CAA/FAA Bonded Structures Workshop
Westland Helicopters Ltd -
Design, Development & Substantiation
Of Bonded Structures

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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

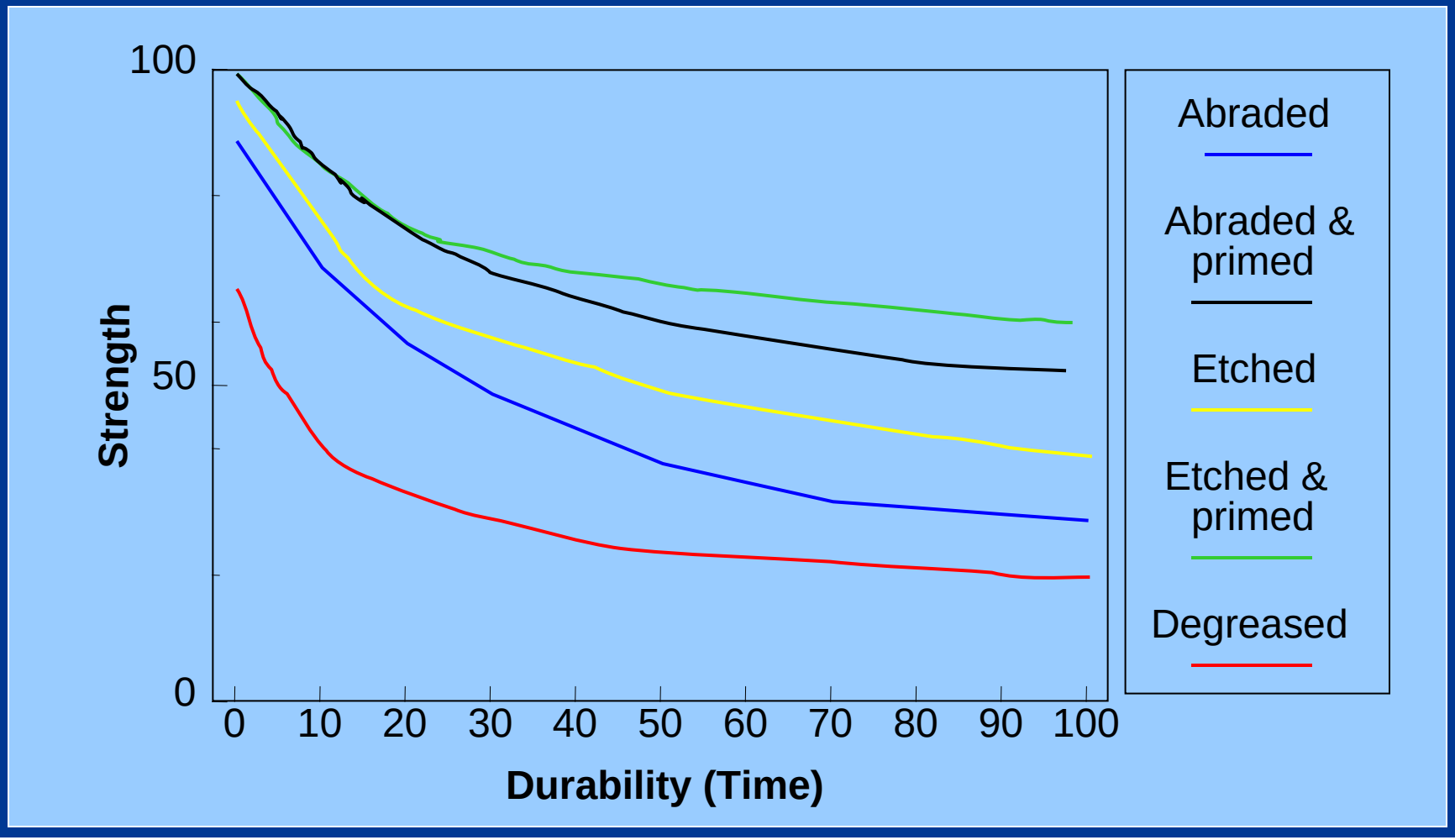
Titanium

- 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



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

Type of component	Preferred method	Alternative method	Other methods
Thermoset	Vapour Blast / Tear Ply	Wet manual abrasion method + detergent scrub	Wet and dry manual abrasion & Vacu blast
Thermoplastic	Corona Discharge	Vacu blast	Wet manual abrasion method

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

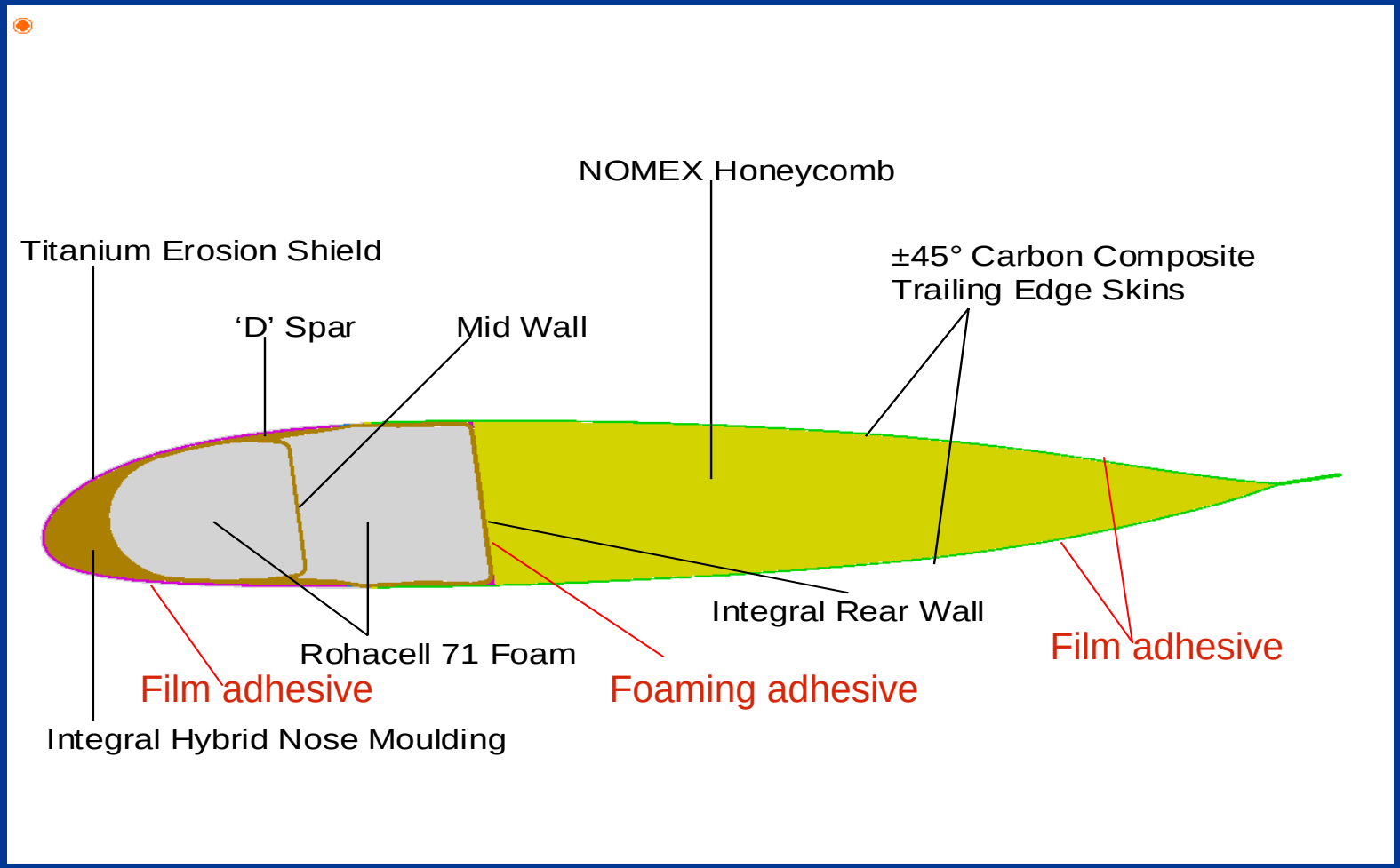
- **Repairs schemes must be validated.**

- **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.

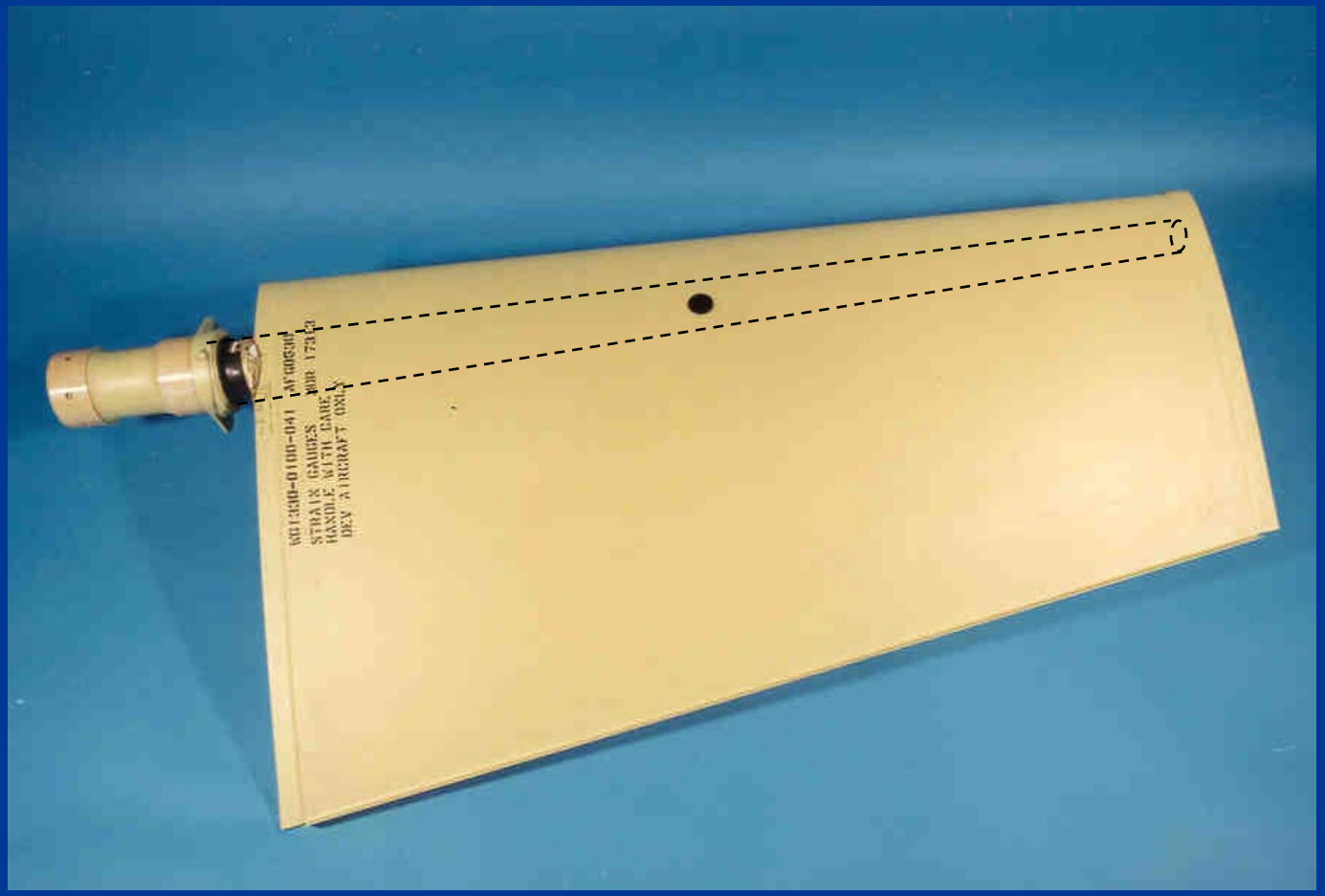
Bonded structure examples
1) Main Rotor Blades (cont)



Bonded structure examples
1) Main Rotor Blades (cont)

- Room temperature curing adhesives are used for the 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.

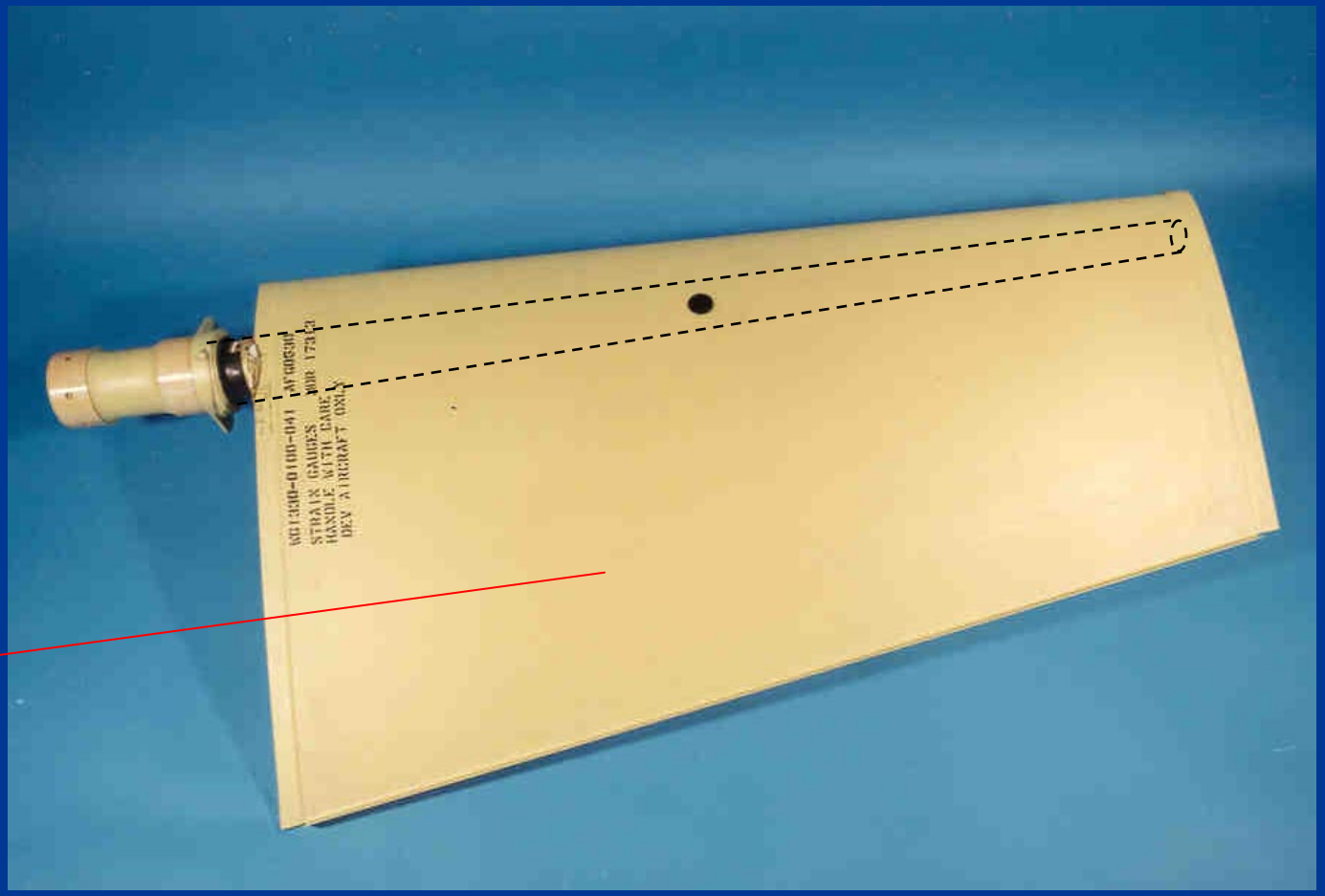
Bonded structure examples
2) Composite Tailplane (cont)



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)



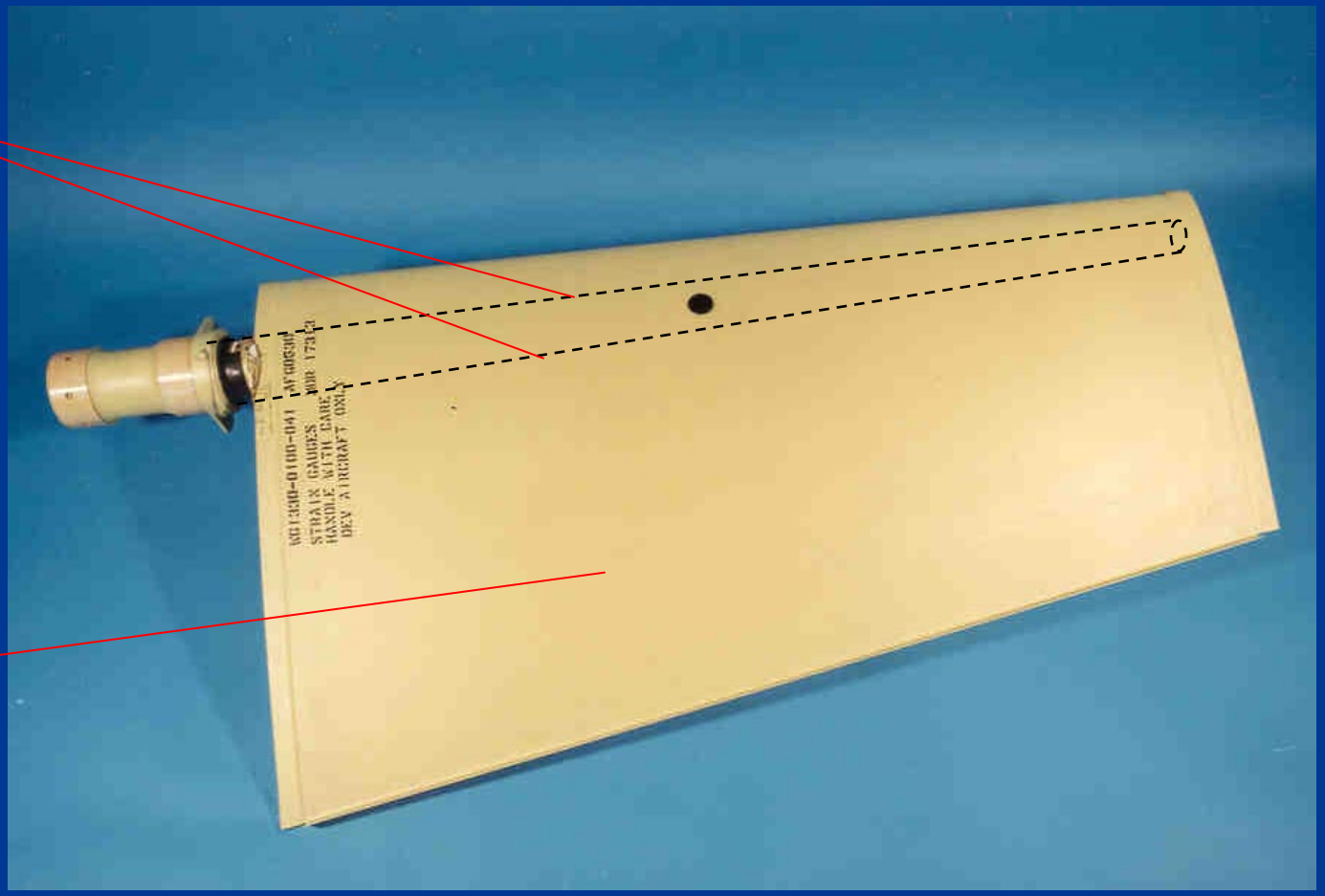
Bonded structure examples
2) Composite Tailplane (cont)

- 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.

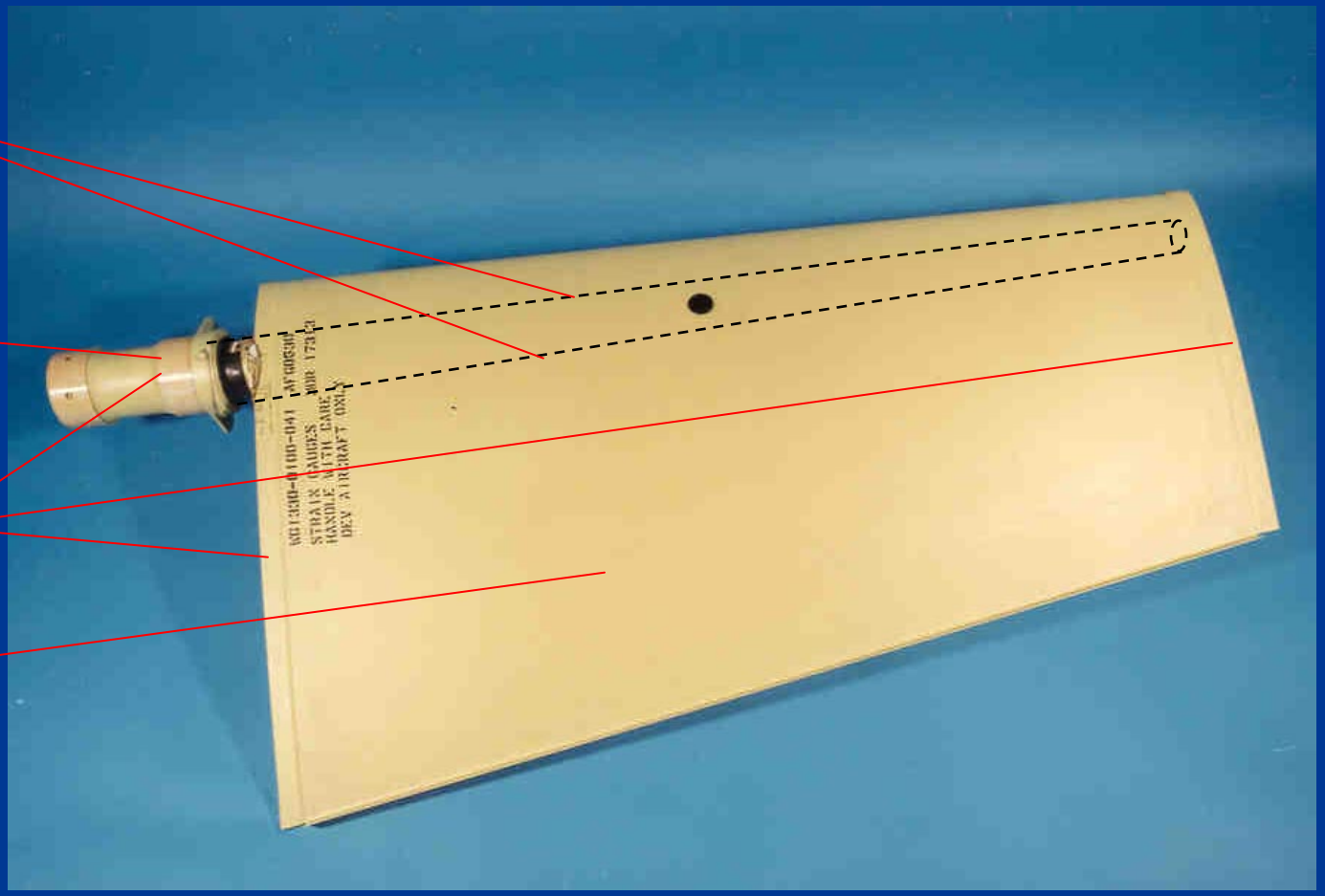
Bonded structure examples
2) Composite Tailplane (cont)

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.

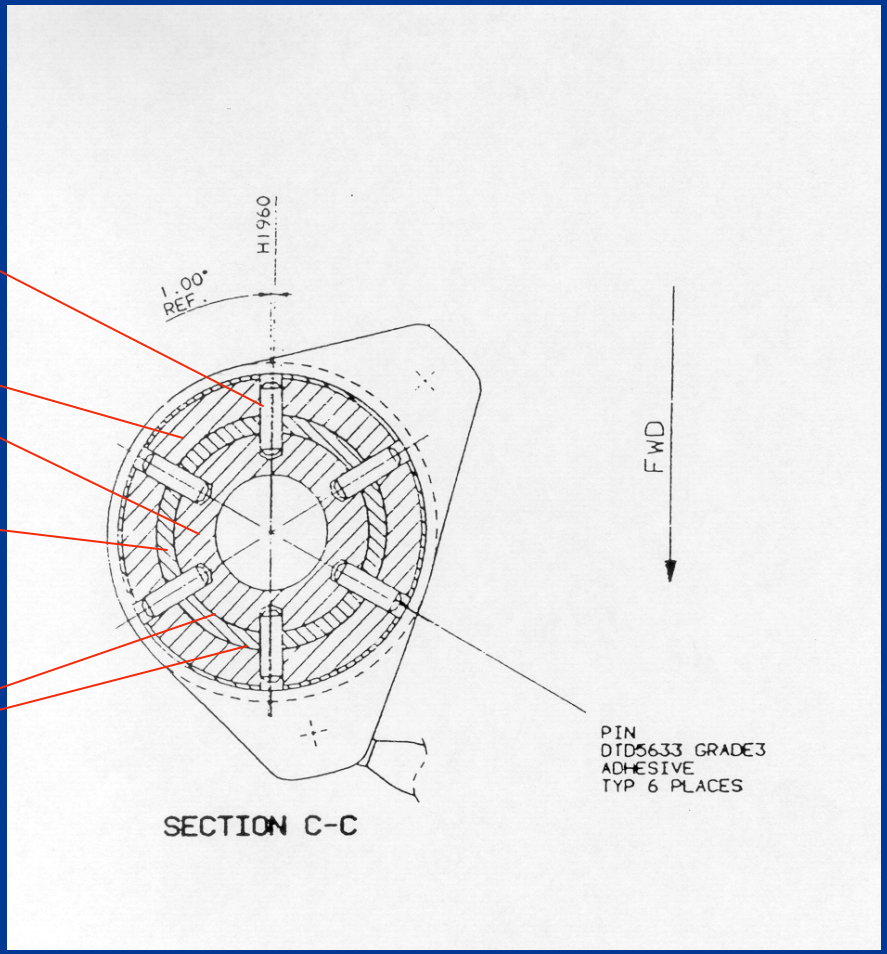
Bonded structure examples
2) Composite Tailplane (cont)

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.