Material and Process Substantiation

• All new adhesives and processes must be subjected to rigorous qualification tests to approve them for use on the aircraft.

• The testing required will be dictated by the intended use of the material / process and its application.
Adhesives - Qualification testing

- Peel - 90 Deg roller
- Single and double lap shear
- Climbing drum peel
- Sandwich tensile
- Hot/wet sustained load tests
- Double lap shear fatigue
- Tg
Surface Preparation Process - Qualification testing

- Similar test regime to that of the adhesive
- Additionally, salt spray corrosion tests may be required to assess the protection of the substrate, if metallic.
Design of Joint

- Surface Preparation
  - Metallic
  - Composite
- Bonding Technique
  - Adhesive type
  - Joint type / overlap size
- Secondary fastening
- Inspection
Surface Preparation - Metallic

- Aluminium
- Nickel
- Titanium
- Stainless steel
- Chemical etch vs abrasion
- Bonding primers
**Aluminium**

- Chromic Acid Anodise or Vacu-blast
- Chromic Acid provides good bond surface and corrosion protection
- The replacement of Chromic Acid anodising with Sulphuric Acid anodising is under consideration. Phosphoric Acid whilst giving good bond strength was not suitable for corrosion protection.
Nickel

- Ferric Chloride / Hydrochloric Acid etch
- Sodium Dichromate / Sulphuric Acid de-smut
Nickel

- Ferric Chloride / Hydrochloric Acid etch
- Sodium Dichromate / Sulphuric Acid de-smut

Titanium

- Immerse in Nitric / Hydrofluoric Acid pickle
- Etch in alkaline / peroxide
Stainless Steel

- Sulphuric Acid etch
- Sodium Dichromate / Sulphuric Acid de-smut
Effect of bond priming on surface treatment

![Graph showing the effect of bond priming on surface treatment.](image-url)
Advantages of bond priming

- Provides a chemical key between the adhesive and metallic substrate
- Increases bond durability
- Improves corrosion resistance (if chromate)
- Allows for storage of treated substrate prior to bonding
Surface Preparation - Non-Metallic

- Five types of techniques can be used for the surface preparation of composites
  - Manual abrasion - wet and dry
  - Vapour-blast
  - Vacu-blast
  - Tear-ply
  - Corona discharge
# Preferred surface treatments

<table>
<thead>
<tr>
<th>Type of component</th>
<th>Preferred method</th>
<th>Alternative method</th>
<th>Other methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermoset</td>
<td>Vapour Blast / Tear Ply</td>
<td>Wet manual abrasion method + detergent scrub</td>
<td>Wet and dry manual abrasion &amp; Vacu blast</td>
</tr>
<tr>
<td>Thermoplastic</td>
<td>Corona Discharge</td>
<td>Vacu blast</td>
<td>Wet manual abrasion method</td>
</tr>
</tbody>
</table>
Choice of structural adhesives

- Film - Epoxy 125C /175C cure
  Phenolic 175C cure
- Foaming - 125C and 175C cure
- Two part paste - RT cure Epoxy, Acrylic or elevated cure Epoxy. Use of cartridges now common. Gap filling possible
- Anaerobics
- Contact
Designing for Repair

- What are the critical damage risk areas?
- How will the area be repaired?
- Does the scheme repair the damage?
- Does the repair affect component performance?
- Does the component repair adversely affect helicopter performance?
Designing for Repair

- Each repair scheme has to be checked for:
  - Strength
  - Stiffness
  - Mass/Balance
  - Aerodynamics
  - Material Properties
Designing for Repair

- Repairs schemes must be validated.

- There are three levels of evaluation used:
  * By inspection (Visual and NDT)
  * By calculation
  * By test (Proof/Proving test or structural qualification test)
Bonded structure examples
1) Main Rotor Blades

- A number of different adhesives may be used in the design of a blade.
- The principal structural adhesives are likely to be elevated temperature curing epoxy film adhesives for critical bonded joints such as composite skin to spar and honeycomb core, and the heater mat and erosion shield to spar bonds.
- Foaming epoxy film adhesives are used to provide shear connections between the honeycomb, foam and spar.
Bonded structure examples
1) Main Rotor Blades (cont)

- Titanium Erosion Shield
- ‘D’ Spar
- Mid Wall
- Nomex Honeycomb
- ±45° Carbon Composite
- Trailing Edge Skins
- Rohacell 71 Foam
- Integral Hybrid Nose Moulding
- Film adhesive
- Foaming adhesive
- Integral Rear Wall
- Film adhesive
Bonded structure examples
1) Main Rotor Blades (cont)

- Room temperature curing adhesives are used for the less critical bonding operations and secondary bonding.

- No secondary fasteners, since bond areas are large and bond stresses are low.

- Blade structure is suitable for NDT inspection and the dynamic balancing process will exercise the bonds and may reveal any disbonds.

- Blades can be repaired through the use of bonded patches or separating at bond-lines to replace significant structural parts.
Bonded structure examples
2) Composite Tailplane (cont)
Bonded structure examples
2) Composite Tailplane (cont)

- A number of different adhesives were used in the design of a tailplane.

- The principal structural adhesives were elevated temperature curing epoxy film adhesives for the bonding of the skin to the foam core.
Bonded structure examples
2) Composite Tailplane (cont)
Bonded structure examples
2) Composite Tailplane (cont)

- A number of different adhesives were used in the design of a tailplane.

- The principal structural adhesives were elevated temperature curing epoxy film adhesives for the bonding of the skin to the foam core.

- Foaming epoxy film adhesives were used to provide shear connections between the foam and spar.
Bonded structure examples
2) Composite Tailplane (cont)

Foaming adhesive

Film adhesive
Bonded structure examples
2) Composite Tailplane (cont)

- A number of different adhesives were used in the design of a tailplane.

- The principal structural adhesives were elevated temperature curing epoxy film adhesives for the bonding of the skin to the foam core.

- Foaming epoxy film adhesives were used to provide shear connections between the foam and spar.

- Room temperature curing adhesives were used for the end caps and bonding the spar to the metallic end fitting. In the latter bond the adhesive has a secondary gap filling role.
Bonded structure examples
2) Composite Tailplane (cont)

- Foaming adhesive
- Mechanical fasteners
- Paste adhesive
- Film adhesive
Bonded structure examples
2) Composite Tailplane (cont)

- Fail-Safe torsional load path between the metallic end fitting and the composite spar is provided by steel pins.
Bonded structure examples
2) Composite Tailplane (cont)

- Steel pins
- Aluminium end fittings
- Composite spar
- Paste adhesive
Bonded structure examples
2) Composite Tailplane (cont)

• Fail-Safe torsional load path between the metallic end fitting and the composite spar is provided by steel pins.

• Structure can be NDT inspected in the foam to skin and end cap regions.

• Repairs to the skins may be effected by bonding on of patches or stripping back to the spar / end fitting stage.