สำนักงานการบินพลเรือนแห่งประเทศไทย
The Civil Aviation Authority of Thailand

GUIDANCE MATERIAL FOR COMPOSITE REPAIR WORKSHOPS

CAAT-GM-AIR-514
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Approved By

Air Chief Marshal
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The Civil Aviation Authority of Thailand

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TABLE OF CONTENTS

ABBREVIATIONS

AD	Airworthiness Directive
AMC	Acceptable Means of Compliance
AOG	Aircraft On Ground
APU	Auxiliary Power Unit
ATA	Air Transport Association
CAAT	The Civil Aviation Authority of Thailand
CMM	Component Maintenance Manual
CRS	Certificate of Release to Service
EASA	European Union Aviation Safety Agency
FAA	Federal Aviation Administration
MOE	Maintenance Organisation Exposition
NDT	Non-Destructive Testing
P/N	Part Number
SB	Service Bulletin
SRM	Structural Repair Manual
TCAR	Thailand Civil Aviation Regulation

0. INTRODUCTION

0.1 Scope and Applicability

The Civil Aviation Authority of Thailand (CAAT) is the Competent Authority for maintenance organisations[1] that are involved in the maintenance of Thai registered aircraft and components intended for fitment thereto as established by TCAR AIR Part-145, 145.A.1 General. CAAT is therefore responsible for the final approval of these maintenance organisations and for establishing procedures detailing how TCAR AIR Part-145 applications and approvals are managed.

This Guidance Material (GM) is applicable to TCAR AIR Part-145 applicants and TCAR AIR Part-145 maintenance organisations regardless of whether their principal place of business is located within Thailand or internationally. The provisions of this GM are complementary to the maintenance organisation certification requirements detailed in TCAR AIR Part-145 and do not supersede or replace any associated regulatory requirements.

0.2 Purpose

The purpose of this GM is to provide guidance regarding key elements, which must be considered as minimum requirements for compliance with TCAR AIR Part-145, when dealing with repairs on composite aircraft structures with particular reference to the development of a composite repair workshop for bonded repairs.

0.3 Associated Instructions

CAAT has developed associated provisions (guidance, forms, and templates) that detail specific matters, which need to be considered as an integral part of this GM. This information is available on the CAAT website (www.caat.or.th)

0.4 Communication

All documents and correspondence between the maintenance organisation and CAAT should be in English. The official e-mail is air-amo@caat.or.th.

0.5 References

- Air Navigation Act B.E. 2497
- Requirements of the Civil Aviation Authority of Thailand No. 2 on Repair Station Certificate
- Requirement of the Civil Aviation Authority of Thailand No. 3 on Aircraft Parts Production of Repair Station Certificate Holder
- Requirements of the Civil Aviation Authority of Thailand No. 5 on Foreign Repair Station Certificate
- Requirements of the Civil Aviation Authority of Thailand No. 20 on Modifications and Repairs Approval Requirements
- Requirements of the Civil Aviation Authority of Thailand No. 40 on Foreign Repair Station Certificate
- Thailand Civil Aviation Regulation on Repair Station Certificate Requirements (TCAR AIR Part-145)

[1]The terms “Maintenance Organisations” and “Repair Stations” should be read interchangeably in this Guidance Material.

- Acceptable Means of Compliance to Thailand Civil Aviation Regulation on Repair Station Certificate Requirements (AMC to TCAR AIR Part-145)
- EASA AMC 20-29 Composite aircraft structures
- SAE AIR 5719A Teaching points for an awareness class on critical issues in composites maintenance and repair
- FAA AC 65-33A Development of training and qualification programs for composite maintenance technicians
- FAA AC 20-107B Composite aircraft structures

1. TCAR AIR Part-145 REGULATION OVERVIEW

1.1 Maintenance and Manufacture

Composite aircraft structure activities in a maintenance organisation may be considered in terms of:
- Maintenance (repairs, overhauls, etc.)
- Parts fabrication (normally limited to fabrication of secondary structural elements)

In particular, requirements for the fabrication of parts are contained in Requirement of the Civil Aviation Authority of Thailand No. 3 on Aircraft Parts Production of Repair Station Certificate Holders and in TCAR AIR Part 145, 145.A.42(b)3 and related AMC. Additional information is provided in CAAT-GM-AIR-512 Guidance Material for Fabrication of Parts.

1.2 TCAR AIR Part-145 Approval – Ratings Required

The activities described in section 1.1 may be performed under:
- Ax rating (Line or Base aircraft maintenance scope of work)
- Bx rating (engines or APU)
- Cx rating (components maintenance scope of work)

In addition, an NDT capability is needed to establish the presence and extent of damage and inspect the repair at the end of the process. This may, for example, be performed by the maintenance organisation in the course of maintenance within one of the above-mentioned ratings.

In order to establish the correct TCAR AIR Part-145 approval for the intended level of maintenance, the requirements of Appendix II to TCAR AIR Part-145 is applied (Class and ratings system used for the approval of TCAR AIR Part-145 Repair Station Certificate). The decision whether to perform such activity within an Ax, Bx or Cx rating is determined by the maintenance data, when particular equipment and facilities are required for which a workshop (components maintenance environment) needs to be considered.

Fabrication of parts could be considered under all ratings provided that it remains within the limitations of TCAR AIR Part-145.

As general guidance, maintenance of aircraft composite structures may be considered under:
- **Ax rating (Line or Base) when performed in accordance with:**
  - The aircraft maintenance data (e.g., SRM) or,
  - If CAAT agrees this component maintenance data (only when the component is installed on the aircraft) may be used.

Note:

1. The temporary removal of a component for maintenance, in order to improve access to that component, may be allowed except when such removal generates the need for additional maintenance. This will be subject to a control procedure in the MOE.
2. Maintenance of aircraft composite structures outside the hangar should be avoided whenever possible

- **Bx rating (engine or APU), when the activity is carried out on an installed engine, APU or engine or APU components, in accordance with:**
  - Engine or APU maintenance data or,
  - If CAAT agrees this component maintenance data, only whilst such components are fitted to the engine or APU may be used.

- **Cx rating (component maintenance) in all cases when a component overhaul task is performed in accordance with:**
  - Component maintenance data
  - In the case of components repair, when it is necessary to work on the uninstalled component and at the same time particular facilities and equipment are required for which a workshop is to be expected, the normal objective being the performance of a permanent repair

2. COMPOSITE STRUCTURE REPAIR

2.1 Basic Types of Composite Structures

There are two basic types of composite structure:

- Sandwich
  Thin, high strength skins are separated by, and bonded to, lightweight honeycomb cores
- Solid Laminate
  Assembled so that the fibre orientation provides most of the desired mechanical properties and the solid matrix largely determines the environmental performance

2.2 Basic Types of Composite Repairs

There are two basic types of composite repairs:

- Bonded
- Bolted

The choice between the two types of repairs is not a TCAR AIR Part-145 decision and is associated with advantages and disadvantages in both cases (e.g. bonded repairs provide more uniform stress distribution but require a more rigid process regarding control and time). In general terms, non-critical repairs may be bonded or bolted, while critical repairs will be bolted.

2.2.1 Bolted Repairs

The basic concept of the bolted repair is that the damaged area is covered by a doubler, which is mechanically joined to the structure using fasteners.

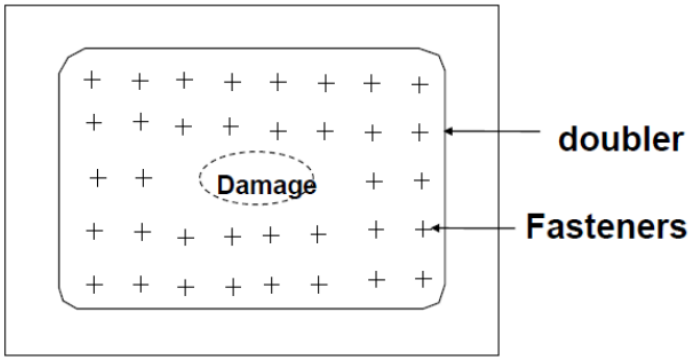

Figure 1: Basic elements of a bolted repair

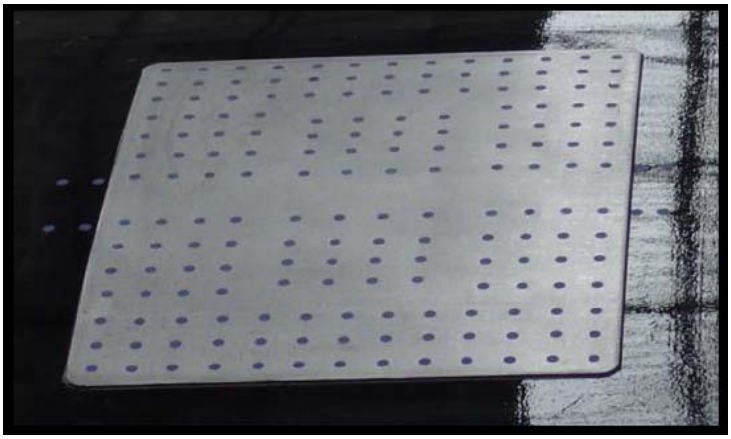

Figure 2: Example of a bolted repair

2.2.2 Bonded Repairs

Various types of bonded repairs are possible, such as resin injection, core replacement, structural repairs using Prepreg and adhesive film, bonding plates and wire mesh replacement, etc.

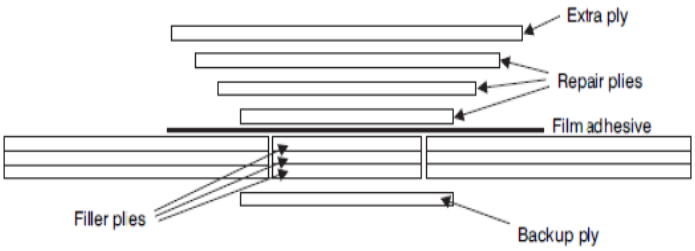

Figure 3: Typical laminate bonded repair

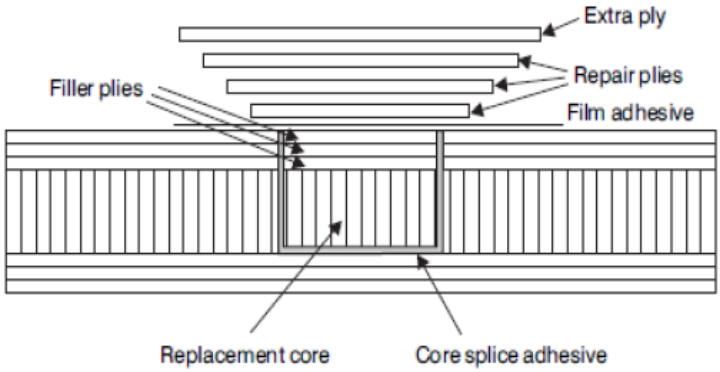

Figure 4: Typical sandwich panel bonded repair

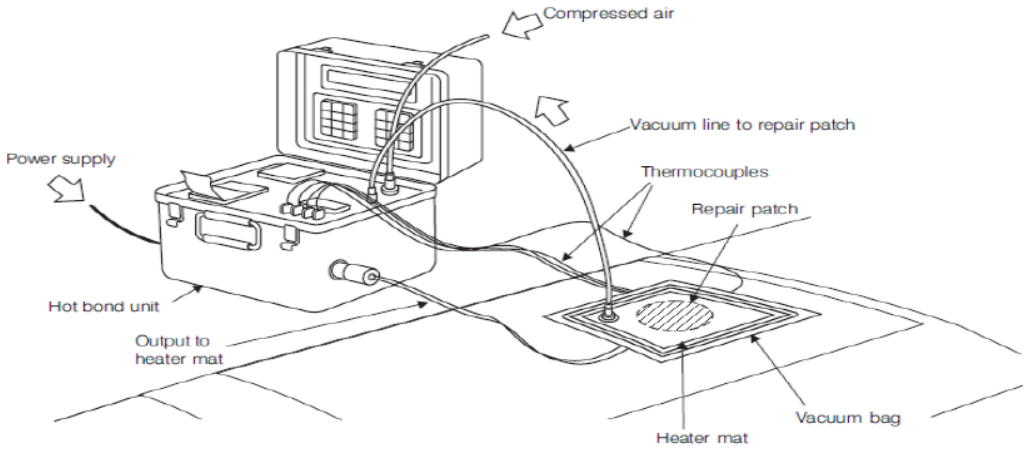

Figure 5: Example of portable equipment for one side access bonded repair

2.3 Compliance of the Composite Repair Workshop with TCAR AIR Part-145

In order to perform bonded repairs, the maintenance organisation must be specifically organised in terms of personnel, facilities and equipment, process control, etc.

In the following chapters of this GM, minimum requirements have been established for the set-up of a composite repairs workshop. Appendix 1 contains a checklist to facilitate verification of the requirements by the maintenance organisation.

Note: this GM does not supersede the need to comply with any applicable maintenance data or requirement

3. GENERAL REQUIREMENTS

3.1 Approved Data

TCAR AIR Part-145, 145.A.45(a) states: “The organisation shall hold and use applicable current maintenance data in the performance of maintenance, including modifications and repairs”. TCAR AIR Part-145, 145.A.45(b) along with the related AMC clarifies what is intended to be the applicable maintenance data.

Particular care must be taken with respect to the following:

- TCAR AIR Part-145, 145.A.48(c)4 states, “The maintenance organisation shall ensure that damage is assessed, and modifications and repairs are carried out using CAAT approved data”
- Specific repair data can be accepted when that data is provided by manufacturer. In the absence of manufacturer provided repair data, the maintenance organisation must comply with provisions contained in Requirement of the Civil Aviation Authority of Thailand No. 3 on Aircraft Parts Production of Repair Station Certificate Holders and Requirements of the Civil Aviation Authority of Thailand No. 20 on Modifications and Repairs Approval Requirements, which are available on the CAAT website.
- Operators and maintenance organisations wishing to complete major repairs or alterations outside the scope of approved repair documentation should be aware of the extensive analysis, design, process, and test substantiation required to ensure the airworthiness of a certificated structure. Documented records and the certification approval of this substantiation should be retained to support any subsequent maintenance activities.

3.2 Maintenance Records

Composite aircraft structures repair is to be considered a complex maintenance task. The maintenance organisation must use work cards to record the repair, which must be subdivided into clear stages to ensure a record of the accomplishment of the complete maintenance task.

Particular care must be taken to record:

- Part identification, (i.e. P/N and approved repair data used)
- Raw material traceability by using a reference which allows traceability to the relevant certificate, (adhesives, Prepreg, resins, fasteners, etc.)
- Note: prepreg (pre-impregnated) means composite fibres, where material such as epoxy is already present
- Process application, curing time, out-of-fridge time, etc.
- Product conformity, (i.e. the records must be able to demonstrate compliance with approved repair procedures)

3.3 Training for Composite Technicians

The maintenance organisation is required by TCAR AIR Part-145, 145.A.30(e) to “establish and control the competence of personnel involved in any maintenance in accordance with a procedure and to a standard agreed by the CAAT”.

Therefore, a training program should be developed for the qualification of composite technicians. For additional information, SAE AIR 5719A and FAA AC 65-33A (section 7) provide detailed guidelines and a sample course syllabus, which can be used in order to develop training and qualification programs for composite maintenance technicians.

It is recommended that the training would also include an aircraft type training module (limited to the Structure ATA chapters) at least for those structural repair technicians who are authorised for aircraft on-board repairs (e.g. requiring interpretation of the SRM to define corrective actions). Such structural repair technicians should be authorised on the specific aircraft type.

3.4 Safety Precautions

Aircraft maintenance chemicals (abrasives, cleaners, corrosion preventatives, paint stripes, surface treatments, sealants, paints, solvents, etc.) may be hazardous. The maintenance organisation is responsible for evaluation of the hazards in the workplace, ensuring the awareness of personnel and addressing safety precautions. The following elements should be taken into account:

- Understand the warnings for using specific chemicals as published by the chemical manufacturer. Refer to the Material Safety Data Sheet, which accompanies the material. This is the primary source of information when determining the risk associated with any substance used in the workplace
- Observe the aircraft or component manufacturer`s warning and cautions in the applicable maintenance data
- Use personal protective equipment (gloves, respirators, glasses, boots, etc.) to prevent skin, eyes, respiratory and digestive tracts from being exposed to chemicals
- Make sure that sufficient ventilation exists
- Many combinations of chemicals are incompatible and may produce toxic fumes and violent reactions. Extreme caution is required to ensure that maintenance chemicals are only mixed in accordance with the specific mixing procedure
- Set up first-aid measures in the workplace (eye washers, etc.)

4. PARTICULARITIES OF MAINTENANCE ORGANISATION FACILITIES AND PROCESSES

4.1 Incoming Inspection of Raw Material

TCAR AIR Part-145, 145.A.42(a) and AMC to TCAR AIR Part-145, AMC1 145.A.42(a)5 require the maintenance organisation to ensure that purchased raw and consumable materials meet the required specification and have appropriate traceability to the manufacturing and supplier source.

In the case of materials used for composite repairs (Prepreg, resins, etc.) supplier laboratory test reports should also accompany each batch of material received. In addition, the maintenance organisation may perform sample verification testing, by itself or using an independent laboratory, in order to establish confidence in the quality of materials received from the suppliers.

4.2 Material Handling and Storage

Materials used for bonded repairs are subject to specific handling and storage conditions, which require adequate facilities and equipment to be available.

The conditions of storage and shelf-life limitation must be in accordance with the manufacturer`s instructions to prevent deterioration and damage of the stored items. In particular, the maintenance organisation must refer to the Material Safety Data Sheet that accompanies the material, as well as any other instructions that may be published in the relevant maintenance data.

In particular, the maintenance organisation needs to establish procedures to cover the following aspects:

4.2.1 Shelf-life and temperature considerations

Material specifications normally specify shelf-life when the material is stored at the specified temperatures. Prepreg and adhesives need to be stored in sealed containers often near -18°C in order to retard the aging or partial curing and to extend the shelf-life. The period of time the material is outside the freezer must be recorded ("out time" record log) in order to demonstrate that the total allowable out-of-freezer time is not exceeded

4.2.2 Storage and handling recommendations

- Particular care should be taken to prevent contamination of Prepreg materials and film adhesives during handling (e.g. skin oil), by the use of appropriate gloves, protective containers and moisture-tight bags
- Freezer storage conditions must be strictly controlled (regularly monitored temperature, highest allowed temperature, location and orientation of the stored roll to prevent fiber breaking or resin migration
- If the maintenance organisation cuts the roll into "kits" before refreezing, procedures should be in place to ensure the materials are not contaminated during the handling and kitting process (i.e. the out time is recorded and the material is correctly bagged before refreezing)

4.2.3 Unserviceable aircraft components incoming area

An incoming area for unserviceable components is expected at least in the case of a maintenance organisation working under a Cx rating (components maintenance). In this area an inspection process should be carried out to ensure, as a minimum, the availability of a "clear work order" approved data for the required repair and all required information from the customer or operator necessary for the issue of the CRS (identification, hours, cycles, origin, AD/SB, etc.)

4.3 Composite Bonded Repair Workshop

The workshop represents the core area of the repair process and may have different layouts and sizes depending on the intended scope of work.

For an Ax/Bx rated maintenance organisation, as a minimum, a support workshop area is expected. The possibility to perform such repairs on-wing outside the hangar or workshop should be evaluated on a case-by-case basis by the maintenance organisation.

For a Cx rated maintenance organisation, the repair process flow should be evaluated in order to establish a workshop layout that is tailored to the needs. A possible basic example is the following:

- Sanding room, where paint removal is performed in order to have complete access to the damaged area
- Preparation room, where the component is prepared for the repair (cleaning, surface preparation, etc)
- Clean room, where the structural bonding is performed. Care should be taken to accomplish the repair within the remaining allowable "out time" of the material and the maintenance organisation should specify in its procedures the maximum time for accomplishment. (refer section 5.2)

- Cure room, where curing should be accomplished by controlling the appropriate parameters such as vacuum, pressure, temperature, etc. with respect to time in accordance with maintenance data
- Inspection, where the final inspection process is performed (NDT, CRS, records, etc.)

4.4 Tools and Equipment

Regardless of the facilities layout, the following tools and equipment should be available and managed in accordance with TCAR AIR Part-145, 145.A.40 depending on the intended scope of work:

- Autoclave, capable of providing positive pressure and temperatures consistent with the repair process
- An air-circulating oven capable of providing the required cure or drying temperature and equipped with vacuum capability when required
- A method of temperature and pressure control (vacuum bag, thermal blanket, heat lamp, etc.)
- Lay-up and clean rooms must be environmentally and operationally controlled in terms of:
  - temperature and humidity
  - air filtration and pressurisation (capable of providing slight positive over-pressure)
  - design, to minimise dirt traps (sealed floors, recessed lights, etc.)
  - routine cleaning schedules (established and recorded)
  - restrictions, to avoid potential contaminations (eating, smoking, cutting, uncontrolled sprays, dust, oily vapours, etc.)
- Freezers must be capable of maintaining the required storage conditions of materials (adhesives, Prepreg, etc.)
- Cleaning equipment to accomplish the various cleaning processes
- Spray room for spraying the primer and paint finish (adhesively bonded metallic structures)
- Honeycomb core cutters with the capability to cut, rout and profile the honeycomb
- Part drying capability should be used to dry the part from moisture before lay-up and bonding of the repair (e.g. a large oven with integral vacuum capability and dry air input into the vacuum bag of the part)
- Laboratory test facilities are recommended to perform in-process quality control
- Cutting tools, diamond or carbide saws and router bits which are suitable for cutting and trimming of composites
- A dedicated kit storage area for storage of kitted detail parts prior to bond helps to reduce contamination of detail parts

4.5 NDT to Support Composite Repairs

Various NDT methods should be available in order to perform the required inspections before (to establish the extent of the damage) and after the repair process (to confirm the condition of repair). The need for specific training in composite repair NDT techniques must be assessed.

4.6 Workshop Procedures

The maintenance organisation must ensure the overall composite repair processes is controlled according to procedures that are available to the maintenance personnel, relevant for the work to be carried out and up to date. In particular, those procedures must ensure that the minimum requirements of this GM are followed (i.e. records of material handling, tooling, clean room control, work cards, etc.).

Where maintenance organisation procedures are used to establish material or adhesive alternatives, the associated equivalency assessment must be appropriately documented and compliant with approved data.

5. APPENDIX 1: COMPOSITE REPAIR WORKSHOP COMPLIANCE CHECKLIST

Subject	S/US	MOE ref	Remarks
Approved data (refer to CAAT-GM-AIR-514 Section 3.1)			
Applicable and current maintenance data is used for the performance of composite repairs			
Maintenance records (refer to CAAT-GM-AIR-514 Section 3.2)			
Work card records show that all maintenance requirements have been complied with. Examples include drying times, atmospheric workshop conditions during the repair, batch numbers of materials etc.			
Training for composite technicians (refer to CAAT-GM-AIR-514 Section 3.3)			
Maintenance personnel: - adequately trained, qualified and authorised by the maintenance organisation for composite repairs - staff authorised for aircraft on-wing repairs have received aircraft type structural course			
Training syllabus: - available - syllabus contents are adequate for the type of repairs carried out - SAE AIR 5719 and FAA AC 65-33A Guidelines			
Training records are available			
Safety precautions (refer to CAAT-GM-AIR-514 Section 3.4)			
Safety precautions are observed (refer to Material Safety Data Sheet)			
Incoming inspection of raw materials (refer to CAAT-GM-AIR-514 Section 4.1)			
Incoming inspection of raw or consumable materials ensures they meet the required specification and have appropriate traceability: - conformity statement to specification - manufacturer and supplier traceability - laboratory test reports			
Material handling and storage (refer to CAAT-GM-AIR-514 Section 4.2)			
Material handling and storage is done in accordance with the manufacturer`s instructions: - controlled temperature storage area for materials and adhesives (i.e. freezer) - manufacturers specifications for storage conditions and shelf-life followed (refer to Material Safety Data Sheet) - quarantine area available			

Subject	S/US	MOE ref	Remarks
Procedures exist to ensure that rolls of Prepreg are handled correctly. The out time is recorded during the goods-in inspection and the roll is not contaminated during the thawing out process prior to inspection. Any faults in the levels of resin saturation of the Prepreg should be noted.			
If the maintenance organisation cuts the roll into kits before refreezing, procedures must be in place to ensure the materials are not contaminated during handling and kitting process (i.e. the out time is recorded and the material is correctly bagged before refreezing)			
Facility requirements (refer to CAAT-GM-AIR-514 Section 4.3)			
The size and structure of facilities is appropriate for the type of work carried out: - sanding room - preparation room - clean room (see next check item) - cure room - inspection room			
A clean room for structural bonding is in place. Cross refer to the maintenance data (SRM, CMM, etc.) for special environmental conditions required for the repairs: - temperature and humidity control - positive pressure - air filtration system available - adequate lighting available - records of the environmental conditions available, if applicable			
Cleanliness and adequate separation of dirty and clean areas (rub down area segregated from lay-up shop): - cleaning schedule - check if any vent areas into facility are local to contamination sources (kitchen vent outlet, etc.)			
Racking to store the repaired items awaiting repair or finished and adequate segregation and identification of each			
Tools & equipment (refer to CAAT-GM-AIR-514 Section 4.4 and CAAT-GM-AIR-511)			
Overall tool record listing all tooling kept in the workshop			
Tools are adequate for the type of repairs carried out in the scope of work (Includes hand tools, air tools, vacuum tools, lay-up molds etc., where applicable): - special tools and equipment required by the maintenance data (i.e. autoclave, oven, vacuum bag, honeycomb cutters) - use of alternative tools			
Control of composite workshop tooling if used outside the workshop. Record keeping of what tooling was used on what area or aircraft registration			
Calibration of tooling including vacuum, temperature measuring and general measuring instruments			

Subject	S/US	MOE ref	Remarks
NDT (refer to CAAT-GM-AIR-514 Section 4.5)			
NDT capability to support composite repairs: - If NDT is used to determine damage level prior to repair or integrity of repair, evaluate technique used - NDT after damage removal, if appropriate, to ensure no further damage caused by removal process			
Personnel are trained in composite repair NDT techniques			
Workshop procedures (refer to CAAT-GM-AIR-514 Section 4.5)			
Workshop procedures are: - available and up-to-date - relevant for the work carried out			
Workshop procedures cover the minimum requirement of CAAT-AIR-GM-514. For example: - recording method used to monitor out time of materials - handling of materials - use of tooling including autoclaves and specific vacuum equipment			
In case maintenance organisation procedures are used for material and adhesive alternatives, check equivalency assessment is appropriately documented and in accordance with approved data			

Note:

S = Satisfied

US = Unsatisfied

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