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Teaching Points for an Awareness Class on "Critical Issues in Composite Maintenance and Repair"

RATIONALE

This document was developed to fulfill the need for a standardized checklist regarding critical issue awareness for composite structure maintenance and repair.

1. SCOPE

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

1.1 Purpose

The purpose of this AIR is to establish a standard teaching checklist for an awareness course covering the critical technical issues associated with the maintenance and repair of composite aircraft structures. This document describes terminal course objectives (TCOs) and teaching points, which in combination serve as a course checklist for organizations developing this awareness course.

1.2 Field of Application

The course is intended to address critical composite structural safety and certification issues as opposed to building specific skills among individual team members. Specific skill-building is outside the scope of this course and is not the intent of the contents of this document.

1.3 Product Classification

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1.4 Form

TCOs, in addition to subordinate objectives which support the TCOs, indicate student learning expectations for each section of the course, while teaching points convey items that should be covered within each TCO. TCOs are listed at the second numbering sequence (e.g. 3.1) in this document. Teaching format is at the discretion of the teaching institution, and those objectives and teaching points which refer to laboratory learning environments are suggestions in teaching format only (e.g. section 6.2.4). In general, laboratory exercises are intended to reinforce objectives and teaching points listed in other sections of this AIR.

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 the referenced documents 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 724-776-4970 (outside USA), www.sae.org.

AIR4844	Composites and Metal Bonding Glossary
ARP4916	Masking and Cleaning of Epoxy and Polyester Matrix Thermosetting Composite Materials
AIR4938	Composite and Bonded Structure Technician/Specialist: Training Document
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 Repairs
ARP5144	Heat Application for Thermosetting Resin Curing
ARP5256	Mixing Resins, Adhesives and Potting Compounds
AIR5278	Composite and Bonded Structure Engineers: Training Document
AIR5279	Composite and Bonded Structure Inspector: Training Document
ARP5319	Impregnation of Dry Fabric and Ply Lay-Up
AE-27	Design of Durable, Repairable, and Maintainable Aircraft Composites
R-336	Care and Repair of Advanced Composites, 2nd Ed.

2.1.2 Other Industry Publications

AC145-6	Repair Stations for Composite and Bonded Aircraft Structure
14CFR Part 147	Aviation Technician Schools
CMH-17	Composite Material Handbook 17

3. BASE KNOWLEDGE

Basic knowledge in the technology of composite materials is provided to those students having limited exposure and/or understanding of composite materials technology. Prior to the exposure to critical issues involved with the maintenance and repair of composite materials in commercial aerospace applications (Sections 4, 5, and 6 below), the student must understand the fundamentals of the technology to enhance learning. This subject will provide an overview of maintenance and repair, to be later reinforced in the main course outlined in Sections 4, 5, and 6. Included in base knowledge is: (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 the corresponding subordinate objectives are listed.

3.1 After completing this unit, 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 as a first topic in the awareness course.

3.1.1 The student will be able to distinguish among adhesive, resin, fiber and core applications and uses.

3.1.2 The student will be able to describe critical composite processing parameters.

3.1.3 The student will be able to describe composite material properties, failure modes and effects of processing.

3.1.4 The student will be able to describe various composite machining, assembly and finishing processes.

3.1.5 The student will be able to describe stiffened laminate and sandwich applications and structural properties.

3.1.6 The student will be familiar with information sources that have a glossary of terms for reference.

3.2 After completing this unit, 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 basic 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 and maintenance and repair processes.

3.2.1 The student will be able to list the basic steps in maintenance procedures from damage detection through repair completion.

3.2.2 The student will be able to list key composite and expendable materials needed for simple laminate structure repair including storage requirements.

3.2.3 The student will be able to list the necessary tooling and equipment to accomplish a simple laminate structural repair.

3.2.4 The student will understand personal and equipment safety requirements.

3.2.5 The student will be able to 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 be able to describe the process of metal bonding.

3.2.7 The student will be able to discuss the importance of approved data, methods and procedures used in product-specific, composite maintenance and repair.

3.3 After completing this unit, the student will understand other critical elements of composite maintenance and repair.

While having an overview of composite materials technology and related maintenance and repair is a necessary part of a student's preparation for more in depth study, there are other considerations, including the selection of repair methodology, electromagnetic effects and surface finishing and re-finishing, waste disposal, and trends in development of repair technology. Understanding skill limitations and the importance of utilizing source documentation is introduced. This content is best taught following the composites materials technology summary presentation and repair overview, and prepares the student for later teaching materials which focus on safety issues along with maintenance and repair processes.

3.3.1 The student will be able to discuss basic issues affecting the selection of bonded or bolted repairs.

3.3.2 The student will be able to describe various electrical requirements and effects, including prevention of corrosion, hazards of electromagnetic interference and electrostatic discharge (lightning protection systems) and how they need to be considered during repair processes.

3.3.3 The student will understand the need for protective coatings and surface finishing steps used for composite aircraft structure.

3.3.4 The student will be able to describe typical paint and surface layer removal techniques for finished composite parts.

3.3.5 The student will know the issues related to the proper disposal of wastes from the composite repair process.

3.3.6 The student will know why understanding personnel skill limits and where to receive assistance during maintenance is essential.

3.3.7 The student will be able to discuss the importance of documenting and sharing information about damage scenarios discovered in service between OEM, maintenance and repair organizations and regulators.

3.4 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.

3.4.1 The student will explain the general lack of standards available for composite engineering practices and realize that composite maintenance and repair requires special acquired skills.

3.4.2 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 certified products will be introduced.

3.4.3 The student will discuss emerging damage and repair inspection technologies, such as bond testing, moisture meters, interferometer (3D characterization). The need for industry to properly substantiate emerging inspection process technology before it can be applied to certified products will be introduced.

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

3.4.5 The student will be able to outline the process for repair structural substantiation and approval to meet regulatory requirements.

4. TEAMWORK AND DISPOSITION

This section of the class is organized to highlight the importance of teamwork in the disposition of damaged composite structure during maintenance and repair. Each member of the team must have training that qualifies them for the specific tasks he or she will perform. The training would start with an awareness of critical composite maintenance and repair issues, such as provided by the current course. Additional training is needed to develop specific skills and perform tasks on the structural components of a given aircraft type, which have unique repair design, process and inspection details. It is unlikely that one person will attain all the special skills needed for engineering disposition, inspection and repair of damage to a given structure. Instead, trained engineers, inspectors and technicians will work as a team from the time of damage detection until an approved repair is properly executed. Approval of a new repair design and process for critical composite structures will require an interface with engineers having the necessary skills and data to substantiate structural integrity of the repair per regulations.

4.1 After completing this unit, the student will understand roles and responsibilities

This part of the class will help students understand the roles and responsibilities of engineers, inspectors and technicians involved in composite maintenance and repair. It also discusses a vital interface between personnel trained in composites with pilots, operations and line maintenance personnel that may first become aware of a need for damage disposition. The content introduces several subjects covered in greater depths by other sections of the class. These include an overall view of the composite inspection, damage disposition and repair process. It also covers approved documents used to guide the team on acceptable designs, inspection methods and repair processes. The content of this section should be presented at the start of the class to help link different facets of composite repair and maintenance.

4.1.1 The student will be able to describe critical safety aspects of repair design, process planning, and approval.

4.1.1.1 Qualified engineering personnel must use approved information and data to design repairs.

4.1.1.2 The intent of permanent repairs to structural components is to restore the original component long-term performance characteristics. They must meet all regulatory requirements for static strength, damage tolerance and durability. The existing inspection frequency for the airplane may be sufficient to ensure continued airworthiness of the repair; otherwise additional inspections will be specified.

4.1.1.2.1 Category A Repair can be defined as a permanent repair for which the inspections given in the maintenance documentation are sufficient and no other actions are necessary.

4.1.1.2.2 Category B Repair can be defined as a permanent repair for which supplemental inspections are necessary at the specified threshold and repeat intervals.

4.1.1.2.3 Category C Repair can be defined as a time-limited repair which must be replaced or reworked within a specified time limit. Also supplemental inspections can be necessary at a specified threshold and repeat interval.

4.1.1.3 The intent of temporary repairs to structural components is to restore performance characteristics for a limited time. They must meet all regulatory requirements for static strength but must be replaced, or reworked to a permanent condition, within a specified time (for example: a limiting number of flight cycles or hours). Periodic inspection requirements may be imposed to ensure continued airworthiness of the repair.

4.1.1.4 Repairs to structure that is critical to safety of flight are subject to the same regulatory requirements for fatigue and/or damage tolerance as the structure.

4.1.1.5 Repairs to moveable control surfaces must consider the effects on the overall part stiffness, weight, balance and flutter characteristics.

4.1.1.6 Repair design and process instructions in approved documentation must be strictly followed.

4.1.1.7 Repair designs and processes in approved documents may not be extended to components or zones other than those specified.

4.1.1.8 Component records must be reviewed for previous repairs and/or previous allowed damage.

4.1.1.9 In the event that an approved repair design or process is not available, the maintenance engineer must follow regulatory procedures for repair design, process planning, and approval.

4.1.2 The student will be able to briefly describe the steps in composite damage detection, inspection and repair processes.

4.1.2.1 Pilots, operations and line maintenance personnel must report flight or ground incidents that may damage the aircraft to qualified maintenance personnel for disposition on the airworthiness of composite structure.

4.1.2.2 Pilots, operations and line maintenance personnel are generally not capable of determining the airworthiness of composite aircraft structure that may have been damaged by anomalous flight or ground incidents, and must be trained to contact qualified maintenance personnel before further flight.

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

4.1.2.4 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.

4.1.2.5 Any available documentation must be reviewed for approved inspection techniques using, for example, NDI methods in the OEM's structural repair manual (SRM) or other approved repair instructions.

4.1.2.6 A specified damage assessment must then be compared to any allowable damage limits (ADL) provided for the specific component

4.1.2.7 Documentation must be reviewed for repair designs, processes and quality controls for specified damages).

4.1.2.8 Whenever approved repair designs, processes and quality controls do not exist for a particular damage scenario, the regulatory procedures for repair design, process planning, and approval must be followed).

4.1.2.9 The student must be able to list basic steps in performing a bonded and bolted repair.

4.1.2.10 Other considerations are vital to performing a proper repair.

4.1.2.10.1 Protective coatings and features (bonding strap, static discharge wicks, etc.) must be restored to the repaired area.

4.1.2.10.2 The mass balance of repaired flight control surfaces must be checked against operational balance limits.

4.1.2.10.3 The clearances of flight control surfaces must be checked against operational limits.

4.1.2.10.4 Surface smoothness of the completed repair must meet applicable aerodynamic requirements.

4.1.2.10.5 Acoustical features such as perforations must be restored according to repair documentation.

4.1.2.10.6 Damage and repair details shall be recorded in the appropriate reports such as the component record card

4.1.3 The student will be able to list basic non-destructive inspection (NDI) methods used for damage assessment and post repair inspection.

4.1.3.1 General visual inspection is the first and most common method used for damage detection.

4.1.3.2 Other NDI methods may be needed for more complete damage assessment after a qualified inspector has visually detected the damage. The best NDI methods for damage characterization depend on damage types and structural details.

4.1.3.2.1 Several manual and automated tap tests may be used with some limitations for damage inspection of composite and metal bond components, including both laminate and sandwich construction.

4.1.3.2.2 Pulse-echo (P/E) and through-transmission ultrasonic (TTU) methods require special training and a detailed understanding of structural design detail for accurate assessments. TTU methods require two-sided access to a part, whereas P/E can be performed when only one-side access exists.

4.1.3.2.3 Bond testers are instruments that use the mechanical impedance method.

4.1.3.2.4 Moisture meters are often used to detect the presence of moisture when making repairs to glass fiber reinforced plastic (GFRP) or Aramid fiber reinforced plastic (AFRP) materials.

4.1.3.2.5 X-radiography (x-ray) is a one-sided inspection technique that has some application to composite parts such as detection of fluid ingression in some sandwich parts.

4.1.3.2.6 Eddy current has little or no use for detecting damages within composite structures and for inspecting composite bonded repairs for integrity.

4.1.3.2.7 Recent advances in NDI technology for composite structures include thermography and shearography.

4.1.3.3 Approved documentation should be reviewed to determine proper inspection methods for a given structural detail and damage scenario.

4.1.4 The student will be able to distinguish the skills needed for structures engineers, inspectors and technicians dealing with composite maintenance and repair.

4.1.4.1 Operations personnel, line maintenance, structures engineers, inspectors and repair technicians all have vital roles to play in the proper maintenance and repair of composite structures.

4.1.4.1.1 The structures engineer at the OEM, operator or maintenance repair operation requires an engineering Bachelor of Science degree or equivalent 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.

4.1.4.1.2 The inspector requires formal training in the use of a variety of composite inspection techniques, and must have good eyesight and hearing. Inspectors trained for NDI require different levels of certification to become competent in specified methods. Detailed knowledge of the specific aircraft structural components and approved documentation such as the OEM structural repair manual (SRM) and nondestructive inspection (NDI) documentation is required.

4.1.4.1.3 The repair technician must have formal training in composite repair processing and in the use of repair equipment. Familiarity with OEM drawing systems, and the approved documentation, and detailed knowledge of the specific aircraft structural components is also needed. Finally, the repair technician should have good manual dexterity in order to perform the highly skilled tasks associated with executing a composite repair.

4.1.5 The student will be able to recognize his or her skill limits in practice and where to find assistance.

4.1.5.1 Multiple Team members provide process accountability to ensure proper damage disposition and repair integrity.

4.1.5.1.1 When damage to a composite aircraft component is first discovered, the extent of damage must be assessed by personnel qualified in the appropriate inspection techniques.

4.1.5.1.2 Repair designs and processes must be approved by the appropriate authority, or be in compliance with approved repair documentation.

4.1.5.1.3 In the case of a repair not being available in the approved documentation, the maintenance engineer must communicate with the OEM and/or follow the regulatory approval process.

4.1.5.1.4 The repair must be performed by a qualified technician in a controlled environment, using approved materials and processes with specified in-process controls.

4.1.5.1.5 A qualified inspector using approved methods must approve the completed repair before the repaired component can be returned to service.

4.1.5.2 All aspects of composite maintenance and repair are interlinked such that each member of a repair team should understand his/her role and have the training needed to properly complete their tasks.

4.2 After completing this unit, the student will be able to identify and describe information contained in documentation

This part of the course is intended to expose students to documents used in composite maintenance and repair, including those describing acceptable 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 were substantiated to meet regulations. Limits on the damages 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. The content of this section may best be taught after the student has gained an awareness of roles and responsibilities, and has been exposed to composite damage types and inspection procedures.

4.2.1 The student will be able to describe requirements in material and process specifications and approved repair information.

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

4.2.1.1.1 Identify quality control requirements, specimen fabrication, test methods, inspection procedures and acceptance criteria.

4.2.1.1.2 Outline or reference process documents needed for fabrication of specimens used in quality control.

4.2.1.1.3 Outline shipping and handling requirements used to ensure the material storage and working life.

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

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

4.2.1.4 The OEM's structural repair manual (SRM) or other authorized source documentation are used to:

4.2.1.4.1 Define detection and inspection procedures needed to disposition the damage for a particular structural component.

4.2.1.4.2 Define allowable damage limits and allowable repair sizes.

4.2.1.4.3 Define acceptable repair designs and processes for the specified damage sizes and locations described for a given structure.

4.2.1.4.4 Provide design and process details for time limited and permanent composite repairs, including specified limits for their use.

4.2.1.5 All documents and information applied in composite inspection, damage disposition and repair must be approved for use on a particular structural component.

4.2.2 The student will be able to demonstrate the use of source documents.

4.2.2.1 Specifications are used for material purchase, acceptance, storage and handling.

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

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

4.2.2.4 Service bulletins and newsletters based on field history may be used to supplement previous maintenance and repair information documented for a particular component.

4.2.2.5 All designs, materials and processes and inspection techniques used for repair of a given damage on a specific structural component must be approved.

4.2.2.6 Damages that require inspections and repairs 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 The student will be exposed to and will demonstrate the use of regulatory documents.

4.2.3.1 Overview

4.2.3.1.1 Regulatory authorities with jurisdiction for a particular repair issue documents that specify requirements and compliance guidance for the maintenance of civil aircraft.

4.2.3.1.1.1 The Federal Aviation Administration (FAA) provides Federal Aviation Regulations (14 CFR).

4.2.3.1.1.2 In Europe, the legal basis covering design, production and maintenance of aeronautical Products, Parts and appliances, including related personnel and organizations, is covered by Regulation (EC) 216/2008issued by the European parliament and council. In addition, implementing rule 1703/2003 lays down airworthiness and environmental certification standards, and implementing rule 2042/2003 addresses continuing airworthiness.

4.2.3.1.1.3 Transport Canada Civil Aviation (TCCA) provides Canadian Aviation Regulations (CAR) which cover all aspects of aviation including production, certification, and maintenance of aeronautical products.

4.2.3.1.2 U.S. registered aircraft operating to or within foreign jurisdictions must meet the FAA as well the requirements of the country in which the aircraft will be operating. Many countries have bilateral agreements (e.g., BASA's with U.S.) in place to minimize duplication in the certification process.

4.2.3.1.2.1 Bilateral agreements facilitate the reciprocal and initial airworthiness certification of civil aeronautical products imported and/or exported between two signatory countries.

4.2.3.1.2.2 Bilateral Airworthiness Agreement (BAA) or Bilateral Aviation Safety Agreement (BASA) with Implementation Procedures for Airworthiness (IPA) provides for airworthiness technical cooperation between the FAA and its counterpart civil aviation authorities. BAA and IPA contains only type certification provisions, whereas BASA contains both type and operation provisions. BAA and BASA are treaties that the United States establishes with other countries, and are not considered to be aviation regulatory requirements.

4.2.3.1.2.3 Specific information on individual country agreements can be obtained on the FAA website, http://www.faa.gov/aircraft/air_cert/international/bilateral_agreements/baa_basa_listing/

4.2.3.2 Identify Regulatory Documents

4.2.3.2.1 FAA – 14 CFR

4.2.3.2.1.1 Part 43 prescribes general maintenance requirements applicable to various categories of aircraft.

4.2.3.2.1.2 Part 65 [Subparts D & E] prescribes requirements for the certification of mechanics and repairmen respectively.

4.2.3.2.1.3 Part 145 prescribes requirements for the certification of repair stations

4.2.3.2.1.4 Part 183 describes the requirements for designating private persons to act as representatives of the (FAA) Administrator in examining, inspecting, and testing persons and aircraft for the purpose of issuing airman, operating, and aircraft certificates.

4.2.3.2.1.5 Parts 91 [Subpart E], 121 [Subpart L], 125 [Subpart G] and 135 [Subpart J] provide additional maintenance requirements for specific types of operations.

4.2.3.2.2 EASA

4.2.3.2.2.1 The Annex to European regulation 1702/2003 (Part 21) prescribes procedural requirements for environmental protection and certification, including design and production organization approval, repairs and continued airworthiness.

4.2.3.2.2.2 In Europe, implementing rule 2042/2003 Annex III (Part 66) prescribes requirements for certifying staff.

4.2.3.2.2.3 In Europe, implementing rule 2042/2003 Annex II (Part 145) and Annex IV (Part 147) prescribe requirements for maintenance and training organization approvals respectively.

4.2.3.2.2.4 The European/EASA system differs to that of the FAA. The requirements for responsible individuals are embedded, both directly and less directly, throughout the appropriate requirements. For example, Part 66 for licensed certifying maintenance staff, and Part 21 Subpart J for DO CVE (Design Organization Compliance Verification Engineer).

4.2.3.2.3 TCCA

4.2.3.2.3.1 TCCA CAR 571 prescribes requirements in respect of the maintenance and elementary work performed on aircraft.

4.2.3.2.3.2 TCCA CAR 403 prescribes requirements for holders of and applicants for "Aircraft Maintenance Engineer" licenses and ratings, as well as requirements for approved training organizations.

4.2.3.2.3.3 TCCA CAR 573 prescribes the maintenance organization requirement for aeronautical products or the provision of maintenance services.

4.2.3.2.3.4 TCCA AWM 505 "Delegation of Authority" contains the procedures and conditions where, pursuant to the Aeronautics Act, the Minister may authorize persons to act on his behalf with respect to the airworthiness of aeronautical products.

4.2.3.2.3.5 TCCA addresses the continued airworthiness process through CAR Part VI "General Operating and Flight Rules" and CAR Part VII "Commercial Air Services".

4.2.3.2.3.6 Airworthiness Directives (AD) are issued to address the mandated requirements that relate to safe operation of aircraft (FAA per 14 CFR Part 39, EASA per IR 21A.3B, and TCCA per CAR 593).

4.2.3.2.4 Guidance Documents

4.2.3.2.4.1 FAA issues guidance providing supportive information of showing compliance with regulatory requirements. Guidance may include Advisory Circulars (AC) and Policy Statements (PS). In general, an AC presents information concerning acceptable means, but not the only means, of complying with 14 CFR.

4.2.3.2.4.1.1 AC 145-6: "Repair Stations for Composite and Bonded Aircraft Structure"

4.2.3.2.4.1.2 AC 65-31A: "Training, Qualification, and Certification of Nondestructive Inspection (NDI) Personnel"

4.2.3.2.4.2 Many foreign authorities may have their own guidance supporting the compliance of regulatory requirements. EASA publishes guidance [i.e., AMC (Acceptable Means of Compliance)] or uses harmonized AC's. TCCA publishes guidance, such as Advisory Circulars (AC), Policy Letters (PL) and Staff Instructions (SI).

4.2.3.3 Demonstrate the use of documents related to specific topical areas. Student should identify alternative sources for the following at instructor's discretion

4.2.3.3.1 Legal basis for certifying production parts

4.2.3.3.2 Personnel certification

4.2.3.3.3 Repair station certification

4.2.3.3.4 Maintenance

4.2.3.3.5 Mandated regulations

4.2.4 The student will be able to describe the requirements and engineering approvals necessary for valid sources of technical information and maintenance instructions.

4.2.4.1 Repair of composite structural parts must be in compliance with the airworthiness regulations associated with various categories of aviation products.

4.2.4.1.1 14 CFR Part 23, EASA CS-23, and TCCA AWM Chapter 523 provide airworthiness requirements applicable to Normal, Utility, Acrobatic and Commuter category small airplanes. In addition, EASA has CS-VLA "Very Light Aeroplanes" and CS-22 "Sailplanes and Powered Sailplanes'; and TCCA has Airworthiness Manual AWM Chapter 522 "Gliders and Powered Gliders" and AWM Chapter 523-VLA "Very Light Aeroplanes".

4.2.4.1.2 14 CFR Part 25, EASA CS-25 and TCCA AWM Chapter 525 provide airworthiness requirements applicable to Transport category/Large airplanes.

4.2.4.1.3 14 CFR Part 27, EASA CS-27 and TCCA AWM Chapter 527 provide airworthiness requirements applicable to Normal category/Small rotorcraft.

4.2.4.1.4 14 CFR Part 29, EASA CS-29 and TCCA AWM Chapter 529 provide airworthiness requirements applicable to Transport category/Large rotorcraft.

4.2.4.1.5 14 CFR Part 33, EASA CS-E and TCCA AWM Chapter 533 provide airworthiness requirements applicable to aircraft engines

4.2.4.1.6 14 CFR Part 35, EASA CS-P and TCCA AWM Chapter 535 provide airworthiness requirements applicable to propellers.

4.2.4.2 All composite inspection and repair design, materials and processes must be substantiated to meet airworthiness regulations. Composite inspection and repair design, materials and processes that have not been previously approved must follow the regulatory processes for structural substantiation.

4.2.4.3 Important regulations for the structural substantiation of a composite repair may include:

4.2.4.3.1 Strength and deformation

4.2.4.3.2 Proof of structure

4.2.4.3.3 Inspections and other procedures

4.2.4.3.4 Materials and workmanship

4.2.4.3.5 Fabrication methods

4.2.4.3.6 Protection of structure

4.2.4.3.7 Accessibility provisions

4.2.4.3.8 Material strength properties and design values.

4.2.4.3.9 Damage tolerance and fatigue evaluation of structure.

4.2.4.3.10 Flutter (aeroelastic stability).

4.2.4.3.11 Fire protection of flight controls, engine mounts, and other flight structure

4.2.4.3.12 Acoustical protection features restoration

4.2.4.3.13 Corrosion and durability protective features

4.2.4.3.14 Flammability

4.2.4.3.15 Electrical bonding and protection against lightning and static electricity

4.2.4.3.16 Instructions for Continued Airworthiness

4.2.4.4 FAA issues guidance of showing compliance of airworthiness requirements for composite structures. Guidance includes:

4.2.4.4.1 AC 20-107A: "Composite Aircraft Structure" [4/84] (EASA has AMC No.1 to CS 25.603. TCCA has AC 500-009)

4.2.4.4.2 AC 21-26: "Quality Control for the Manufacture of Composite Structures" [6/89]

4.2.4.4.3 AC 23-20: "Acceptance Guidance on Material Procurement and Process Specifications for Polymer Matrix Composite Systems" [9/03]

4.2.4.4.4 AC 35.37-1: "Guidance Material for Fatigue Limit Tests and Composite Blade Fatigue Substantiation" [9/01]

4.2.4.4.5 FAA also issues Policy Statements (PS) supporting the certification of composite structures. PS are listed in the FAA website.

4.3 After completing this unit, the student will have demonstrated an awareness of course principles applied to composite damage disposition and repair

This part of the class, which is organized as a lab exercise, helps integrate principles previously learned on key aspects of teamwork and the use of source documentation. In particular, the special team skills needed for damage inspection and disposition, as well as those applied to execute and evaluate the quality of an approved repair will be applied in a case study. This lab is envisioned for teams of students, which include at least one member for each of the three major functions (inspector, technician, and engineer). Even if the individuals that comprise the team don't have a career path that is leading down the specified discipline, they should be aware of the roles and can take that position for the purposes of the lab. The content of this lab is best shared at the end of the course, after students have been exposed to all other areas, although the timing of the laboratory is optional to suit the needs of student learning.

4.3.1 A team of students will identify a typical structural component and understand the specific configuration and materials used for fabrication of the damaged component.

4.3.1.1 Each member of the team should be able to identify the specific hardware component used in the lab.

4.3.1.2 Source document (appropriate drawings and associated parts of repair manuals and specifications) should be available to understand the design configuration, structural details, materials and processes that comprise the damaged component.

4.3.1.3 Team discussions of the structural component are needed to plan damage inspection, disposition and repair.

4.3.2 A team of students will perform a damage assessment and map the damage as accurately as possible using general visual inspection, the tap test or pulse echo (P/E) ultrasonic equipment.

4.3.2.1 General visual inspection of the exterior surface will be compared with available data on the structural component to determine access for interior surface inspections and part design details that will affect subsequent NDI.

4.3.2.2 Source documents will be reviewed for selection of the inspection method and procedures needed for the specific damage location.

4.3.2.3 A complete inspection will be performed to identify the characteristics and full extent of hidden damage, which will be mapped for purposes of damage disposition.

4.3.2.4 The map of existing damage will be compared with any records of allowable damage and previous repairs for the specific part.

4.3.3 A team of students will utilize source documentation represented by a training repair manual (TRM) which simulates an OEM's structural repair manual (SRM) to understand the component's allowable damage limits, and review any repair options contained in the TRM based on the mapped damage.

4.3.3.1 The damage map and location developed during a complete inspection will be compared to source documentation to determine whether the damage is within allowable damage limits.

4.3.3.2 If the damage exceeds allowable damage limits specified in the source document, it will be compared against repair damage size limits.

4.3.3.2.1 If the damage is within repair damage size limits, a repair option will be selected from those specified in the source document.

4.3.3.2.2 If the damage is outside repair size limits, the engineer will take responsibility for contacting the OEM or other engineering resources for data needed to gain approval for a new repair.

4.3.3.3 The team must record damage details and repair disposition in the component master work sheet (or equivalent) for the specific component.

4.3.4 A team of students will write an appropriate repair procedure and in-process quality control (QC) plan based on the chosen repair option.

4.3.4.1 The available source documents will be reviewed for an appropriate repair procedure, a list of repair materials, appropriate tooling and an in-process quality control plan.

4.3.4.2 The available source documents will be reviewed for repair process details on moisture removal, bond surface preparation, damage removal, control and preparation of repair materials, and the safety equipment required.

4.3.4.3 Requirements for repair material storage and out-time are reviewed along with material handling requirements as shown in the source documents.

4.3.4.4 The repair process steps and required in-process quality controls are recorded on work sheets.

4.3.5 A team of students will write an appropriate post-repair inspection and approval plan.

4.3.5.1 The available source documents will be reviewed to define post-repair inspection procedures and approval plans. Document this information on work sheets.

4.3.5.2 Appropriate inspection techniques and details of the procedure needed for the specific repair location are listed on work sheets.

4.3.5.3 The available source documents will be reviewed to identify what disposition is needed to address a specified process anomaly, and provide this information on work sheets.

4.3.5.4 The available source documents will be reviewed to determine what special surface coatings and structural function checks are needed to restore the repaired component to service, and provide this information on work sheets.

5. DAMAGE DETECTION AND CHARACTERIZATION

This section of the class is intended to familiarize students with the typical types of composite damage, characteristics of the damage and appropriate inspection procedures. It integrates technical information and labs to ensure students understand what causes damage in composite materials and the inspection methods needed for detection and complete characterization. Although most composite damages and manufacturing anomalies have some visual indications, it is essential to realize that there will also be hidden features that need to be characterized for damage disposition and repair quality control. Source documents are used to identify the design details and appropriate inspection procedures for damage or repair in a particular location of a structural component. Once damage is characterized, source documents will also be used for disposition and repair. Damage and repairs that are beyond the limits of source documents will require special approvals, which substantiate the repair meets structural requirements.

5.1 After completing this unit, the student will recognize composite damage types and sources

This part of the class will help students learn about the types of damage that can occur to sandwich and skin stiffened composite structures. This will include some understanding of the most critical damage features affecting structural integrity. Some initial exposure on how to interpret damage characteristics, disposition and repair versus data provided in source documents will provide a basis for subsequent course content. This will include a brief introduction to damages and repairs outside of those covered by source documents and the need to follow the regulatory process in seeking approval. A lab exercise is provided to allow students to damage composite laminates in a controlled environment. The content of this section and the associated lab is best provided after exposure to roles and responsibilities but before parts of the course that provide more detailed content on composite inspection, disposition and source documents.

5.1.1 The student will identify sources and characteristics of damage to Composite Sandwich and Laminate Stiffened Structures.

5.1.1.1 Damage and defects that are found in composite structures can be sorted into three types that relate to the source:

5.1.1.1.1 Processing anomalies caused by fabrication, handling and assembly including voids, delaminations, porosity, inclusions, bond surface contamination, disbonding, impact damages, damaged fastener holes and edge defects.

5.1.1.1.2 Service damage can be caused on the ground or during flight operations. Some of these include thermal damage from adjacent systems, sonic fatigue, dropped tools, service vehicle impacts, aircraft handling accidents, bird strikes, runway debris, and other foreign object impacts occurring during maintenance or service.

5.1.1.1.3 Environmental damage occurring in service include hail, lightning strike, ultraviolet (UV) radiation, high intensity radiated fields (HIRF), rain erosion, moisture/fluid ingression and ground-air-ground (GAG) cycling of other damage types.

5.1.1.2 Pictorial and schematic examples of different composite damage and defect types may be a useful aid in the instruction process. It is essential to recognize that real-world damage may often have details that are not as easily characterized as those created in a controlled laboratory setting.

5.1.1.3 Pictorial and schematic examples of different sources of processing anomalies, service damage and environmental damage may be a useful aid in the instruction process.

5.1.2 The student will describe damage types and their significance to structural integrity.

5.1.2.1 Matrix imperfections such as surface blemishes or matrix cracks that are caused by processing, service damage, or environmental effects are seldom critical to the structure unless the degradation is widespread.

5.1.2.2 Delaminations and disbonds form at the surface between layers in a laminate or at the cured interface of two elements. These types of damages can be critical, particularly for parts loaded in compression and shear, where local instability, stress concentration and load redistribution affect structural integrity. Some delaminations may not be critical if constrained to the surface layers of thick parts.

5.1.2.3 Fiber breakage or cracking is usually limited to a zone of impact or a broken element that reacted to high loads (during operations or ground impact). Since composite structures are typically designed to be fiber dominant, any significant areas of fiber breakage can be critical.

5.1.2.4 Nicks, scratches and gouges may not be critical if the damage is limited to outer coating of resin in thin parts, or even the outer layers of fiber in thicker parts.

5.1.2.5 Dents are typically caused by an impact event, and can be critical depending on the full extent of fiber and matrix damage, including delamination and disbonding.

5.1.2.6 Punctures are defined as impact damage that penetrates the face-sheet of a sandwich structure or the skin and elements of a skin-stiffened structure. This type of damage can be critical depending on the size of the puncture and surrounding, hidden delamination and disbonding.

5.1.2.7 Erosion can occur at the leading edge of parts due to air flow over the part and the impingement of debris, rain and other particles in the air. Matrix degradation and local exposure of fibers due to erosion is typically not critical unless widespread or combined with other damaging mechanisms (fluid ingression and GAG degradation).

5.1.2.8 Lightning can cause damage depending on the energy levels of the strike. While rare, high energy lightning strikes may cause extensive damage that requires immediate repair.

5.1.2.9 Combinations of damage generally result from impact and can be critical depending on the full extent of fiber and matrix damage, including delamination and disbonding. For complex components and closed box structures, additional damage may be induced far beyond the immediate damage site. It is essential to inspect and understand the effect of these complex damages when designing a successful composite repair.

5.1.2.10 Fluid ingression can cause additional damage to the composite part. Damage that allows ingression must be addressed in a timely manner to avoid allowing excessive fluid accumulation in the component. Water penetrating into a core structure, coupled with freeze and thaw cycles can break down core cells and cause disbonding of the core from the facesheet. Hydraulic fluid can likewise have a corrosive effect when left in contact with unprotected composite for long periods of time.

5.1.3 The student will understand the technical data and structural analysis necessary for repair design and process substantiation.

5.1.3.1 Sufficient data must exist to ensure that repair material and process variability is covered by the regulatory rules used in structural substantiation for a particular damage to specific components.

5.1.3.2 Repairs performed while an aircraft is in service are controlled by a delegating authority devoted to the maintenance of civil aircraft.