

FAA pre-requisite 1

Understand the basics of
composite materials technology

Introduction

- In any type of work is easier to obey the rules if you have a basic understanding of the underlying science and technology
- Example. The importance of good surface preparation when adhesively bonding metals and other materials.

Learning new words

- When taking up any new job, hobby or other activity it almost always means learning new words and their meaning in the context of the new occupation.
- In composites this means words like
 - Carbon fiber
 - Glass fiber
 - Aramid fiber

More new words

- Resin
- Adhesive
- Bagging film
- Release film
- Honeycomb
- De-bulking
- Vacuum system

A1. Distinguish among resin, fiber and core applications and uses

- Epoxy resins most common in aircraft.
- Phenolic resins in cabins due to low smoke emission and toxicity.
- Polyimide and Bis-maleimide resins used in high-temperature areas.
- Two-part resins RT cure and 93°C (200°F).
- One –part pastes, film adhesives and pre-pregs are hot-cured.

Resins continued

- Accurate weighing and thorough mixing essential for 2-part systems.
- Adhesives are chemically similar to resins but have a higher viscosity. Their maximum service temperature depends on formulation and cure temperature.
- Must use the correct material for each application.

Fiber types

- Common fibers are carbon, glass, aramid.
- Quartz fiber sometimes used for radomes.
- Boron fiber used for repairs to metal parts.
- All fibers must be laid up in the correct direction given in the SRM.
- Must use correct type and weight of fabric.
- Transverse strength of composites is low.

Core applications

- Sandwich structures use thin skins and core materials to give stiff, light, structures.
- Sandwich structure easier to repair but more easily damaged.
- Solid laminate structure more resistant to damage but harder to repair.
- Radome core thickness must be correct to pass the wave test.

Core Materials

- Balsa wood
- Polystyrene foam (Styrofoam)
- PVC foam
- Polyurethane foam
- Polymethacrylimide foam (Rohacell)
- Aluminum Alloy Honeycomb
- Carbon, Glass and Aramid fabric honeycomb

A2. Describe various composite processing parameters

- Workshop must be clean and dry.
- Temperature 18°C (64°F) to 30°C(86°F), Relative Humidity 60% maximum.
- Positive pressure of filtered air in clean room to keep out dust and dirt.
- Tooling clean and in good condition.
- Component must be clean and dry.
- Composite surface correctly prepared.

Composite processing continued

- Dryness check with moisture meters for glass and aramid parts.
- SRM drying procedure for carbon parts.
- Correct repair materials must be in good condition and within shelf life.
- Each ply must be correct material, weave and weight and laid in correct direction.
- Vacuum pressure correct, leakage in limit.

Composite processing continued

- All release films, breather cloths and bagging film laid up correctly.
- Thermocouples correctly located.
- Cure time and temperature correct.
- Commence bonding as soon as lay-up is complete.
- After cure remove release films and peel plies with care to avoid damage.

A3. Composite design parameters and effects of processing

- Strength in fiber direction due to fibers.
- Stiffness in fiber direction due to fibers.
- Impact resistance depends on toughness of fibers and strain to failure of the resin.
- ILSS depends on resin properties.
- Compression strength depends on the modulus of the resin.
- Operating temperature depends on the resin.

Composite design parameters

- Creep resistance depends on the fiber.
- Matrix must be fully cured or maximum operating temperature will be reduced.
- If plies are not de-bulked under vacuum then voids may be present.
- The correct finish on fibers is important.
- Fatigue resistance depends on relative fatigue strain to failure of fiber and resin.

A4. Composite machining, assembly and finishing

- Machining is covered well in a video from Du Pont.
- See SRM for design of cutting tools, drills.
- See SRM for cutting and drilling speeds and feed rates.
- Use backing plates, plywood or plastic.
- Always cut fibers in tension.
- Always use sharp tools.

A4. Machining Composites

- Tools used for aramids must not be used on carbon or glass.
- Blunt tools will not cut aramids.
- Diamond coated bandsaw for composites.
- High speed bandsaw for honeycomb.
- Hot wire cutters for some foams.
- Not for polyurethane due to toxic fumes.
- Check cutting methods for foam core.

A4. Composite Machining

- Water jet cutting good but expensive.
- Oscillating saws good, use carefully.
- Grinding burrs good for corner radii.
- Power drills pneumatic, no sparks allowed.
- High speed grinders for light sanding.
- Orbital sanders good for local paint removal.
- Abrasive papers AlO_2 or Si.C

A4. Composite Machining

- Reamers may be needed for close tolerance holes.
- Lubrication and cooling to avoid overheating matrix resin. Use Boelube.
- Boelube melts at 49°C(120°F).
- Diamond coated wheel trimmers good for cutting panel edges.

A4. Composite assembly

- Adhesive bonding for thin parts.
- Bolts or blind fasteners for thick parts.
- Bolts plus adhesive bonding.

A4. Composite finishing

- Special surface finishing films of adhesive or resin may be used for appearance.
- Primers and paints.
- Special coatings for protection.
- Lightning protection.
- Erosion protection, leading edges.
- Anti-static coatings.

A5. Stiffened laminate and sandwich applications

- Stiffened laminates used for wing, and empennage structures and now for fuselage and engine pylons.
- Sandwich structures used for ailerons, elevators, rudders, spoilers, flaps, fairings, trailing edge panels, undercarriage doors, radomes, floor panels, galleys and overhead stowage bins.

A6. SAE AIR 4844 Composite and Metal Bonding Glossary

- This document has been updated recently and is useful when new words need to be explained.
- New words can be added on request to the Commercial Aircraft Composite Repair Committee (CACRC).
- Send them to Kerri Rohall at kerrir@sae.org

B1. Understand basics of composite materials maintenance and repair

- B1 List basic steps in maintenance procedures from damage detection through repair completion.
- Ensure good lighting and workshop conditions. 18-30°C (64-86°F) and RH 60% max:
- Good access to components.
- Sound staff training.

B1 Maintenance Procedures

- Good inspection needs good equipment.
- Check SRM for permitted repairs.
- Cut away damage.
- Check part number with IPC.
- SRM for materials and lay-up sequence.
- Honeycomb type, weight and treatment.
- Check materials are in stock.
- Check materials within shelf life.

B1. Maintenance Procedures

- Check all damage has been removed.
- Remove more material if necessary.
- Repeat NDI if necessary.
- Remove paint in area to be bonded.
- Dry bonding area to SRM.
- Lay film adhesive or paste to bottom skin.
- Fit new honeycomb in correct orientation.
- Join honeycomb to core with potting.

B1 Maintenance Procedures

- If heat is required bond honeycomb in place before fitting top skin.
- Sand honeycomb flush with top skin.
- Dry top skin to SRM.
- Lay film adhesive and top skin in correct orientation for each ply.
- Bond repair patch using vacuum pressure and heat if required.

B1. Maintenance Procedures.

- Use thermocouples and a hot-bonder to ensure correct cure cycle.
- Take care when removing vacuum bag and release films to avoid damage.
- Use NDI to confirm a sound repair.
- Replace any protective coatings to SRM.
- Paint as required.

B2. Key composite and expendable materials

- B2. List key composite and expendable materials needed for simple laminate structure repair, including appropriate storage requirements.
- Carbon, glass and aramid fabrics and prepregs.
- Film and paste adhesives, liquid resins.
- Potting compounds, foaming films.

B2. Key composite and expendable materials

- Vacuum bag film and sealant tapes.
- Release films, perforated release films.
- Bleeder and breather cloths.
- Peel plies.
- Release fabrics and mold release liquids and waxes.
- Sealants, thiokol, polythioether and silicone.

B3. Tooling and Equipment

- B3. List the necessary tooling and equipment to accomplish a simple laminate structural repair.
- Flat workbench, electronic scales,
- Mixing trays, paintbrushes, mixing sticks,
- Sharp scissors, roll of tissue, clean rags, drills, reamers.
- Mold or tool to maintain part profile.

B3, Tooling and Equipment

- Hand tools, pneumatic drills, grinders, and cutting discs, tank cutters, grinding burrs.
- High speed bandsaw for expanded honeycomb, Stanley knives.
- Abrasive papers, acetone, files.
- Vacuum pump, piping and gauges.
- Thermocouples, hot-bonder, heater blankets and heater lamps.

B4. Health and Safety

- B4. Adhere to personal and equipment safety requirements.
- Wear overalls, gloves and goggles if needed. Use barrier creams and gloves.
- Avoid skin contact with adhesives, resins, solvents and sealants.
- Use sealed containers for solvents.
- Wear masks or use ventilation booths for resin mixing so that fumes are not inhaled.

B4. Health and Safety

- Use all guards supplied.
- Handle tools with care.
- Read Material Safety Data Sheets.
- Read Product Data Sheets for mixing ratios, cure schedules and Safety info.
- Obtain medical assistance in the event of an accident. Immediately if eye contact occurs.

FAA Pre-requisite 2

- B5. Describe the differences between repairing composite and metal structures, including discussions about metal bonding.
- Metal needs special surface preparation and primers for good bonding.
- Metals are not porous.
- Metals are isotropic, same in all directions.

B5. Differences between Metals and Composites

- Composites have in-plane properties that depend on ply orientation.
- Transverse strength is low.
- Surface preparation easier but composites must be dried before bonding.
- Composite skins porous till resin is cured.
- Primers seldom used in bonding composites.

B5. Similarities between Metal and Composite Bonding

- The correct bonding pressure is needed.
- Use correct cure temperature and time .
- A film adhesive is used to bond patches to both metals and composites.
- Both use anodized aluminum honeycomb.
- Original primer must be restored around the patch area before painting.

Understand the critical elements of composite maintenance and repair

- J1. Discuss issues affecting the selection of bonded or bolted repairs.
- Bolts may be used with plates for temporary repairs to honeycomb panels.
- Bonded repairs if material 2mm or less.
- Bolted repairs if material 2mm or more.
- Check SRM for required repair type.

J2. Electrical requirements and effects

- J2. 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 the repair processes.
- Fasteners must be suitable for the type of composite being used to avoid corrosion.

J2 Electrical requirements and effects

- All bolts in carbon composite must be made from bare Titanium, Ti coated with Al or Corrosion resistant steel.
- Aluminum and alloy steel fasteners not permitted in carbon composites.
- Glass and Aramid composites no problem.
- Lightning protection systems essential on radomes, aileron, elevator and rudder tips and engine nacelles.

J2 Electrical requirements and effects

- Electrostatic discharge protection needed on radomes and windows to dissipate static charge generated by airflow.
- Another form is precipitation static due to raindrops, hail, dry ice, snow. This can interfere with radio communication.
- Always replace these systems to the SRM.

J3. Protective coatings

- J3. Understand the need for protective coatings and surface finishing steps used for composite aircraft structure.
- Anti-static coatings to BMS 10, Type 1 used for all fiberglass areas except radomes and antennae.
- BMS 10, Type 2 used for radomes is less conductive.

J3. Protective coatings

- Lightning protection usually aluminum strips on the outside of radomes or picture frames of Aluminum at rudder, elevator and aileron tips.
- Other systems are flame-sprayed aluminum, metal coated fabric, wire mesh and expanded foil mesh.
- Erosion resistant coatings may be polyurethane paint or overshoes, or metal shields on leading edges, helicopter blades and engine fan blades.

J4. Paint and surface layer removal

- J4. Describe paint and surface layer removal techniques for finished composite parts.
- Paint removal a problem. Airlines may need ten or more repaints in a lifetime.
- SA MA 4872 tells how to qualify a paint removal system.
- Many methods have been tried.

J4. Paint and surface layer removal

- PPG Aerospace PRC De Soto supply Desothane HS, CA 8000 topcoat and an intercoat.
- These can be removed with a benzyl alcohol-based solvent without damage to the primer coat, which lasts the aircraft life.
- Other methods are Dry Plastic media, Wet media, chemical stripper, thermal stripping.
- Sponge Jet system, an abrasive in a soft base.

J5. Waste disposal

- J5. Discuss proper disposal of wastes from the composite repair process, including EPA/OSHA requirements.
- Must work to local regulations, or better.
- Resin, film and paste adhesives, and pre-pregs and potting compounds should be fully cured before disposal.
- Dust and small trimmings should be collected in a vacuum bag for disposal.

J5. Waste Disposal

- Waste solvents should be re-cycled.
- All other composite waste e.g solidified paint brushes, rags, tissues, off-cuts must be disposed of as hazardous waste.
- See MSDS or contact Company Safety Officer for correct disposal procedures.

J6. Emerging advances in repair

- J6. Discuss emerging advances in repair process technologies that may appear for bonded and bolted repair and quality control.
- GMI Aerospace, Paris, now have a second blanket and control on their hot-bonders so that extra heat can be supplied to a cold spot. Improves temperature uniformity over the repair area.

J6. Emerging advances in repair

- Adhesives have been developed that can be cured below their service temperature.
- Examples are, Cytec FM 300-2, Huntsman Epocast 52, Hysol EA 9390, EA 9396 and EA 9396-C2.

J7. Emerging damage and repair inspection technologies

- Test equipment has been made more portable.
- RD Tech and NDT Solutions have produced a Portable Phased Array Ultrasonic system.
- The Woodpecker has been developed to provide a print-out of a scan and also to give depth information on thick laminates.

J7. Emerging damage and repair inspection technologies

- An endoscope technique can be used to detect cracks in GLARE.
- Holography and Shearography are useful but cannot yet measure bond strength.
- Moisture meters for carbon composite seem to have disappeared from the market.
- Carbon composites should be dried to the SRM.

J8. Knowing your skill limits

- It is always less embarrassing to ask than to make a mistake.
- Ask a skilled person with experience.
- Read the Material Safety Data Sheet (MSDS), don't guess. Read the SRM.
- Get help from qualified NDI personnel.
- Use the correct tools and equipment.
- If you are not sure, check.

J9. Information about damage

- J9. Discuss the importance of documenting/sharing information about damage scenarios discovered in service between OEM and Maintenance Organisations and Regulators.
- Talk to other airlines and operators.
- Read Incident Reports and Maintenance Occurrence Reports (MOR'S).
- File MOR's yourself if a fault is found.

J9. Information about damage

- A fault on one aircraft of a type can happen to them all.
- Request modification action if necessary.
- Implement Service Bulletins well within their time limits.
- If you hear of a problem check your own aircraft as soon as possible. Don't wait for a Mandatory Service Bulletin.