46
14	Written Exam		1	
15	Practical Assessment			12
	Total Hours		17	58
	Course Length		75 Hours	

Teaching Level 1
Teaching level 1 includes the transferring of knowledge from the instructor to the student, through instruction, lecture, demonstration and by having topic-related discussions. Knowledge transfer can take place in a classroom (physical training) as well as through online learning (Computer Based Training (CBT)). The content of e-learning modules should be structured in such a way, keeping in mind that discussions are not possible (it is classified as passive learning), and the participant should be able to understand the material without the intervention of an instructor. Online classes or e-learning modules should be arranged in such a way that the participant has the opportunity to ask questions to the designated instructor or to provide (general) comments. Teaching level A does not include a practical application (hands-on) or the development of practical skills.

Teaching Level 2
Teaching level 2 includes the transferring of knowledge from the instructor to the student, through instruction, lecture, demonstration, topic-related discussions, and limited practical application, but does not include the development of sufficient manipulative skill to perform basic operations. Knowledge transfer can take place in a classroom (physical training) as well as through online learning (Computer Based Training (CBT)). The content of e-learning modules should be structured in such a way, keeping in mind that discussions are not possible (it being classified as passive learning), that the participant should be able to understand the material without the intervention of an instructor. Online classes or e-learning modules should be arranged in such a way that the participant has the opportunity to ask questions to the designated instructor, o to provide (general) comments. Online classes or e-learning modules must contain sufficient demonstration by means of explanatory videos. A high degree of interaction must be built in. Teaching level B requires some hands-on manipulative skills, or practical demonstration of the skills and their accompanying actual or simulated components/equipment, but still may be taught primarily in the classroom environment.

Teaching Level 3
Teaching level 3 includes the transferring of knowledge from the instructor to the student, through instruction, lecture, demonstration, having topic related discussions and a high degree of practical application to develop sufficient manipulative skill to accomplish return to service (normal operation). Teaching level C requires hands-on skill, as well as sufficient and appropriate instructional aides to train the participants to develop manipulative skills sufficient to simulate return to service mechanical skill. At this level, the teaching aids must be similar to or be the actual items of equipment on which the participant is expected to develop the required skill levels. A teaching level C subject cannot be taught solely by instruction or lecture in the classroom; the appropriate training aids and hands-on experience must be used. E-learning modules can be used as a guide through practical assignments. Teaching level C includes a high degree of practical application (hands-on) and a strong focus on the development of practical skills.


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Module 1 - Introduction to Aircraft Composite Structure

In Module 1, you'll learn about composite materials and their applications in aircraft structures. You will discuss the advantages and disadvantages of composite materials, their electrical and thermal conductivity, and coefficients of thermal expansion (CTE). Additionally, you will explore various applications of composite materials in the aviation industry.

Learning Goals

Upon successful completion of this module, the student will be able to:

- Describe composite materials and their applications in aircraft structures;
- Discuss the advantages and disadvantages of composite materials;
- Understand the electrical and thermal conductivity of composite materials;
- Explain the coefficients of thermal expansion (CTE) for composite materials;
- Identify various applications of composite materials in the aviation industry.

Topics

1. Advantages/Disadvantages
2. Electrical and Thermal Conductivity
3. Coefficients of Thermal Expansion (CTE)
4. Applications

Module 2 - Composite Structure Classification, Repair Categories and Repair Team Roles and Responsibilities

In Module 2, you'll learn about the classification of composite structures, repair categories, and the roles and responsibilities of team members involved in composite repair processes. You will identify the skills and responsibilities of engineers, inspectors, and aircraft maintenance technicians. Additionally, you'll understand the differences between primary, secondary, and critical structural elements, and the various categories of repairs.

Learning Goals

Upon successful completion of this module, the student will be able to:

- Identify the skills, roles, and responsibilities of team members involved in composite repair processes;
- State the differences between structural classifications and repair categories;
- Understand the roles and responsibilities of engineers, inspectors, and aircraft maintenance technicians;
- Differentiate between primary, principal structural elements (PSE), fatigue critical baseline structure (FCBS), secondary, and interior structures;
- Explain the differences between Category A and Category B permanent repairs.

Topics

1. Roles and Responsibilities
    a. Engineer (degreed)
    b. Inspector
    c. Aircraft Maintenance Technician
2. Structure Classifications
    a. Primary
    b. Principal Structural Elements (PSE)
    c. Fatigue Critical Baseline Structure (FCBS)
    d. Secondary
    e. Interior
3. Repair Categories
    a. Category A – Permanent Repair
    b. Category B – Permanent Repair

Module 3 - Aircraft-Specific Repair Material Requirements

In Module 3, you'll learn about aircraft-specific repair material requirements. You will identify and verify that the repair material matches the specifications called for in the repair documentation. This includes understanding aerospace material specifications, material certification requirements, and the process of receiving inspection, and product identification.

Learning Goals

Upon successful completion of this module, the student will be able to:

- Identify the correct repair material specified in the repair document;
- Understand aerospace material specifications;
- Comprehend material certification requirements;
- Perform receiving inspection to verify material compliance;
- Identify repair materials accurately.

Topics

1. Repair Material Requirements
    a. Aerospace Material Specifications
    b. Material Certification Requirements
    c. Receiving Inspection
    d. Product Identification

Module 4 - Matrix Systems

In Module 4, you'll deepen your understanding of matrix systems used in composite materials. You will learn about the differences between thermoplastic and thermosetting matrix materials, their roles and limitations, and their storage and handling requirements. You will also determine and calculate various mix ratios, describe the cure cycle, and understand matrix cross-linking terminologies. Additionally, you'll learn to select appropriate filler materials and calculate resin system mix ratios with fillers.

Learning Goals

Upon successful completion of this module, the student will be able to:

- State the difference between thermoplastic and thermosetting matrix materials;
- Describe the roles and limitations of matrix materials;
- Understand the storage and handling requirements for matrix materials;
- Determine and calculate various mix ratios accurately;
- Describe the cure cycle and matrix cross-linking terminologies;
- Select appropriate filler materials and calculate resin system mix ratios with fillers;
- Understand the effect of improper mix ratios and mis-cures (under-cured and over-cured).

Topics

1. Thermoplastics
2. Thermosets
3. Mixing and Mix Ratios
    a. Weight (accuracy of scales)
    b. Volume
    c. Mixing Process
    d. Improper Mix Ratios
4. Curing of Resins
    a. A, B, and C Stages
    b. Flow versus Gelation
    c. Glass Transition
    d. Viscosity
    e. Curing Reactions
    f. Effect of Mis-Cures (under-cured and over-cured)

Module 5 - Safety and Environment

In Module 5, you'll learn about safety and environmental considerations when working with polymeric materials. You will understand the personal hazards, describe the four common paths of entry, and evaluate a typical Safety Data Sheet (SDS). You will also learn to select the recommended personal protection equipment (PPE) and understand proper waste disposal procedures.

Learning Goals

Upon successful completion of this module, the student will be able to:

- State the personal hazards of working with polymeric materials;
- Describe the four common paths of entry for hazardous materials;
- Evaluate a typical Safety Data Sheet (SDS);
- Select recommended personal protection equipment (PPE);
- Understand waste disposal procedures;
- Recognize the risks of fumes, vapors, dust, and skin contact;
- Comprehend exothermic reactions and flammability concerns.

Topics

1. Fumes, Vapors, and Dust
2. Skin Contact
3. Safety Data Sheet (SDS)
4. Personal Protective Equipment (PPE)
5. Exothermic Reactions
6. Waste Disposal
7. Flammability

Module 6 - Adhesives Review

In Module 6, you'll review the properties and applications of adhesives used in composite repairs. You will learn about the correct applications of adhesives, surface preparation requirements, bond line control methods, and common failure modes. Additionally, you will identify the adhesive materials required per the repair documentation.

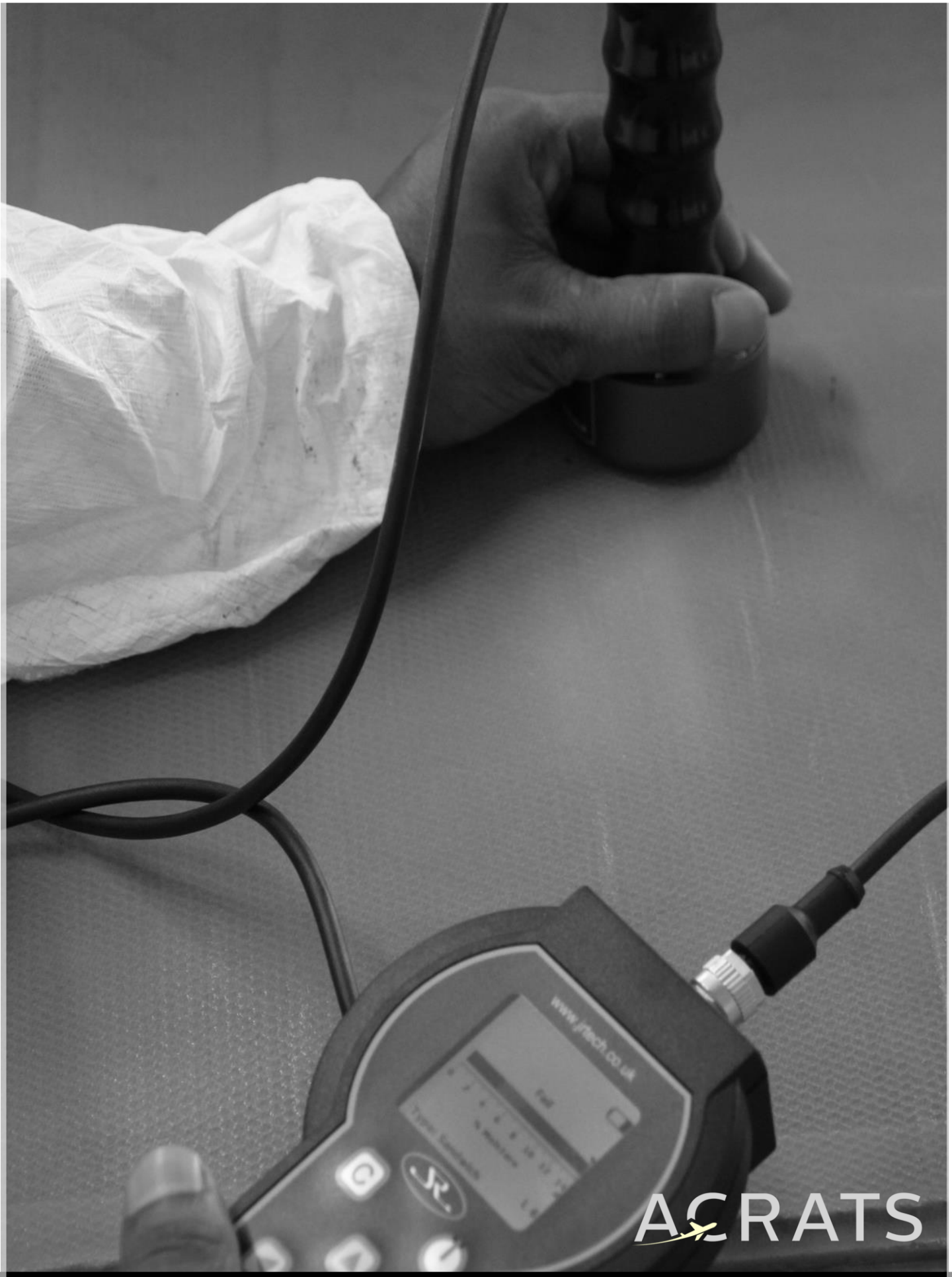
Learning Goals

Upon successful completion of this module, the student will be able to:

- Explain the properties and correct applications of adhesives;
- Understand surface preparation requirements for adhesive bonding;
- Describe bond line control methods;
- Identify common adhesive failure modes;
- Recognize the adhesive materials required per the repair documentation.

Topics

1. Film
2. Liquid
3. Paste
4. Supported/Unsupported
5. Surface Preparation
6. Bond Line Control
    a. Micro Beads
    b. Carriers
    c. Scrim Cloth
    d. Knit
    e. Veil
7. Failure Modes
    a. Adhesion
    b. Cohesion
8. Foams
    a. Core Splice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Module 7 - Adhesives Review

In Module 7, you'll learn about the design considerations for aircraft structures. You will explore the benefits and limitations of sandwich structures, solid laminate structures, and solid laminate monolithic structures. Additionally, you'll understand different joint types, electromagnetic effects, ply layup, protective coatings, and sealant requirements. The module will also cover impact resistance, balance and symmetry, and other critical factors in aircraft design.

Learning Goals

Upon successful completion of this module, the student will be able to:

- Describe the benefits and limitations of sandwich structures and solid laminate structures;
- Explain solid laminate monolithic structures and their applications;
- Understand different joint types, including bolted and bonded joints;
- Describe electromagnetic effects (EME) and conductive layers in composite structures;
- Explain the requirements for protective coatings and sealants;
- Understand impact resistance, balance and symmetry in aircraft design;
- Describe other design considerations such as acoustic properties, sonic fatigue, elevated surface temperature requirements, erosion protection, galvanic compatibility, and transmissivity.

Topics

1. Typical Sandwich Design
2. Solid Laminate and Monolithic Design
3. Advantages/Disadvantages of Solid Laminates versus Sandwich Structures
4. Joint Types
    a. Bolted
    b. Bonded
5. Impact Resistance
6. Balance and Symmetry
7. Electromagnetic Effects (EME)
8. Conductive Layers
9. Sealants
10. Primers
11. Finishes
12. Acoustic Properties
13. Sonic Fatigue
14. Elevated Surface Temperature Requirements
15. Erosion Protection
16. Galvanic Compatibility
17. Transmissivity

Module 8 - Heat Transfer and Cure Cycle Management

In Module 8, you'll learn about heat transfer and cure cycle management for composite repairs. You will operate and control heat application equipment to meet repair cure cycle requirements. Additionally, you'll understand the principles of heat transfer and how they affect the ability to meet these requirements. The module will cover the usage of various heat application equipment, thermocouple placement, and insulation and airflow control.

Learning Goals

Upon successful completion of this module, the student will be able to:

- Operate and control heat application equipment to meet repair cure cycle requirements;
- Describe the principles of heat transfer;
- Understand how heat transfer affects the ability to meet cure cycle requirements;
- Use various heat application equipment effectively;
- Place thermocouples correctly for temperature monitoring;
- Manage insulation and airflow control during the curing process.

Topics

1. Heat Transfer Basics
2. Equipment Usage
    a. Autoclave
    b. Oven
    c. Hot Bonders
    d. Heat Blankets
    e. Hot Air Blower
    f. Infrared
    g. Heat Lamps
3. Thermocouple Placement
4. Insulation and Airflow Control

Module 9 - Source Documents Review

In Module 9, you'll review common OEM manuals and documents used for repairing composite structures. You will learn about the limitations of these documents and the importance of following written instructions during repairs. Additionally, you will locate appropriate maintenance data for a given aircraft composite part and understand the various types of source documents and their specific purposes.

Learning Goals

Upon successful completion of this module, the student will be able to:

- Describe common OEM manuals used for composite structure repairs;
- Understand the limitations of using these manuals;
- State the importance of following written instructions for repairs;
- Locate appropriate maintenance data for a given aircraft composite part;
- Identify and understand various types of source documents and their specific purposes.

Topics

1. ATA iSpec2200/S100D
2. Structural Repair Manuals
    a. Allowable Damage Limits (ADL)
    b. Repair Limits
3. Component Maintenance Manual
4. Engineering Orders
5. Maintenance Organization Specific Documents
6. SAE AMS-CACRC ARPs
7. Regulatory Documents
    a. Airworthiness Directives
    b. Service Bulletins
    c. Advisory Circulars
    d. Rule Making Task
8. Material and Processes Specifications
    a. OEM
    b. Vendor
    c. Internal

Module 10 - Bonded Repair Design Considerations

In Module 10, you'll learn about the design considerations for bonded repairs. You will understand the differences between prepreg repairs, wet lay-up repairs, and bolted repairs. Additionally, you'll learn about various sanding and ply stack-up techniques. The module will also cover how to calculate ply overlap dimensions using 50:1 and 30:1 taper ratios for different ply face sheets using carbon and fiberglass plies.

Learning Goals

Upon successful completion of this module, the student will be able to:

- Describe the differences between prepreg, wet lay-up, and bolted repairs;
- Explain sanding and ply stack-up techniques;
- Calculate ply overlap dimensions using 50:1 and 30:1 taper ratios for different ply face sheets;
- Understand the design considerations for various repair methods;
- Recognize the limitations and requirements for repair areas.

Topics

1. Repair Design
    a. Prepreg
    b. Wet Lay-Up
    c. Support Tooling Requirements
    d. Doubler Overlay
    e. Pre-Cured Patch
    f. Bolted
    g. Nonstructural (cosmetic)
2. Taper Sanding and Step Sanding
3. Part Drying Requirements
    a. Physical Water
    b. Absorbed Moisture
4. Ply Stack-Up
    a. Small Ply Down
    b. Large Ply Down
5. Repair Area Limitations


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Module 11 - Inspection Techniques

In Module 11, you'll learn about various Non-Destructive Inspection (NDI) techniques and their limitations when used in the manufacture and repair of composite structures. You will practice performing visual inspections, tap tests, and low-skill instrumented inspections. Additionally, you'll learn how to correctly map damaged areas and understand different types of damage and inspection methods.

Learning Goals

Upon successful completion of this module, the student will be able to:

- List various Non-Destructive Inspection (NDI) techniques and their limitations;
- Perform visual inspections, tap tests, and low-skill instrumented inspections;
- Correctly map damaged areas;
- Understand different types of damage in composite structures;
- Compare NDI techniques for metal versus composite structures.

Topics

1. Types of Damage
2. Pre- and Post-Repair Inspection
3. Visual
4. Tap Testing (this method is to be taught to teaching Level 3)
5. Low-skill Inspection Instrument (this method is to be taught to teaching Level 3)
6. Ultrasonic (Pulse-Echo, TTU, Bondtesters)
7. Thermography
8. X-Ray
9. FT-IR (Fourier Transform Infrared for heat damage)
10. Comparison of NDI Techniques for Metal versus Composite Structure

Module 12 - Damage Assessment

In Module 12, you'll learn how to assess damage to composite structures. You will identify material types, sizes, and the number of plies, and map the limits of damage using visual inspections, tap tests, or appropriate NDI methods. This module will cover part identification, material identification, ply identification, damage mapping, and understanding SRM repair zones.

Learning Goals

Upon successful completion of this module, the student will be able to:

- Assess damage to identify material type, size, and number of plies;
- Map the limits of damage using visual inspections, tap tests, and NDI methods;
- Identify parts and materials correctly;
- Understand damage mapping techniques for visible and non-visible damage;
- Utilize Structural Repair Manuals (SRM) for identifying repair zones.

Topics

1. Part Identification
2. Material Identification
3. Ply Identification
4. Damage Mapping (Sizing)
    a. Visible Damage
    b. Non-visible Damage
    c. Inspection Techniques
5. SRM Repair Zones

Module 13 - Hands-On Exercises and Assessment Criteria

In Module 13, you'll engage in extensive hands-on exercises to develop the skills necessary for repairing fiber-reinforced structures using wet lay-up and prepreg materials, vacuum bagging techniques, and hot bond equipment. You will perform various repairs on honeycomb sandwich parts, foam-cored parts, and parts with significant curvature. This module will ensure you can meet the criteria outlined in repair documentation, including damage assessment, material identification, and proper cure cycles.

"For some of the repairs, foam-cored parts are an alternative to honeycomb parts. At least one of the repairs must be a fiberglass part. At least 50% of the repairs must use a hotbonder as the control method. At least one of the repairs must require restoration of the electromagnetic effects (EME) surface layer. At least one of the repairs is to be a part with a significant curvature."

Learning Goals

Upon successful completion of this module, the student will be able to:

- Repair fiber-reinforced structures using wet lay-up and prepreg materials;
- Utilize vacuum bagging techniques and hot bond equipment effectively;
- Perform repairs on honeycomb sandwich parts with skin and core damage;
- Conduct repairs on parts with significant curvature and restore electromagnetic effects (EME) surface layers;
- Meet repair documentation criteria, including damage assessment, material identification, and proper cure cycles.

Assessment Criteria

- ✓ Damage Assessment;
- ✓ Core removed without causing additional damage to far side inner skin;
- ✓ Taper sanding meets repair document requirements;
- ✓ Correct material and orientation of original plies identified;
- ✓ Repair plies positioned and oriented correctly;
- ✓ Cure cycle(s) meets repair document requirements;
- ✓ Repair meets post-repair inspection requirements;

Topics (List of Repairs)

1. Repair to Honeycomb Sandwich Part (Wet Lay-Up)
2. Repair to Honeycomb Sandwich Part (Prepreg)
3. Repair to Edge Band of Honeycomb Sandwich Part

14 - Examination

The written examination consists of 50 multiple choice questions. The examination contains questions from each of the topics listed in the outline for each part. The examination will be closed book.

15 - Practical Assessment

The practical assessment will be a separate, hands-on repair. The practical assessment will be similar to one of the hands-on exercises. This practical assessment will test your ability to perform the entire repair process, from damage assessment to post-repair inspection, ensuring that you can apply the skills and knowledge gained throughout the course.

Assessment Criteria

- ✓ Damage Assessment;
- ✓ Damage Removal;
- ✓ Repair Preparation;
- ✓ Repair Lay-up;
- ✓ Vacuum Bagging;
- ✓ Repair Cure;
- ✓ Post Repair Inspection;
- ✓ Record Keeping.

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training@acrats.com

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