Presented by

Helge Hicken

NDT Engineer
Materials & Processes
Testing Technology

Rudders structural inspections

AIRBUS

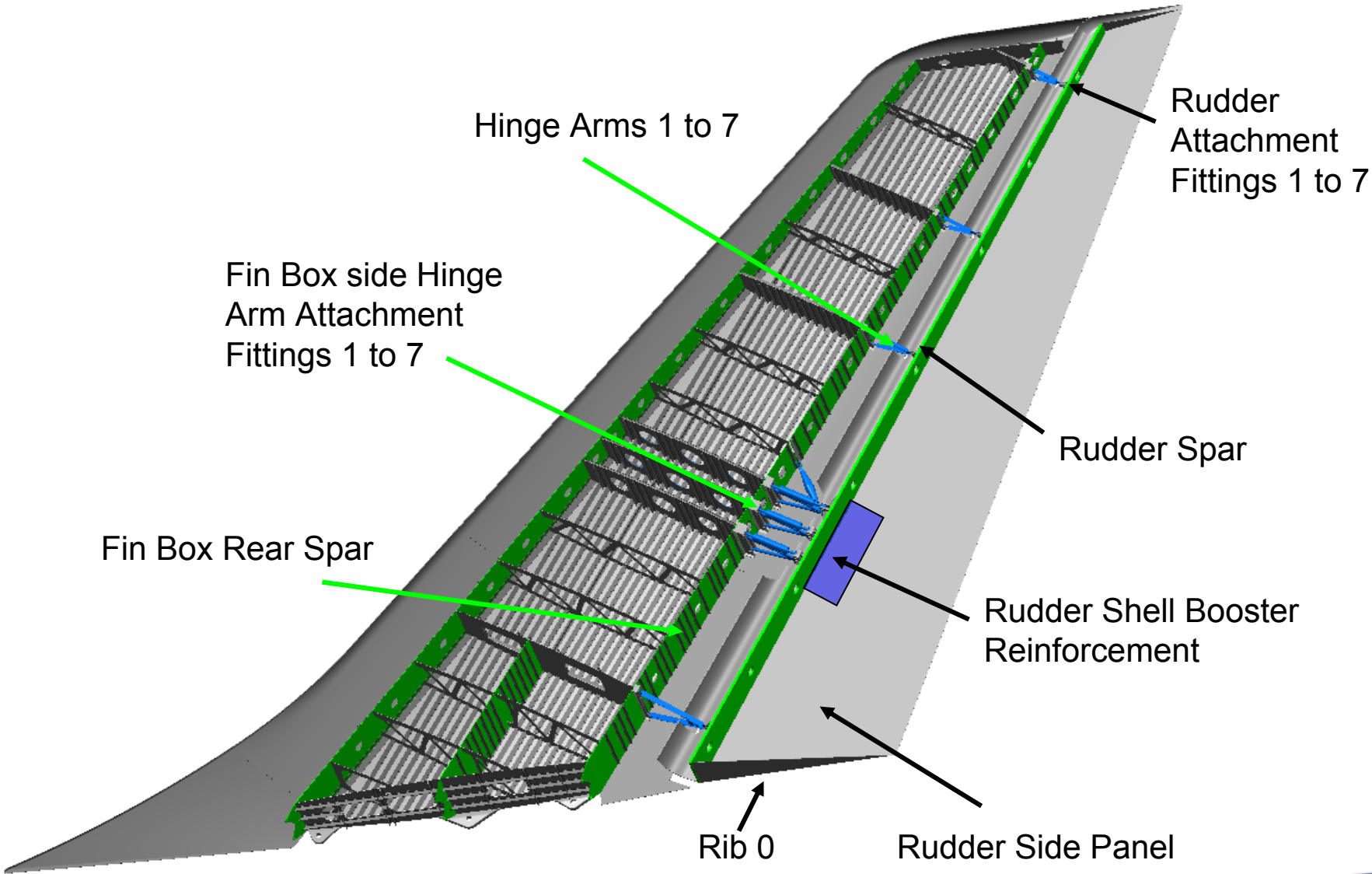
- INTRODUCTION
- RUDDER DESIGN PRINCIPLE PRE MOD 8827
- DESCRIPTION OF DAMAGE TO BE DETECTED
- INSPECTION METHODS
- CONCLUSION

Introduction

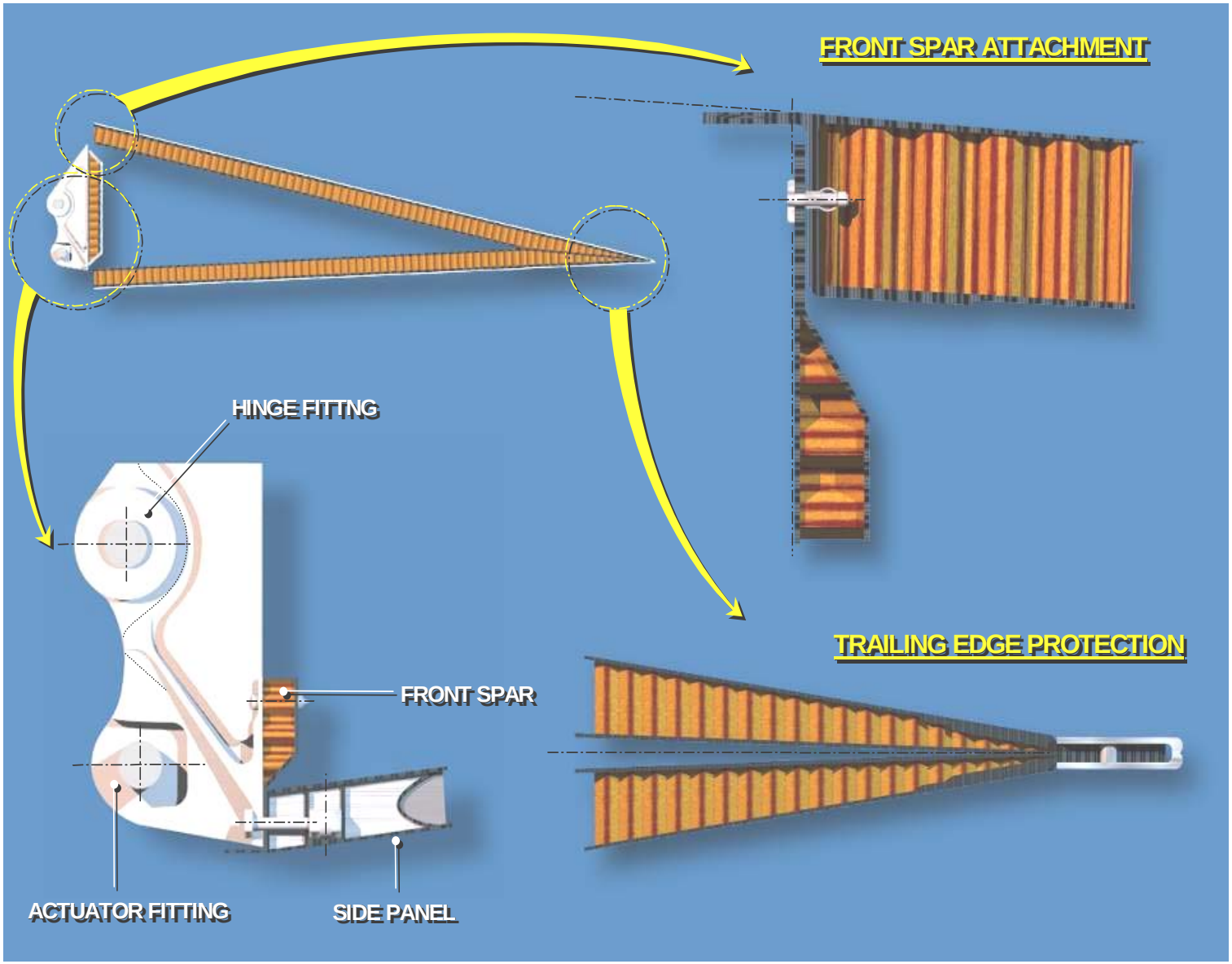
- The maintenance program of A310 / A300-600 rudder Pre MOD 8827 and A330 / A340 Pre MOD 40904 has been improved to introduce additional inspection on the rudder, specifically at the Z-Profile.

- INTRODUCTION
- RUDDER DESIGN PRINCIPLE PRE MOD 8827
- DESCRIPTION OF DAMAGE TO BE DETECTED
- INSPECTION METHODS
- CONCLUSION

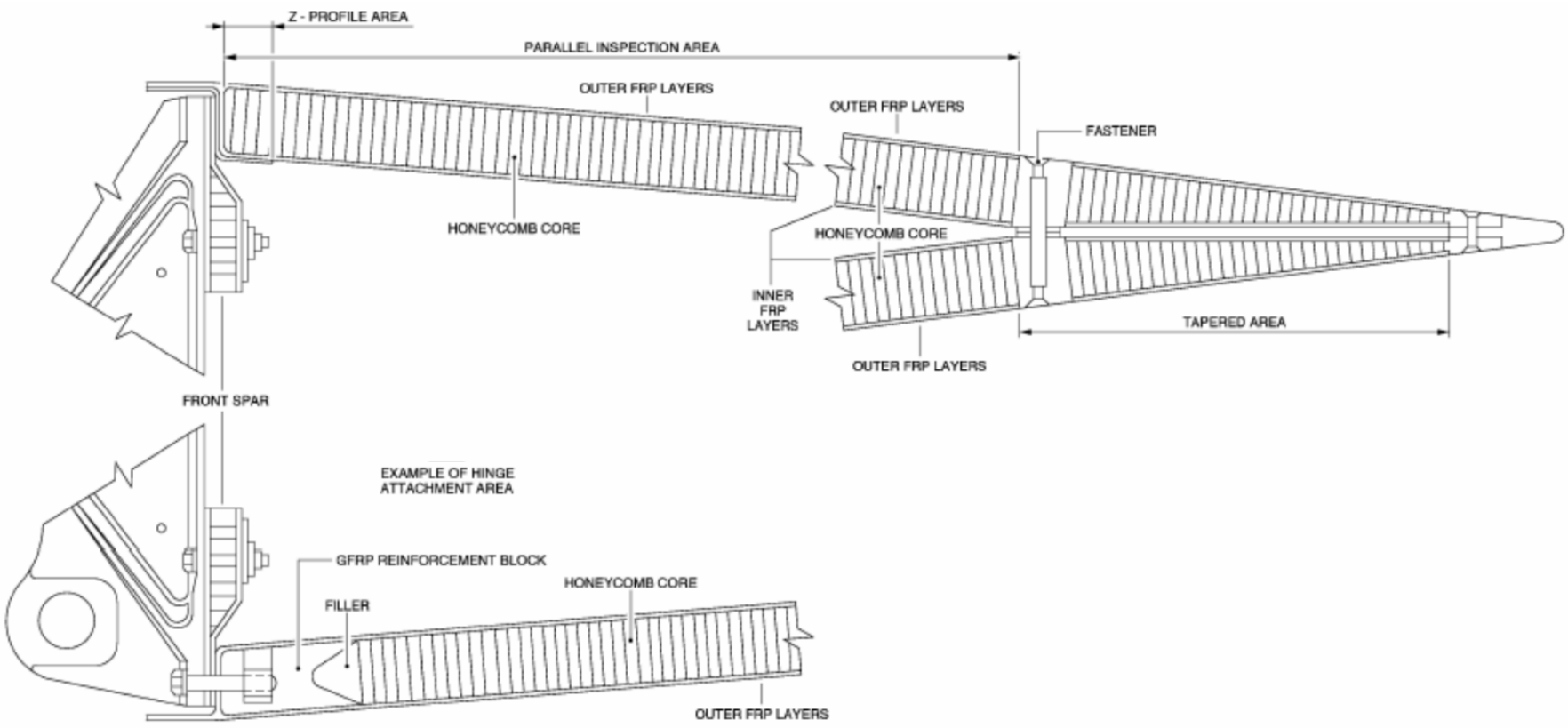
Rudder Design Principle Pre MOD 8827



Rudder Design Principle Pre MOD 8827

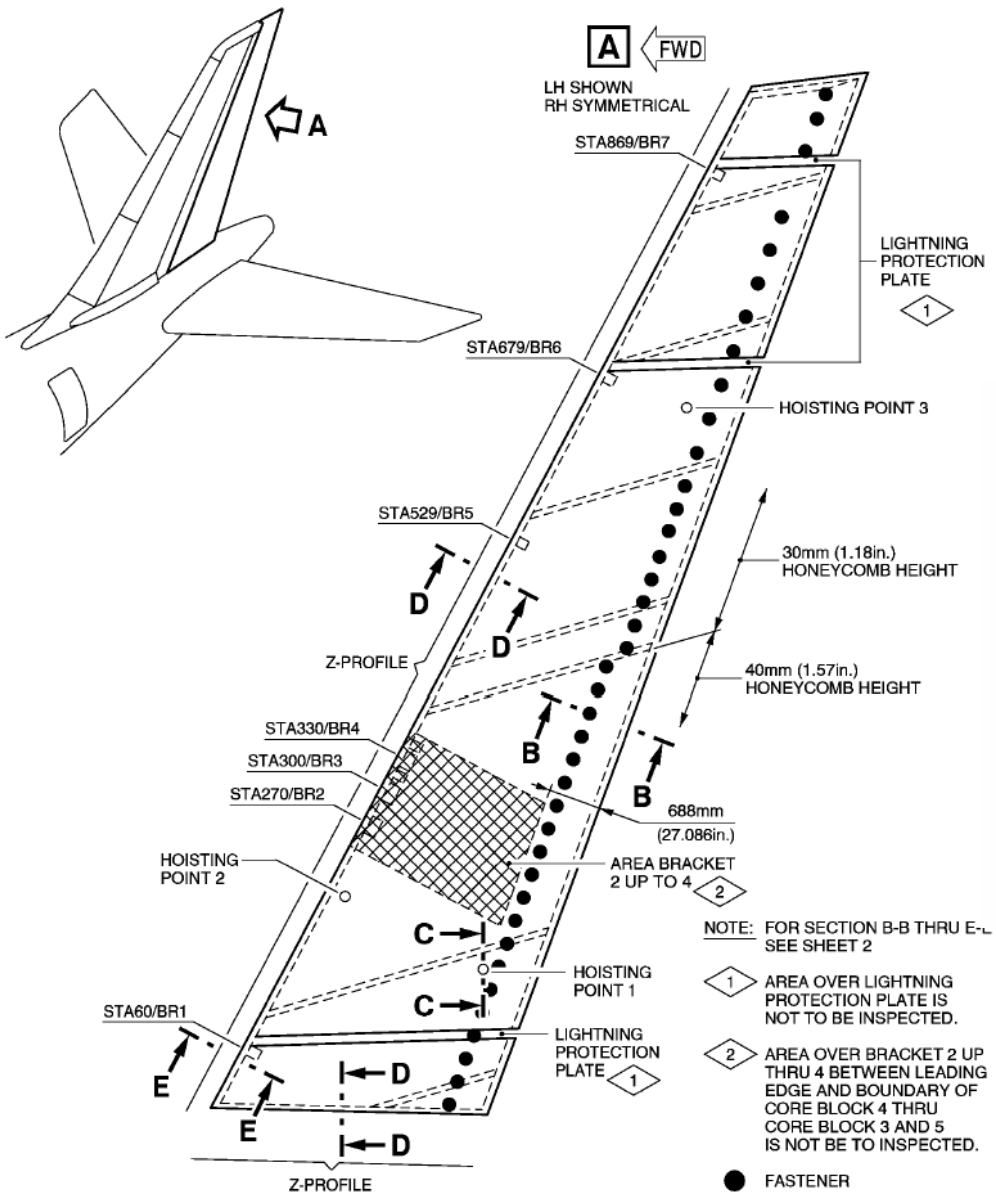


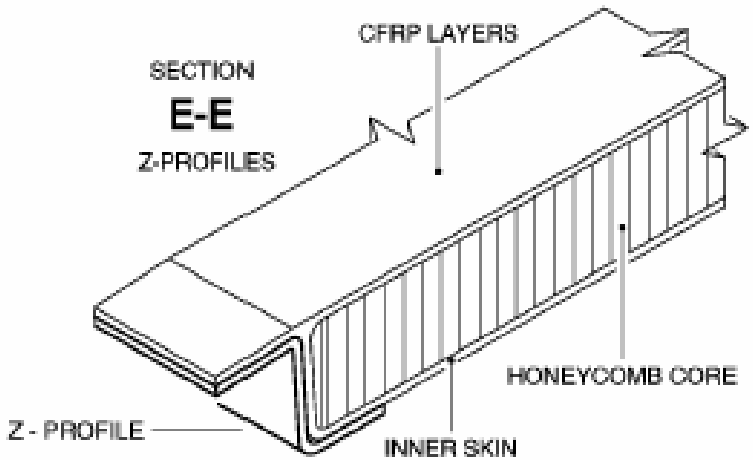
Rudder Design Principle Pre MOD 8827



Rudder Design Principle Pre MOD 8827

Design of the Z-Profile



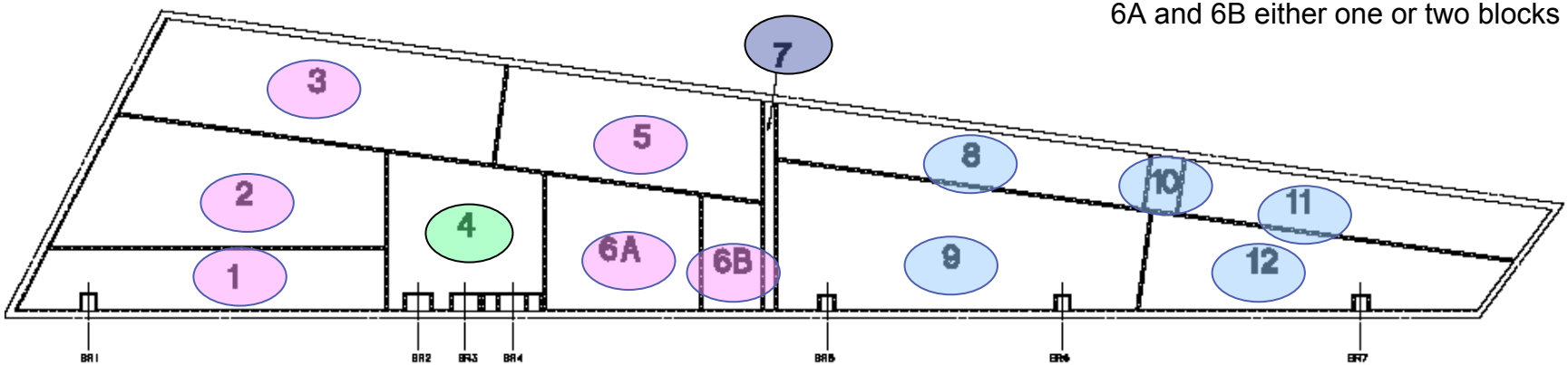


Rudder Design Principle Pre MOD 8827

Rudder Panel Design

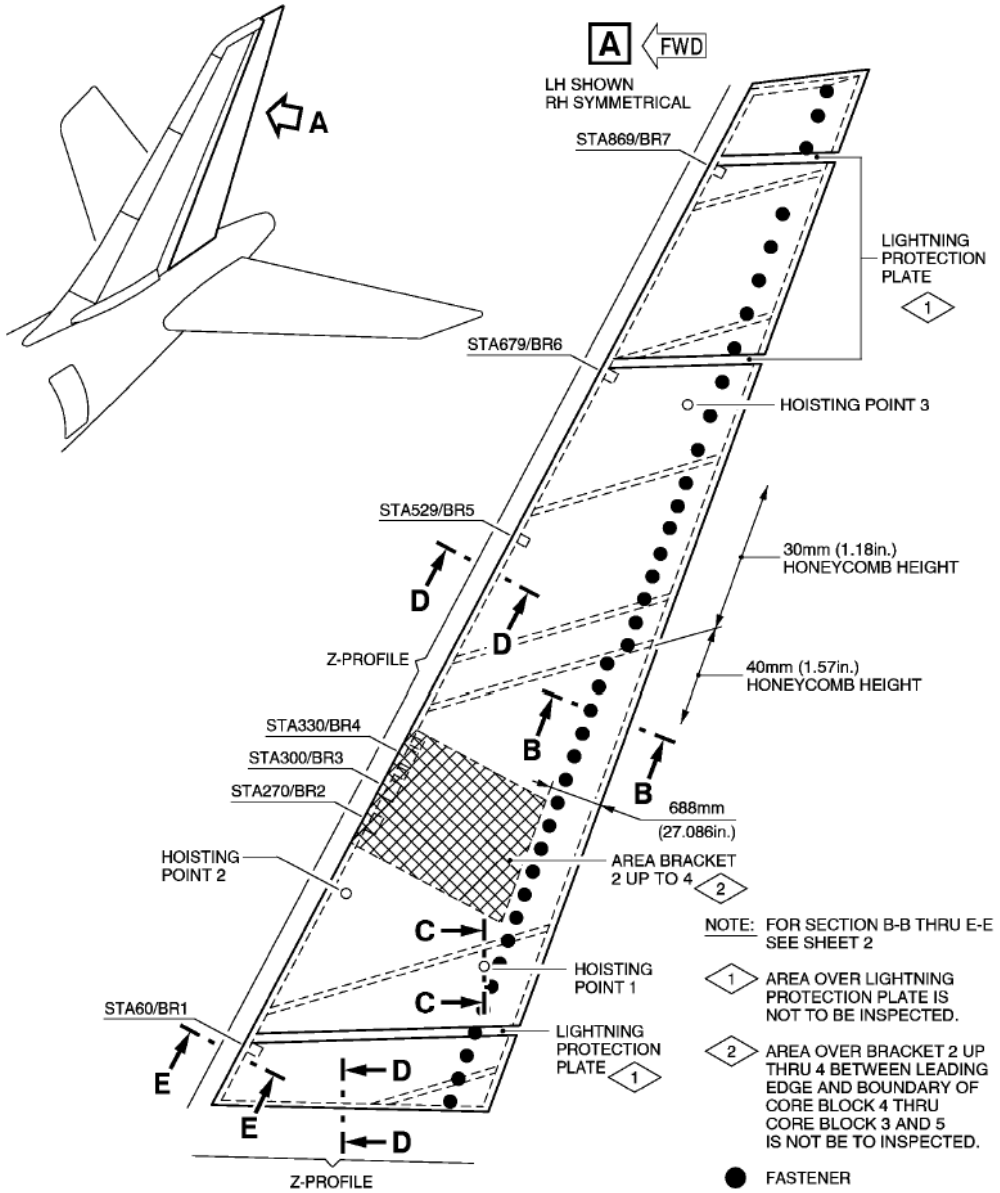
Core block no.	Core height [mm]
1,2,3,5,6	40
7	Transition from 30 - 40
8 to 12	30
4	39

6A and 6B either one or two blocks



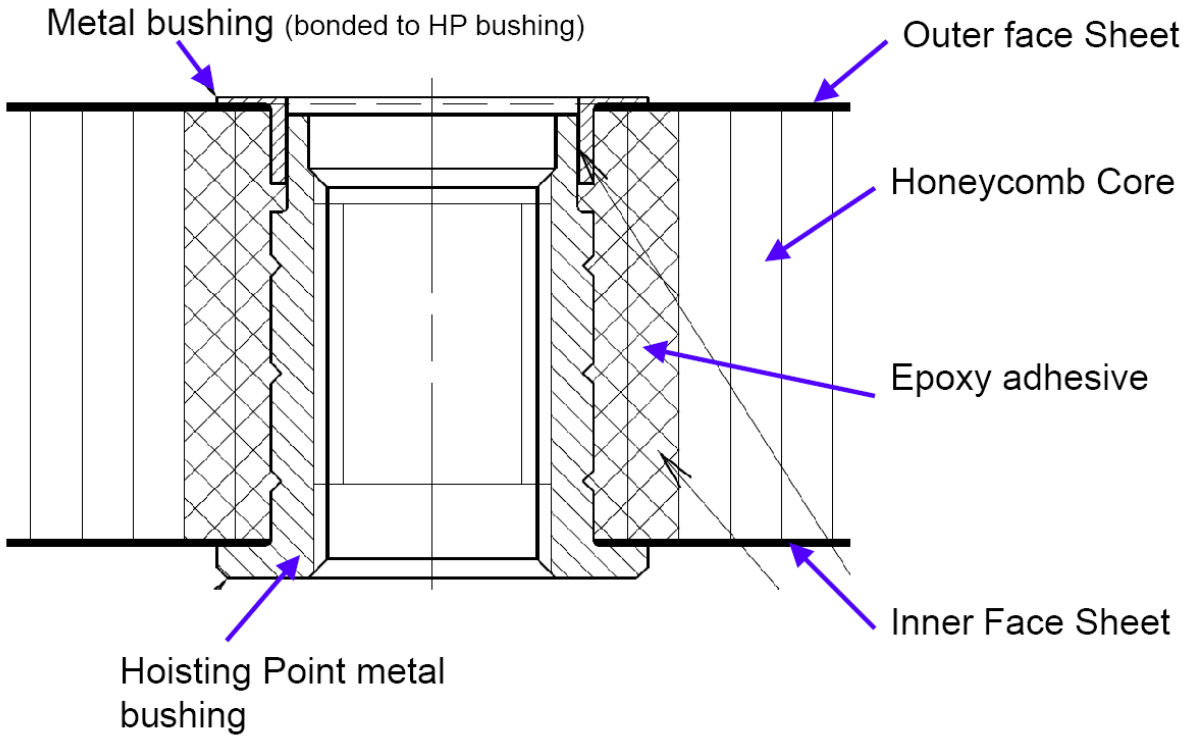
Rudder Design Principle Pre MOD 8827

- Lightning protection plate
- Trailing edge fastener
- Hoisting points
- Layer overlap
- Additional layers in the booster area (BR2 – BR4)



Rudder Design Principle Pre MOD 8827

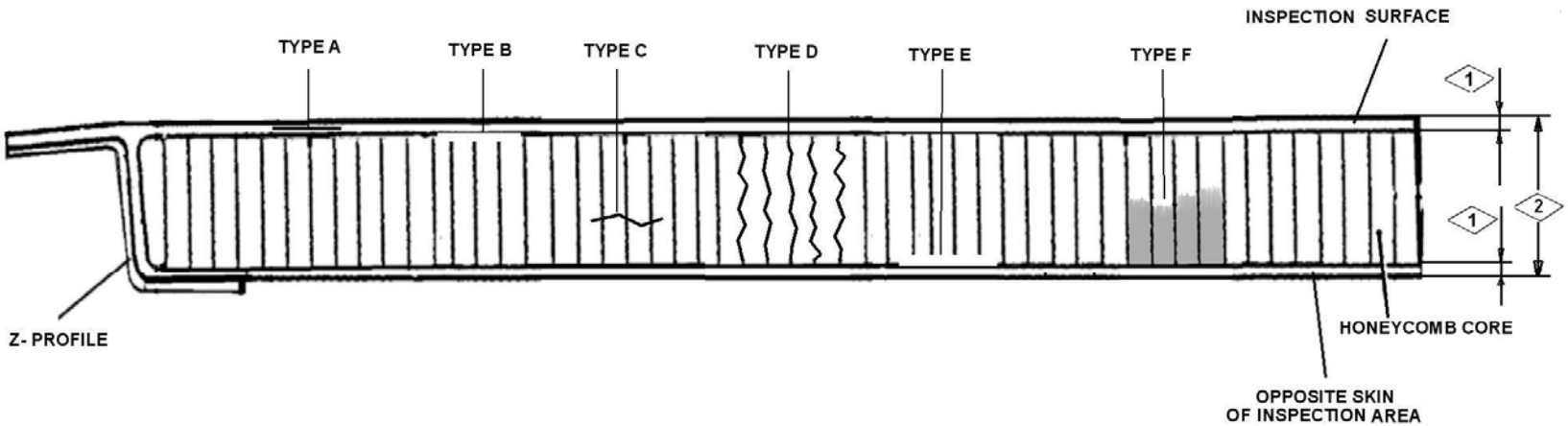
Design of a Hoisting Point



- INTRODUCTION
- RUDDER DESIGN PRINCIPLE PRE MOD 8827
- DESCRIPTION OF DAMAGE TO BE DETECTED
- INSPECTION METHODS
- CONCLUSION

Description of Damage to be Detected

- Delamination between plies of outer CFRP skin, parallel to surface, area 25mm x 25mm (Type A)
- disbonding between the outer skin and the honeycomb core, area 25mm x 25mm (Type B)
- Cracked honeycomb core parallel to the inspection surface, area 25mm x 25mm (Type C)
- Crushed honeycomb core in parallel area 25mm x 25mm (Type D)
- disbonding between inner skin and honeycomb core, area 25mm x 25mm (Type E)
- Fluid ingress in honeycomb core, area 100 mm² with IRT (Type F)



1 RANGING FROM 0.1mm (0.004in.) TO 2,5 mm (0.098in.)

2 MAX. NOMINAL THICKNESS OF THE SANDWICH STRUCTURE 42mm (1.65 in.)

- INTRODUCTION
- RUDDER DESIGN PRINCIPLE PRE MOD 8827
- DESCRIPTION OF DAMAGE TO BE DETECTED
- INSPECTION METHODS
- CONCLUSION

INSPECTION METHODS

- TAP TEST / WOODPECKER
- ELCH
- BONDMASTER
- ULTRASONIC
- INFRARED THERMOGRAPHY
- X-RAY

INSPECTION METHODS : Tap Test / Woodpecker

Manual Tap Test

Extremely simple NDT instrument

Pocket size, ultra low cost

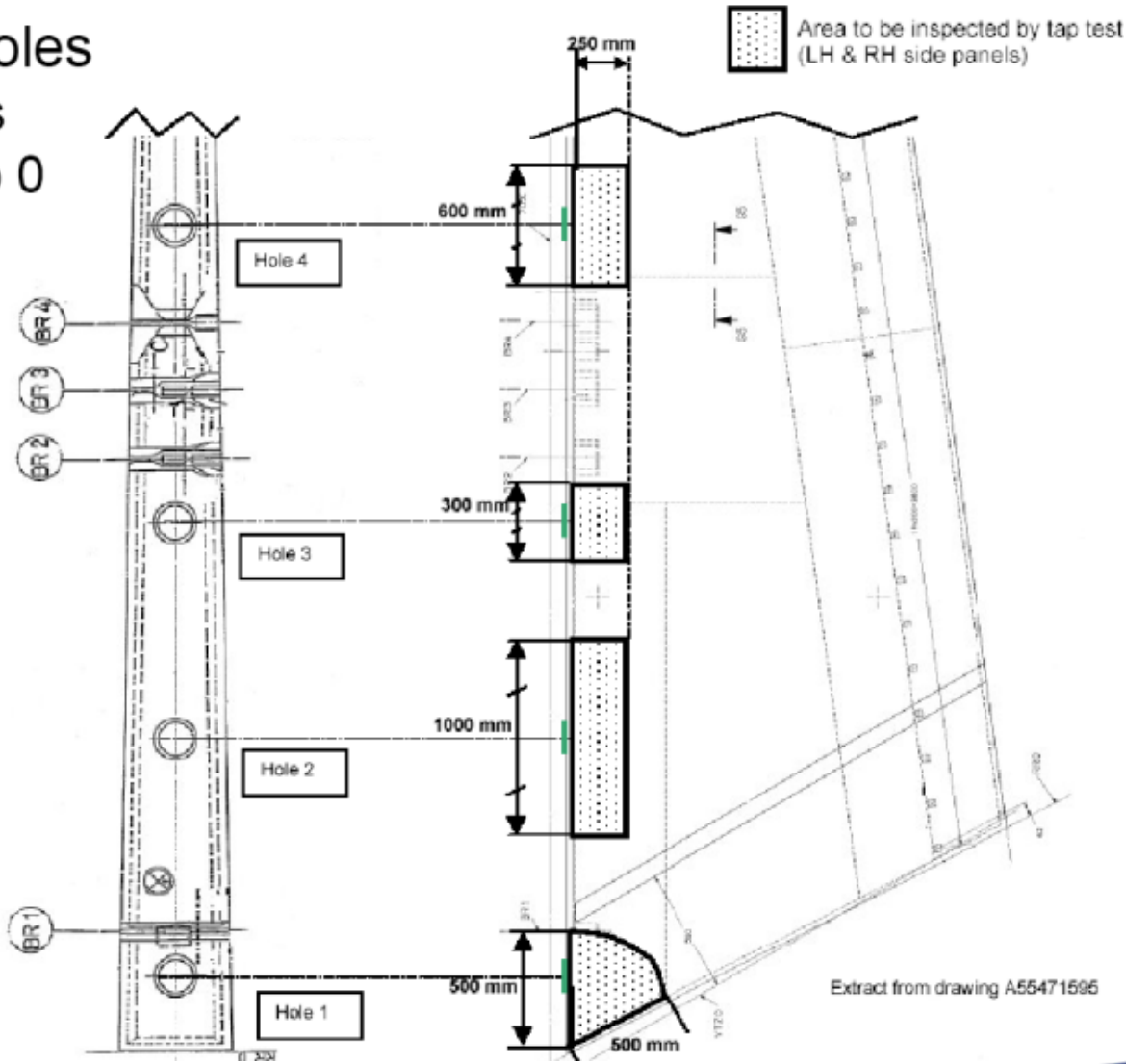
Available everywhere

Mitsui Woodpecker

- Simple NDT instrument
- Pocket size, low cost
- Available
- Simple use
- Allows detection of outer skin disbonding
- Procedure in NTM

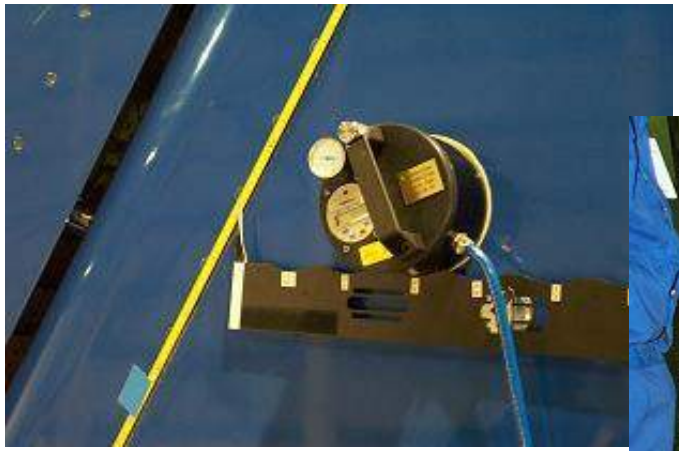
INSPECTION METHODS : Tap Test / Woodpecker

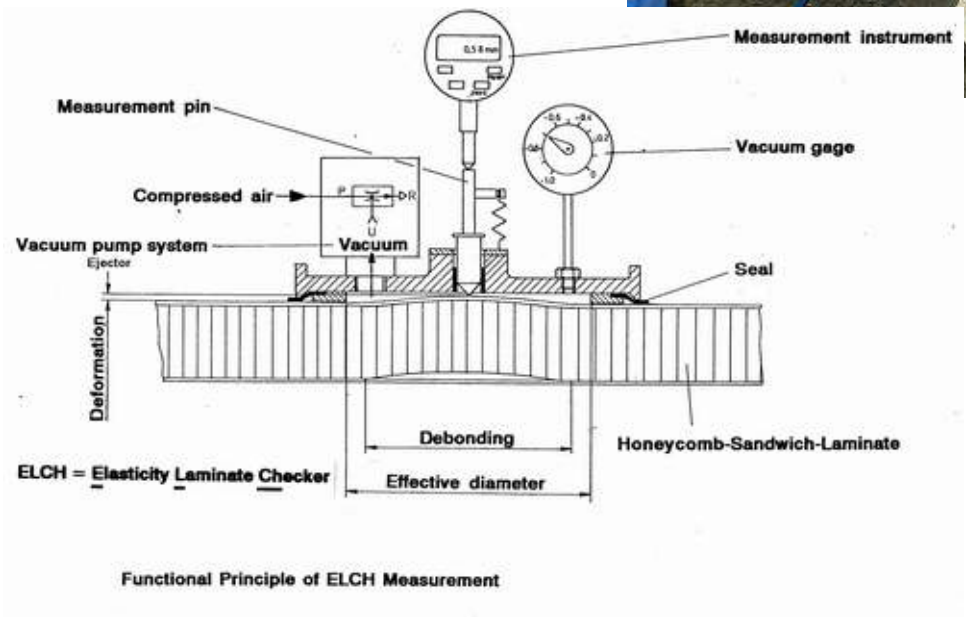
- 4 lower inspection holes
  - 1 above the servos
  - Others below to rib 0



Inspection through holes

INSPECTION METHODS : ELCH-Test





Functional Principle of ELCH Measurement

- The ELCH puts a defined force perpendicular to the surface, all expected disbonding cases will be detected as a stiffness loss comes with the disbonding

INSPECTION METHODS : BONDMASTER

BONDMASTER is a resonance testing device used already for several inspection tasks on the AIRBUS NTM.

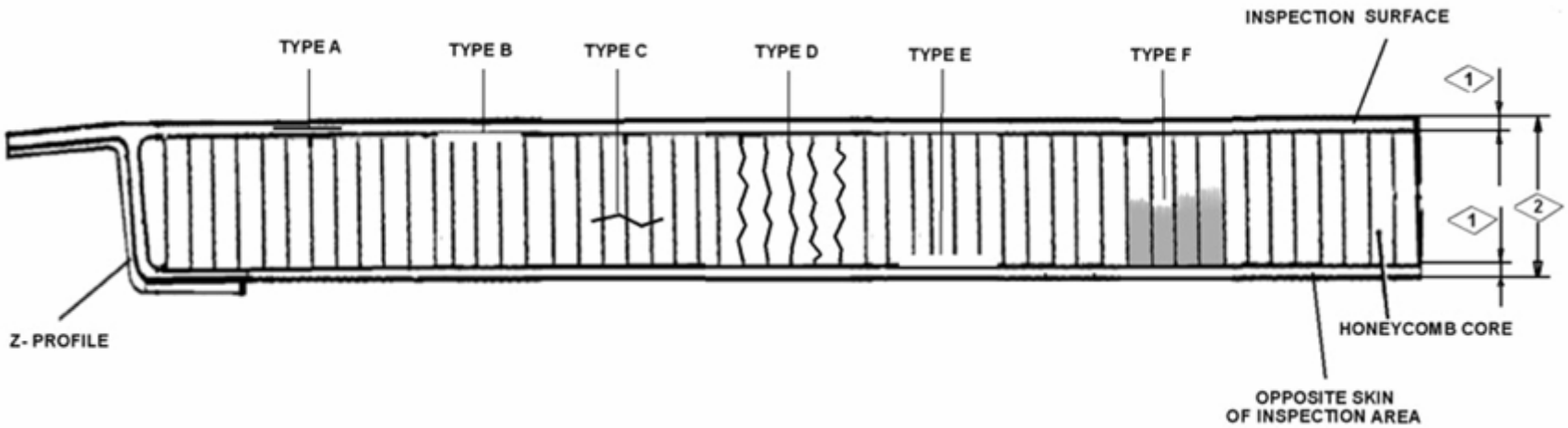
Procedures exist for top skin disbonding inspection on sandwich, for bond testing Al-structures (FOKKER-BOND-TEST alternative) etc.

Applicability for rudder inspection

- External defects can be found.
- Procedure in NTM.
- Rear side defect detection is under investigation.
- Equipment pocket size, battery powered, easy to carry, easy to handle, quick in use

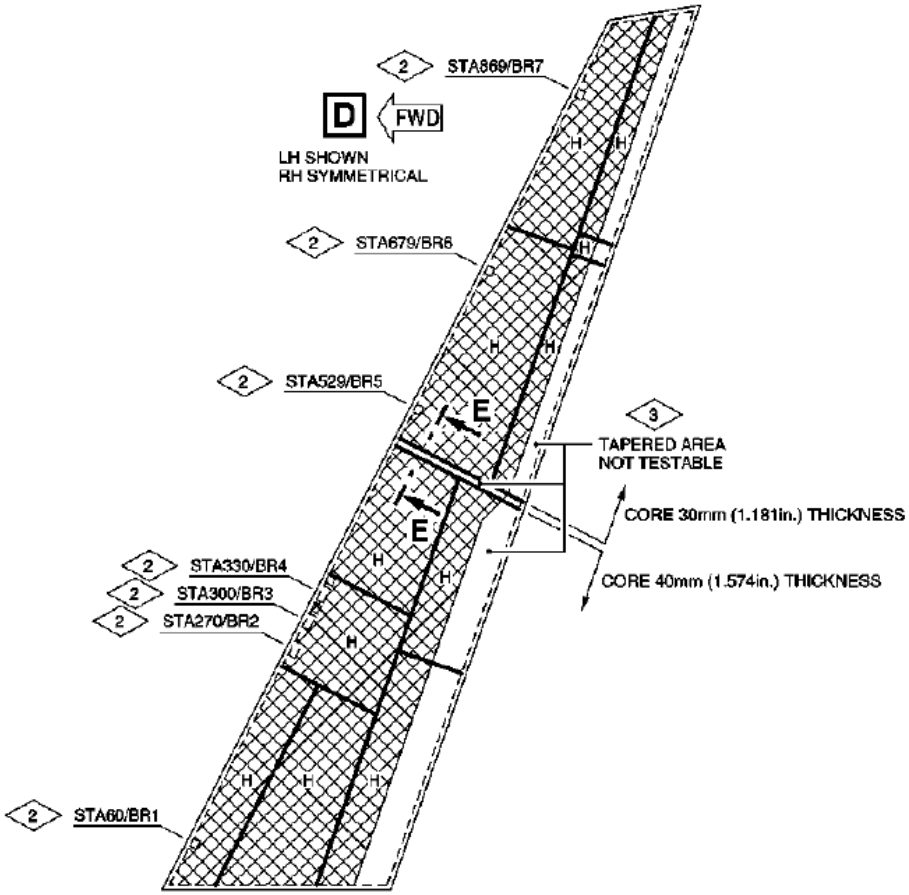
INSPECTION METHODS : ULTRASONIC

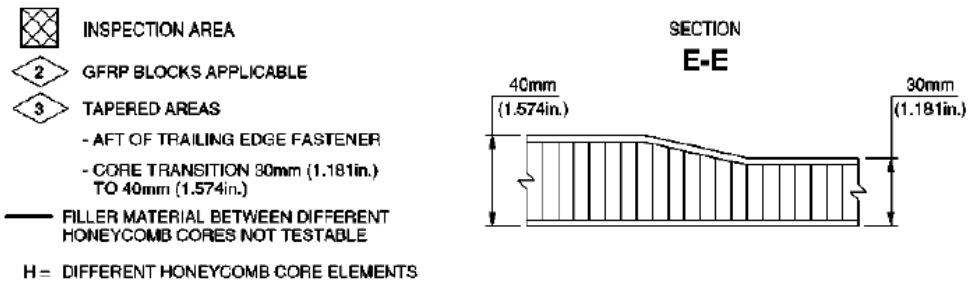
Principle of UT Inspection for Rear Side Disbonding



- The back wall echo (BE) of the core is observed.
- BE is tuned to max screen height at undamaged area
- Rear side disbonding reduces echo to 50% (-6dB)
- Crack in the core may reduces the TOF (time of flight) of the BE – echo comes earlier
- Crushed core damps vibration = >24 dB BE attenuation
- Water – depending on part orientation – full damping or intensive echoes in different locations

INSPECTION METHODS : ULTRASONIC



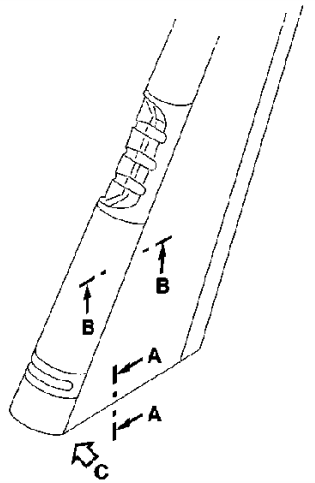


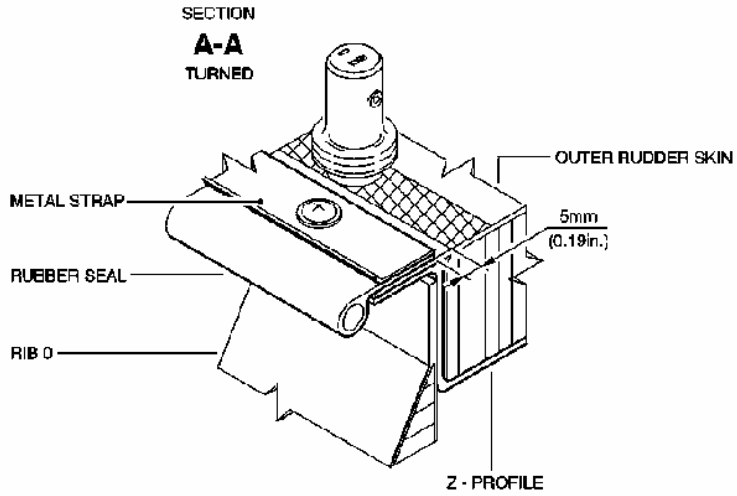
The rudder structures, which can be inspected by UT method are :

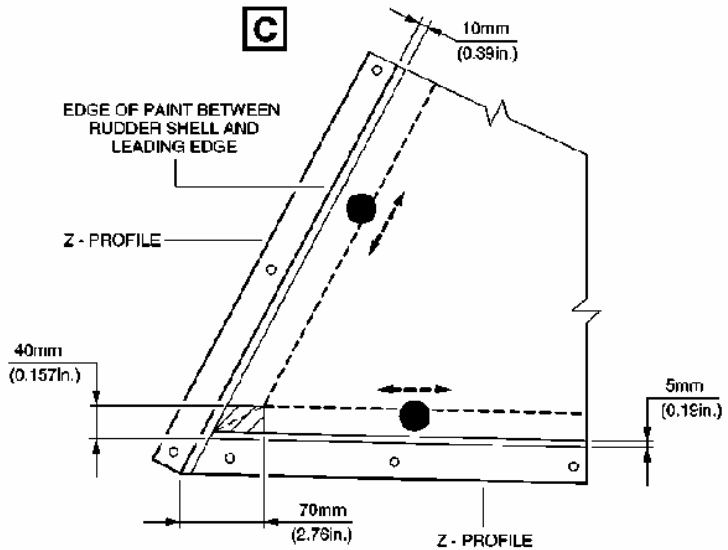
- Sandwich with different thickness,
- Sandwich with different core density,
- Edges with Z-profile, in parallel areas.

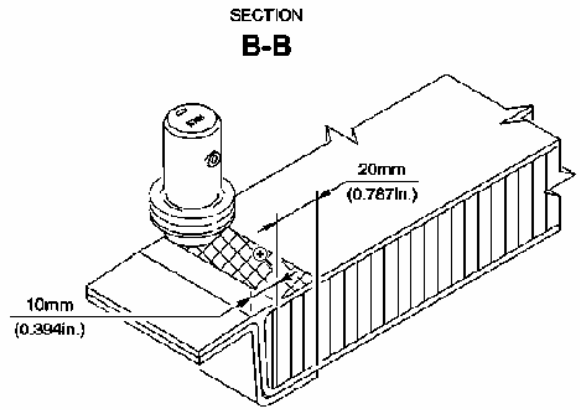
The knowledge of the structure is essential for the assessment of indications.

INSPECTION METHODS : ULTRASONIC







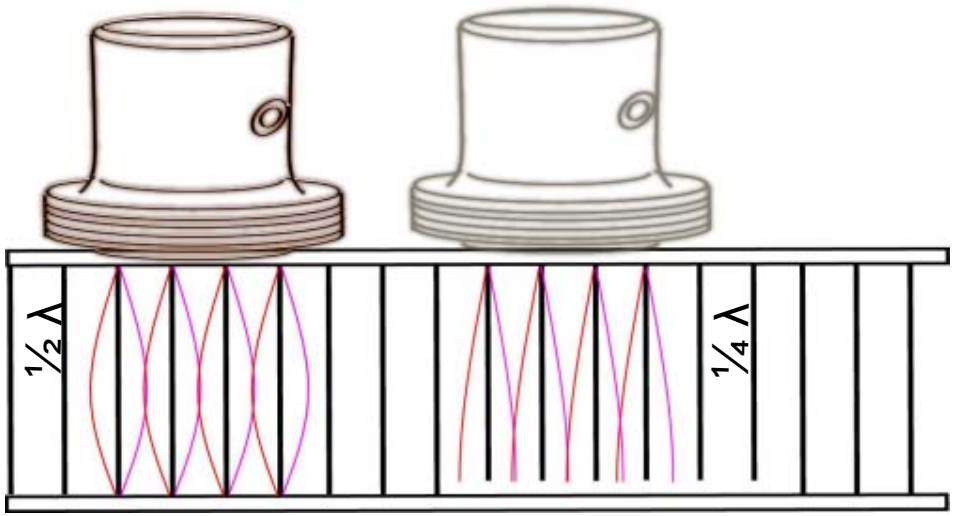


INSPECTION METHODS : ULTRASONIC

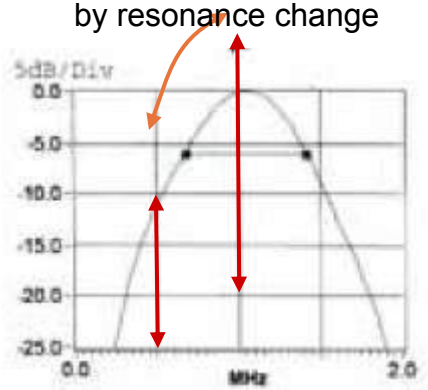
Physical effect of measurement

- The UT Procedure uses a kind of guided wave.
- System must be tuned to core height (membrane length = ½ λ)
- Therefore UT equipment should fulfil specific characteristics:
  - •square wave pulse excitation (preferred)
  - •good filter capabilities to tune the receiver

Transducer operates with a certain bandwidth – disbonding causes a resonance shift to longer wavelength λ = lower frequency, echoes with lower frequency excite only reduced amplitude in transducer: back wall echo loss between 6db and 12 db



Amplitude reduction
by resonance change



INSPECTION METHODS : ULTRASONIC

Inspection equipment

- **Preferred equipment**
  - Instrument: Panametrics EPOCH 4Plus from OLYMPUS NDT
  - Search Unit: K1SM, 0°, 1 MHz from GE IT C539, 0°, 1 MHz from OLYMPUS NDT

    This flaw detector has filter capabilities, which can be directly accessed and a square wave pulse – feature which enhance the signal.

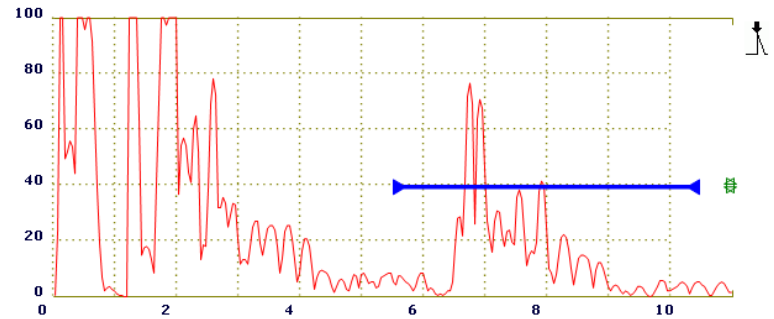
- **Alternative equipment**
  - Instrument: USM25/35 from GE IT
  - The GE flaw detectors lack suitable filter capabilities and have only spike excitation – with the settings provided by Airbus the inspection can be done, the sensitivity is sufficient, but reduced resolution compared to EPOCH 4 Plus

Note: Only the EPOCH4 Plus has this specific feature, newer EPOCH versions do not allow optimal filter tuning

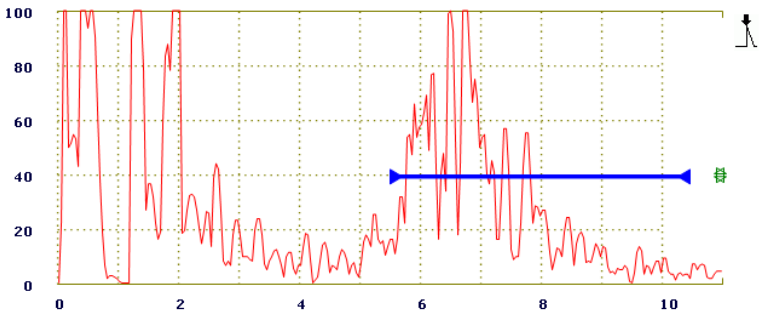
- Allows detection of:
  - Inner and outer skin disbonding
  - Fluids
  - Crushed core
- UT is only considered for inspection of specific limited areas

INSPECTION METHODS : ULTRASONIC

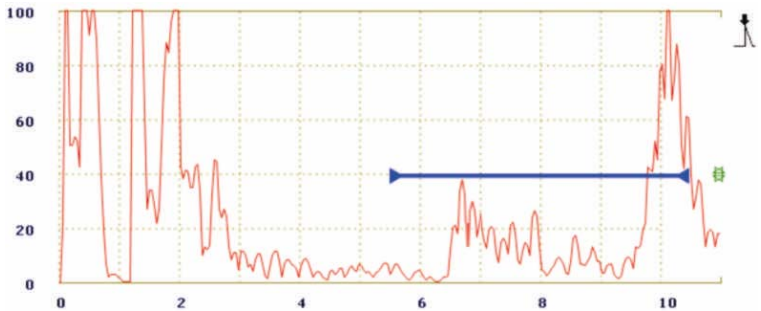
BE with no indication



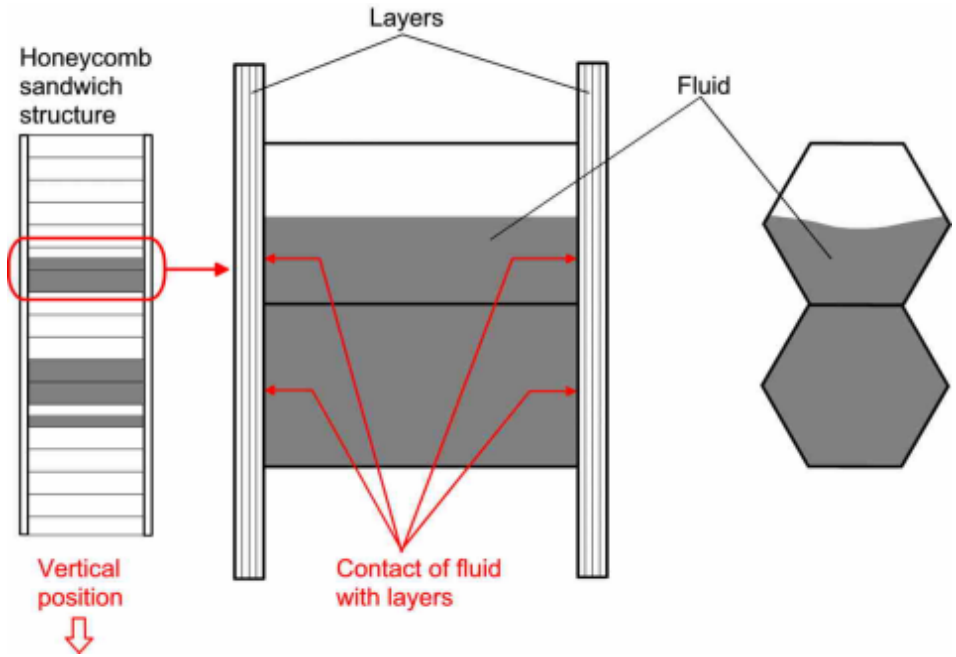
BE with partly filled cells (A-scan is vibrating when surrounding area is tapped)



BE plus additional echo from complete filled cells



Fluid indication in vertical position

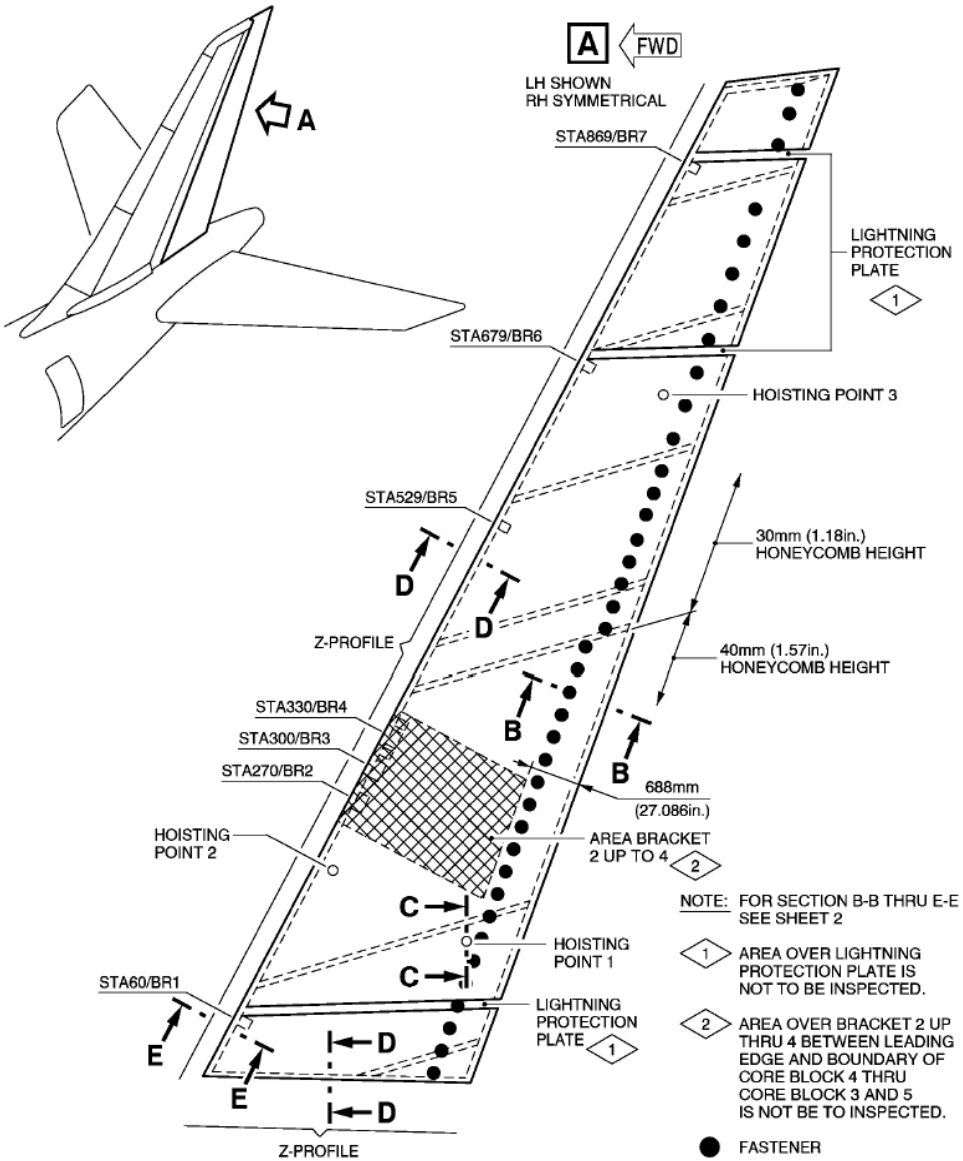


INSPECTION METHODS : Thermography

- Allows detection of fluids in honeycomb cells

INSPECTION METHODS : Thermography

Structural features



- Fasteners
- Hoisting points
- Edges with Z-profile
- Bracket
- Lightning protection plate
- Top layer overlapping
- Core splice
- Areas of lightning protection plates are not to be inspected
- Area of bracket 2 to 4 only the rear bolting zone can be inspected

Detailed knowledge about the structure is necessary in order to evaluate inspection result

INSPECTION METHODS : Thermography

Equipment kit

Infrared camera FLIR E45

- Real time imaging
- Auto-adjustment of contrast and brightness
- Resolution <0,2°C near ambient temperature
- Temperature range 0°C to 100°C
- Chart of color range = Grey (white = hot)
- Filed of view min. = 24°x18°, max. 34°x25°
- Focus range lower value <500 mm
- If possible, a tripod can be used

Hot air Fan Leister Hotwind S

- 400 l/min
- 2 mbar
- Temperature range 150°C up to 200°C max**.**
  In use at the Rudder the outlet temperature of the Hot Air Fan shall not exceed 160°C.

Contact Thermometer

- Probe for contact measurement of temperature.

The complete equipment together with some added components can be lend or purchased as a kit from Airbus Spares network

INSPECTION METHODS : Thermography

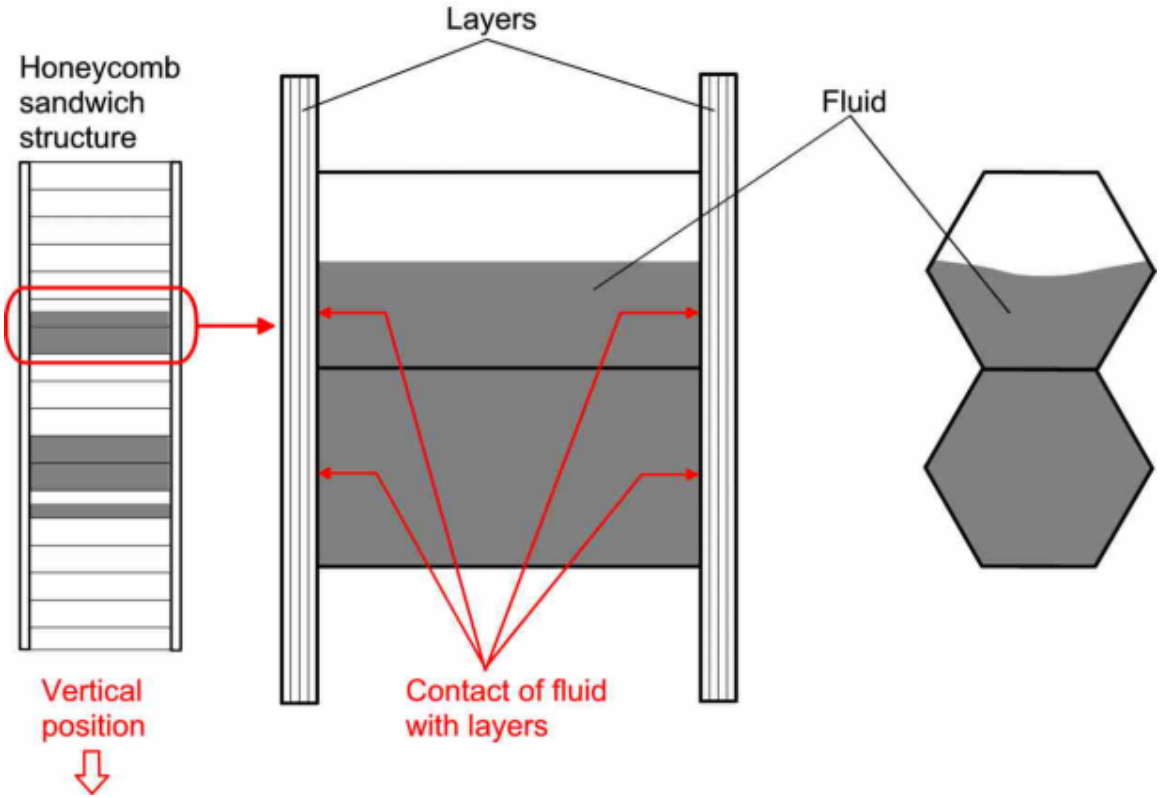
Thermal Loading Conditions

Heating-up with the help of an hot air fan (convection heating) is the optimum compared to other means of heating

It transports a lot of thermal energy very fast.
This inspection method renders the best performance even in edge regions (Z-profiles) of rudder
Contact heating blanket were an option, but not practical in this application.

INSPECTION METHODS : Thermography

Fluid indication in vertical position

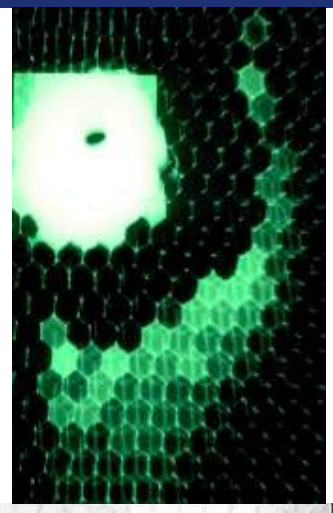


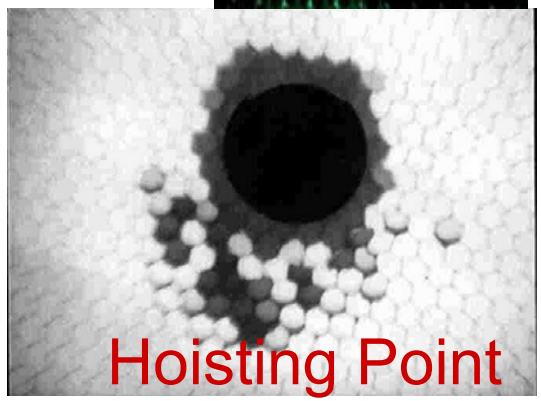
Indication at a hoisting point

- **A vertical position is a required condition because the inspection method needs the contact of fluid with the layers**

INSPECTION METHODS : X-Ray

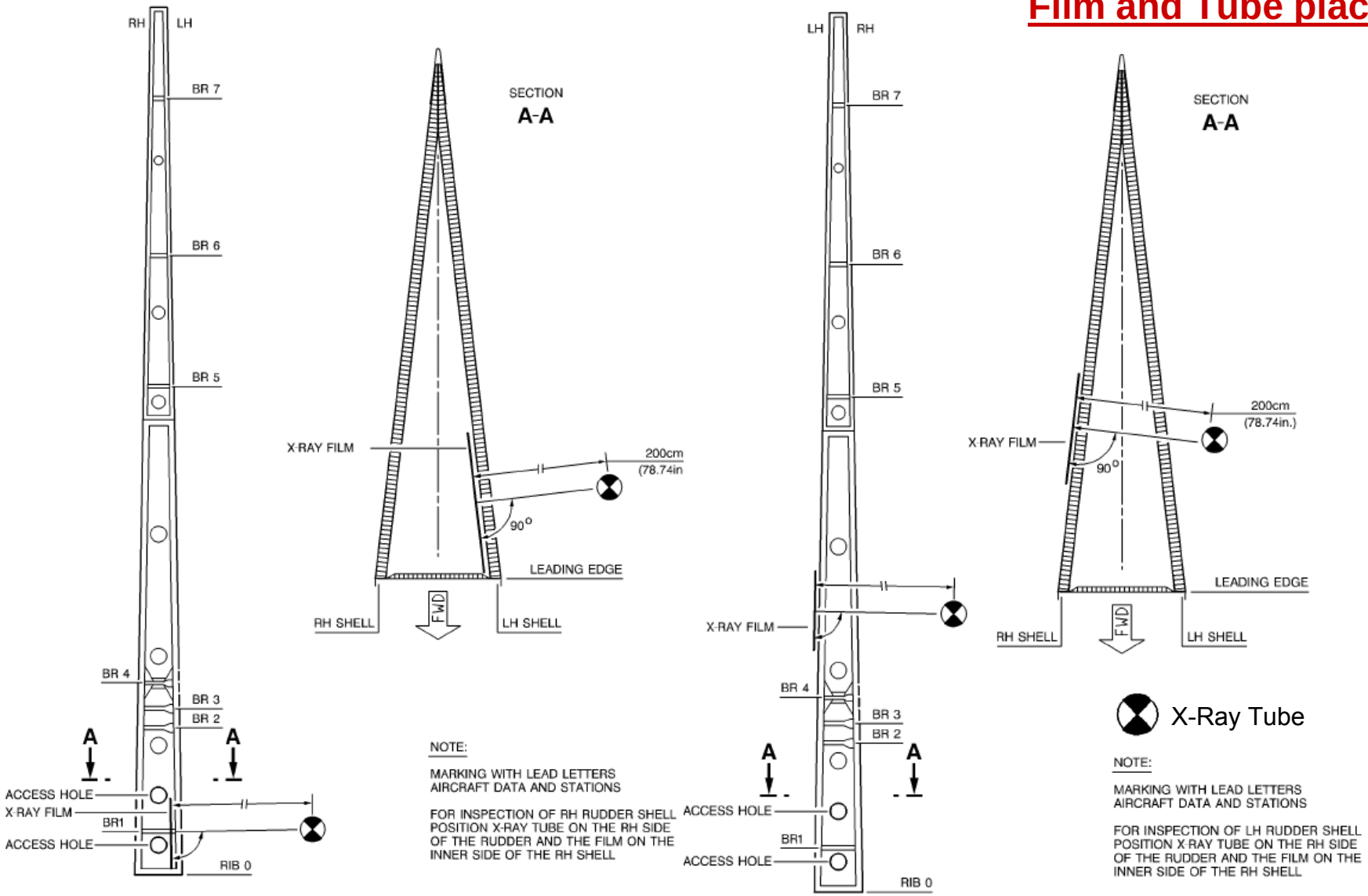
- Allows detection of fluids in honeycomb cells
- Needs special safety precautions
- Bulky equipment, limited portability
- Needs special sensitive film (D7)
- Access to the rudder interior is limited: positioning the film inside is not always possible
- Considered for investigating the nature of indications from UT or thermography





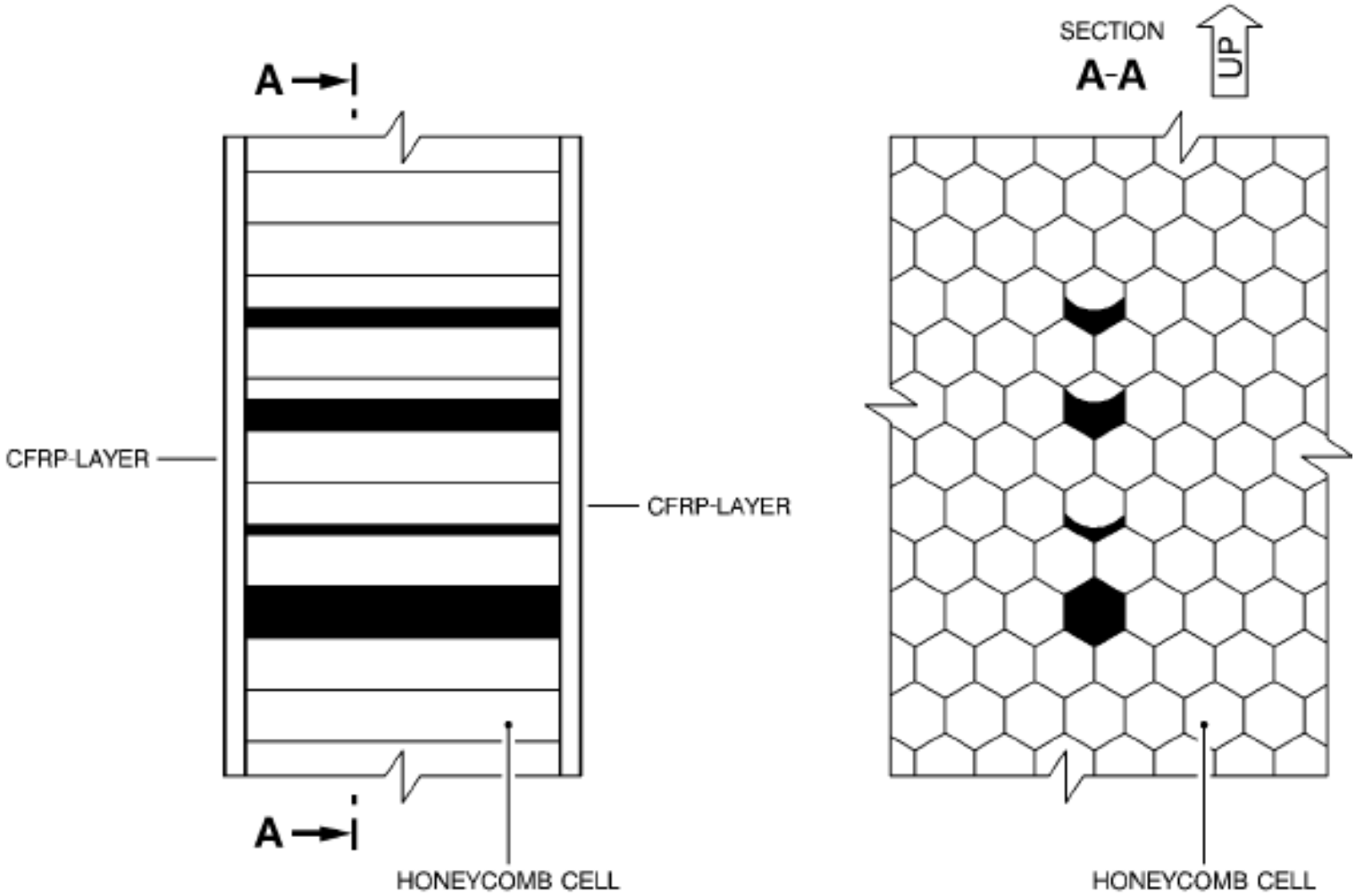
INSPECTION METHODS : X-Ray

Film and Tube placement



INSPECTION METHODS : X-Ray

Typical Indication of Fluid



- INTRODUCTION
- RUDDER DESIGN PRINCIPLE PRE MOD 8827
- DESCRIPTION OF DAMAGE TO BE DETECTED
- INSPECTION METHODS
- CONCLUSION

Conclusion

- The improved maintenance program is introducing :
  - a specific ultrasonic procedure allowing to inspect even the inner skin bonding of the sandwich panel
  - Combined with a new infrared thermography inspection procedure it allows also to detect the fluid entrapped in honeycomb cells

- Airbus is supporting the Operator and MRO by providing a dedicated training. Also required material can be made available for the infrared inspection through AIRBUS spare network.