Damage Detection and Characterization

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Damage Detection and Characterization

- **Recognize Composite Damage Types and Sources (Module D)**

- **Describe Composite Damage and Repair Inspection Procedures (Module H)**

Damage Detection and Characterization (Module D)

- **Recognize Composite Damage Types and Sources**
  - **D1**: Identify Sources and Characteristics of Damage to Composite Sandwich and Laminate Stiffened Structures
  - **D2**: Describe Damage Types and their Significance to Structural Integrity
  - **D3**: Understand the information and analysis necessary for repair design and process development/substantiation
  - **D4**: Distinguish differences in repair disposition procedures for those damages covered by source documentation, and those that aren't
  - **D5**:Describe the regulatory approval process for damages not covered by source documentation
  - **D6**: Damage laminate coupons in a controlled laboratory environment and visually inspect the extent of the front and any back side surface damage

Recognize Composite Damage Types and Sources

D1: Identify Sources and Characteristics of Damage to Composite Sandwich and Laminate Stiffened Structures

- *Processing anomalies and in-process handling damages*
  - Voids, delaminations, porosity, impact damages and edge dents
- *In-service damages*
  - Tool drops, ground vehicle impacts, bird strikes, runway debris, heat sources, fluids, sonic fatigue
- *Environmental damages*
  - Hail, lightning strike, UV radiation, rain erosion, moisture ingression, GAG cycling

Recognize Composite Damage Types and Sources

D2: Describe Damage Types and their Significance to Structural Integrity

- Matrix Imperfections (Cracks, porosity, blisters, etc.)
- Delaminations and disbonds
- Fiber Breakage
- Nicks, Scratches, Gouges
- Dents
- Punctures
- Combinations of Damages (source of damage: impact)
- Damaged Fastener Holes, edge erosion

Recognize Composite Damage Types and Sources

D3: Understand the information and analysis necessary for repair design and process development/substantiation

- *Repair design*
  - Original part strength and stiffness data from database used for Type Certificate
  - Approved strength and stiffness data for repair materials and repair fasteners
  - Repair design criteria for permanent repairs are fundamentally those that were used to design the part that is to be repaired
- *Repair processing*
  - Sufficient research and testing must be performed to ensure that the materials and processes employed by the end user will provide adequate repairs per the repair designs

Recognize Composite Damage Types and Sources

D4: Distinguish differences in repair disposition procedures for those damages covered by source documentation, and those that aren't

- *Consult source documentation (SRM)*
  - Allowable damage limits
  - Repair options
  - Follow detailed repair instructions
- *Damage not covered by approved repair documentation*
  - Approved data must be used for repair design
  - Approved materials and processes must be used for repair
  - SRM repair information for similar components may not be used without agreement from OEM

Recognize Composite Damage Types and Sources

D5: Describe the regulatory approval process for damages not covered by source documentation

- *In the event that the damage is not covered by an approved repair, there are several options:*
  - **Contact the OEM for an approved repair**
    - Most time consuming option
  - **Replace the damaged part**
    - Speediest option
  - **Prepare a specific repair for the damage not covered and get it approved**
    - DER or OEM approval

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D6: Damage laminate coupons in a controlled laboratory environment and visually inspect the extent of the front and any back side surface damage

- **Laboratory**
  - The instructor will demonstrate the use of the calibrated drop tower and impactor
  - Students will pair up to damage laminate panels using a calibrated drop tower and impactor
  - The instructor will demonstrate the visual inspection technique
  - Students will each visually inspect a damaged panel and map the damage

Safety Message

When damage is above the allowable damage limits for a specific component and approved data exists for repair, source documentation (e.g., SRM) will typically provide the necessary instructions for maintenance actions. This includes the appropriate NDI methods to accurately map the extent of the damage and an approved repair that can be performed to allow the aircraft to be returned to service.

Distinguish differences in repair disposition procedures for damages covered by source documentation, and those that aren't

Safety Message (cont'd)

If the damage is of a level not covered by previously approved data that has been documented and made available, then the original equipment manufacturer (OEM) must be contacted for repair disposition, or a DER will be needed to develop a repair design and generate the data needed to substantiate the repair.

Damage disposition and subsequent repair designs and processes must be based on approved data, which substantiates the structural integrity. Without such data, the airworthiness of the structure is in question.

Damage Detection and Characterization

- **Describe Composite Damage and Repair Inspection Procedures (Module H)**
  - **H1**: Describe NDI techniques currently available in the field
  - **H2**: Describe critical steps necessary for making damage dispositions, including inspection and a draft process for QC plan for repair
  - **H3**: Describe the critical steps necessary for inspecting a completed bonded repair, including NDI and interpretation of results
  - **H4**: Demonstrate, and have students perform various damage assessments, including visual inspection, tap test and ultrasonic inspection
  - **H5**: Demonstrate, and have students perform various post-repair acceptance inspections, including visual inspection, tap test and ultrasonic inspection

Describe Composite Damage and Repair Inspection Procedures (Module H)

H1: Describe NDI techniques currently available in the field

- Visual inspection, surveillance and detailed
- Tap coin or hammer
- Pulse echo ultrasonic equipment
- Bond testers
- Moisture meters
- Eddy current equipment
- Radiography

Describe Composite Damage and Repair Inspection Procedures

H2: Describe critical steps necessary for making damage dispositions, including inspection and a draft process for QC plan for repair

- *Damage disposition*
  - Damage detection – visual inspection
  - Damage assessment – Tap and/or instrumented NDI
    - Consult SRM or MPD document for specified inspection instructions
  - Consult SRM for ADLs and repair options
- *Quality control (QC) plan for a bonded repair*
  - Surface preparation and moisture removal
  - Damage removal and scarfing (or hole drilling)
  - Repair material preparation and lay down
  - Repair bagging and cure parameter monitoring

Describe Composite Damage and Repair Inspection Procedures

H3: Describe the critical steps necessary for inspecting a completed bonded repair, including NDI and interpretation of results

- Interrogate in-process QC printouts
- Visual inspection (light enhanced)
- NDI inspection – tap (thin face sheets) or P/E
  - Check instrumented NDI results with standards if available
- If flight control panel – check balance condition
- Defects detected – repair rejected and removed
- Repair approved – restore all protections systems

Describe Composite Damage and Repair Inspection Procedures

H4: Demonstrate, and have students perform various damage assessments, including visual inspection, tap test and ultrasonic inspection

- **Laboratory**
  - *Students will participate in performing various NDI assessments of damaged panels in a controlled laboratory environment*
  - *The inspection techniques to be used will be:*
    - visual inspection (flashlight enhanced)
    - the tap test
    - pulse echo ultrasonic equipment

Describe Composite Damage and Repair Inspection Procedures

H5: Demonstrate, and have students perform various post-repair acceptance inspections, including visual inspection, tap test and ultrasonic inspection

- **Laboratory**
  - *Students will participate in performing various NDI assessments of bonded repairs to laminate panels in a controlled laboratory environment*
  - *The inspection techniques to be used will be:*
    - Visual inspection (flashlight enhanced)
    - Tap test
    - Pulse echo ultrasonic equipment

Describe Composite Damage and Repair Inspection Procedures

Safety Message

In-service inspections of composite components are necessary for safe flight operations just as they are for those components fabricated from metals. In-service damages to composite parts from various sources are likely to occur during an aircraft's operational life. Per maintenance instructions, damages may be detected using visual inspection or by directed NDI.

Visual indications of outside surface damage should be followed up with a backside inspection if accessible. If damage is first detected using visual methods, NDI techniques such as pulse echo or even a simple tap hammer will generally be needed to determine the full extent of the damage and make the correct disposition.

Describe Composite Damage and Repair Inspection Procedures

Safety Message (cont'd)

The correct use and_ interpretation of NDI are required to accurately define the extent of damages so that correct damage dispositions can be made.

In the event of in-service damages, it is crucial for safe flight operations that these damages are discovered, either by operations personnel, or directed maintenance inspections, before they become critical.

After damage has been discovered, the correct damage disposition must be made in order that the damage can, either be determined to be acceptable, or the damaged component can be repaired and the aircraft returned to safe flight operations.

Describe the critical steps necessary for inspecting a completed bonded repair, including NDI and interpretation of results

Safety Message

Defects may be present in the bond line or within the repair patch due to poor surface preparation, material storage and handling, and cure process mistakes.

It is essential to use the appropriate inspection methods for specific types of bonded repair (i.e. sandwich, laminate stiffened or metal-bond components).

Visual inspection can be, in some cases, just as valuable as NDI methods such as pulse-echo for detecting flawed bonded repairs.

Misuse of equipment during post-repair inspections, or misinterpretation of inspection results may be detrimental to safety.