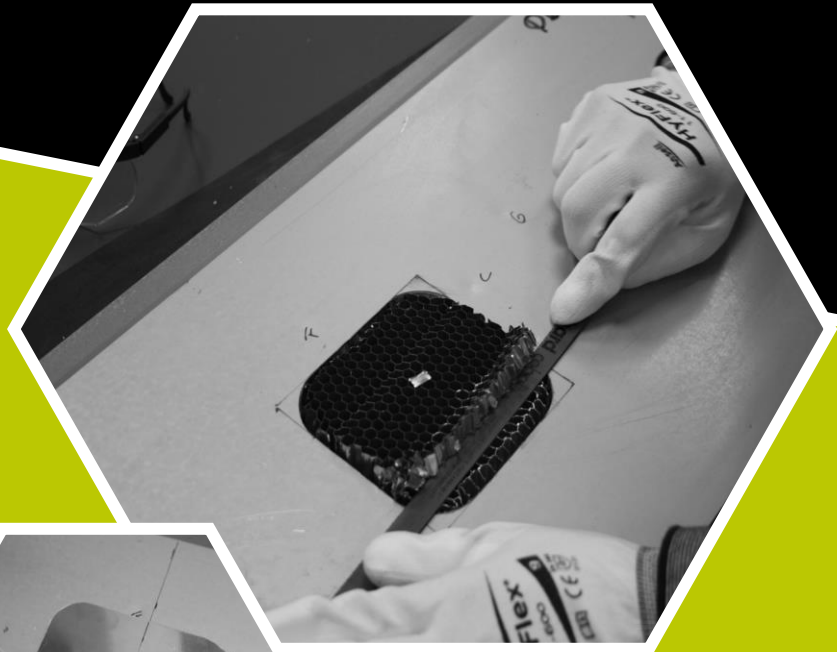


# SAE AIR4938 PART 4

# METAL TO METAL

# Bonding



# ACRATS

DETAILED COURSE OUTLINE ATS2074

COMMERCIAL AIRCRAFT STRUCTURE METALBOND REPAIR (SAE AIR4938 PART 4)



**Course Title**

Commercial Aircraft  
Composite Structure  
Metalbond Repair  
(SAE AIR4938 Part 4)



**Course Tag**

SAE AIR4938  
Metal to Metal  
Bonding



**Course ID**

ATS2074



**Course Duration**

5 Working Days



**Prerequisites**

General Composite  
Structure Repair  
(SAE AIR4938 Part 1)



**Learning Hours**

Classroom: 14,5 Hours  
Practical: 25,5 Hours



**Highest Standards**

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



**Scope and Purpose**

The ACRATS metal to metal bond course provides comprehensive training on the repair and maintenance of metalbond structures in commercial aircraft. This course covers essential topics, including material selection, surface preparation, adhesion principles, safety protocols, and repair techniques. Participants will gain hands-on experience with pre-bond treatments, adhesives, metal parts, vacuum bagging techniques, and hot bond equipment. The curriculum is designed to ensure that participant can perform accurate damage assessments, execute effective repairs, and maintain the structural integrity and safety of aircraft. This course meets the formal training requirements for certification as an aircraft composite repair technician and prepares participants for advanced repair tasks.



**Course Module Overview**

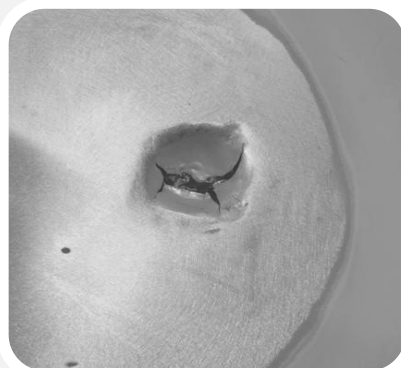
- Introduction to Aircraft Metalbond Structure
- Metalbond-Specific Repair Material Requirements
- Adhesion
- Safety and Environment
- Surface Preparation and Time Limitations
- Adhesives
- Metalbond-Specific Design Considerations
- Heat Transfer and Cure Cycle Management
- Pressure Requirements
- Source Documents
- Repair Considerations
- Inspection Techniques
- Hands-On Exercises



**Learning Goals**

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

- Describe the application and critical elements of metalbond structures;
- Identify and select the correct materials for metalbond repairs;
- Understand and apply adhesion principles for effective bonding;
- Demonstrate proper safety practices and the use of Personal Protective Equipment (PPE);
- Prepare metal surfaces for bonding and understand time limitations;
- Select and handle adhesives correctly for various repair scenarios;
- Design metalbond repairs considering structural and environmental factors;
- Manage heat transfer and cure cycles to meet repair requirements;
- Control pressure requirements and ensure proper core venting and air entrapment;
- Navigate and utilize source documents for repair procedures;
- Assess damage and perform thorough damage evaluations;
- Identify, form, and fit check repair parts to meet repair documentation;
- Conduct various inspection techniques to ensure repair quality;
- Execute hands-on repair exercises to demonstrate proficiency in metalbond repairs.



Topic		Teaching Level	Classroom Hours	Practical Hours
1	Introduction to Aircraft Metalbond Structure	1	0,5	-
2	Metalbond-Specific Repair Material Requirements	1	1	-
3	Adhesion	1	1	-
4	Safety and Environment	1	1	-
5	Surface Preparation and Time Limitations	3	2	-
6	Adhesives	1	0,5	-
7	Metalbond-Specific Design Considerations	1	1	-
8	Heat Transfer and Cure Cycle Management	3	1	-
9	Pressure Requirements	3	1	-
10	Source Documents	2	1	-
11	Repair Considerations	3	3	-
12	Inspection Techniques	1	1	-
13	Hands-on Exercises and Assessment Criteria	3	-	25,5
14	Written Exam	-	0,5	-
15	Practical Assessment	-	-	-
Total Hours			14,5	25,5
Course Length			40 Hours	

**Teaching Level 1**

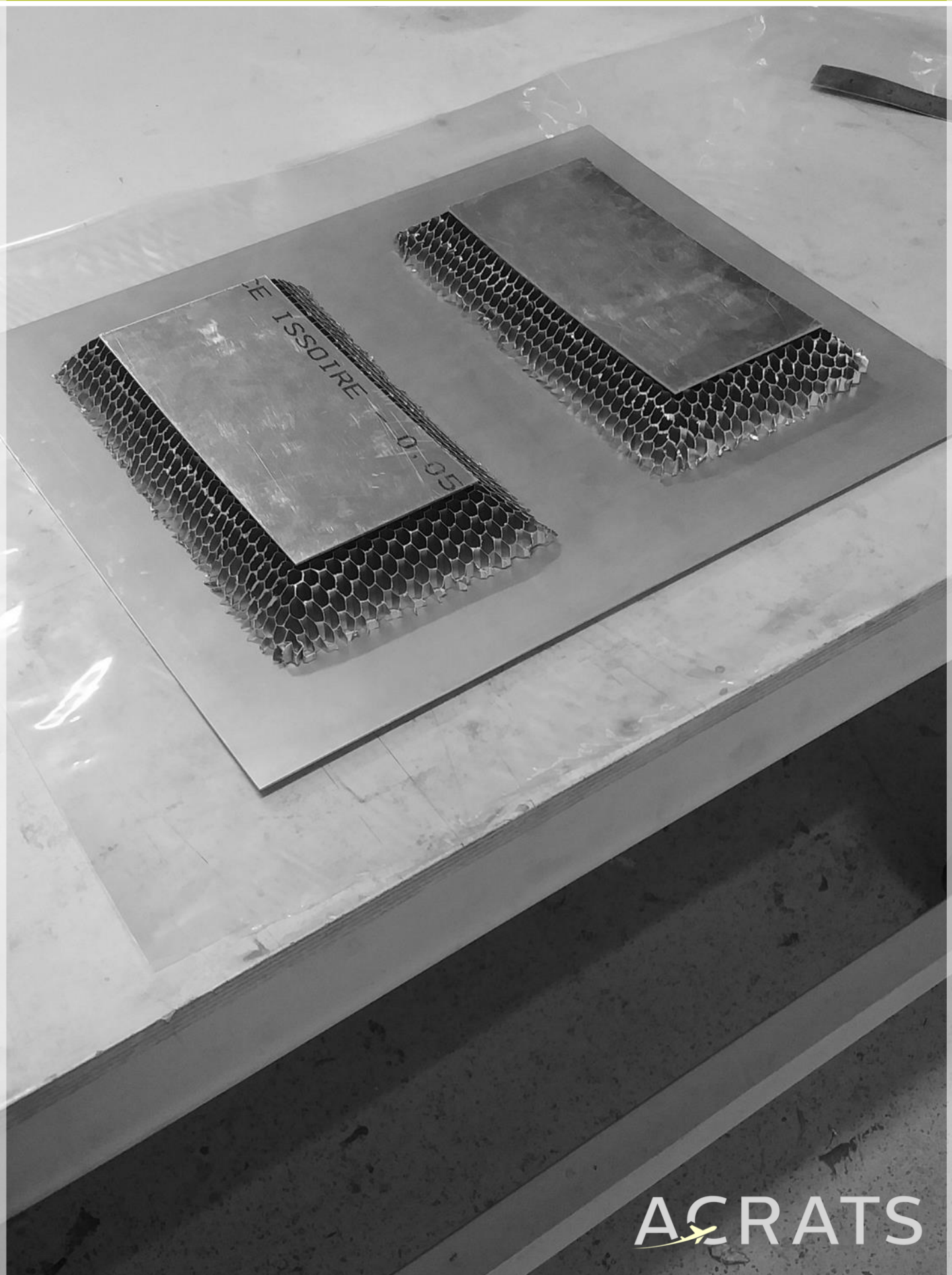
Teaching level 1 includes the transferring of knowledge from the instructor to the student, through instruction, lecture, demonstration and by having topic-related discussions. Knowledge transfer can take place in a classroom (physical training) as well as through online learning (Computer Based Training (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, or 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.



## Module 1 - Introduction to Aircraft Metalbond Structure

In Module 1, you'll be introduced to the basics of aircraft metalbond structures. This module covers common applications of metalbonding in the aviation industry and highlights critical issues in the maintenance, repair, and overhaul of these structures. You will also explore key guidelines such as AIR6291 and AIR5719, which provide important teaching points for awareness in composite maintenance and repair.

### Learning Goals

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

- Describe common applications of metalbonding in aircraft structures;
- Identify and explain critical issues in aircraft metalbond maintenance, repair, and overhaul;
- Understand and apply guidelines from AIR6291 for repair process evaluation of aluminum bonded structures;
- Understand and apply guidelines from AIR5719 for awareness in composite maintenance and repair.

### Topics

1. Common Metalbond Applications
2. Critical Issues in Aircraft Metalbond Maintenance, Repair, and Overhaul
  - a. AIR6291, Guidelines for Repair Process Evaluation of Aluminum Bonded Structure
  - b. AIR5719, Teaching Points for an Awareness Class on "Critical Issues in Composite Maintenance and Repair"

## Module 2 - Metalbond-Specific Repair Material Requirements

In Module 2, you'll learn about the specific material requirements for metalbond repairs in aircraft structures. This module covers the selection and identification of the correct aluminum alloy and core materials for repairs. You will explore different types of aluminum alloys, core materials, and the considerations for bonding other metals. This module ensures that you can select the appropriate materials for effective and safe metalbond repairs.

### Learning Goals

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

- Describe the criteria for selecting aluminum alloys for metalbond repairs;
- Identify the differences between bare and clad aluminum sheets;
- Explain the importance of pre-primed sheets and various heat treatments;
- Describe the types and forms of core materials used in metalbond repairs;
- Identify the appropriate core alloys and surface treatments;
- Discuss considerations for bonding other metals in metalbond repairs.

### Topics

1. Aluminum Alloy Selection
  - a. Bare versus Clad
  - b. Pre-Primed Sheet
  - c. Heat Treatments
2. Core Materials
  - a. Forms
  - b. Alloys
  - c. Surface Treatments
3. Discussion of Bonding Other Metals

### Module 3 - Adhesion

In Module 3, you'll learn about the critical factors influencing adhesion in metalbond repairs. This module covers the differences between chemical and mechanical bonding, the importance of surface tension and surface energy, and the various types of failure that can occur during the adhesion process. You will gain a thorough understanding of how to ensure strong and reliable bonds in aircraft metalbond repairs.

#### Learning Goals

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

- Describe the differences between chemical bonding and mechanical bonding;
- Explain the role of surface tension and surface energy in adhesion;
- Identify and describe different types of adhesion failures;
- Discuss how corrosion, surface preparation, and contamination can affect adhesion;
- Explain the concept of cohesion and mixed mode failures in metalbond repairs.

#### Topics

1. Chemical Bonding Compared to Mechanical Bonding
2. Surface Tension and Surface Energy
3. Types of Failure
  - a. Adhesion
  - b. Corrosion
    - i. Surface Prep and Contamination
  - c. Cohesion
  - d. Mixed Mode

### Module 4 - Safety and Environment

In Module 4, you will learn about the essential safety and environmental considerations in aircraft metalbond repairs. This module emphasizes the importance of using Personal Protective Equipment (PPE) correctly and understanding the information provided in Safety Data Sheets (SDS). You will also learn proper waste disposal procedures to ensure a safe and compliant working environment.

#### Learning Goals

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

- Demonstrate proper use of Personal Protective Equipment (PPE);
- Describe the purpose and content of Safety Data Sheets (SDS);
- Explain the procedures for safe disposal of hazardous materials;
- Identify potential hazards associated with metalbond repair materials;
- Apply best practices for maintaining a safe and environmentally compliant workspace.

#### Topics

1. SDS (Safety Data Sheet)
2. Waste Disposal
3. PPE





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## Module 5 - Surface Preparation and Time Limitations

In Module 5, you will learn the critical steps involved in preparing metal surfaces for metalbond repairs. This module will guide you through various surface preparation methods, including solvent cleaning, electrochemical treatment, chemical conversion, and mechanical abrasion. You will also learn about proper primer application, handling, and storage of prepared surfaces. Emphasis will be placed on understanding time limitations and acceptance criteria to ensure high-quality repairs.

### Learning Goals

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

- Describe and prepare metal surfaces as required by repair documents;
- Remove prior surface treatments and perform surface cleaning and chemical treatments;
- Apply primers correctly and understand primer thickness requirements;
- Explain the time limitations associated with surface preparation;
- Handle and store prepared surfaces properly;
- Perform acceptance tests such as the Water Break Free Test and use a Polarizing Filter to ensure surface readiness.

### Topics

1. Solvent Cleaning
2. Electrochemical
3. Chemical Conversion
4. Mechanical Abrasion
5. Primers
6. Primer Thickness Requirements
7. Time Limits
8. Proper Handling and Storage of Prepared Surfaces
9. Acceptance Criteria
  - a. Water Break Free Test
  - b. Polarizing Filter

## Module 6 - Adhesives

In Module 6, you will learn about the different types of adhesives used in metalbond repairs, including film adhesives, paste adhesives, and core splice adhesives. This module will cover the correct application techniques for each type of adhesive, as well as the handling and storage requirements to maintain their effectiveness. By the end of this module, you will have a comprehensive understanding of how to select and manage adhesives for metalbond repairs.

### Learning Goals

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

- Describe the different types of adhesives used in metalbond repairs;
- Identify the correct adhesive for specific repair applications;
- Apply adhesives correctly according to repair documentation;
- Handle and store adhesives properly to maintain their effectiveness.

### Topics

1. Film Adhesives
2. Paste Adhesives
3. Core Splice Adhesive
4. Proper Handling and Storage



## Module 7 - Metalbond-Specific Design Considerations

In Module 7, you will learn about the critical design requirements specific to metalbond parts. This module covers various aspects such as impact shields, corrosion resistance, drainage paths, isolation layers, acoustical treatments, electromagnetic concerns, and aerodynamic considerations. By understanding these design elements, you will be better equipped to ensure the structural integrity and performance of metalbond components.

### Learning Goals

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

- Describe the design requirements for metalbond parts;
- Explain the importance of impact shields in metalbond design;
- Understand and apply principles of corrosion resistance, including interfacial hydration prevention;
- Identify and implement proper drainage paths and isolation layers;
- Incorporate acoustical treatments and electromagnetic considerations in metalbond design;
- Evaluate aerodynamic considerations in the design of metalbond parts.

### Topics

1. Impact Shields
2. Corrosion Resistance
  - a. Interfacial Hydration (Moisture Ingression)
3. Drainage Paths
4. Isolation Layers
5. Acoustical Treatments and Layers
6. Electromagnetic Concerns
7. Aerodynamic Considerations

## Module 8 - Heat Transfer and Cure Cycle Management

In Module 8, you will learn about the principles of heat transfer and the management of cure cycles for metalbond repairs. This module emphasizes the importance of controlling the cure cycle to meet specific repair document requirements. You will gain hands-on experience with various equipment used in the curing process, including autoclaves, ovens, hot bonders, heat blankets, hot air blowers, heat lamps, and infrared heaters. Additionally, the module covers thermocouple placement and the control of insulation and airflow to ensure effective and precise curing.

### Learning Goals

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

- Describe the principles of heat transfer in the context of metalbond repairs;
- Understand and explain the limitations of various heat application equipment;
- Control the cure cycle to meet specific repair document requirements;
- Demonstrate the correct placement of thermocouples for accurate temperature monitoring;
- Manage insulation and airflow to ensure consistent and effective curing.

### Topics

1. Heat Transfer Basics
2. Equipment Limitations
  - a. Autoclave
  - b. Oven
  - c. Hot Bonders
  - d. Heat Blankets
  - e. Hot Air Blowers
  - f. Heat Lamp
  - g. Infrared Heaters
3. Thermocouple Placement
4. Insulation and Airflow Control



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## Module 9 - Pressure Requirements

In Module 9, you will learn about the critical aspects of pressure management in metalbond repairs. This module focuses on understanding and applying the correct pressure requirements to ensure successful repair outcomes. You will gain practical experience in placing core vent materials correctly and controlling both vacuum and positive pressure in accordance with repair document specifications. Additionally, the module addresses techniques to prevent air entrapment during the repair process.

### Learning Goals

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

- Describe the pressure requirements for metalbond repairs;
- Demonstrate the correct placement of core vent materials;
- Control vacuum and positive pressure to meet repair document requirements;
- Understand and apply techniques to prevent air entrapment during repairs.

### Topics

1. Vacuum Levels
2. Positive Pressure
3. Core Venting
4. Air Entrapment

## Module 10 - Source Documents

In Module 10, you'll learn to navigate and utilize various repair documents essential for metalbond repair procedures. This module covers the identification, description, and compliance with key documents such as Structural Repair Manuals (SRMs), Component Maintenance Manuals (CMMs), and engineering orders. You will gain an understanding of allowable damage limits, repair limits, and regulatory documents, including airworthiness directives and service bulletins. Additionally, this module emphasizes the importance of following OEM, vendor, and internal material and process specifications to ensure repair quality and compliance.

### Learning Goals

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

- Identify and describe the purpose of key repair documents;
- Navigate Structural Repair Manuals and Component Maintenance Manuals;
- Understand and apply allowable damage limits and repair limits;
- Comply with regulatory documents including airworthiness directives and service bulletins;
- Follow OEM, vendor, and internal material and process specifications.

### Topics

1. ATA iSpec 2200/S1000D
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 11 - Repair Considerations

In Module 11, you'll learn the comprehensive process of evaluating and executing metalbond repairs. This module will guide you through identifying various types of damage, understanding repair considerations, and selecting appropriate materials and techniques to meet repair document requirements. You will learn to assess damage limitations, select and form repair parts, and ensure proper fit and compliance. The module covers critical aspects such as material selection, thermal management, and bond line thickness control, ensuring high-quality and durable repairs.

### Learning Goals

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

- Identify and assess various types of damage, including corrosion, disbonds, and lightning strike damage;
- Evaluate repair considerations and limitations, considering proximity to other damages and repairs;
- Select appropriate materials and perform material substitution when necessary;
- Size, form, and fit check repair parts according to repair document requirements;
- Control bond line thickness and manage thermal effects during repair;
- Utilize proper techniques such as vacuum bagging and use of contact materials.

### Topics

1. Damage Assessment and Limitations
  - a. Corrosion
  - b. Contamination
  - c. Dents
  - d. Disbonds
  - e. Scratches, Nicks, and Gouges
  - f. Punctures
  - g. Cracks
  - h. Lightning Strike / Heat Damage
2. Proximity to Other Damage and Repairs
3. Material Selection and Substitution
4. Repair Part Sizing
5. Verifilm Check
6. Core Selection and Sizing
7. Septum
8. Bond line Thickness Control
9. Tooling Requirements
10. Contour Management/Material Forming
11. Damage Removal/Previous Repair Removal
12. Contaminant Removal/Prevention
13. Thermal Management
14. Effect of Vacuum Levels on Film Adhesives
15. Techniques
  - a. Vacuum Bagging
  - b. Contact Materials

## Module 12 - Inspection Techniques

In Module 12, you'll learn about various inspection methods essential for maintaining the integrity and safety of aircraft metalbond structures. This module will provide you with the knowledge and skills to perform inspections using techniques such as tap testing, visual inspection, and polarized light inspection. You will also be introduced to advanced methods including ultrasonic testing, X-ray, thermography, and eddy current. By the end of this module, you will be proficient in selecting and applying the appropriate inspection technique to identify and evaluate potential issues in metalbond repairs.

### Learning Goals

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

- Describe various inspection methods used in metalbond repairs;
- Conduct tap test, visual, and polarized light inspections;
- Measure film thickness accurately;
- Utilize bond testers including harmonics resonance and ultrasonic methods;
- Perform advanced inspection techniques such as X-ray, thermography, and eddy current;
- Assess the condition of metalbond repairs, identifying corrosion, contaminants, and other issues.

### Topics

1. Film Thickness Measurement
2. Bond Testers
  - a. Harmonics Resonance
  - b. Ultrasonic
3. Tap Test
4. Visual
  - a. Corrosion
  - b. Contaminants
  - c. Exposed Metal
  - d. Water Break Free Test
5. Polarized Filter Inspection
6. X-Ray
7. Thermography
8. Eddy Current
9. Conductivity
10. Hardness





## Module 13 - Hands-On Exercises and Assessment

In Module 13, you will engage in extensive hands-on practice to solidify your understanding and skills in repairing metalbond structures. This module emphasizes proper safety practices and the application of pre-bond treatments, adhesives, metal parts, vacuum bagging techniques, and hot bond equipment. Through practical exercises, you will perform various repairs and demonstrate your competence by completing a minimum of three specified repairs. Additionally, you will conduct destructive testing on one of your repairs to identify failure modes and perform a wedge test, ensuring a comprehensive understanding of repair integrity.

### Learning Goals

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

- Demonstrate proper safety practices during metalbond repairs;
- Perform repairs on metalbond structures using pre-bond treatments, film, and paste adhesives, and vacuum bagging techniques;
- Conduct various types of repairs including dent, skin and core, trailing edge, one side flush, and skin crack repairs;
- Execute a destructive test to identify failure modes and conduct a wedge test;
- Meet the criteria outlined in repair documentation through accurate and effective repair techniques.

### Assessment Criteria

- ✓ Damage removed without causing additional damage
- ✓ Surface preparation meets repair document requirements
- ✓ Correct repair materials identified
- ✓ Repair patch is positioned correctly
- ✓ Cure cycle(s) meets repair document requirements
- ✓ Repair meets post repair inspection requirements

### Topics (List of Repairs & Tests)

1. Repairs
  - a. Dent Repair
  - b. Skin and Core Repair
  - c. Trailing Edge Repair
  - d. One Side Flush Repair
  - e. Skin Crack Repair
2. Destructive Test
  - a. Identify Failure Modes
  - b. Wedge Test

## 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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