AIRCRAFT TECHNICAL BOOK COMPANY

B2

AVIATION MAINTENANCE TECHNICIAN CERTIFICATION SERIES

MATERIALS AND HARDWARE

6

COMPLIANT WITH EASA EASA PART 66/147

EASA 2023-989 COMPLIANT

Update notices for this book will be available online at www.actechbooks.com/revisions.html
If you would like to be notified when changes occur, please join our mailing list at www.actechbooks.com

VERSION	EFFECTIVE DATE	DESCRIPTION OF REVISION(S)
001	2018.08	Module creation and release.
001.1	2023.04	Inclusion of Measurement Standards for clarification, page iv. Minor appearance and format updates.
002	2024.07	Regulatory update for EASA 2023-989 compliance.

Module was reorganized based upon the EASA 2023-989 subject criteria.

MATERIALS AND HARDWARE

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

Sealant Base	Accelerator (Catalyst)	Mixing Ratio by Weight	Application Life (Work)	Storage (Shelf) Life After Mixing	Storage (Shelf) Life Unmixed	Temperature Range	Application and Limitations
EC-801 (black) MIL-S-7502A Class B-2	EC-807	12 parts of EC-807 to 100 parts of EC-801	2–4 hours	5 days at –20 °F after flash freeze at –65 °F	6 months	–65 °F to 200 °F	Faying surfaces, fillet seals, and packing gaps
EC-800 (red)	None	Use as is	8–12 hours	Not applicable	6–9 months	–65 °F to 200 °F	Coating rivet
EC-612 P (pink) MIL-P-20628	None	Use as is	Indefinite non-drying	Not applicable	6–9 months	–40 °F to 200 °F	Packing voids up to ¼"
PR-1302HT (red) MIL-S-8784	PR-1302HT-A	10 parts of PR-1302HT-A to 100 parts of PR-1302HT	2–4 hours	5 days at –20 °F after flash freeze at –65 °F	6 months	–65 °F to 200 °F	Sealing access door gaskets
PR-727 potting compound MIL-S-8516B	PR-727A	12 parts of PR-727A to 100 parts of PR-727	1½ hours minimum	5 days at –20 °F after flash freeze at –65 °F	6 months	–65 °F to 200 °F	Potting electrical connections and bulkhead seals
HT-3 (grey–green)	None	Use as is	Solvent release, sets up in 2–4 hours	Not applicable	6–9 months	–60 °F to 200 °F	Sealing hot air ducts passing through bulkheads
EC-776 (clear amber) MIL-S-4383B	None	Use as is	8–12 hours	Not applicable	Indefinite in airtight containers	–65 °F to 200 °F	Top coating

Figure 3-26. General sealant information.

6.3.1 SECTION B

REPAIR PROCEDURES FOR COMPOSITE MATERIALS AND STRUCTURES

LAYUP MATERIALS AND TOOLS

Prepreg and dry fabrics can be cut with hand tools, such as scissors, pizza cutters, and knives. Materials made from Kevlar® are more difficult to cut than fiberglass or carbon and tools wear quicker. A squeegee and a brush are used to impregnate dry fibers with resin for wet layup. Markers, rulers, and circle templates are used to make a repair layout.

AIR TOOLS

Air driven power tools, such as drill motors, routers, and grinders, are used for composite materials. Electric motors are not recommended, because carbon is a conductive material that can cause an electrical short circuit. If electric tools are used, they need to be of the totally enclosed type. [**Figure 3-27**]

CAUL PLATE

A caul plate made from aluminum is often used to support the part during the cure cycle. A mold release agent, or parting film, is applied to the caul plate so that the part does not attach to the caul plate. A thin caul plate is also used on top of the repair when a heat bonder is used. The caul plate provides a more uniform heated area and it leaves a smoother finish of the composite laminate.

SUPPORT TOOLING AND MOLDS

Certain repairs require tools to support the part and or maintain surface contour during cure. A variety of materials can be used to manufacture these tools.

The type of material used depends on the type of repair, cure temperature, and whether it is a temporary or permanent tool. Support tooling is necessary for oven and autoclave cure due to the high cure temperature. The parts deform if support tooling is not used. There are many types of tooling material available. Some are molded to a specific part contour and others are used as rigid supports to maintain the contour during cure.

VACUUM BAG MATERIALS

Repairs of composite aircraft components are often performed with a technique known as vacuum bagging. A plastic bag is sealed around the repair area. Air is then removed from the bag, which allows repair plies to be drawn together with no air trapped in between. Atmospheric pressure bears on the repair and a strong, secure bond is created. [**Figure 3-28**]

Figure 3-27. Air tools used for composite repair.

RELEASE AGENTS
Release agents, also called mold release agents, are used so that the part comes off the tool easily after curing.

BLEEDER PLY
The bleeder ply creates a path for the air and volatiles to escape from the repair. Excess resin is collected in the bleeder. The structural repair manual indicates what type and how many plies of bleeder are required. As a general rule, the thicker the laminate, the more bleeder plies are required.

PEEL PLY
Peel plies are often used to create a clean surface for bonding purposes. A thin layer of fiberglass is cured with the repair part. Just before the part is bonded to another structure, the peel ply is removed. They can be difficult to remove if overheated. Some coated peel plies can leave an undesirable contamination on the surface. The preferred peel ply material is polyester that has been heat-set to eliminate shrinkage.

LAYUP TAPES
Vacuum bag sealing tape, also called sticky tape, is used to seal the vacuum bag to the part or tool. Always check the temperature rating of the tape before use to ensure that you use appropriately rated tape.

Perforated Release Film Perforated parting film is used to allow air and volatiles out of the repair, and it prevents the bleeder ply from sticking to the part or repair. It is available with different size holes and hole spacing depending on the amount of bleeding required.

BREATHER MATERIAL
The breather material is used to provide a path for air to get out of the vacuum bag. The breather must contact the bleeder.

VACUUM BAG
The vacuum bag material provides a tough layer between the repair and the atmosphere. The vacuum bag material is available in different temperature ratings, so make sure that the material used for the repair can handle the cure temperature. Two small cuts are made in the bagging material so that the vacuum probe valve can be installed. Reusable bags made from silicon rubber are available that are more flexible. Some have a built in heater blanket that simplifies the bagging task.
[**Figures 3-29, 3-30, and 3-31**]

VACUUM EQUIPMENT
A vacuum pump is used to evacuate air and volatiles from the vacuum bag so that atmospheric pressure consolidates the plies. A dedicated vacuum pump is used in a repair shop. For repairs on the aircraft, a mobile vacuum pump could be used. Most heat bonders have a built in vacuum pump. The vacuum lines that are used in the oven or autoclave need to be able to withstand the high temperatures in the heating device. A vacuum pressure regulator is sometimes used to lower the vacuum pressure during the bagging process.

HEAT SOURCES

OVENS
Composite materials can be cured in ovens using various pressure application methods. [**Figure 3-32**] Typical oven cure temperatures are 120°C and 175°C. Ovens have a temperature sensor to feed temperature data back to the oven controller. The oven temperature can differ from the actual part temperature depending upon the location of the oven sensor and the location of the part in the oven.

Figure 3-29. A mold of an inlet duct.

Figure 3-28. Five-axis CNC equipment for tool and mold making.

Figure 3-30. Bagging materials.

To deal with these differences, at least two thermocouples must be placed on the part and connected to a temperature sensing device (separate chart recorder, hot bonder, etc.) located outside the oven. Some oven controllers can be controlled by thermocouples placed on the repair part.

AUTOCLAVE

An autoclave system allows a complex chemical reaction to occur inside a pressure vessel according to a specified time, temperature, and pressure profile in order to process a variety of materials. [**Figure 3-33**] Autoclaves that are operated at lower temperatures and pressures can be pressurized by air, but if higher temperatures and pressures are required for cure cycle, a 50/50 mixture of air and nitrogen or 100 percent nitrogen should be used to reduce the chance of an autoclave fire.

Modern autoclaves are computer controlled and the operator can write and monitor all types of cure cycle programs. The most accurate way to control the cure cycle is to control the autoclave controller with thermocouples that are placed on the actual part.

Most parts processed in autoclaves are covered with a vacuum bag that is used primarily for compaction of laminates and to provide a path for removal of volatiles. The bag allows the part to be subjected to differential pressure in the autoclave without being directly exposed to the autoclave atmosphere. The vacuum bag is also used to apply varying levels of vacuum to the part.

ON AIRCRAFT HEATING

Typical on-aircraft heating methods include heat blankets, infrared heat lamps, and hot air devices. All heating devices must be controlled by some means so that the correct amount of heat can be applied. This is particularly important for repairs using prepreg material and adhesives, because controlled heating and cooling rates are usually prescribed.

HEAT BLANKET

A heat blanket is a flexible heater. It is made of two layers of silicon rubber with a metal resistance heater between the two layers of silicon. Heat blankets are a common method of applying heat for repairs on the aircraft. Heat blankets may be controlled manually; however, they are usually used in conjunction with a

Figure 3-31. Bagging of complex part.

Figure 3-32. Walk-in curing oven.

Figure 3-33. Autoclave.

heat bonder. Heat is transferred from the blanket via conduction. Consequently, the heat blanket must conform to and be in 100 percent contact with the part, which is usually accomplished using vacuum bag pressure. [**Figure 3-34**]

HEAT LAMP

Infrared heat lamps can also be used for elevated temperature curing of composites if a vacuum bag is not utilized. However, they are generally not effective for producing curing temperatures above 65°C, or for areas larger than two square feet. It is also difficult to control the heat applied with a lamp, and lamps tend to generate high surface temperatures quickly. If controlled by thermostats, heat lamps can be useful in applying curing heat to large or irregular surfaces. Heat bonders can be used to control heat lamps.

THERMOCOUPLES

A thermocouple is a thermoelectric device used to accurately measure temperatures. It may be connected to a simple temperature reading device, or connected to a hot bonder, oven, or other type of controller that regulates the amount of heat. Thermocouples consist of a wire with two leads of dissimilar metals that are joined at one end. Heating the joint produces an electric current, which is converted to a temperature reading with a thermocouple monitor.

THERMOCOUPLE PLACEMENT

Thermocouple placement is the key in obtaining proper cure temperatures throughout the repair. In general, the thermocouples used for temperature control should be placed as close as possible to the repair material without causing it to become embedded in the repair or producing indentations in the repair. They should also be placed in strategic hot or cold locations to ensure the materials are adequately cured but not exposed to excessively high temperatures that could degrade the material structural properties.

TYPES OF LAYUPS

WET LAYUPS

During the wet layup process, a dry fabric is impregnated with a resin. Mix the resin system just before making the repair. Lay out the repair plies on a piece of fabric and impregnate the fabric with the resin. After the fabric is impregnated, cut the repair plies, stack in the correct ply orientation, and vacuum bag. Wet layup repairs are often used with fiberglass for nonstructural applications.

Figure 3-34. Heat blankets.

Carbon and Kevlar® dry fabric could also be used with a wet layup resin system. Many resin systems used with wet layup cure at room temperature, are easy to accomplish, and the materials can be stored at room temperature for long period of times. The disadvantage of room temperature wet layup is that it does not restore the strength and durability of the original structurel.

Epoxy resins may require refrigeration until they are used. This prevents the aging of the epoxy. The label on the container states the correct storage temperature for each component. The typical storage temperature is between 4°C and 27°C for most epoxy resins.

PREPREGS

Prepreg is a fabric or tape that is impregnated with a resin during the manufacturing process. The resin system is already mixed and is in the B stage cure. Store the prepreg material in a freezer below -18°C to prevent further curing of the resin. The material is typically placed on a roll and a backing material is placed on one side so that the prepreg does not stick together. The prepreg material is sticky and adheres to other plies easily during the stack-up process. You must remove the prepreg from the freezer and let the material thaw, which might take 8 hours for a full roll. Store the prepreg materials in a sealed, moisture proof bag. Do not open these bags until the material is completely thawed to prevent contamination of the material by moisture. After the material is thawed and removed from the backing material, cut it in repair plies, stack in the correct ply orientation, and vacuum bag. Do not forget to remove the backing material when stacking the plies. Cure prepregs at an elevated cure cycle. The most common temperatures used are 120°C and 200°C. Autoclaves, curing ovens, and heat bonders can be used to cure the prepreg material.

Consolidation is necessary if parts are made from several layers of prepreg, because large quantities of air can be trapped between each prepreg layer. Remove this trapped air by covering the prepreg with a perforated release film and a breather ply, and apply a vacuum bag. Apply the vacuum for 10 to 15 minutes at room temperature.

Uncured prepreg materials have time limits for storage and use. [**Figure 3-35**] The maximum time allowed for storing of a prepreg at low temperature is called the storage life, which is typically 6 months to 1 year. The material can be tested, and the storage life could be extended by the material manufacturer. The maximum time allowed for material at room temperature before the material cures is called the mechanical life. The recommended time at room temperature to complete layup and compaction is called the handling life. The handling life is shorter than the mechanical

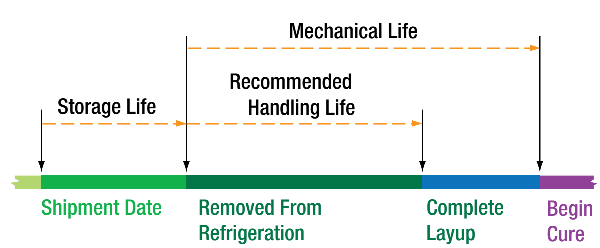

Figure 3-35. Storage life for prepeg materials.

life. The mechanical life is measured from the time the material is removed from the freezer until the time the material is returned to the freezer. The operator must keep records of the time in and out of the freezer. Material that exceeds the mechanical life needs to be discarded.

Many repair facilities cut the material in smaller kits and store them in moisture proof bags that thaw quicker when removed from the freezer. This also limits the time out of the freezer for a big roll.

All frozen prepreg materials need to be stored in moisture proof bags to avoid moisture contamination. All prepreg material should be protected from dust, oil, vapors, smoke, and other contaminants. A clean room for repair layup would be best, but if a clean room is not available, the prepreg should be protected by storing them in bags or keeping them covered with plastic. Before starting the layup, cover the unprotected sides of the prepreg with parting film, and clean the area being repaired immediately before laying up the repair plies.

WET LAMINATED LAYUP TECHNIQUES

Read the structural repair manual and determine the correct repair material, number of plies required for the repair, and the ply orientation. Dry the part, remove the damage, and taper sand the edges of damaged area. Use a piece of thin plastic, and trace the size of each repair ply from the damaged area. Indicate the ply orientation of each ply on the trace sheet. Copy the repair ply information to a piece of repair material that is large enough to cut all plies. Impregnate the repair material with resin, place a piece of transparent release film over the fabric, cut out the plies, and layup the plies in the damaged area. The plies are usually placed using the smallest ply first taper layup sequence, but an alternative method is to use the largest ply first layup sequence. In this sequence, the first layer of reinforcing fabric completely covers the work area, followed by successively smaller layers, and then is finished with an extra outer layer or two extending over the patch and onto the sound laminate for some distance. Both methods are illustrated in **Figures 3-36 and 3-37**.

BLEEDOUT TECHNIQUE

The traditional bleedout using a vacuum bag technique places a perforated release film and a breather/bleeder ply on top of the repair. The holes in the release film allow air to breath and resin to bleed off over the entire repair area. The amount of resin bled off depends on the size and number of holes in the perforated release film, the thickness of the bleeder/breather cloth, the resin viscosity and temperature, and the vacuum pressure.

NO BLEEDOUT

Prepreg systems with 32-35 percent resin content are typically no-bleed systems. These prepregs contain exactly the amount of resin needed in the cured laminate; therefore, resin bleedoff is not desired. Bleedout of these prepregs results in a resin starved repair or part. Many high strength prepregs in use today are no-bleed systems. No bleeder is used, and the resin is trapped/sealed so that none bleeds away. Consult the maintenance manual to determine if bleeder plies are required for the repair. A sheet of solid release film (no holes) is placed on top of the prepreg and taped off at the edges with flash tape. Small openings are created at the edges of the tape so that air can escape. A breather and vacuum bag are installed to compact the prepreg plies. The air can escape on the edge of the repair but no resin can bleed out. [**Figure 3-38**]

MIXING RESINS

Epoxy resins, like all multi part materials, must be thoroughly mixed. Some resin systems have a dye added to aid in seeing how

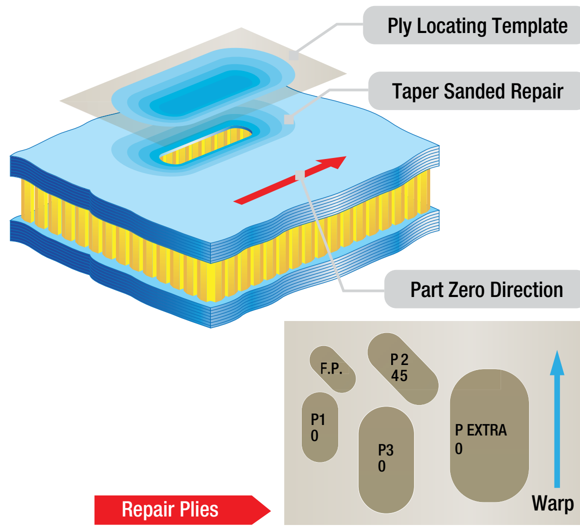

Figure 3-36. Repair layup process.

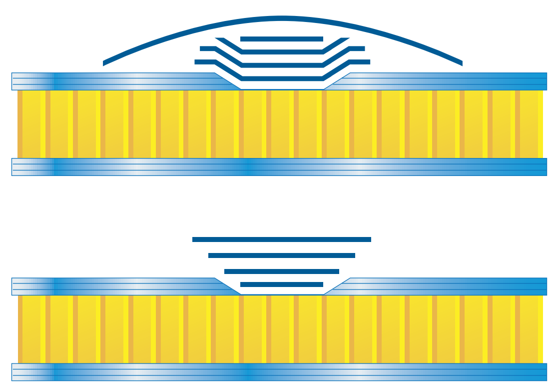
Figure 3-37. Different lay-up techniques.


Figure 3-38. Vacuum bagging of contoured part.