AIPS
Airbus Process Specification

Bonding metal/metal parts
Structural bonding process

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1 Scope

This Airbus Process Specification defines the Engineering requirements for the process of structural bonding of metallic sandwich parts with metallic skins.

This specification does not give detailed instructions; these are given in the Process Instructions (PI) / Airbus Process Instruction (AIPI) and the Work Instructions.

This specification shall not be used as an inspection document

It shall be applied when mentioned in the relevant standard, material specification or Definition Dossier.

2 Normative References

Only normative references cited in the text are listed hereafter.

The latest issue of the publication referenced shall be used.

A1016	Airbus Directive – First Article Inspection
A1091	Airbus Requirements for the Management of Hazardous Substances
AIMS12-00-000	Airbus Material Specification – Ancillary materials – Technical Specification
AIPS02-01-001	Airbus Process Specification – Chromic Acid Anodizing (CAA)
AIPS02-01-006	Airbus Process Specification – Phosphoric sulphuric anodising (PSA) of aluminium alloys prior to structural bonding
AIPS06-02-002	Airbus Process Specification – Non-structural adhesive bonding
AIPS06-02-005	Airbus Process Specification – Manufacturing of metallic sandwich parts - Bonding process
AIPS06-02-006	Airbus Process Specification – Structural bonding of thermoset and thermoplastic matrices composite parts
AIPS09-01-002	Airbus Process Specification – Cleaning with liquid non aqueous agents
AITM1-0003	Airbus Test Method – Determination of the glass transition temperature
AITM3-0008	Airbus Test Method – Determination of the extent of cure by differential scanning calorimetry
AITM6-3004	Airbus Test Method for inspection processes – Visual inspection
AITM6-4007	Airbus Test Method – Manual ultrasonic inspection of GLARE laminates and adhesively bonded doublers for the detection of damage as a result of visible inspections
AITM6-4013	Airbus Test Method – Ultrasonic through transmission inspection in squirter and immersion technique of adhesively joined metal parts
AITM6-4015	Airbus Test Method – Manual ultrasonic through transmission inspection of bonded assemblies (metal to GLARE/metal to metal)
AITM6-5002	Airbus Test Method – Ultrasonic resonance impedance inspection using fokker bond tester
AITM6-5003	Airbus Test Method –Tap test
EN 2243-1	Aerospace series – Determination of the single lap shear strength
EN 2243-2	Aerospace series – Determination of the apparent peel load
EN9103:	Aerospace series – Quality management systems - Variation management of key characteristics
EN ISO 14644-1	Cleanrooms and associated controlled environments – Part 1: Classification of air cleanliness
EN ISO 14644-3	Cleanrooms and associated controlled environments – Part 3: Metrology and test methods

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3 Definition, Applicability and Limitations

3.1 Definition

Ancillary materials: Materials used during manufacturing that are not incorporated into the finished part.

Inner Quality: The Inner Quality of a bonding part is described by typical quality characteristics (e.g. porosity, bond line thickness, disbonds), which can be determined by NDI methods and microscopic examination of cross sections.

Manufacturer: The company or organization responsible for producing the part against an Airbus drawing.

Manufacturing shop: The specific work shop intended for manufacture according to this process specification.

Normal Work Conditions: Combination of temperature and relative humidity under which uncured material is processed according to requirements for clean rooms as stated in AIPS06-02-007.

Process Instructions: A document that provides a complete and detailed description of a specific manufacturing process. It specifies all relevant process parameters, measures for quality assurance and inspection schedules for equipment and production facilities. A process instructions could be supplemented by additional documents like part related work instructions. It is a complete detailed in house process instruction and shall be used in conjunction with the drawing and relevant AIPS.

Quality Assurance: Quality assurance department responsible for the manufacturing shop entrusted with the manufacturing according to this process specification.

Reference manufacturing shop (RMS): A manufacturing shop selected in order to develop a manufacturing process and to improve on current processes.

Reference manufacturing shop group (RMSG): A group of experts (from Engineering, Manufacturing Engineering and Manufacturing Quality) responsible for a manufacturing process. This group is in charge of validation of the technical requirements and technical qualifications. For each manufacturing process, a reference manufacturing shop group is nominated.

Responsible Design Office: Engineering (Stress, Design) and supporting functions (Materials & Processes) responsible for design and certification of a part.

Rework: Removal of production and assembly related non-conformances with the aim of reaching the required component condition defined in the engineering documents.

Specific Work Conditions: Specific combination of temperature and relative humidity which deviates from Normal Work Conditions (including tolerances). Specific Work Conditions may effect the Work-Life and therefore need to be validated by M&P and could require specific qualification activities.

Storage Life: The maximum period of time at storage conditions as specified in the relevant Material specification, excluding Work Life needed for manufacturing.

Structural materials: Materials incorporate into a structural part during manufacturing.

Storage Conditions: Environmental conditions, in particular temperature (e.g. $T \leq -18$ ºC) under which uncured material is kept in store before given out to Manufacturing.

Tack Life: The maximum period of time at work conditions as specified in the relevant Material Specification, that the remaining material have sufficient tack to be used for manufacturing. Needs to be defined by Manufacturing Engineering and agreed by the material supplier.

Work Conditions: Environmental conditions, in particular temperature and relative humidity under which uncured material is processed before start of cure.

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Work Life: The maximum period of time at work conditions as specified in the relevant Material Specification, that the material can be used for manufacturing. Deviations of work conditions as hot forming process or application of heat for tack improvement may affect the Work-life and therefore need to be validated by Materials & Processes. This might require specific qualification activities.

Functional Class (FC): The Functional Classification of airframe parts - so called "Functional Class (FC)" is required to define the level of inspection quality requirements for the manufacturing. The purpose of this way forward is to ensure safe operations and quality connected to the manufacture of airframe structure parts.

3.2 Applicability

This Airbus specification is applicable when invoked by the drawing directly or through another document.

When processing to AIPS06-02-007 is required, it shall be invoked on the drawing by the words “Structural bonding of metal/metal parts according to AIPS06-02-007”. Process Work Instructions shall not be called on drawing.

Structural adhesive bonding is used for the production of adhesive bonded joints which are part of the primary or secondary structure of the aircraft and have primary load carrying functions within the component.

This specification is applicable to bond metallic materials to manufacture structural bonded metal joints.

The materials to be processed by the reference manufacturing shop under this specification must be qualified by Airbus according to the relevant Airbus Material Specification.

This specification is applicable to manufacture bonding components using subsequent autoclave- or under pressure-reduced bonding with the possibility of autoclave-free structural bonding processes.

3.3 Limitations

This specification is not applicable for bonding of metal/honeycomb core materials, the process for which is specifically described in specification AIPS06-02-005.

This specification is not for non-structural adhesive bonding, the process for which is described in AIPS06-02-002.

This specification is not applicable for structural bonding of non-metallic parts, the process for which is described in AIPS06-02-006 “Structural bonding of thermoset and thermoplastic matrices composite parts”.

4 Engineering Requirements

Engineering requirements are minimum requirements specified by Responsible Engineering to ensure minimum performance of the manufacturing process.

NOTE: Any deviation from the requirements established here, must be approved (by invoking testing if required) by AIRBUS Quality Assurance.

4.1 Structural materials

Structural materials shall have been qualified in accordance with the relevant Airbus Material Specification.

Structural materials shall be stored according to Storage Conditions stated in the relevant Airbus Material Specification.

The time, materials are kept in store shall not exceed storage life as stated in the relevant Airbus Material Specification (see figure 1).

Structural materials shall be processed under work conditions stated in the relevant Airbus Material Specification.

The time, materials can be processed before start of cure, not exceeding the work life, based on certain work conditions, as stated in the relevant Airbus Material Specification (see figure 1).

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Structural Materials shall only be used within their relevant storage-life and work-life (see figure 1) as indicated in the relevant Airbus Material Specification.

Normal work conditions (including tolerances) as indicated in figure 2 are considered for the determination of work-life as part of a material qualification according relevant Airbus Material Specification.

Specific work conditions can be established in order to consider deviations from normal work conditions (including tolerances) during manufacturing. Specific work conditions may effect the work-life and therefore need to be validated by Airbus Materials & Processes and could require specific qualification activities.

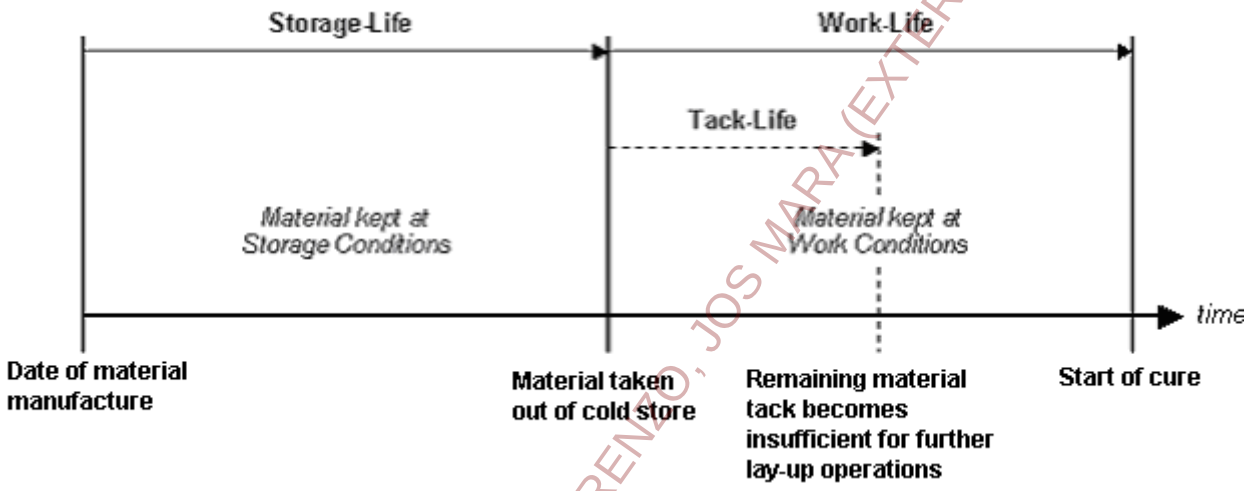

Figure 1: Storage life, work life and tack life

For materials that need to be stored in a freezer, a log shall be kept recording date and time of each transfer of the material in and out of the freezer and the remaining work life.

Structural materials shall be cured according to cure cycles stated in the relevant Airbus Material Specification.

When different materials are cured together, special care shall be taken to use materials specifically defined as compatible. Compatibility of uncured materials needs to be validated by Airbus Materials & Processes and requires in general specific qualification tests. Compatible structural materials are stated in relevant documents (i.e. MPSL, TN) issued by Airbus Materials & Processes.

Cured parts, which are exposed to additional temperature cycles during manufacturing, need to be supported in a sufficient way, if Tg onset of one of the incorporated structural materials will be exceeded.

4.2 Ancillary materials as per AIMS12-00-000

Only qualified materials according to AIMS12-00-000 or materials specifically approved by Airbus shall be used. AIMS12-00-000 distinguish between ancillary materials in direct contact with the uncured structural materials (Type A) and ancillary materials that are not in direct contact with the uncured structural materials (Type B,C). Any ancillary which could affect the structural behaviour needs to be qualified according Type A.

Type B, C material are listed in the AIPI06-02-007 and type A materials are listed in Annex A of this AIPS.

The specific materials to be used in each part shall be identified in the Process Instructions

No change of material is allowed without specific indication in the drawing set and associated documentation.

Materials with PTFE (spatulas, rolls, cutting tables, etc.) are prohibited if not specifically approved for a particular application.

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All ancillary materials to be placed in direct contact with any uncured materials must be stored in sealed polyethylene bags and handled using qualified gloves.

Materials shall be stored in accordance with the requirements of the applicable MS and IPS, or of the material data sheet provided by the supplier, in order to avoid manufacturing problems during the cure cycle or even lack of final quality of the part.

All ancillary materials shall only be used within their relevant storage-life and work-life, in case this has been limited.

4.2.1 Solvents

General requirements for cleaning process are described in AIPS09-01-002.

The solvent agent used shall be defined in the documentation associated to the Process Instructions and testing must be carried out to ensure it is acceptable for the specific application of bonding of metallic substrates.

All metallic surfaces shall be solvent cleaned (both abraded and non-abraded areas) with an approved solvent (see AIPS09-01-002).

4.3 Facilities, equipment and tooling

4.3.1 Facilities

All facilities,equipment and tooling used in the bonding process shall be certified and calibrated under Quality department responsibility.

4.3.1.1 Facilities for pre-treatment

Areas of pre-treatment which are capable to perform required pre-treatment steps – degreasing, alcaline etching, acid etching and anodisation – according to AIPS02-01-001 (Chromic Acid Anodising, CAA) or AIPS02-01-006 (Phosphoric Sulphuric Anodising, PSA).

4.3.1.2 Areas for application of bonding primer

The following facilities must be available for the application of bonding primer:

- Spray cabinets or spray walls with adequate extraction provisions that do not impede the application of the bonding primer; these spray facilities must be well illuminated and have explosion-proof electrical installations.
- Adequate extraction provisions in rooms where bonding primers are applied and/or cured at room temperature.
- No other materials may be processed in rooms where bonding primers are applied.

4.3.1.3 Cleanrooms (lay-up area)

Cutting, lay-up, forming and consolidation of uncured adhesive films and prepregs shall be performed in clean, isolated areas (cleanrooms) to prevent materials from contamination. For the same reason, it is mandatory to use qualified gloves and clean work cloth for any operation within these areas.

The floor shall be paved with easily cleaned materials, and the walls shall be coated with non-releasable washable material.

In order to prevent any contamination coming from the outside, it is recommended that a minimum of 5,0 [Pa] overpressure to be held inside the cleanroom.

It is also recommended for this area to be equipped with a twin-door type gate system. In the case of direct exit outdoors, this shall be mandatory.

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The concentration of airborne particles has to be in compliance with ISO class 8 according EN ISO14644-1.

Cleanrooms need to have controlled temperature and humidity to ensure processing of the materials within their limited work-life under the given work-conditions.

Shops to be qualified according AIPS06-02-007 have to fulfil normal work conditions (incl. tolerances) for cleanroom areas according to figure 2.

It is recommended that the relative humidity in the adhesive/fibre placement area will have a range between 35-40% and temperature between 18-22ºC. If the temperature of the tows is under 10ºC, these conditions will be mandatory.

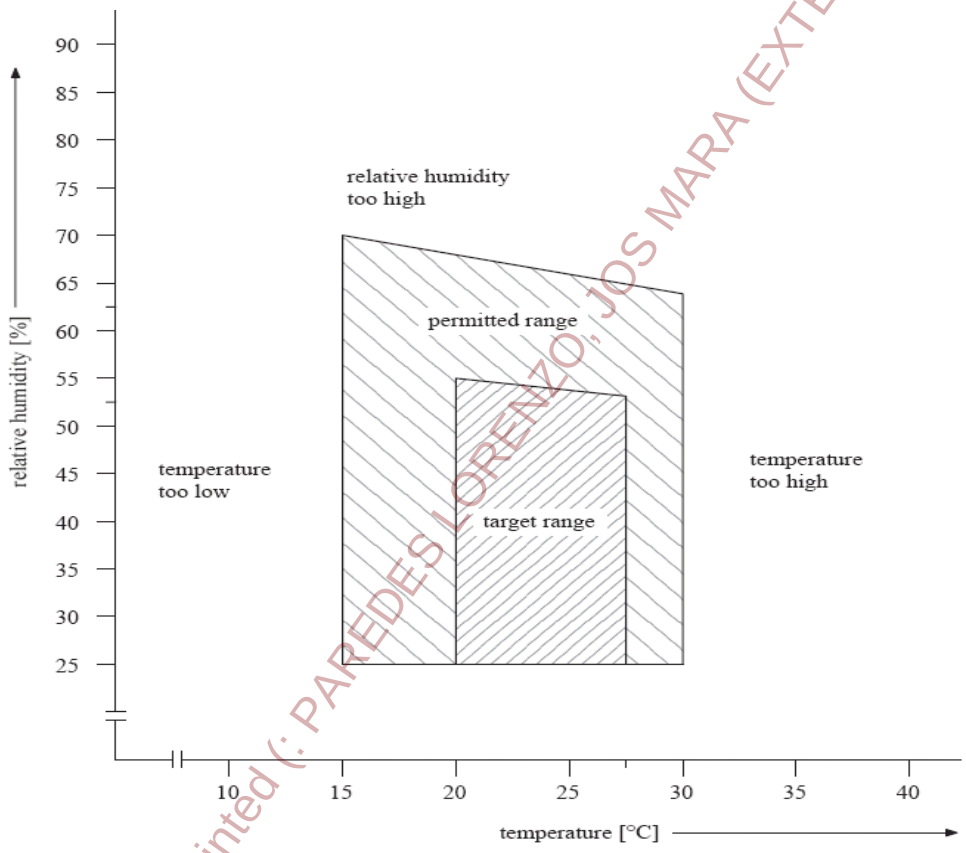

Figure 2: Normal work conditions for cleanrooms

In cleanroom areas, the following is strictly forbidden:

- The use, handling and application of uncured liquid release agents. If this cannot be avoided, application of release agent and lay up shall not take place in the same work area at the same time (the application of release agents in the form of aerosol or any other kind of spray is prohibited without exeption).
- The use of equipment that releases oils, greases, lubricants, fumes or any other type of contaminant.
- The use of tools and utensils that have not been cleaned and maintained appropriately.
- Eating, drinking, smoking and the use of waxes or non-polymerised silicones or any other substance detrimental to good adhesion of the materials.
- Cleaning and maintenance of tools.
- Surface preparation before bonding.
- Any container and contents that can contaminate the clean area.

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4.3.1.4 Storage areas

The following facilities must be available:

- Rooms with special provisions for the storage of adhesives and bonding primer, such as cooling chambers and/or refrigerators with adequate cooling capacity for the storage of adhesives and bonding primers to be kept in cold storage as required in corresponding IPS specifications.
- Calibrated test monitoring/recording equipment for temperature monitoring of the store-rooms.

4.3.2 Equipment

4.3.2.1 Equipment for application of bonding primer

The following equipment must be available:

- Compressed air spray system with suitable spray guns, supplied with oil-free, dry compressed air, or a spray system for the airless spraying of bonding primer. The system must ensure a continuous agitation of the bonding primer so that solid matter can not form sediments.
- Felt rollers for manual application of the bonding primer. The felt rollers must be resistant to the effects of bonding primer.

4.3.2.2 Autoclaves and ovens for curing

The autoclaves and ovens for curing shall be able to follow the cure cycles stated in the relevant Airbus Material Specifications. This requires the control and recording of temperature, pressure and vacuum as applicable.

Equipment used for curing of liquid release agents or silicones shall not be used for curing adhesive films.

4.3.2.3 Thermocouples

Thermocouples shall be distributed evenly in order to record both maximum and minimum temperatures of each part.

The Process Instructions shall define the type, number and location of thermocouples and vacuum intakes to be used for parts or process control specimens.

4.3.2.4 Vacuum in-takes

The Process Instructions shall define the number and orientation of vacuum intakes to be used for the specific part or process control specimens.

Procedures for periodic checking of pressure in the vacuum hoses and their connections shall be established in order to guarantee their perfect working.

4.3.2.5 Tooling

Tools shall be free of all types of contamination.

The following characteristics shall be considered for the tooling design:

- The difference of thermal expansion coefficients between tool and part materials.
- They must be stiff enough to produce parts within the dimensional tolerances, and the tool bulk must be capable of complying with the curing cycle heating/cooling rate requirements.
- When it is not indicated in the tool drawing or in the Process Instructions, the mould surface in contact with the part shall have a surface finish of 125 HRH (Ra = 3.2 μm) or better.
- Whenever possible, the tool shall be designed so that the aerodynamic surface of the part is formed against its surface.

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Curing tools which have been subjected to welding or drill operations during its manufacture or maintenance must be subjected to an appropriate airtightness test as defined in the Process Instruction prior to manufacture of parts.

4.4 Processing

During the manufacturing process of bonding parts, certain critical steps and processing operations (including tool preparation, cutting, lay-up, consolidation, forming, preparation for cure and curing) must be closely controlled. Specific requirements and limits need to be stated in the relevant Process Instructions.

4.4.1 Pre-treatment of aluminium alloys

As described in AIPS02-01-001 (CAA) and AIPS02-01-006 (PSA) a qualified pre-treatment for parts to be bonded is prerequisite for long term stability of bonded joints.

4.4.2 Application of bonding primer

After finishing the pre-treatment process, the bonding primer has to be applied within 2 hours onto the pre-treated bonding surface to protect them against contamination.

Bonding primer application:	Uniform application of primer as specified in the Process Instructions. Thickness as specified in the IPS and Process Instructions. Normally a bonding primer thickness of 2 µm up to 8 µm is required.
Drying/curing	As specified in corresponding IPS and Process instruction.
Storage of primed parts:	Protected against contamination for a max. storage time as specified in corresponding primer AIMS Material Specification.

4.4.3 Thawing of adhesive materials

Materials taken from cold storage shall be kept in airtight sealed bags or containers until the temperature of the materials has sufficiently adapted to the ambient temperature. This is in order to prevent any moisture from condensation on the cold material. The exact conditions shall be determined and indicated in the Process Instructions.

4.4.4 Film adhesive cutting

Film adhesives after cutting (manual or automatic) must not show:

- Contamination.
- Shears.
- Cuts or geometry other than the one indicated in the drawing.
- Defects exceeding the requirements of its applicable AIMS specification.

In order to prevent any contamination, tables on which material is cut manually must be covered with an approved material.

Any material already cut in kits which is not being used immediately shall be placed into polyethylene bags and identified, as minimum, with the following data:

- Part number (P/N).
- AIRBUS material designation.
- Lot and roll number.
- Preparation date.
- Accumulated hours of exposure at room temperature or remaining work life.
- Expiry date.

The airtight sealed bag can be stored in a freezer. The formation of wrinkles and folds must be avoided when placing the kit in the bag or refrigerator.

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If adhesive films are cut manually, perform this by means of cutting templates with a high standard of cleanliness, which are identified with the following data:

- Part or assembly number to which they are applied (P/N).
- Location (according to drawing part list).

4.4.5 Tooling preparation

Prior to bonding, the tools shall be cleaned, checked for defects and treated with release agents (suitable liquids and/or release films for this purpose are indicated in the Process Instructions).

Before application of release agent, tools shall be cleaned to remove any oxidation, dirt, all types of contamination and previously applied release agent.

Tools shall be checked visually for defects in terms of surface quality (imprints, marks, scratches,…) If there are any doubts regarding the airtightness of a tool, it shall be checked by an airtightness test prior to bonding.

Once the tool surfaces are clean, they must be completely dry before applying release agent. Release agents to be used shall be indicated in the Process Instructions.

All operations have to be carried out very carefully in order not to damage the tool and to maintain tool surface requirements.

4.4.6 Application of liquid release agents

Different release agents shall not be used together on the same tool surface.

The Process Instructions shall have a procedure for application of release agents, including reapplication and rework procedures.

4.4.7 Lay-up

During the lay-up, visual inspection of the materials shall be performed following the requirements of the relevant Material Specification.

The separating film shall be removed from the adhesive releasing it in the length direction, taking care to neither alter the alignment nor cause damage.

Place the film taking special care to avoid entrapment of air, dust or foreign materials; formation of wrinkles.

Splice tolerance shall be specially indicated in the drawing or associated documentation. No deviation for these materials is allowed without specific approval of the design Authority.

4.4.7.1 Splice allowance

Table 1 calls out the dimensions, tolerances of splice allowed in the adhesive plies, unless otherwise stated in the drawings.

Table 1: Adhesive splicing

Material type	Orientation	Requirements
Film Adhesive	min. overlap	0 mm
	max. overlap	12 mm

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4.4.8 Set up of parts to be bonded

The appropriate Process Instructions specify the component-specific process activities, such as setting up of components for curing in the autoclave/oven, fixing of parts to be bonded, installation of thermocouples, masking of components and the ancilliarry equipment/material.

For series production the set-up must be the same as that for the manufacture of the first article. The positioning must ensure a stress-free set-up and free movement must be ensured to avoid a deburring of the process.

4.4.9 Curing cycle

The specific cure cycle of each bonded part depends on the adhesive film(s) used in the part and the type and configuration of the element to be manufactured.

The cure cycle applicable to each specific part shall be indicated in the documentation associated with the drawing and in the Process Instructions.

Cure cycles shall be derived from the cure cycle processing window appropriate for each film as indicated in their corresponding MS and IPS. When more than one adhesive material is included in one part, the selected cure cycle must fulfil the processing window of all of them.

AIRBUS shall be informed of any deviation of the above statements and shall approve the modification prior to implementation.

4.4.9.1 Curing parameter

Process parameters need to be established for any processing operation prior to cure (e.g. cutting) and for the cure cycle.
Process parameters applicable to each specific part shall be specified in the Process Instructions and need to be in accordance with information provided in relevant Airbus Material Specifications. The range of permissible process parameters depends on the specific material and is subject of material qualification.

Process parameters for curing:

- Vacuum [1)]
- Temperature gradient for heat-up/cool down rate
- Curing Temperature [1)]
- Pressure gradient [2)]
- Curing Pressure [1)]
- Temperature gradient for cool-down

NOTE 1: Parameters to be considered as a function of time (e.g. dwell temperature)
NOTE 2: The total elimination of the pressure at cool down is not allowed until temperature has fallen below 80°C for 120°C and 180°C curing systems.

4.4.10 Multiple bonding

For multiple bonding, previously cured bonds are again subjected to the curing cycles of the subsequent bonding steps.

The surfaces to be subjected to multiple bonding shall be masked during the curing of the first bond. This masking must not be removed until immediately before the adhesive film for the subsequent bonding step is applied.

Depending on the adhesive used, multiple bonding may be effected either with safetying or without, if a stress-free condition is guaranteed for existing bonds. Make sure that instructions of the material data sheet and/or the component-specific process specification are observed.

The permitted number of bonding steps is specified in the Process Instructions.

If cleaning of the bonded parts is required before further bonding, only approved cleaning agents may be used.

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NOTE: Temperatures above 125°C change the mechanical properties and the corrosion behaviour of aluminium alloys. For this reason, and unless otherwise specified, a maximum of two curing cycles (including repair bonding) are permitted.

4.4.11 Demoulding of bonded parts

The parts shall not be disassembled from the curing tool until after a temperature < +60ºC is reached.

- If applicable , the holes must be drilled before dissambly of the part.During this operation, remove and identify the process control specimens (when required) from the part or autoclave load they represent.
- Any excess of cured adhesive may be removed from the components, as far as necessary for further processing, and as far as required if so specified in the Process Instructions or specified in the drawing and/or necessary for reasons to fit. Adhesive shall then be removed by mechanical means. Care must be taken that neither the bond nor the bonding primer is damaged.
- Use only approved solvents when cleaning bonded components
- The bonded components must be handled in such a way that permanent damage and/or deformation are avoided
- Special measures must be taken (e.g. use of specially equipped transport rigs) to avoid damage to component edges, where these edges are final dimension.

4.5 Quality Requirements

Quality Assurance shall ensure that the following Quality requirements are met, and that the process qualification procedure in accordance with chapter 5 is performed if applicable.

4.5.1 Qualification of the personnel

All the work steps of the manufacturing procedure must be carried out by authorized, trained and competent personnel recognized by an approved training programme.

4.5.2 Materials

Materials shall meet the requirements indicated in their Airbus material specifications.

A material receipt process controlled by Quality Assurance is required for all structural material batches.

Storage of structural and ancillary materials shall be performed in accordance with the requirements of this document and the relevant Airbus material specifications.

Excessive stacking or placing of material in a manner that could cause them to be damaged shall be avoided.

For materials which have to be stored in a freezer, a log shall be kept, recording the date and time of each transfer of the material in and out of the freezer and the remaining work-life.

Processing of adhesive films and ancillary materials shall be performed in accordance with the requirements of this document, the relevant Airbus material specifications and the relevant Process Instructions.

All ancillary materials used shall be products qualified or approved by AIRBUS.

Quality Assurance shall ensure in detail:

- Materials are properly identified by name and specification
- Materials are stored and packaged to preclude damage and contamination
- Perishable materials and adhesive films are within the allowable storage life at the time of release from store and within the allowed work life at start of cure.
- Appropriate procedures for the thawing of materials which have been removed from a freezer (in order to prevent any moisture from condensation on the cold material).

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4.5.3 Inspection of production facilities and measuring equipment

All production facilities and equipment used in the manufacturing process shall be certified and need to be inspected regularly under the responsibility of Quality Assurance.

Cleaning and inspection schedule of the lay-up areas shall be established in Quality Assurance documents. As a reference, the table 2 shows the recommended cleaning and inspection schedules for these areas.

The positive overpressure of Cleanrooms in order to prevent any contamination coming from the outside shall be controlled with a suitable differential pressure-measuring device.

Concentration of particles shall be controlled inside the cleanroom areas in accordance with EN ISO14644-3 to meet the requirements according of Class 8 conditions as stated in EN ISO14644-1. In case that the concentration of particles exceeds its limits, cleaning intervals need to be shortened.

Procedures for periodic checking of pressure in the vacuum hoses and their connections shall be established in order to guarantee their perfect working.

Measuring equipment for autoclaves, curing presses, ovens etc. shall have the capability to record continuously the temperature, pressure and vacuum, as applicable. If continuous recording is not possible, recording at maximum intervals of 10 minutes is recommended. Monitoring systems shall be driven by the lowest thermocouple as long as the highest is considered.

Thermocouples shall be checked electrically before the curing operation. The accuracy of the thermocouple splice box and the recorder must be +3 ºC between 50ºC and 210ºC.

Table 2: Recommended cleaning and inspection schedule

Inspection item	Inspection schedule	Cleaning schedule
Equipment, floors, work benches, tools	Inspection not required	At least weekly
Walls up to a height of 2,10 m		Maximum cleaning interval, 30 days
Rest of walls, ceilings, hanging devices, etc.	Inspection every 30 days	Maximum cleaning interval, 12 month

4.5.1 Inner Quality

The Inner Quality of a metal bonded part is described by several quality characteristics which can be verified by NDI methods and microscopic examination of cross sections supplemented by image analysis:

- Porosity in bondline
- Delaminations/disbonds
- Bond-line thickness
- Inclusions of foreign objects.

Requirements regarding the Inner Quality need to be stated in the drawing sets and/or associated documentation and shall be verified by a First Part Qualification (FPQ) according to the relevant AP a part from serial production control.

4.6 Key Characteristics

Key Characteristics (KCs) according to EN9103 are defined by responsible engineering based on a risk analysis for parts manufactured by this process.

Key Characteristics shall be defined on product level and if necessary also on process level. They shall be subject to variation control by production organization according to EN9103.

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Key Characteristics do not relieve the production organisation from meeting all engineering requirements defined in this document.

Table 3: Key Characteristic

Product Key Characteristic			Process Key Characteristic		
No.	**Designation**	**Requirement/ Limit**	**Sub.-No.**	**Designation**	**Requirement/ Limit**
1	Bond-line performance	Related AIMS / IPS specifications	1.1	Storage life (Section 4.1)	acc. to IPS
			1.2	Work life (Section 4.1)	acc. to IPS
2	Bond-line performance/ inner quality		2.1	Environmental condition: Temperature (Sub-paragraph 4.3.1.3)	max: 30°C min.: 15°C
			2.2	Environmental condition: Humidity (Sub-paragraph 4.3.1.3)	max: 70% min.: 25%
3	Bond-line quality/ adhesion stability	AIPS02-01-001/ AIPS02-01-006	3.1	Pre-treatment of aluminium alloys (Paragraph 4.4.1)	AIPS 02-01-001 AIPS 02-01-006
4	Bond-line quality/ adhesion stability	Related AIMS / IPS specifications	4.1	Thickness of bonding primer (Paragraph 4.4.2)	max.: 2 µm min.: 8 µm
5	Bond-line quality	Drawing	5.1	Adhesive cutting/ contamination (Paragraph 4.4.4)	none
6	Bond-line quality	Related AIMS / IPS specifications	6.1	Tooling preparation – cleaning (Paragraph 4.4.5)	AIPS06-02-007
			6.2	Tooling preparation – application of release agent (Paragraph 4.4.4)	AIPS09-01-002
7	Bond-line quality	Drawing	7.1	Remaining separation foil (Paragraph 4.4.7)	Not acceptable
8	Bond-line performance		8.1	Adhesive splicing → min. gap (Sub-paragraph 4.4.7.1)	0 mm
9	Bond-line quality	AIMS/IPS	9.1	Heat-up rate: low (Sub-paragraph 4.4.9.1)	acc. to relevant IPS
				Heat-up rate: high (Sub-paragraph 4.4.9.1)	
			9.2	Longer curing time (Sub-paragraph 4.4.9.1)	
				Shorter curing time (Sub-paragraph 4.4.9.1)	
			9.3	Higher curing temperature (Sub-paragraph 4.4.9.1)	
				Lower curing temperature (Sub-paragraph 4.4.9.1)	
			9.4	Curing pressure: high (Sub-paragraph 4.4.9.1)	
				Curing pressure: low (Sub-paragraph 4.4.9.1)	
			9.5	Curing vacuum (Sub-paragraph 4.4.9.1)	
10	Part quality	AIMS/IPS	10.1	Demoulding temperature (Paragraph 4.4.11)	acc. to AIMS

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5 Technical Qualification

The Technical Qualification shall be performed, according to the relevant Airbus procedure.

Engineering requirements are any requirements specified by Responsible Engineering to ensure minimum performance of the manufacturing process.

NOTE: Any deviation from the requirements established here, must be approved (by invoking testing if required) by AIRBUS Quality Assurance.

5.1 Definition of Parts/Specimens for Qualification Tests

Parts and specimen for Qualification Tests need to be agreed between the Qualification Body (QB) and the manufacturing shop responsible for the production of these parts/specimens. Parts and specimen will be stated in the Qualification Test Program (QTP).

The manufacturing shop shall produce parts/specimen for qualification tests by working to the Process Instructions subject of the qualification activity. Serial production facilities shall be used under serial production conditions.
The qualification tests shall be made on:

- Coupon specimens
- Generic or serial production part, First Part Qualifications (FPQ) according to relevant AP.

The manufacturing shop shall use adhesives according to the relevant Airbus Material Specifications.

5.2 Qualification Tests

All required qualification tests must be carried out by the manufacturing shop working to the process subject of the qualification activity. The tests must be performed using series production facilities working under serial production conditions.

Stages of the procedure are as follows:

- Provision of materials [1)]
- Acceptance of materials and delivery of the acceptance report
- Manufacturing of parts/specimens
- Inspection and test of parts/specimens
- Visual inspection (adhesive squeeze-out)
- Non-destructive testing (Ultrasonic inspection)
- Dimensional inspection and thickness measurements (e.g. bond-line thickness)
- Delivery of test report
- Delivery of the manufacturing definition dossier (new or significantly changed Process Instructions)

In case that an external manufacturing shop has to run the qualification tests, test report, manufacturing dossier and a set of test specimens for possible crosschecks shall be delivered to Airbus Quality department.

Test specimens manufactured and tested by external manufacturing shops will remain at Airbus disposal throughout the validity period for the qualification in question.

NOTE 1: To AIRBUS specifications or specifications approved by AIRBUS.

5.2.1 Tests on metal bonded Coupon Specimens

The requirements for each test are following the results obtained in the original qualification of the material and shall be stated in the Test Program.

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The qualification tests shall be, at least, the following:

- Single Lap Shear Strength as per specification EN2243-1
- Peel Strength as per specification EN2243-2
- Glass Transition Temperature (Tg) as per specification AITM1-0003
- Degree of cure, %, as per specification AITM3-0008.

The requirements for each test are following the results obtained in the original qualification of the material and shall be stated in the Test Program.

5.2.2 Tests on generic or serial production parts

The workshop to be qualified shall demonstrate the ability to manufacture a structural bonded part, which meets general engineering requirements. This is done either by manufacturing of a generic part or by a serial production part. In both cases the qualification activity should be in accordance to the relevant AP. The selection of the materials for the part to be tested will be stated in the Test Program.

5.2.2.1 Test Program

The Test Program for demonstration of the ability for part manufacturing shall cover the following aspects:

- Visual inspection (adhesive squeeze out, colour of the cured adhesive etc.)
- NDI including Ultrasonic inspection according to AITM6-5002
- Specific dimensional inspection including local thickness measurements and determination of geometrical deviations due to the process
- Microscopic examination of cross sections to determine the Inner Quality in terms of porosity, bond-line thickness etc.
- Additional mechanical tests on a generic or serial production part could be included in the Qualification Test Program.

5.3 Validity period and maintaining qualification

Manufacturing processes, which have been qualified according to this AIPS, shall be applied in the way that they fulfil the requirements of this AIPS. Process parameters, and critical process steps, which might affect the required performances, or the in-service behaviour, shall not be changed. In general, no qualification validity limit is given. Qualification will not be withdrawn unless there are reasons to call it into question.

Qualification can be called into question if any inadequacies are observed:

- Poor results are obtained on finished product,
- Process parameter changed (e.g. cure cycle),
- Definition of requirements are modified.

In all cases, when qualification is called into question, a re-qualification may be required.
Specific cases:

Qualification declared on condition that planned corrective actions are carried out must be subject to a scheduled re-examination.

6 First Part Qualification

Introducing new structural components or major changes into serial production using special manufacturing processes (e.g. metal to metal bonding processes) may require an Engineering decision on the First Part Qualification (FPQ) according to relevant AP.

A First Part Qualification (FPQ) according to the relevant AP shall be launched on request of responsible Engineering. Main objective of an FPQ is to prove, that the Inner Quality of a structural part / component meets the

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requirements of responsible Engineering, taking into account materials, key parameters of the manufacturing process and toolings.

The FPQ typically uses a combination of Non-Destructive Inspection (NDI) and destructive methods (microscopic examination , mechanical tests, physical/chemical analysis).

A FPQ can be required in the frame of developing and introducing a new structural part / component into serial production or if major changes of the manufacturing process have been introduced which could have an effect on the Inner Quality.

A FPQ can be used to confirm that the Inner Quality meets the requirements of responsible Engineering in case of a new Manufacturing shop.

A FPQ can also serve as a feasibility part as part of a process qualification (see chapter 5) to verify the ability of a manufacturing shop for manufacture bonding parts.

As a general rule, a FPQ shall be carried out for parts of “Functional Class” 1 and 2-1.

Table 4 : FPQ vs. Functional class

Measurement	Functional Class [1]				
	1	2-1	2-2	2-3	3
FPQ [2]	X	X	X [3]	X [3]	N/A

N/A→ Not applicable
1) Functional Class as per BOM
2) First Part Qualification project as per Part / Part family
3) Not mandatory, based on individual engineering decision

6.1 First Article Inspection

Quality assurance shall initiate planning and performance of a First Article Inspection (FAI) according to A1016 on the first part produced in serial production.

The FAI typically uses a combination of visual inspection, dimensional inspection, NDI methods and process control methods to verify that manufacturing process as stated in the relevant Process Instructions has produced an acceptable part as described in the definition dossier.

7 Series Production Inspection

During the manufacturing process of bonding parts, certain critical steps and operations (including tool preparation, cutting, lay-up, preparation for cure and curing) must be closely controlled and inspected.

For all parts to be manufactured, serial production inspection schedules shall be established and defined in the Process Instructions, Quality Instructions, drawing set and associated documentation.

The inspections to be made, as well as the inspection criteria and the inspection levels, shall also be defined in the Process Instructions, Quality Instructions, drawing set and associated documentation.

The shop shall perform the following Series Production Inspections under serial conditions.

7.1 Visual Inspection

Visual inspection shall be performed acc. to AITM6-3004 for each part regarding adhesive squeeze out (1 to 2 mm), irregularity of the adhesive squeeze out (porosity), irregular change of adhesive colour, part deformations and scratches on part surfaces. Check if all components are well bonded.

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Defects may be reworked as indicated in the Process Instruction or based on individual decision to be taken by the MRB department or the responsible Design Office.

7.2 Dimensional Inspection

7.2.1 Contour

Any geometrical contour of a metal bonded part (e.g.dimensions, geometry, radius, etc) shall be verified in accordance with the drawing set requirements and/or associated documentation.

7.2.2 Bondline thickness

The bond line thickness is a key measure and an indicator for the bonding strength of the final part. It shall be verified in accordance with the drawing set requirements and/or associated documentation.

7.3 NDI

Non-Destructive Inspection (NDI) shall be performed to ensure detection of any defects required as per the applicable drawings and/or associated documentation. For this purpose, the following test methods shall be used in relation with this Standard in consideration of their respective scope and limitations: AITM6-4007 and/or AITM6-4009 and/or AITM6-4013 and/or AITM6-4015 and/or AITM6-4017 and/or AITM5-5001 and/or AITM6-5002 and/or AITM6-5003.

Drawings and any associated documentation like Process Instructions shall indicate the classification of the part according to AITM6-5002 (when applicable), as well the requirements for Non Destructive Testing.

7.4 Process Control

Any Process parameters related to a Key Characteristic (section 4.6) shall be closely controlled and recorded.

Process parameters of autoclaves, curing ovens, presses and related equipment in terms of temperature, pressure, vacuum and time need to be recorded and controlled continously with a minimum sampling frequency of 0,1 (1/10 min) for each parameter.

Quality assurance shall establish appropriate procedures to identify any deviations of process parameters from requirements stated in the Process Instructions.

Quality Assurance shall inform the MRB department or the Responsible Design Office in case of any deviation, except specific approaches for deviations have already been agreed upon between Quality Assurance and MRB department or the Responsible Design Office.

7.4.1 Process Control Specimens (PCS)

In accordance with Airworthiness guidelines bonding process metal to metal requires additional validation of the adhesive curing process & bonding quality by the use of Process control specimens (PCS). The PCS consists of test coupons, which shall be as much as possible representative to the adhesive curing conditions of bonded part.

Depending on its criticality, each metal/metal bonded part is defined by a Functional class (FC) corresponding to their structural responsibility (ref. to relevant Airbus Manual). This classification goes from class 1 (more responsibility) to 3 (less responsibility). It is stated in the corresponding drawing set (bill of material).

Process control panels shall be manufactured to represent each of the different types of materials used for bonding of the parts they represent. The same batch of adhesive shall be used in any case.

For each part, bonding in accordance with this standard and its related manufacturing instruction, the PCS-type, Test Method applied and its specific acceptance values shall be defined through the corresponding manufacturing documentations referring to the applicable Engineering Standards.

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Unless otherwise specified in the drawings or associated documents, the requirements to be met by the production control tests are included in the IPS (or AIMS if the test is not included in the IPS) for the adhesive material used. As a general rule, 5 specimens shall be tested for each test. Unless otherwise stated, they shall be performed at room temperature with no special prior conditioning.

Process control specimens shall always be cured in the same autoclave/oven load as the parts they represent and depending on the Functional Class of the parts to be bonded under the same vacuum bag.

As a general rule, process control specimens shall be manufactured and tested for each class 1 part.

For class 2 parts, one set of process control specimens shall be manufactured for each cure load.

For class 3 parts PCS are not mandatory unless otherwise defined in the drawing set definition.

The preferred tests for serial production control, which react sensitively to deviations in the production process, are stated in the list below:

Table 5: Process Control specimens vs. Functional class

Functional Class	PCS Test Method Single lap shear strength (EN2243-1) or Peel load metal/metal (EN2243-2)
1	X 1)
2-1	X 1)
2-2	X 1)
2-3	X 2)
3	N/A

N/A→Not applicable
1) PCS-testing may be reduced up to 80% based on process capability demonstration
2) PCS-testing may be removed after min. of 30 test panels successfully demonstrated

When a sufficient database for one specific part exists, confirming the reliability of the specific process, it may be acceptable to reduce PCS-testing to 80%, but to perform the process control test only when there are doubts relating to the final quality of the part (e.g. mandatory in case of any process deviation). This is only applicable with specific approval of the Responsible Design Office presuming, that any results of NDI, visual and dimensional inspections are satisfying. It is also prerequisite, that any First Part Qualification applicable to an item as well as First Article Inspection is successfully performed without any remaining action.

7.5 Serial Production Inspection schedule

Generally, for each metal/metal bonded part, a detailed Inspection Schedule shall be defined by the responsible manufacturing / quality organization. For the purpose of this specification, the “Functional Classification” of a metal/metal bonded part according to their structural responsibility shall be considered. The Functional Class is defined for each metal/metal bonded part, documented on the Bill of Material. Classification criteria are acc. to relevant Airbus Manual.

Taking into account the main “Key Characteristics” of this process (refer to section 4.6) and inspection processes to validate the quality of the bonded item, the following requirements shall be applied, depending on its functional class.

Table 6: Min. inspection requirements vs. Functional class

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Measurement	Functional Class [1]				
	1	2-1	2-2	2-3	3
Storage / Work life control	X	X	X	X	X
Visual Inspection	100%	100%	100%	100%	100%
Contour geometry	X [2]	X [2]	X [2]	X [2]	X [2]
NDI – Inner Quality	100%	100%	100%	X [3]	N/A
Process Control Specimens	X [4]	X [5]	X [5]	X [5]	N/A

N/A → Not applicable
1) Functional Class as per BOM (acc. to relevant Airbus Manual)
2) As a minimum to be validated as per First Article Inspection, if not otherwise agreed.
3) 100% of measurements may be reduced / or sampled after full process capability of the item is demonstrated.
4) Process Control Specimens for each item (tool) shall be cured and performed under the same vacuum bag.
5) Process Control Specimens representing any materials used shall be cured and performed as a minimum once per autoclave load.

8 Rework

Referred to Part related instruction.

9 Environment, Health and Safety

The manufacturing process shall be in line with Airbus Health and Safety and ecoefficiency policies.

Compliance with A1091 shall be ensured for all materials, substances and/or articles implemented during process. In particular, targeted substances according to A1091 shall not be used, if a safer alternative is available.

Uses made of all substances involved in the process shall be documented in Safety Data Sheet as required by REACh regulation (Registration Evaluation and Authorization of Chemicals).

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Annex A
(normative)

Table A.1: Auxiliary material list (continued)

No	Auxiliary material	Application *(Auxiliary material Type)*	Trade name *(Manufacturer)*	Remarks [1] *(IPS)*	Storage life [2]
1	Peel-ply	General use (not allowed for structural bonding) *(TyA)*	60-B/R *(Tygavac Advanced Materials)*	Nylon / 205ºC *(IPS 12-01-003-01)*	12 months
			081111650DPO000 (F-08111 old denomination) *(NCV Industries; Porcher)*	Polyester *(IPS12-01-003-02)*	12 months
			PFG Code 60001 Style 60001/060/0005, /0006, /0008 *(Precision Fabrics Group; PFG)*	Polyester *(IPS12-01-003-03)*	12 months
2	Release agent (liquid)	For general application only (contact between the tool and the outer ply of the part during curing and RT consolidation/compaction of adhesive). Other uses need to be validated by Airbus M & P and could require specific qualification activities *(TyA)*	Frekote 700 NC *(Henkel Loctite Corp.)*	Solvent base	12 months [3]
			Frekote 44 NC *(Henkel Loctite Corp.)*	Solvent base	12 months [3]
			Marbocote TRE 45 ECO *(Marbo)*	Solvent base	12 months [3] [4]
			Mold release 225 *(Ram chemicals)*	Solvent base	6 months from delivery date
3	Release film [5]	For general application only (contact between the tool and the outer ply of the part during curing and RT consolidation/compaction of adhesive). Other uses need to be validated by Airbus M & P and could require specific qualification activities *(TyA)*	A4000 *(Airtech)*	FEP (Grade C) / 260ºC perforated/non-perforated	Unlimited
			A4000 BOS (bondable one side) *(Airtech)*	FEP (Grade C) / 260ºC perforated/non-perforated	18 months from delivery date
			A5000 *(Cytec Process Materials; old Richmond Aircraft Prod.)*	FEP (Grade C) / 260ºC perforated/non-perforated	Unlimited
			WRIGHTLON-5200 *(Airtech)*	ETFE (Grade B) / 260ºC perforated/non-perforated	Unlimited
			VAC-PAK A-6200 *(Cytec Process Materials; old Richmond Aircraft Prod.)*	ETFE (Grade B) / 232ºC perforated/non-perforated	Unlimited
			RF-242-R *(Tygavac Advanced Materials)*	ETFE (Grade B) / 230ºC perforated/non-perforated	Unlimited
			Nowoflon ET 6235 *(Nowofol)*	ETFE (Grade B) / 150ºC [6] perforated/non-perforated	
			WRIGHTLON-4500 *(Airtech)*	PVF (Grade D) / 204ºC perforated/non-perforated	Unlimited
			Tedlar E 3760 white *(Cytec Process Materials; old Richmond Aircraft Prod. or FUS)*	PVF (Grade D) / 204ºC perforated/non-perforated	Unlimited
			WRIGHTLON 4600 *(Airtech)*	PMP (Grade A) / 193ºC perforated/non-perforated	Unlimited
			VAC-PAK E-4760 *(Cytec Process Materials; old Richmond Aircraft Prod.)*	PMP (Grade A) / 205ºC perforated/non-perforated	Unlimited

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Table A.2: Auxiliary material list (concluded)

No	Auxiliary material	Application *(Auxiliary material Type)*	Trade name *(Manufacturer)*	Remarks [1] *(IPS)*	Storage life [2]
3	Self adhesive release film	For general application only (contact between the tool and the outer ply of the part during curing and RT consolidation/compaction of adhesive). Other uses need to be validated by Airbus M & P and could require specific qualification activities *(TyA)*	Chemstik SS203 S Airbus (old name 700-3S) *(Saint Gobain)*	PTFE+Silicone adhesive / 260ºC	
			Chemstik CS206 S *(Saint Gobain)*	PTFE+Silicone adhesive / 260ºC	
			Taconic 6075/05 *(Taconic)*	Glass+PTFE/ silicone adhesive / 260ºC	
			Tooltec A005 *(Airtech)*	Glass+PTFE/ silicone adhesive / 260ºC	18 months
			Tooltec CS-5 *(Airtech)*	PTFE+Silicone adhesive / 260ºC	18 months
			T7503 *(Saint Gobain)*	Glass+PTFE/ silicone adhesive	
			Tooltec CA-5 *(Airtech)*	PTFE+Acrilic adhesive	18 months

Notes:

(1) Fluorinated materials (FEP, ETFE, PVF, PTFE, …) in direct contact with adhesives are prohibited if not specifically approved for a particular application

(2) Storage at 5-28ºC/ 40-60% R.H (unless otherwise stated) in original containers and not exposed to U.V. light (see Material Technical Data Sheet for materials with no specifc information)

(3) Moisture sensitive material, keep container tightly closed when not in use

(4) Storage at 5-18ºC. Once opened, 90 days max at shop conditions

(5) Microperforated release films allows volatiles to escape without any leakage of resin

(6) 230ºC for short times after shop trials

Auxiliary material Type:

Type A *(TyA)* : Materials in direct contact with uncured structural materials, honeycombs or dry fabrics during previous operations, lay-up or curing. They have high contamination transference risk that can affect the structural behaviour.

Type B *(TyB)* : Materials without direct contact with the structural materials, honeycombs or dry fabrics during previous operations, lay-up or curing. They have high influence in the manufacturing process

Type C *(TyC)* : Materials not in direct contact with uncured structural materials, honeycombs or dry fabrics and with low influence in the manufacturing process.

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RECORD OF REVISIONS

Issue	Clause modified	Description of modification
1 03/06		New standard.
2 12/08		Update
3 12/08	2	AIPS02-01-001 and EN9103 added.
	4.3	Headline changed to “Facilities, equipment and tooling”
	4.3.1	Subpara. 4.3.1.1 “Facilities for pre-treatment” and 4.3.1.2 “Areas for application of bonding primer”
	4.3.2.5	Freezers deleted; new subclause 4.3.2.5 “tooling”
	4.4.1 and 4.4.2	Incorporation of “Pre-treatment of Al-alloys” and “Application of bonding primer”; “Process parameter” shifted to Paragraph 4.4.9.1
	4.6	Incorporation of new chapter 4.6 “Key characteristics” incl. Table 3
	7.4.1	Table 3 changed to Table 4; page 16
4 08/11	2	Pre-treatment process according to AIPS02-01-006 (PSA) added
	4.4.1	Pre-treatment process according to AIPS02-01-006 (PSA) added
	Table 3	Pre-treatment process according to AIPS02-01-006 (PSA) added
5 02/13	All	New template
	3.1	Functional class definition added
	4.2	Auxiliary material list annex added
	6	FPQ Vs FC, table 4 added
	7.1	Modified
	7.4.1	Modified and table 5 added
	7.5	Serial production Inspection schedule with respect to Functional classification defined and table 6 added
	Annex A	Auxiliary material list annex added

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