

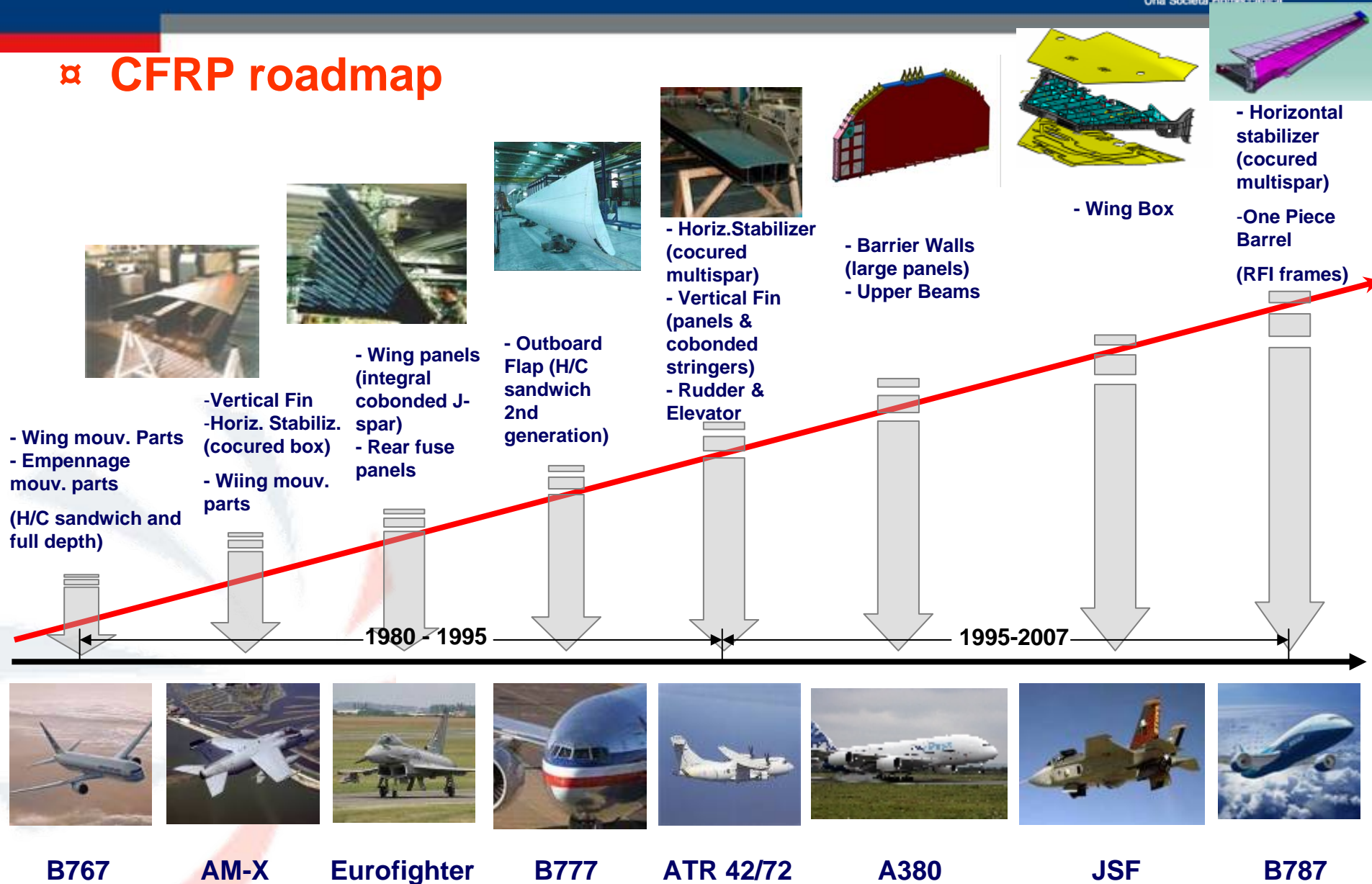


Alenia Experiences on Composite Structures Repairs

Benedetto Gambino

Amsterdam, 10 May 2007

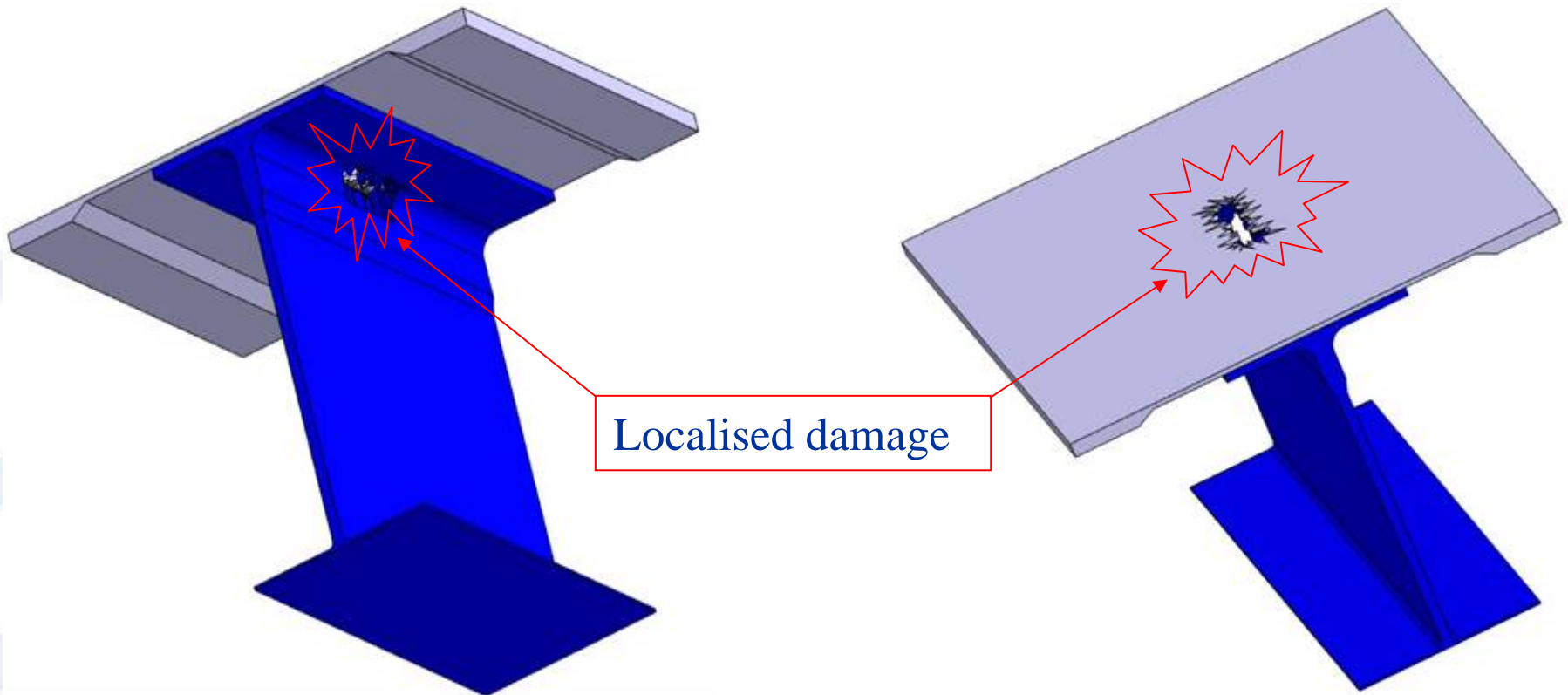
✈ CFRP roadmap



Skin and Rib damage example

Repair Concepts (STEP 1)

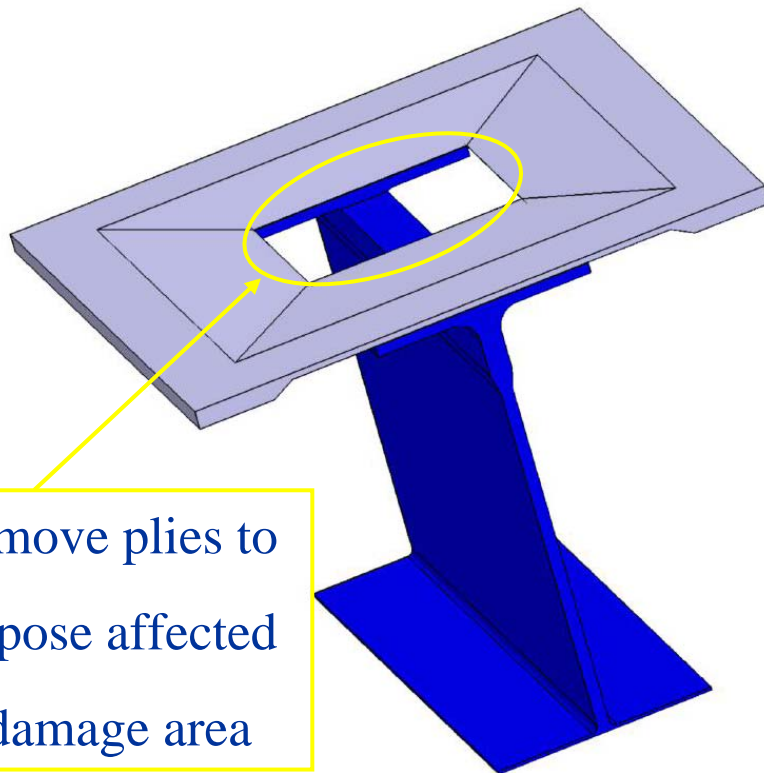
The damage is considered on laminated zone of skin and corner zone of rib's flange



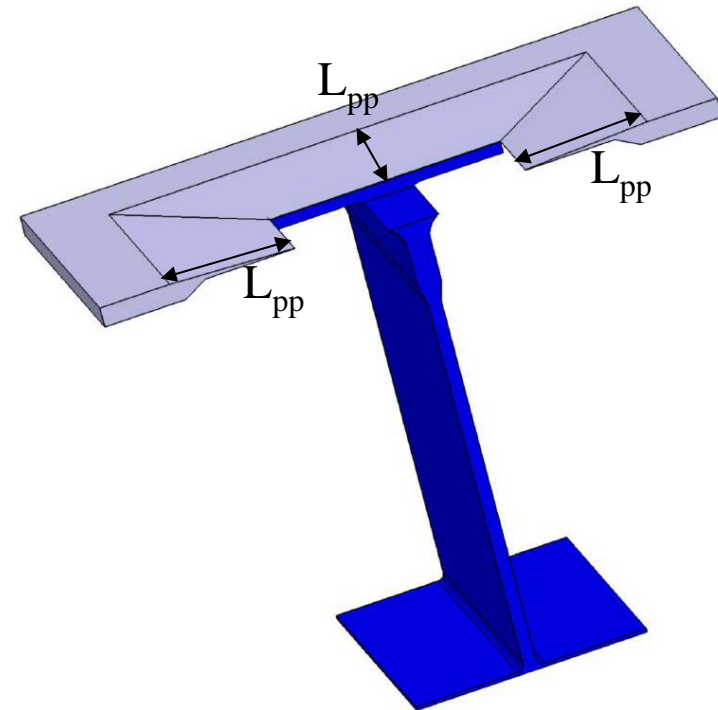
Skin and Rib damage example

Repair Concepts (STEP 2)

Remove crushed zone



Remove plies to expose affected damage area



$$L_{pp} = \text{Peel Ply Length} = n.\text{plies (thickness)} \times 12\text{mm}$$

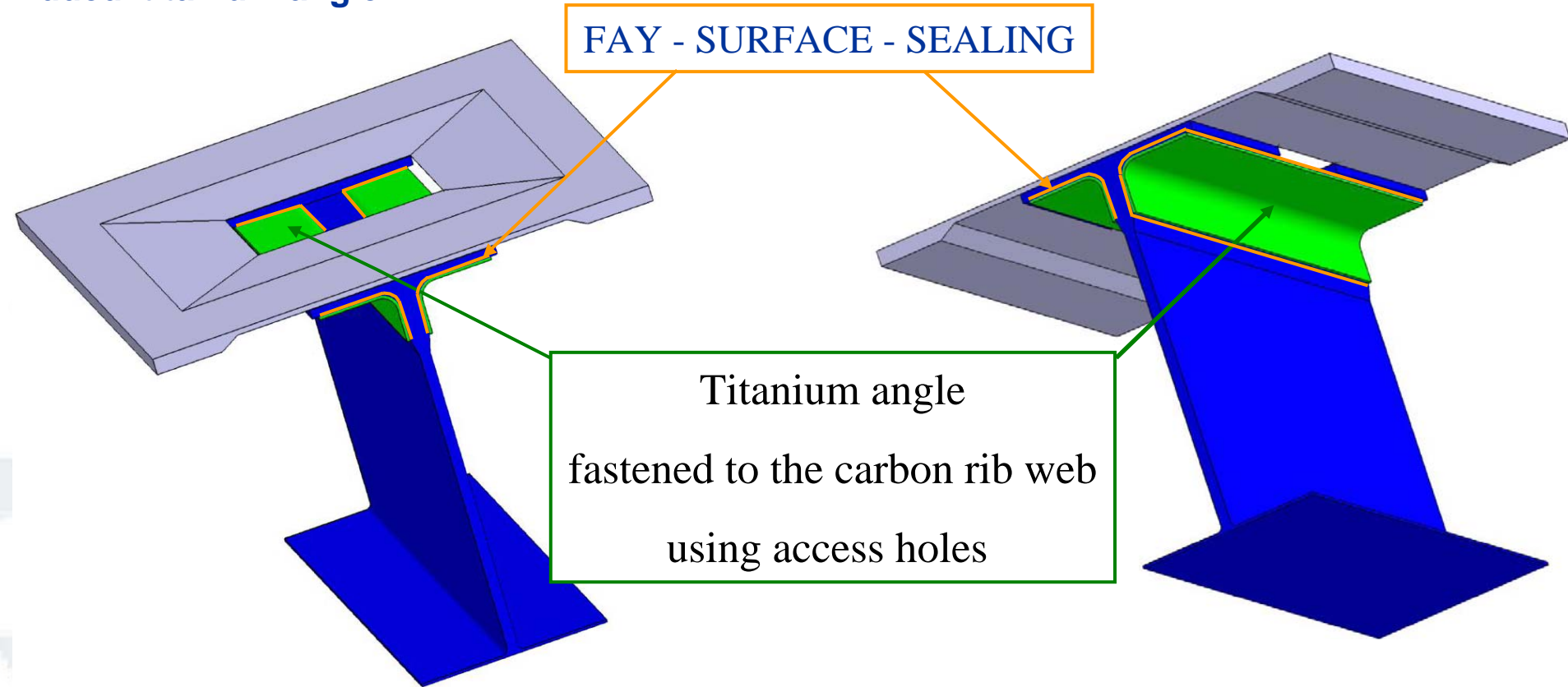
Skin and Rib damage example

Repair Concepts (STEP 3)

Added titanium angle

FAY - SURFACE - SEALING

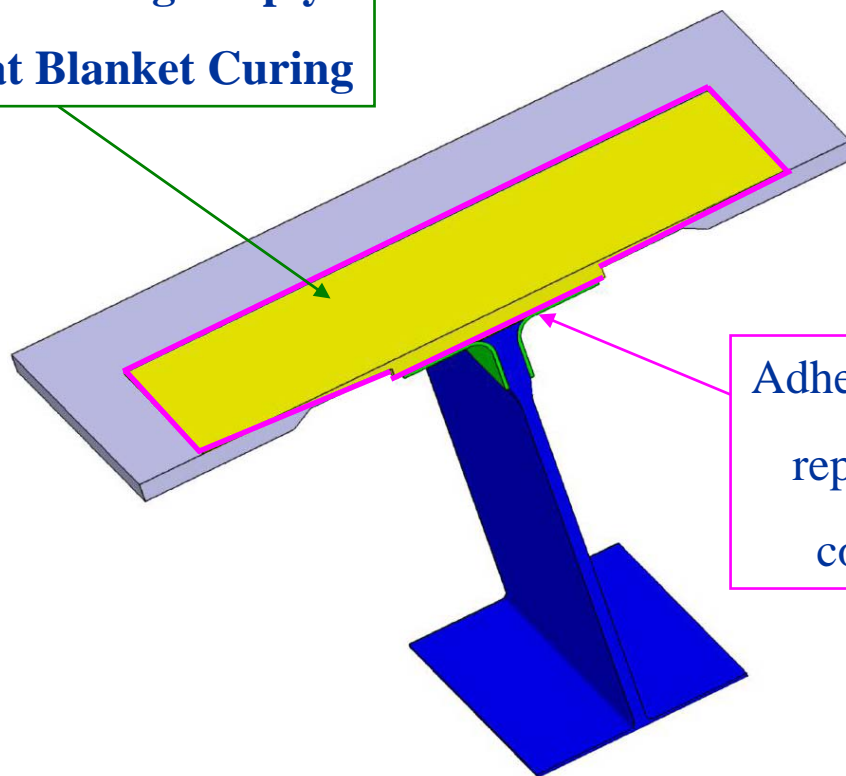
Titanium angle
fastened to the carbon rib web
using access holes



Skin and Rib damage example

Repair Concepts (STEP 4)

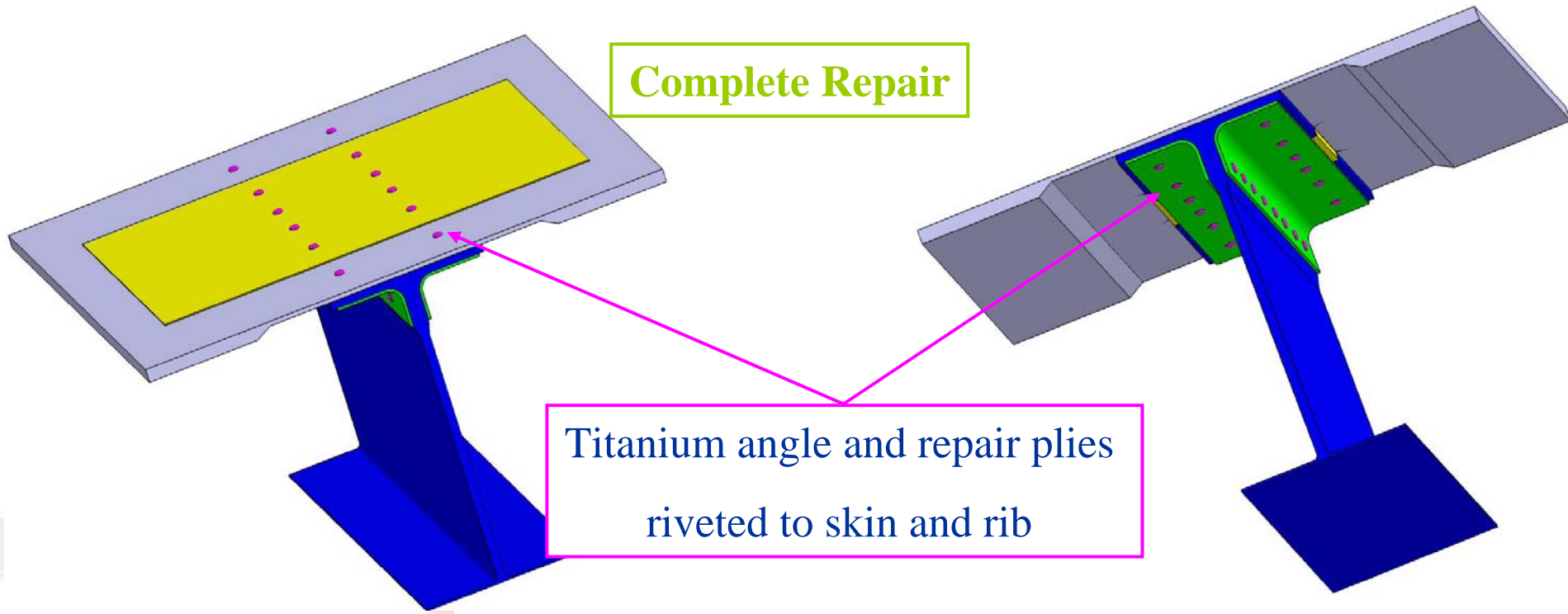
**Replace plies on a ply for ply (prepreg)
+ 2 extra plies (prepreg) + 1 Fiberglass ply
Local Vacuum Bag and Heat Blanket Curing**



Adhesive ply between
repair plies and all
contact surfaces

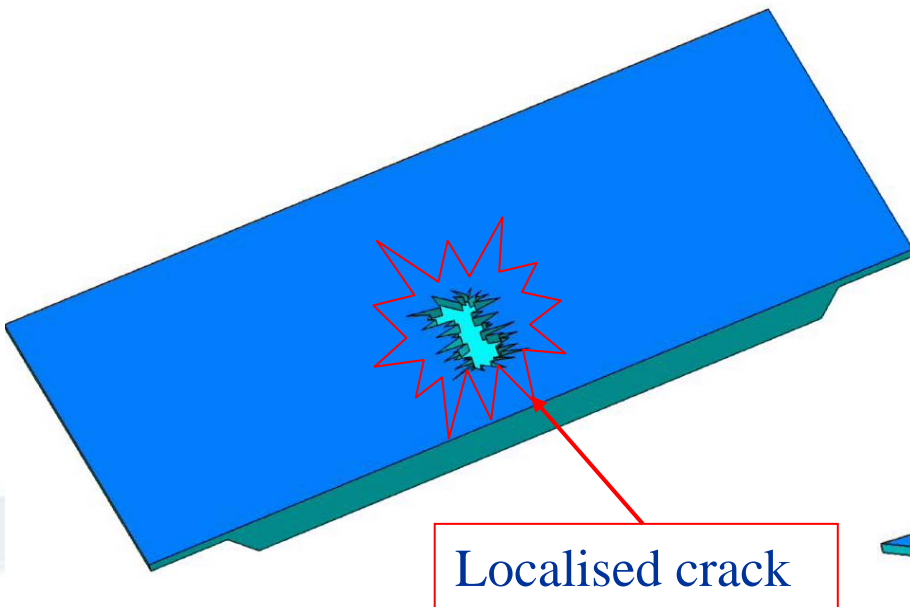
Skin and Rib damage example

Repair Concepts (STEP 4)

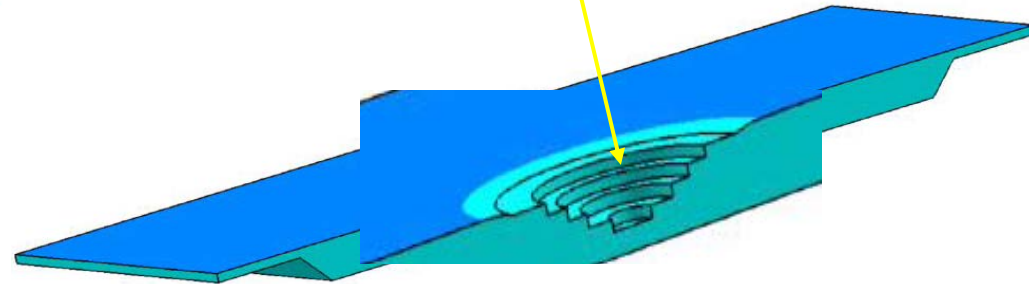


Sandwich panel Damage example

Repair Concepts (STEP 1 & 2)



Remove affected
plies to expose core.
Remove a core plug to
remove damaged core.

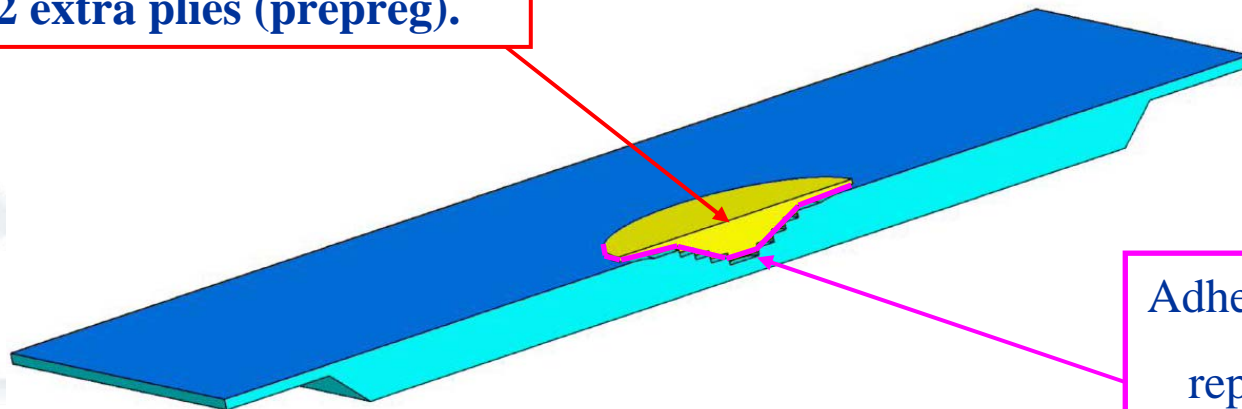


The damage considered is: crushed core and delaminated plies

Sandwich panel Damage example

Repair Concepts (STEP 3)

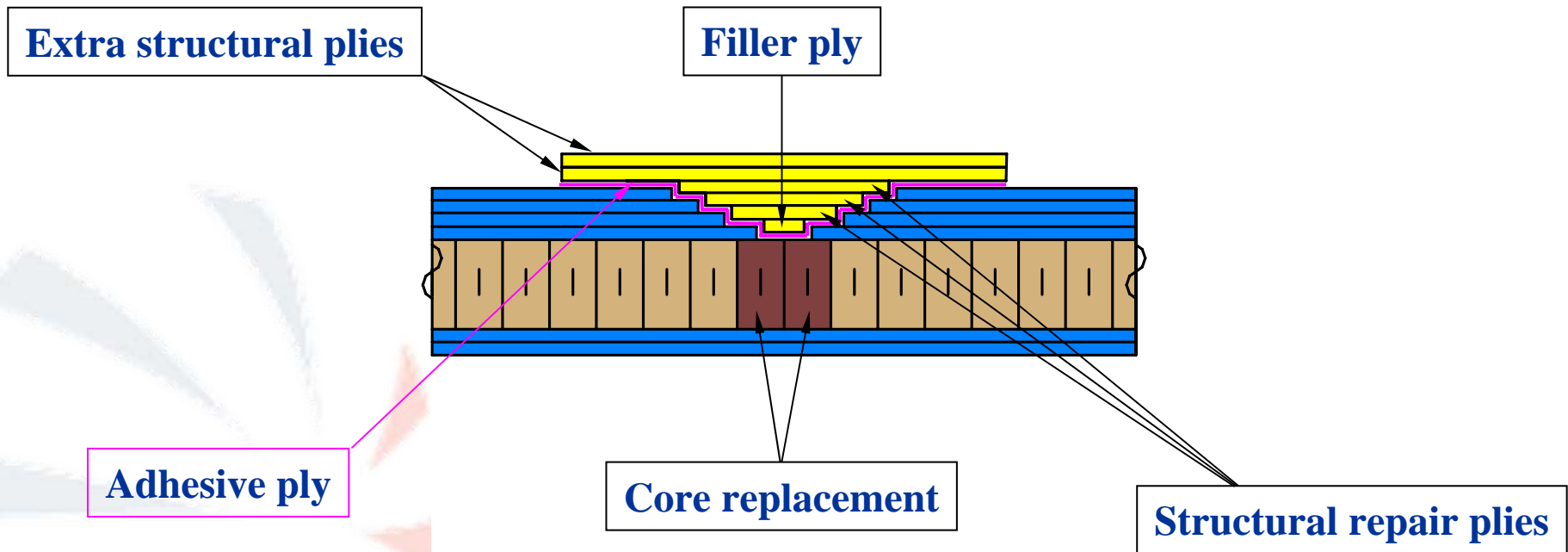
**Bond in a new core plug.
Replace plies on a ply for ply
+ 2 extra plies (prepreg).**

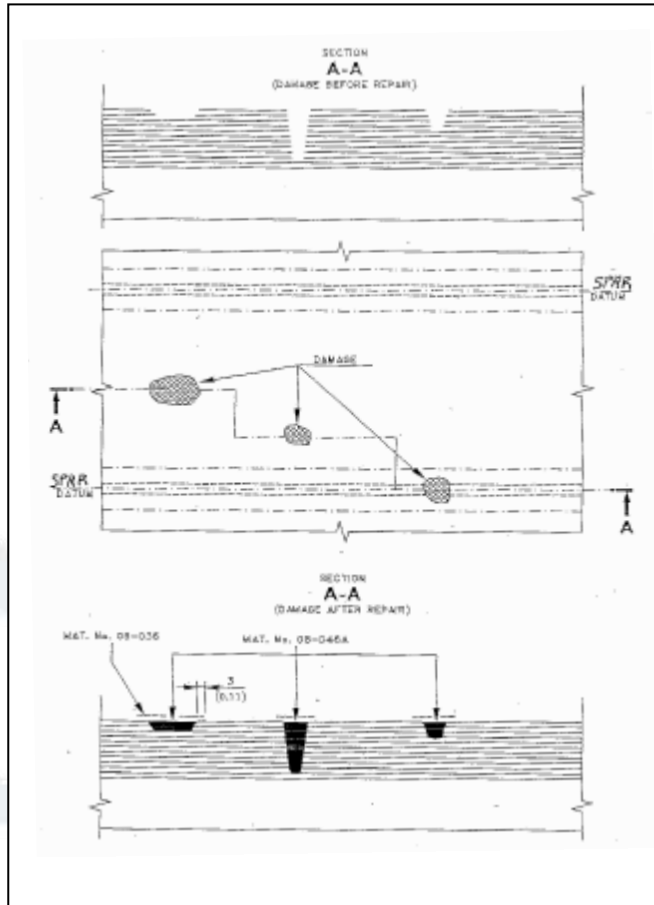


**Adhesive ply between
repair plies and all
contact surfaces**

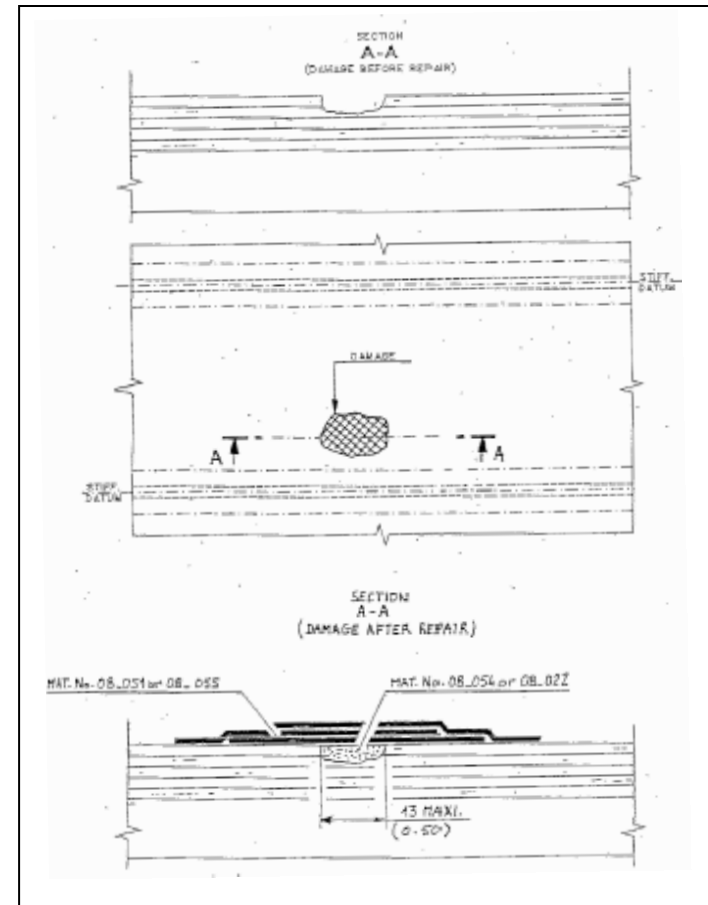
Sandwich panel Damage example

Repair of Sandwich Panel (detail)



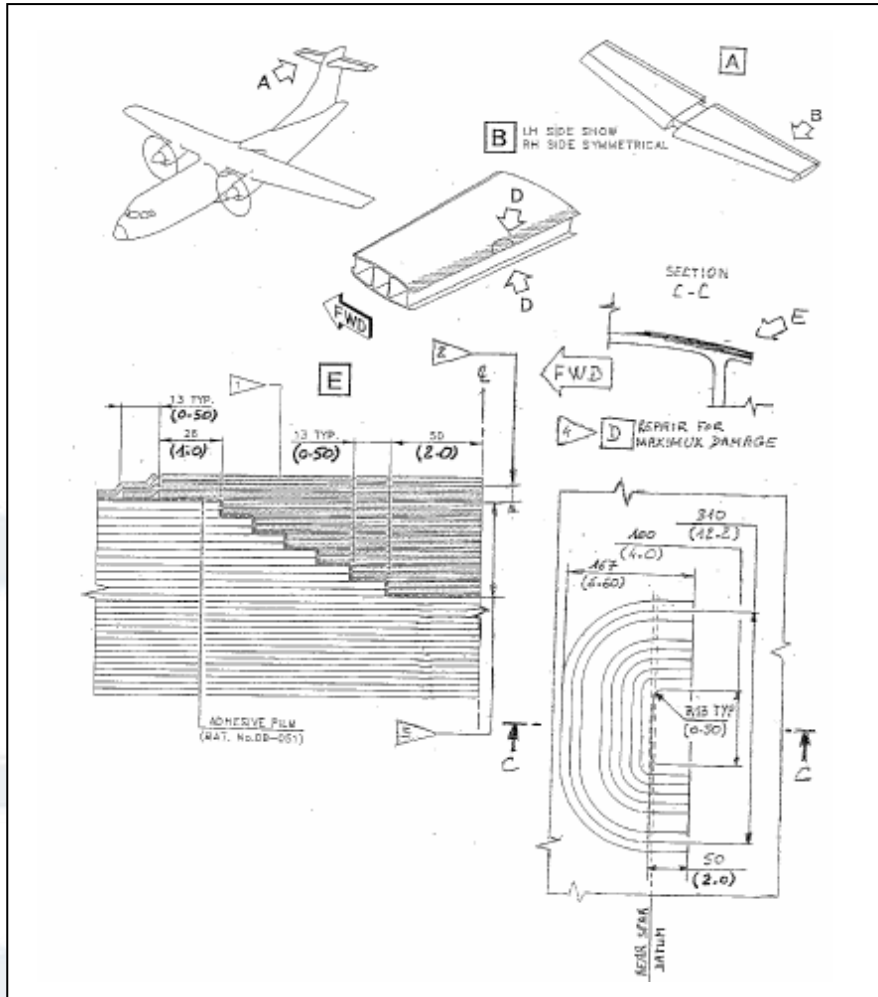


**Repair for Light damage
By Resin Filling**



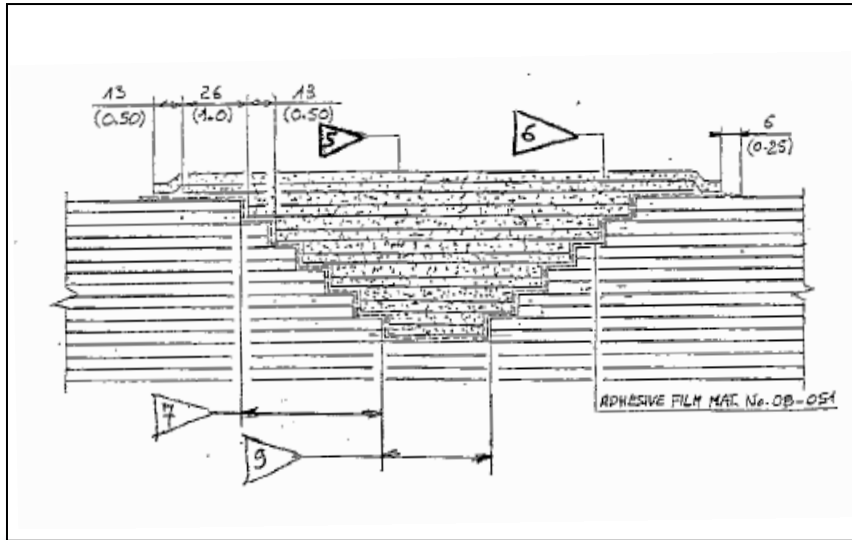
**Repair for Light damage
By Resin Filling and Extra Plies**

HOT BOND REPAIR FOR NON-PERFORATING DAMAGE ON PANEL EDGE CLOSE TO REAR SPAR



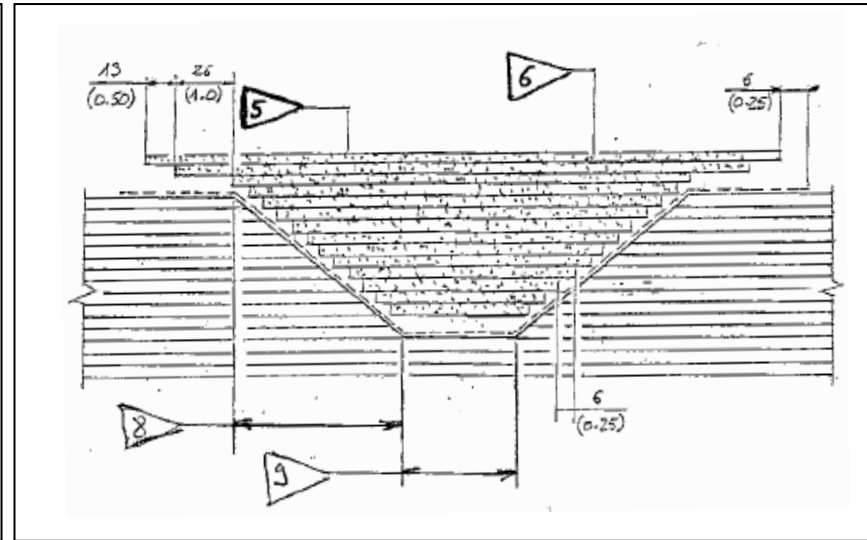
- 1 PUT A FIBER GLASS PLY COVERING THE PATCH IF COPPER MESH WAS PRESENT ON DAMAGED AREA.
USE ALUMINUM FLAME SPRAY TO RECREATE THE ELECTRICAL PATH.
- 2 2 EXTRA PLIES.
- 3 12 REPAIRED PLIES.
- 4 THIS REPAIR IS VALID ON UPPER AND LOWER PANEL EDGES.

HOT BOND REPAIR FOR NON-PERFORATING DAMAGE ON PANEL EDGE CLOSE TO REAR SPAR (cont'd)



1TH PRINCIPLE: STEP CUTTING

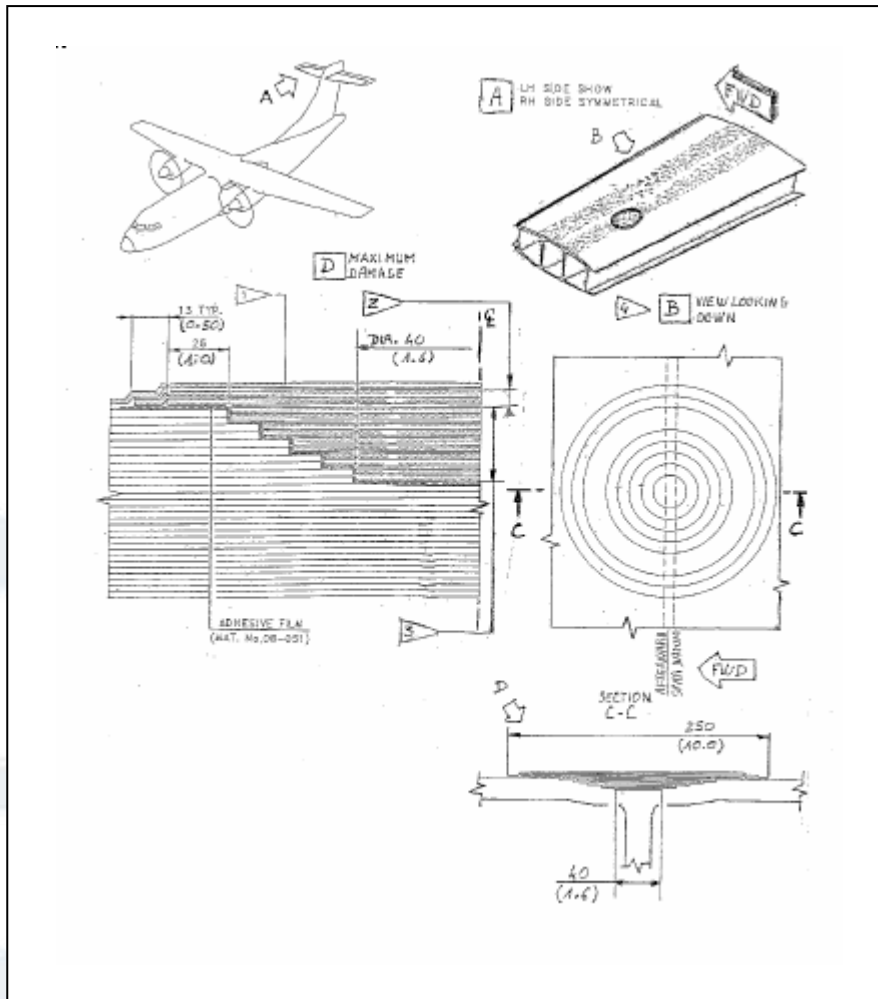
- 5 DETERMINE NUMBER OF PLYS, ORIENTATION AND MATERIAL FROM SPECIFIC COMPONENT STRUCTURE IDENTIFICATION
- 6 THE ORIENTATION OF THE OUTERMOST EXTRA REPAIR PLY HAS TO BE THE SAME AS THE OUTERMOST PLY OF THE ORIGINAL LAMINATE. ANY OTHER EXTRA REPAIR PLY HAS TO BE ORIENTED $+45^\circ$ TO THE EXTRA REPAIR PLY IMMEDIATELY ABOVE IT
- 7 STEP CUTTING: 2 PLYS AT TIME



2TH PRINCIPLE: TAPER SANDING

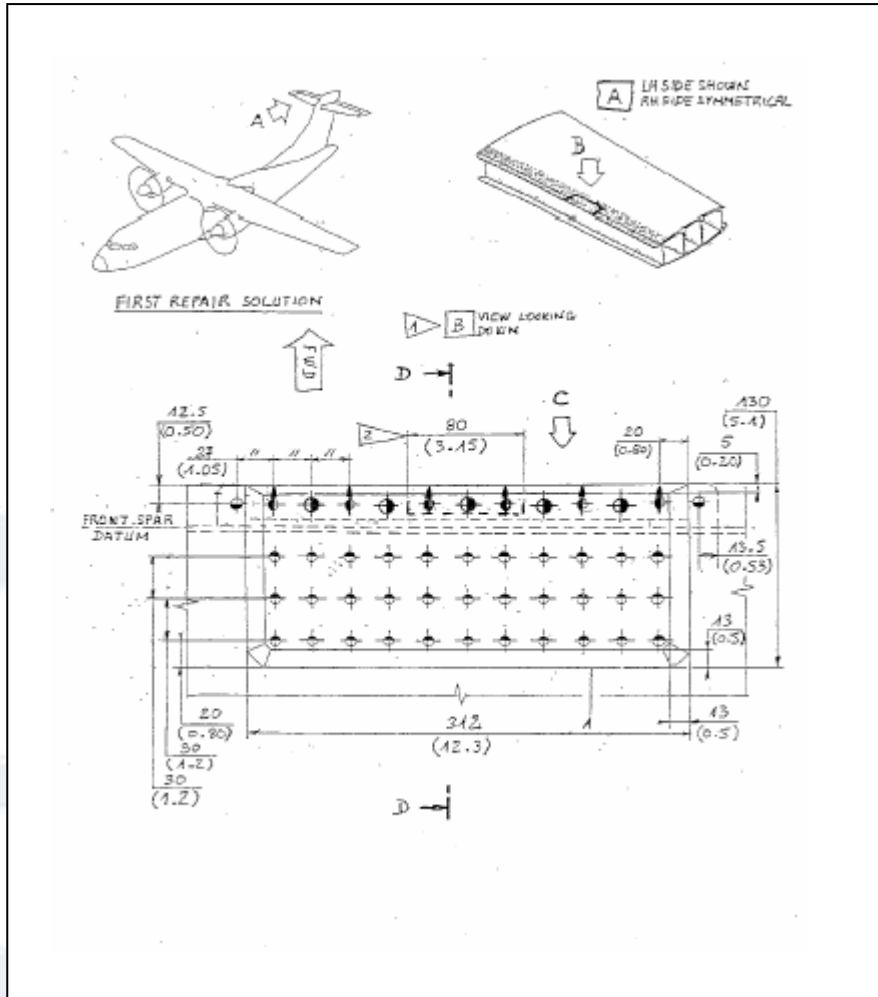
- 8 SANDED RAMP: SLOPE 40:1
- 9 DAMAGE DIAMETER

HOT BOND REPAIR FOR NON-PERFORATING DAMAGE ON THE SKIN AT THE SPAR LOCATION



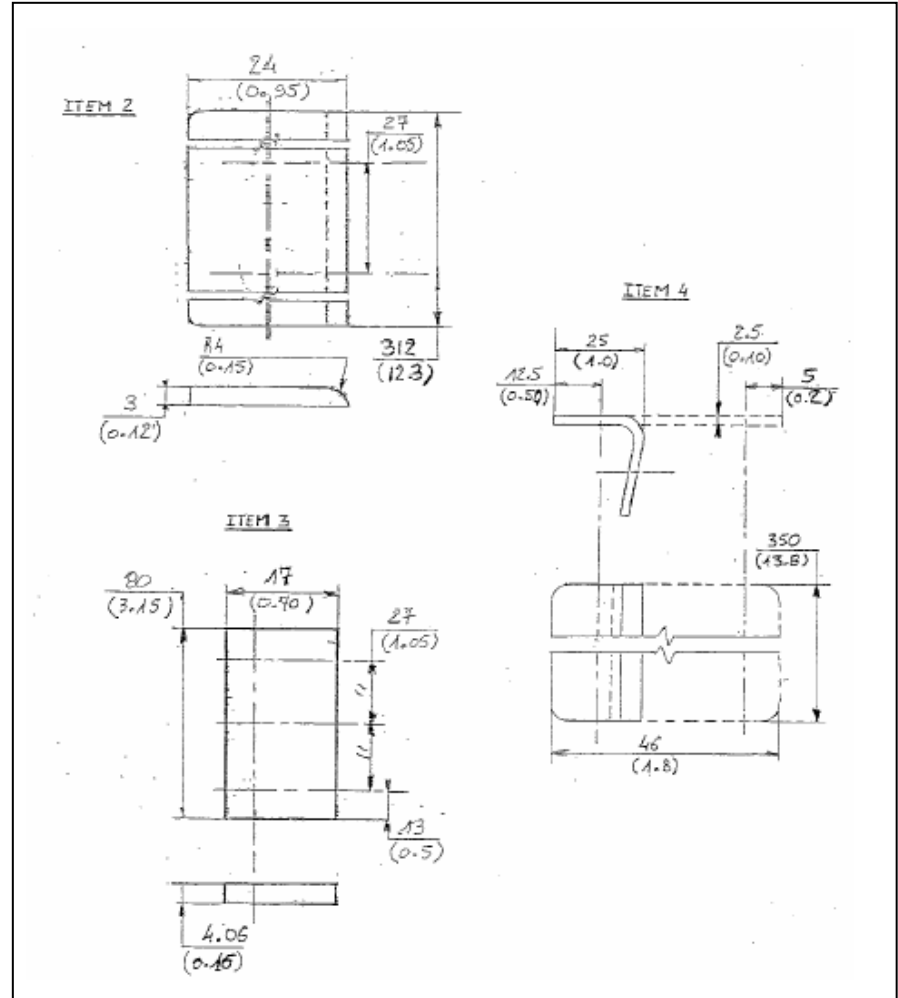
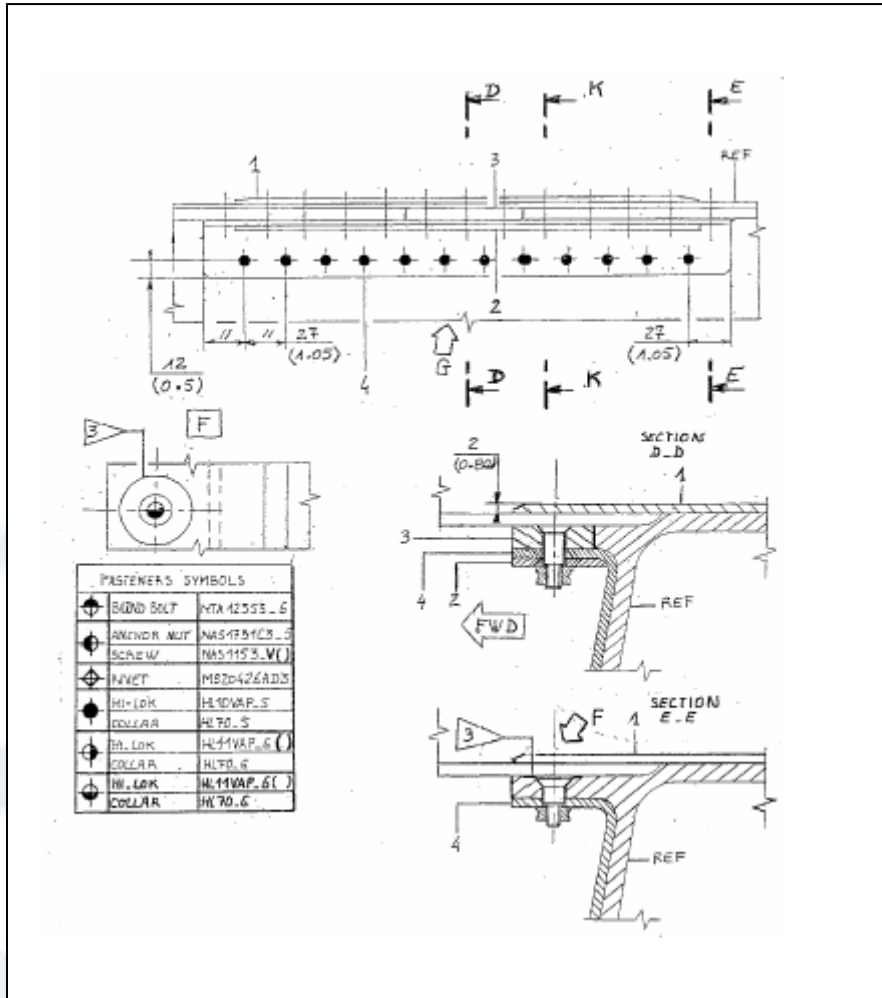
- 1** PUT A FIBER GLASS PLY COVERING THE PATCH IF COPPER MESH WAS PRESENT ON DAMAGED AREA. USE ALUMINUM FLAME SPRAY TO RECREATE THE ELECTRICAL PATH.
- 2** 2 EXTRA PLIES.
- 3** 10 REPAIRED PLIES.
- 4** THIS REPAIR IS VALID ON UPPER AND LOWER PANEL EDGES.

METAL PATCH REPAIR FOR PERFORATING DAMAGE ON FRONT SPAR CAP LOCATION

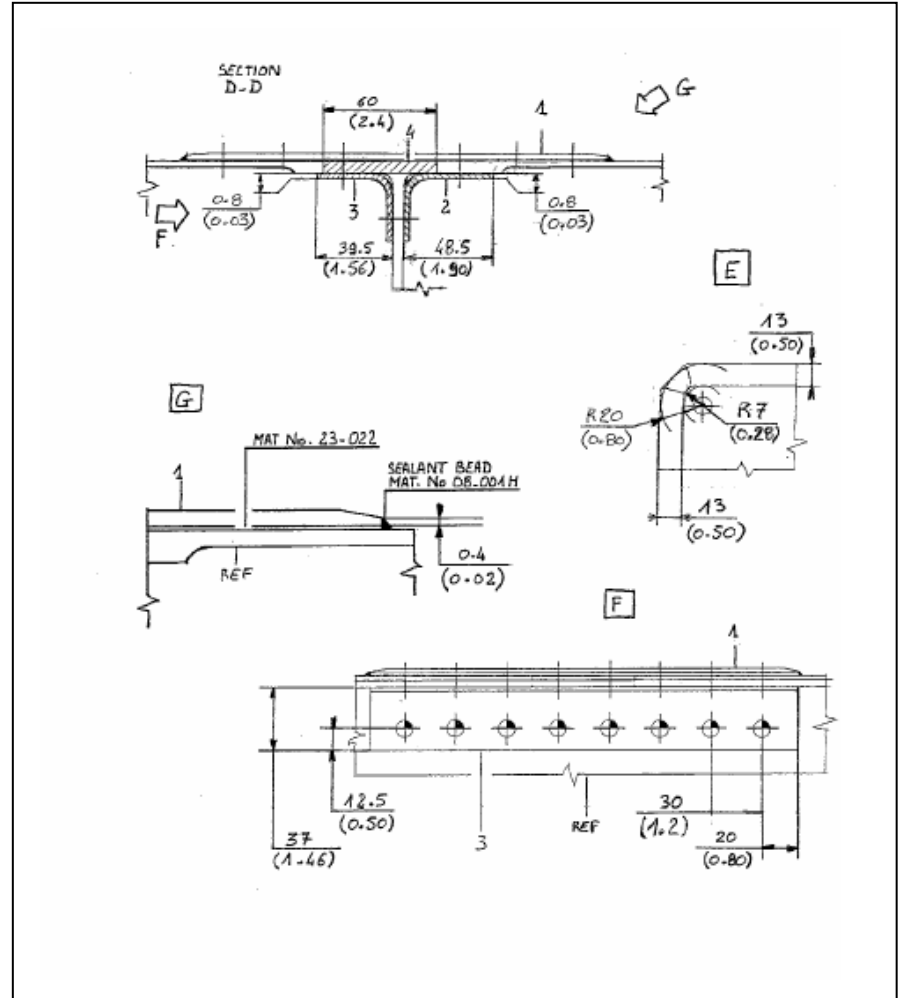
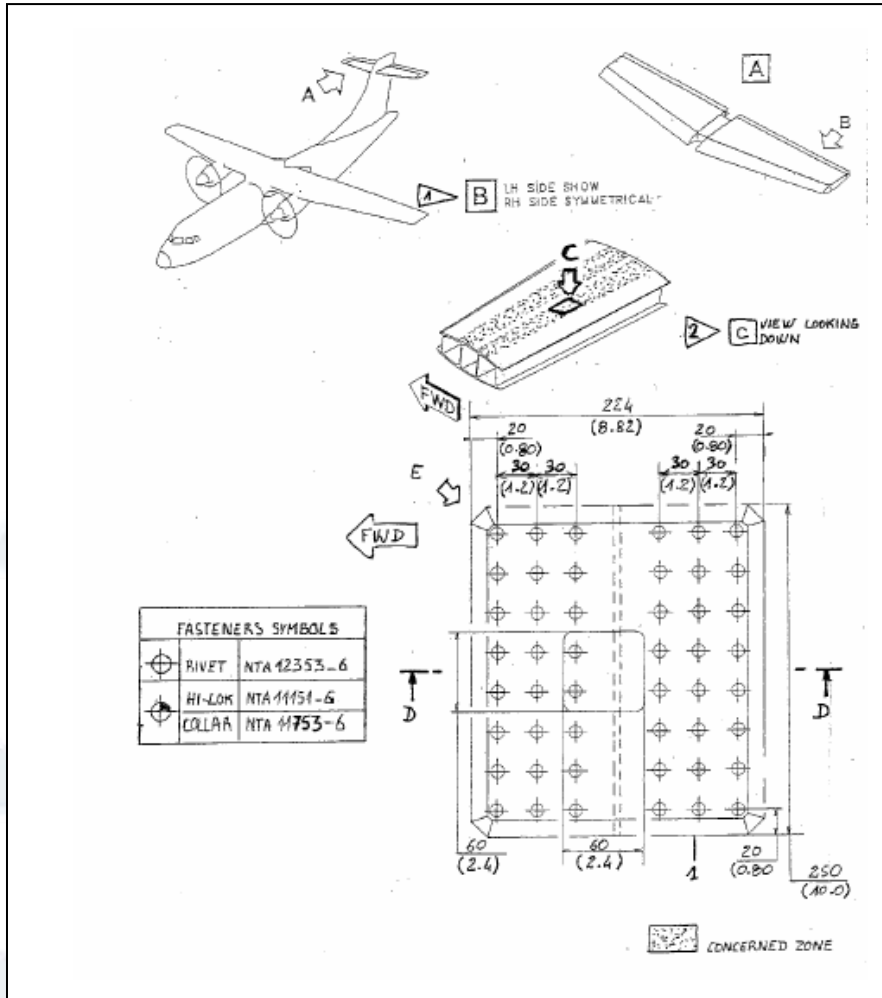


- 1 THIS REPAIR IS VALID ON UPPER AND LOWER PANEL.
- 2 MAXIMUM DAMAGE ALLOWED 80 x 17 mm (3.15") x (0.70")

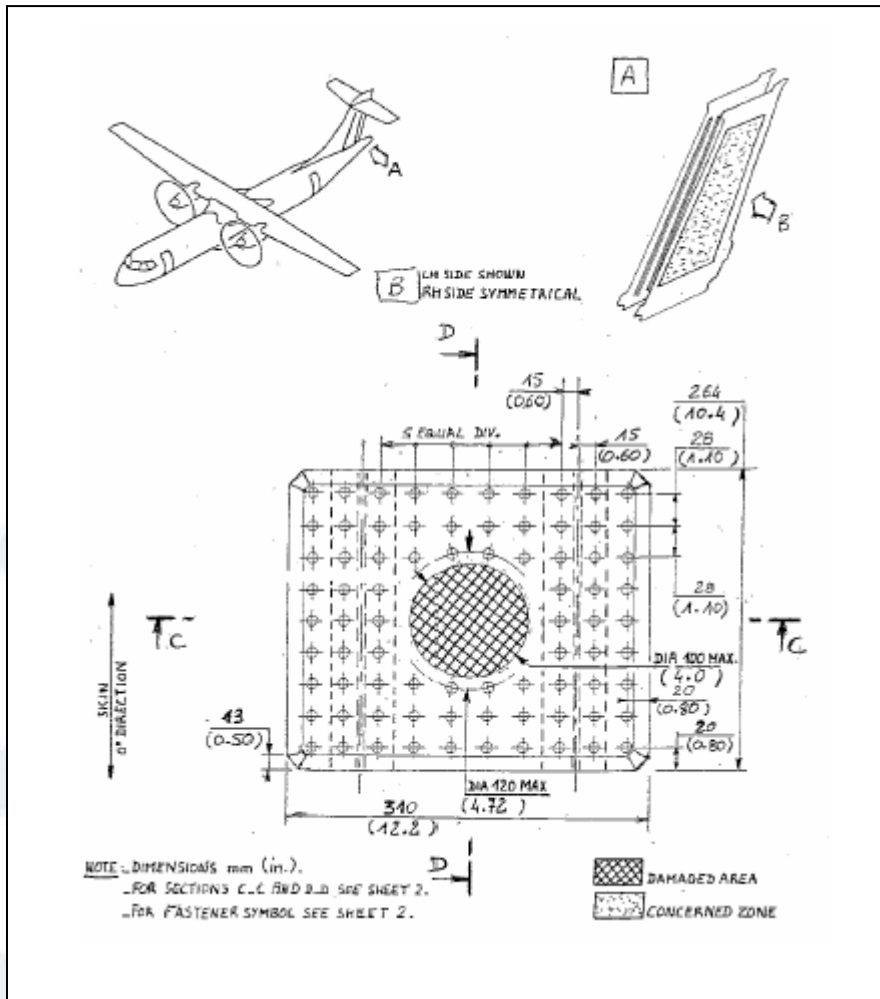
METAL PATCH REPAIR FOR PERFORATING DAMAGE ON FRONT SPAR CAP LOCATION (cont'd)



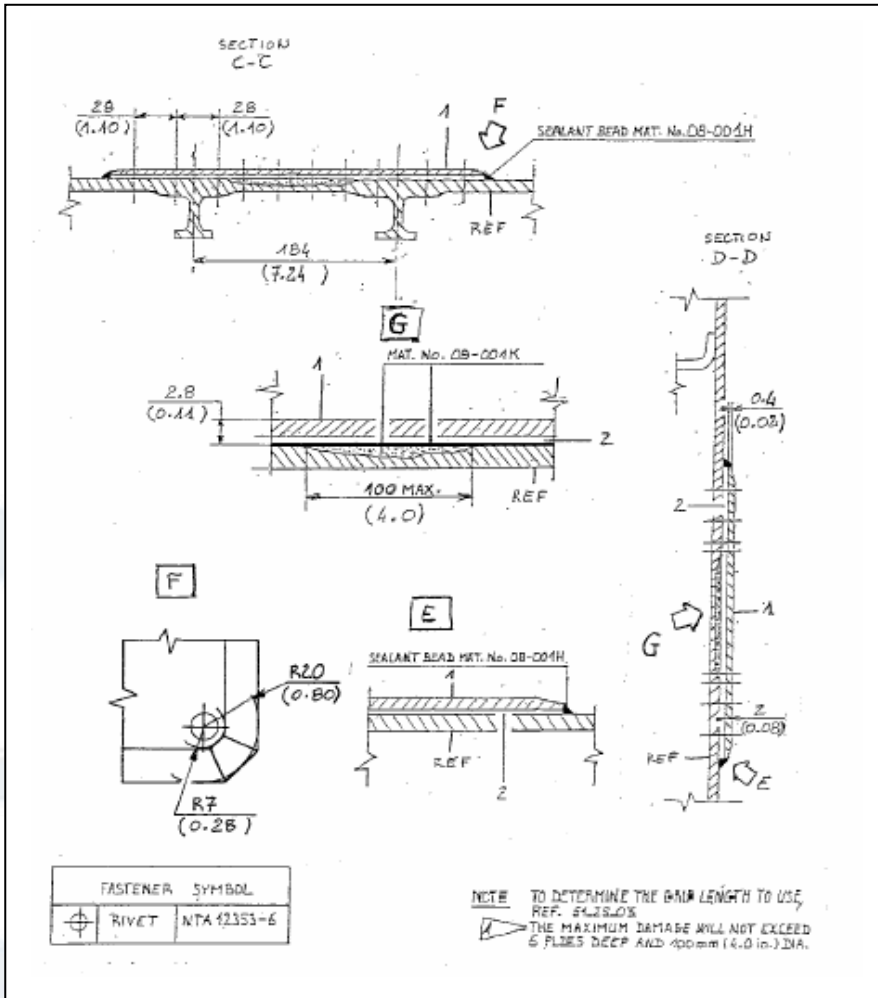
METAL PATCH REPAIR FOR PERFORATING DAMAGE ON THE SKIN AT THE SPAR CAP LOCATION



METAL PATCH REPAIR FOR NON-PERFORATING DAMAGE ON SKIN BETWEEN TWO STRINGERS



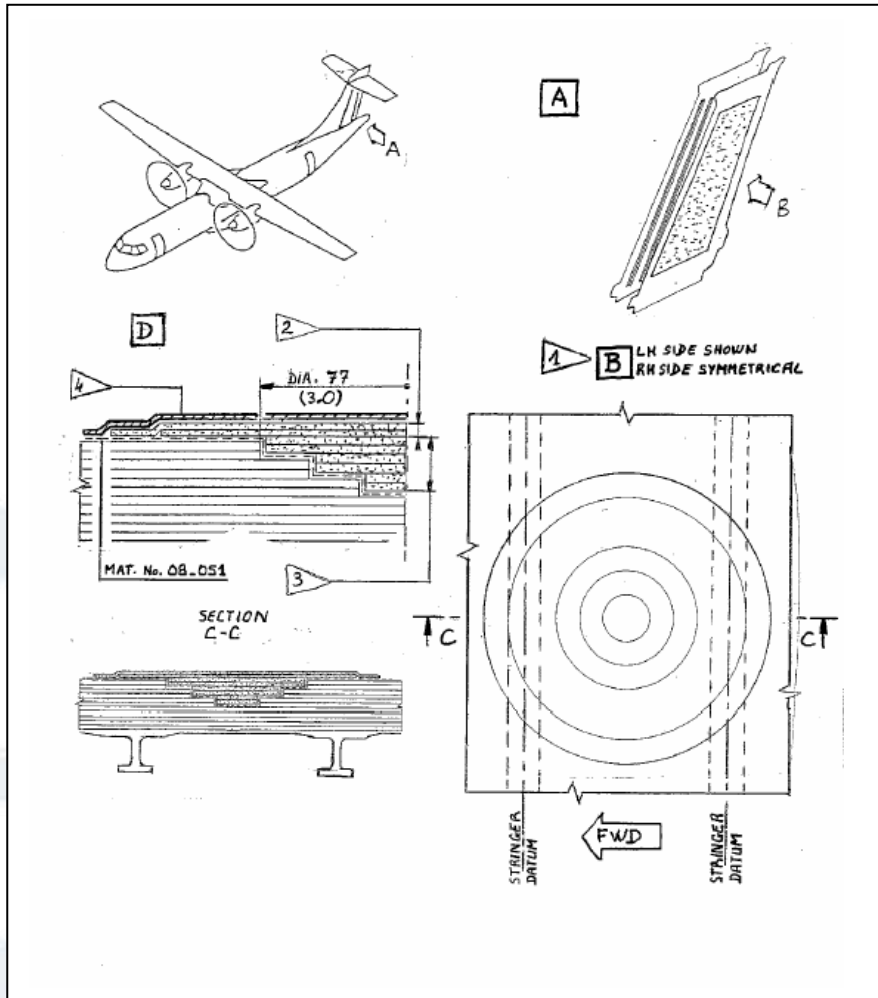
METAL PATCH REPAIR FOR NON-PERFORATING DAMAGE ON SKIN BETWEEN TWO STRINGERS (cont'd)



1

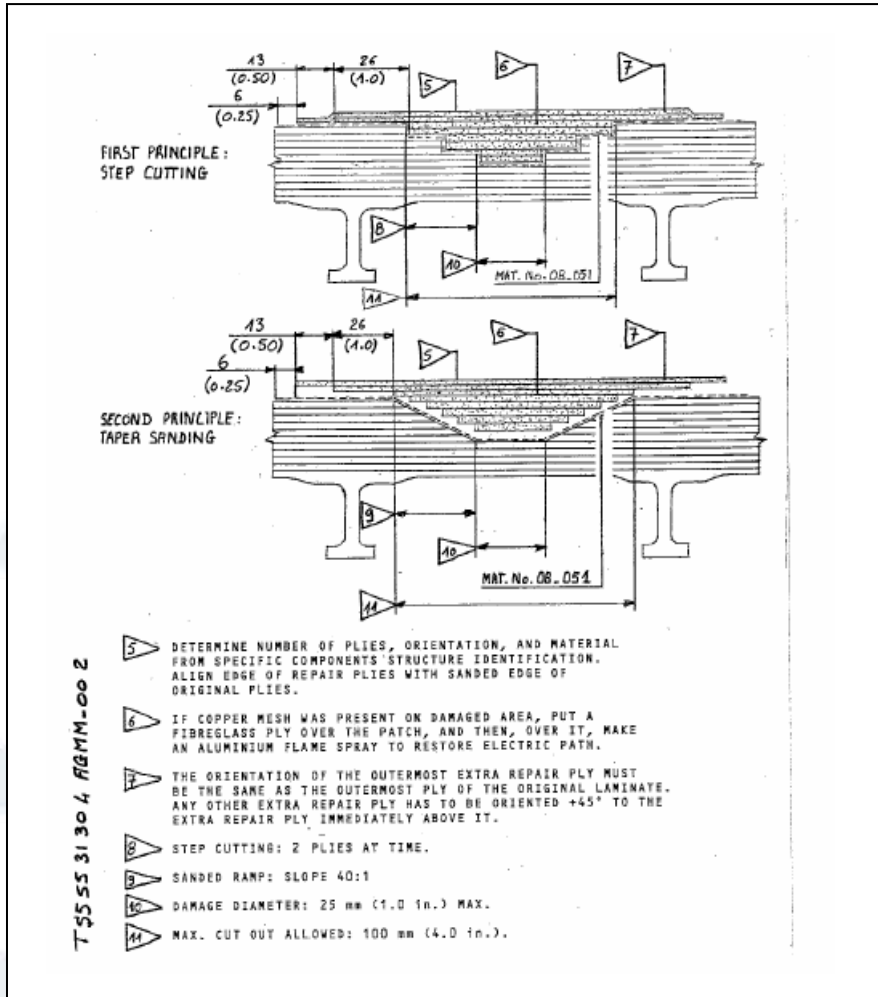
THE MAXIMUM DAMAGE WILL NOT EXCEED 6 PLYS DEEP AND 100 mm (4.0") DIA.

HOT BOND REPAIR FOR NON-PERFORATING DAMAGE ON SKIN BETWEEN TWO STRINGERS



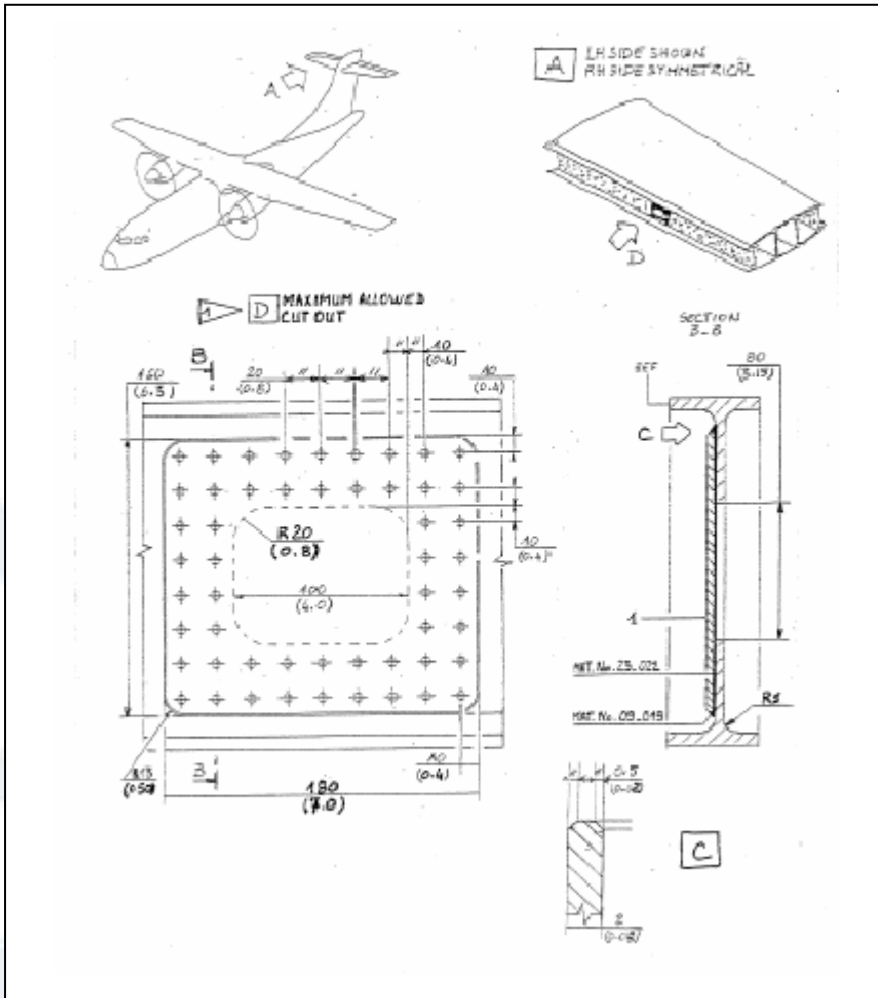
- 1 THIS REPAIR IS VALID ON LHS AND RHS
- 2 2 EXTRA PLIES
- 3 6 RESTORED PLIES
- 4 PUT A FIBER GLASS PLY COVERING THE PATCH IF COPPER MESH WAS PRESENT ON DAMAGED AREA.

HOT BOND REPAIR FOR NON-PERFORATING DAMAGE ON SKIN BETWEEN TWO STRINGERS



- 5** DETERMINE NUMBER OF PLYS, ORIENTATION AND MATERIAL FROM SPECIFIC COMPONENT STRUCTURE IDENTIFICATION
- 6** PUT A FIBER GLASS PLY COVERING THE PATCH IF COPPER MESH WAS PRESENT ON DAMAGED AREA. USE ALUMINIUM FLAME SPRAY TO RECREATE THE ELECTRICAL PATH.
- 7** THE ORIENTATION OF THE OUTERMOST EXTRA REPAIR PLY HAS TO BE THE SAME AS THE OUTERMOST PLY OF THE ORIGINAL LAMINATE. ANY OTHER EXTRA REPAIR PLY HAS TO BE ORIENTED +45° TO THE EXTRA REPAIR PLY IMMEDIATELY ABOVE IT
- 8** STEP CUTTING: 2 PLYS AT TIME
- 9** SANDED RAMP: SLOPE 40:1
- 10** DAMAGE DIAMETER 25 mm (1.0") MAX
- 11** MAX. CUT OUT ALLOWED 100 mm (4.0 ")

REPAIR ACCESS WINDOW PROCEDURE



FULL SCALE FATIGUE TEST

TO SUSTAIN ALLOWABLE DAMAGE A FULL FATIGUE TEST HAS BEEN PERFORMED.



TEST RESULTS SHOW THAT THERE WAS NO ANOMALY AND/OR DAMAGE GROWTH OF SIMULATED DAMAGES.