New Standards. Together

Presented by
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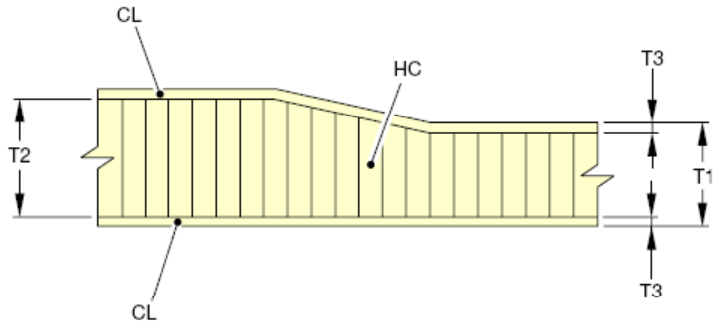
Introduction - AIRBUS sandwich structures

The NDT procedures are valid for flat or shallow curved undisturbed honeycomb sandwich structures.

Challenge:
Single sided access for In Service A/C. Need to inspect the opposite side of the sandwich structure for defects.



CL: FOR DAMAGE TYPES A, B, C, D, E AND F HORIZONTAL
COVER LAYER, MATERIAL CFRP OR GFRP, T3 = THICKNESS OF COVER LAYER, THICKNESS: MINIMUM = 0.4 mm (0.016 in), MAXIMUM = 2.5 mm (0.098 in).

CL: FOR DAMAGE TYPE F VERTICAL
COVER LAYER, MATERIAL CFRP OR GFRP, T3 = THICKNESS OF COVER LAYER, THICKNESS: MINIMUM = 0.4 mm (0.016 in), MAXIMUM = 6.5 mm (0.256 in).

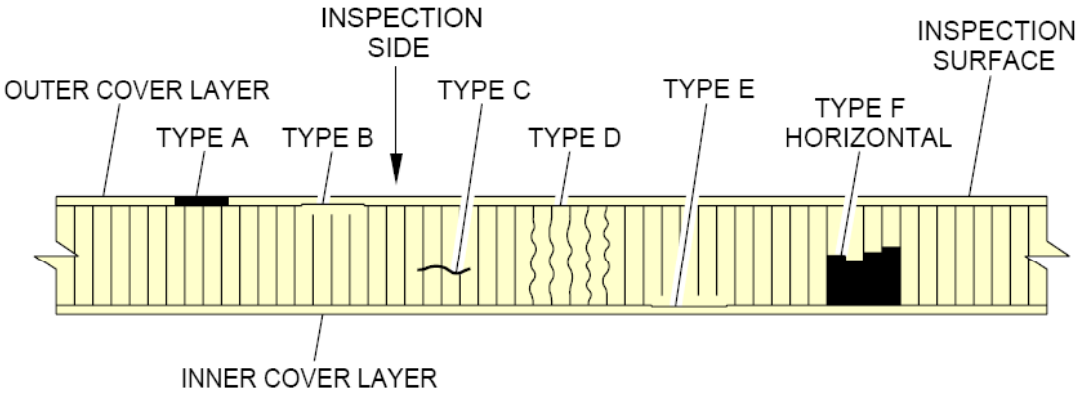
HC: HONEYCOMB CORE, MATERIAL NOMEX HONEYCOMB WITH THE FOLLOWING CELL WIDTH (CW) AND STIFFNESS (S):

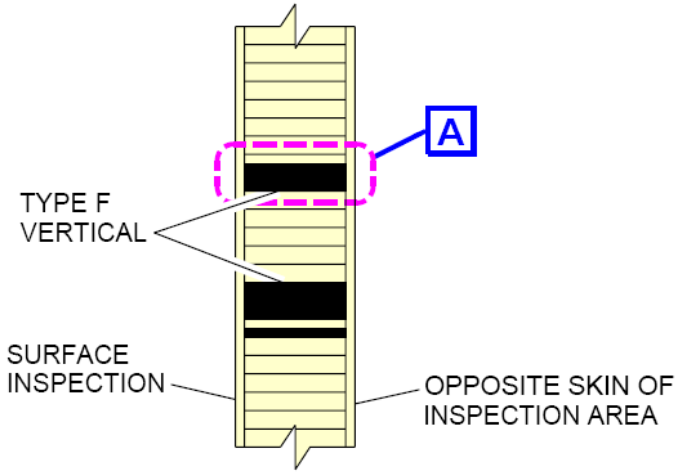
- CW = 3.2 mm (0.126 in) AND S = 48 kg/m³
- CW = 4.8 mm (0.189 in) AND S = 32 kg/m³
- CW = 4.8 mm (0.189 in) AND S = 48 kg/m³
- CW = 4.8 mm (0.189 in) AND S = 64 kg/m³
- CW = 6.4 mm (0.252 in) AND S = 24 kg/m³
- CW = 6.4 mm (0.252 in) AND S = 32 kg/m³
- CW = 6.4 mm (0.252 in) AND S = 48 kg/m³

T1: MINIMUM HONEYCOMB HEIGHT = 30 mm (1.181 in).

T2: MAXIMUM HONEYCOMB HEIGHT = 40 mm (1.575 in).

Possible Damage of FRP Sandwich Structures





Type A: Delamination between the layers of the outer composite skin, parallel to the inspection surface

Type B: Disbond between the outer skin and the honeycomb core

Type C: Cracked honeycomb core parallel to the inspection surface

Type D: Crushed honeycomb core in the parallel area

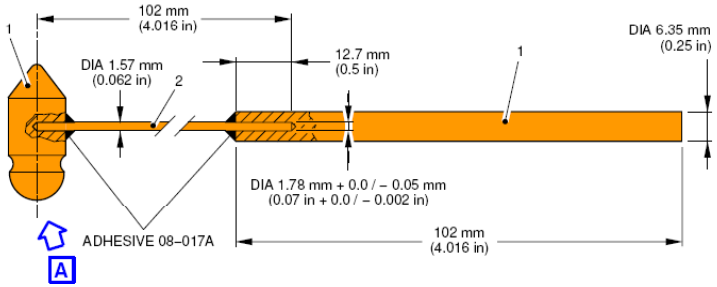
Type E: Disbond between the inner skin and the honeycomb core

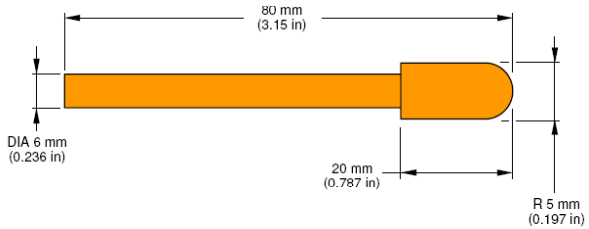
Type F (horizontal / vertical): Fluid ingress into the honeycomb core

Manual Tap Test / WOODPECKER Inspection

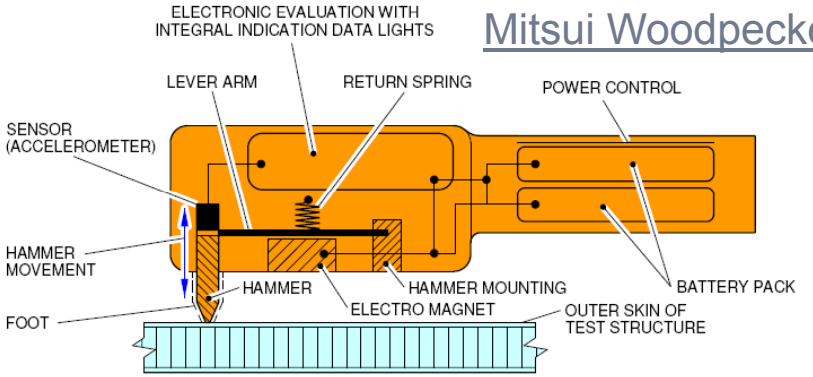
Detection of outer skin delamination / disbonding and cracked core (outer skin thickness max. 2 mm, > 25 x 25 mm detectable damage size in max. 25 mm depth)

Manual Tap Test



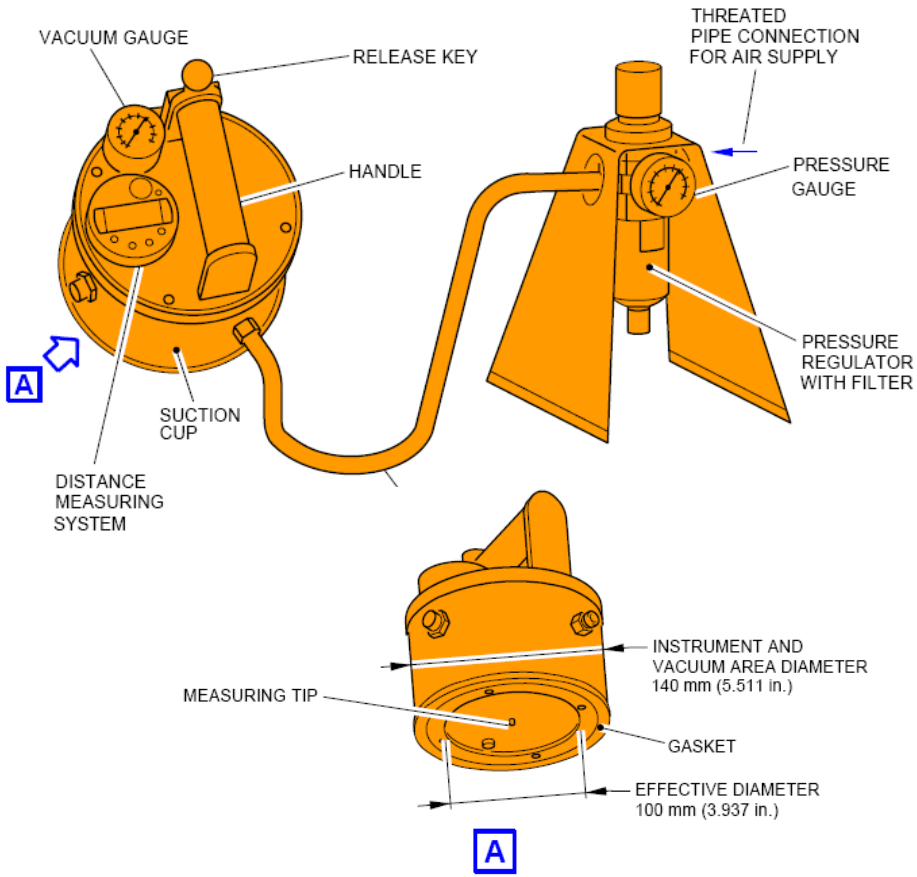


Mitsui Woodpecker



ELCH (Elasticity Laminate Checker) Inspection

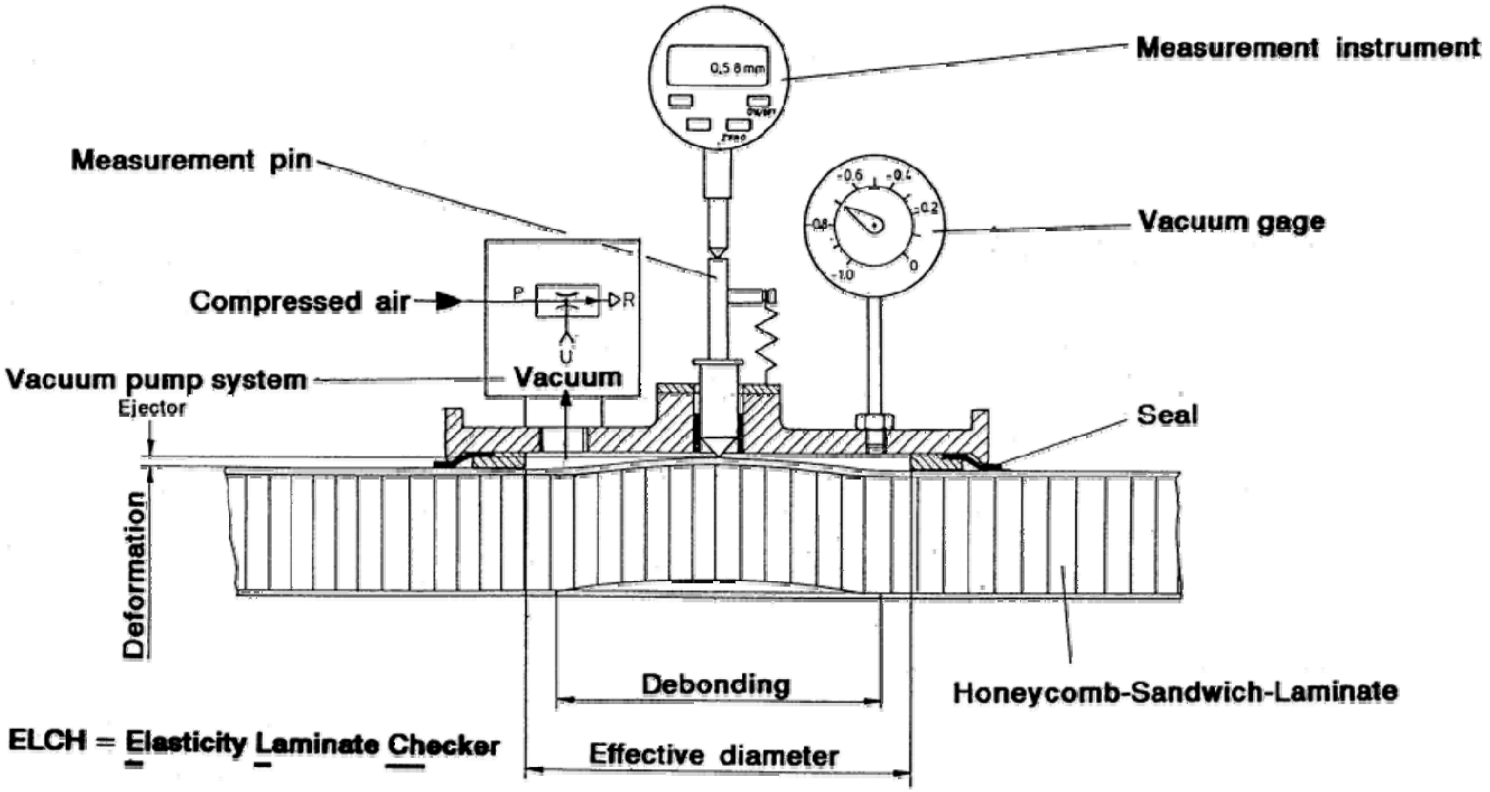
Detection of outer / inner skin disbonding and cracked core (outer skin thickness max. 1.5 mm, > Ø 110 mm detectable damage size, test grid 50 x 50 mm)



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

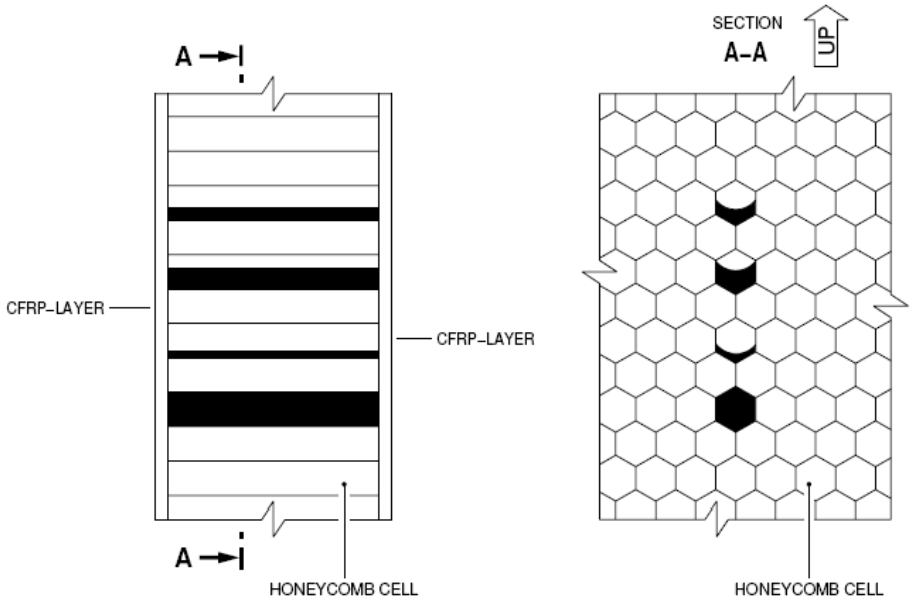
ELCH Inspection Principle

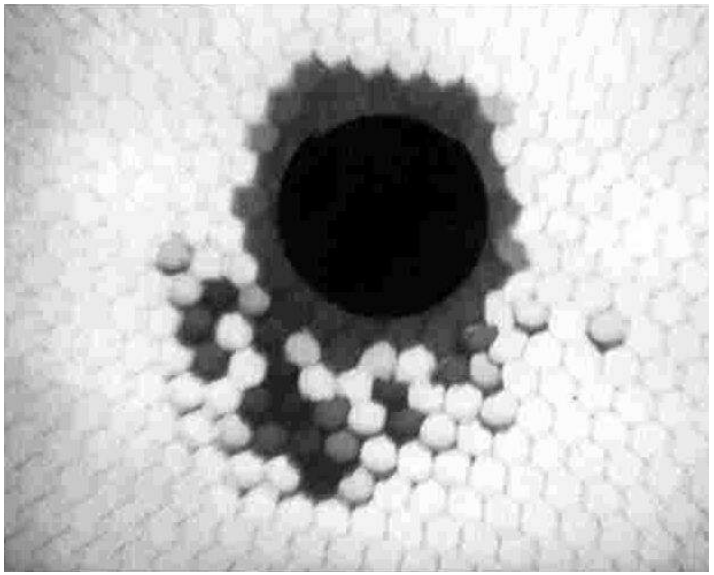
- Loading with a defined vacuum
- Deformation measurement under load
- Max. skin thickness 1.5 mm



X-Ray Inspection

Detection of fluids in honeycomb cells (very sensitive to fluid accumulation, weak radiation 25 kV is mandatory, big effort to perform inspection)





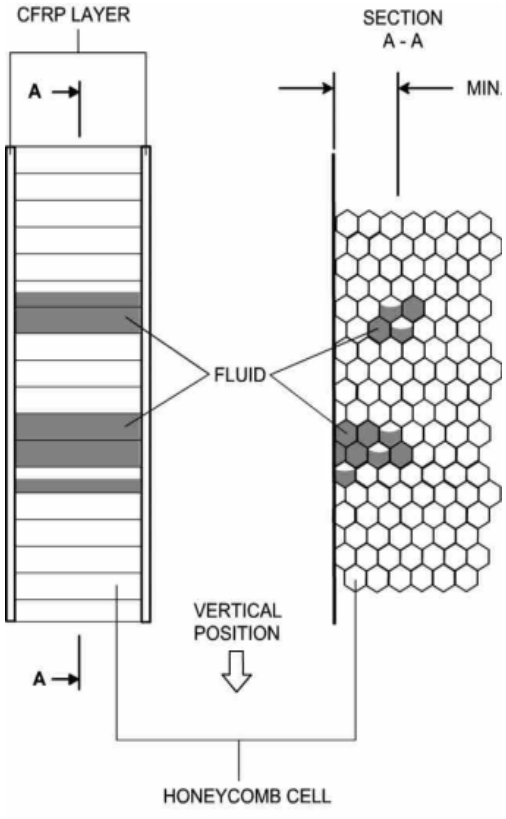
FLUID

NOTE:

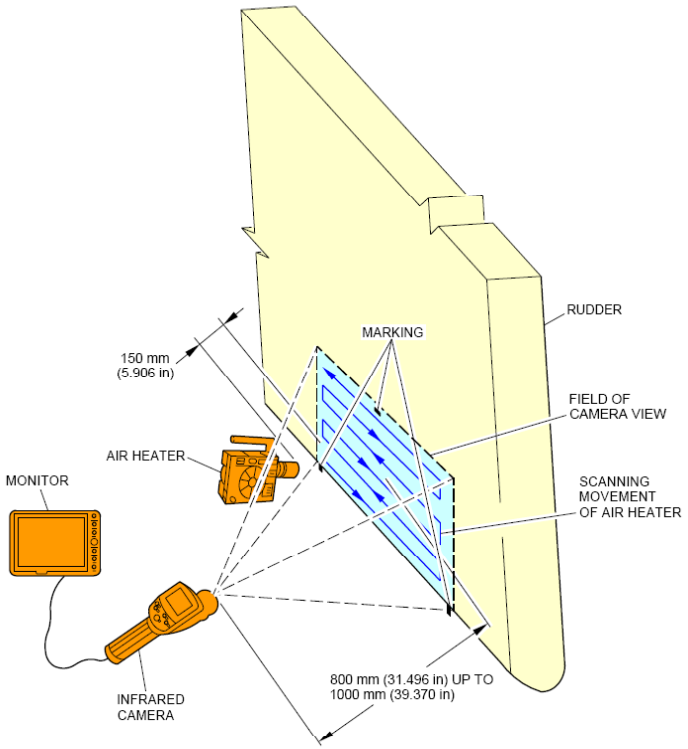
DUE TO THE CAPILLARITY AND THE FORCE OF GRAVITY THE FLUIDITY SHAPES IN THE AIRFRAMES, SHOWN ON SECTION OF A–A, RESULT. SEE ALSO TO THE TYPICAL X–RAY INDICATIONS OF FLUIDITY SHOWN IN THE EXAMPLE OF RADIOGRAPHS

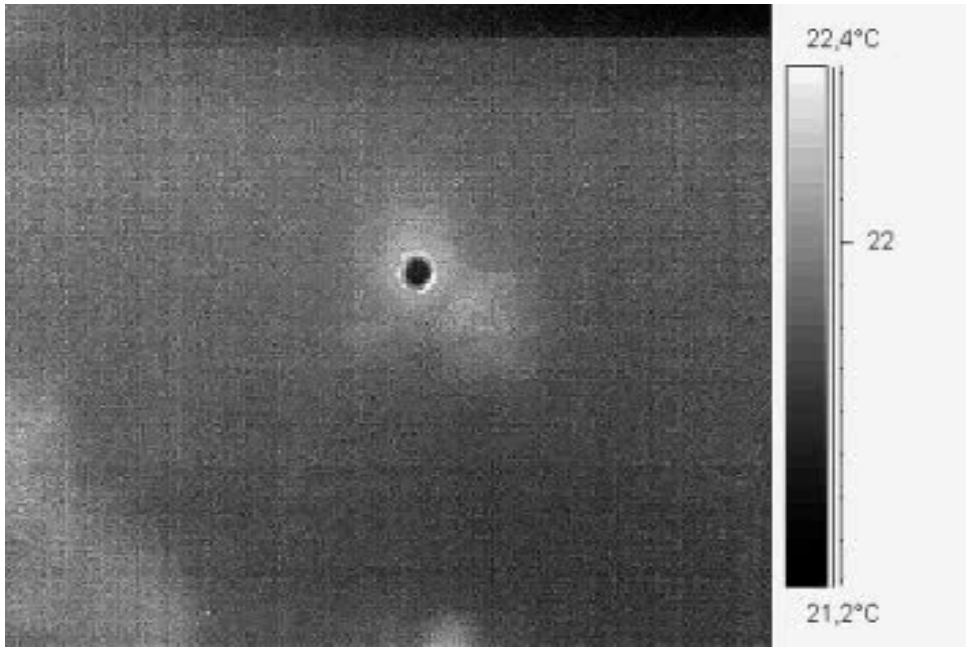
Infra Red Thermography Inspection / Fluid

Detection of fluid in honeycomb core cells (outer skin thickness max. 1.5 mm, detectable damage > 6 ml fluid in sandwich structures up to 40 mm, composite must not be damaged by overheating, new inspection Levels IRT required as per EN 4179 and NAS 410)



Infra Red Thermography Inspection Example / Fluid

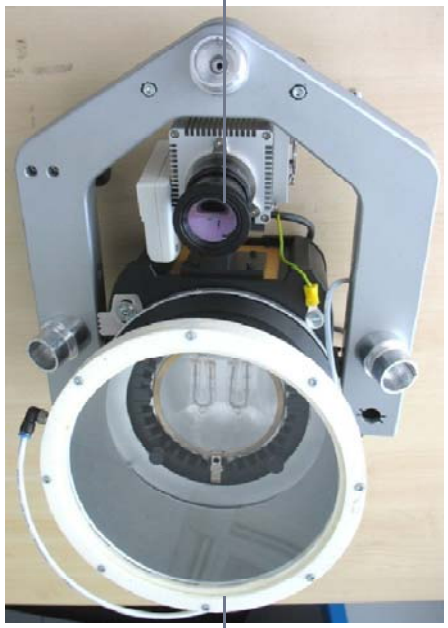




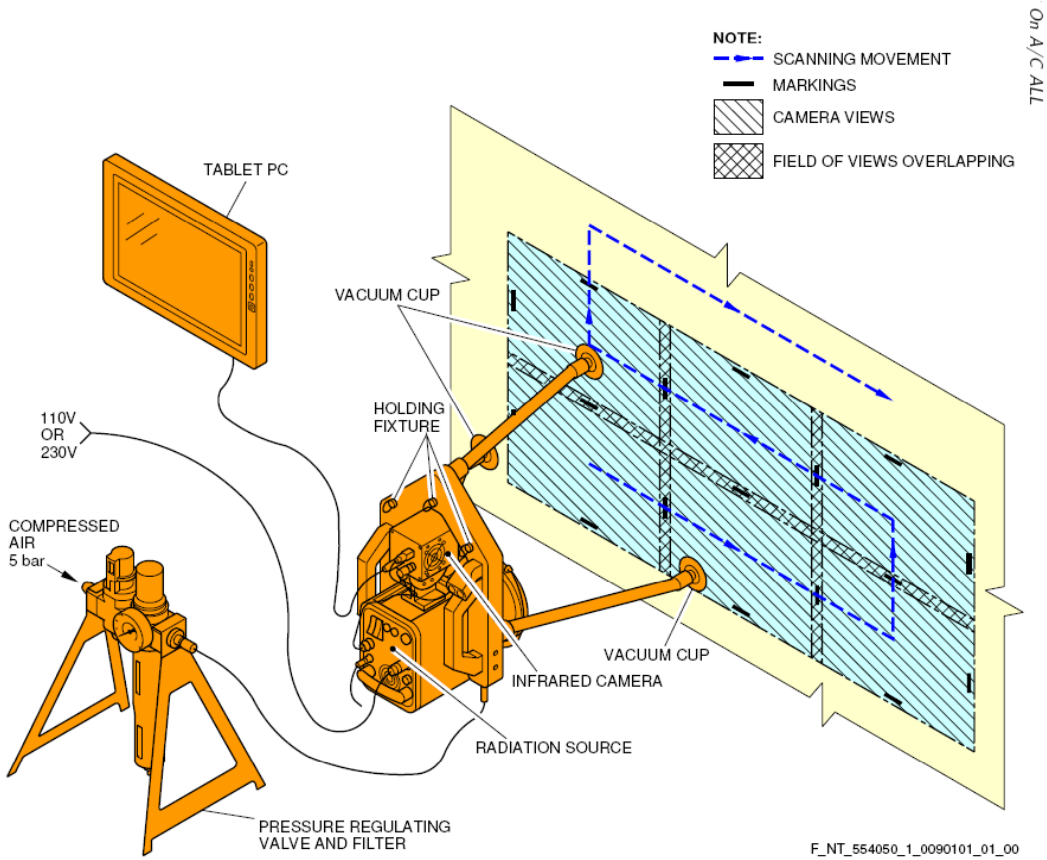
Infra Red Thermography Inspection Additional FRP Layers

Infra Red „GECKO“ to detect additional FRP layers

Infra Red Camara, 9 Hz,
Spectral range 7.5 - 13.5 *µm*

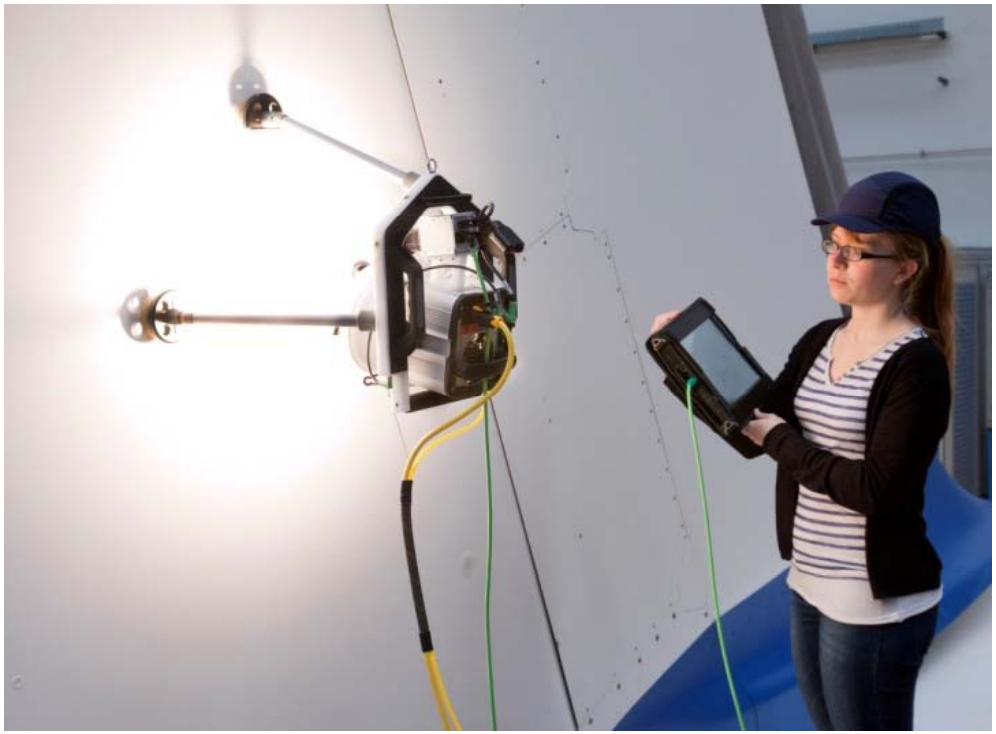


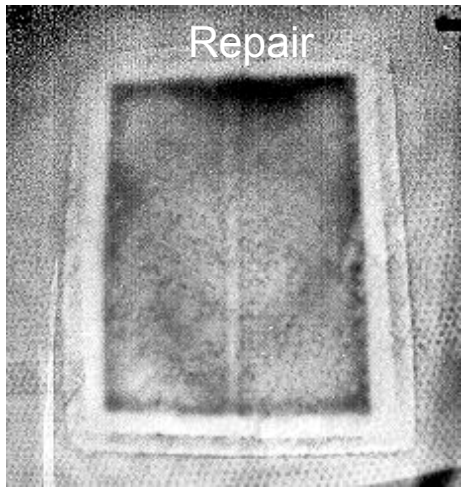
Halogen Lamp
850 - 1250 W

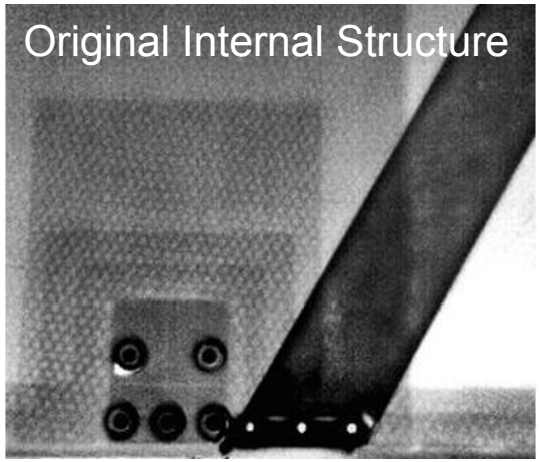


Infra Red Thermography Inspection Additional FRP Layers

Detection of additional FRP layers (max. paint thickness incl. decal foils < 800 *µm, additional 0.25 mm GFRP layer detectable, surface maybe painted matt black (removable)*)

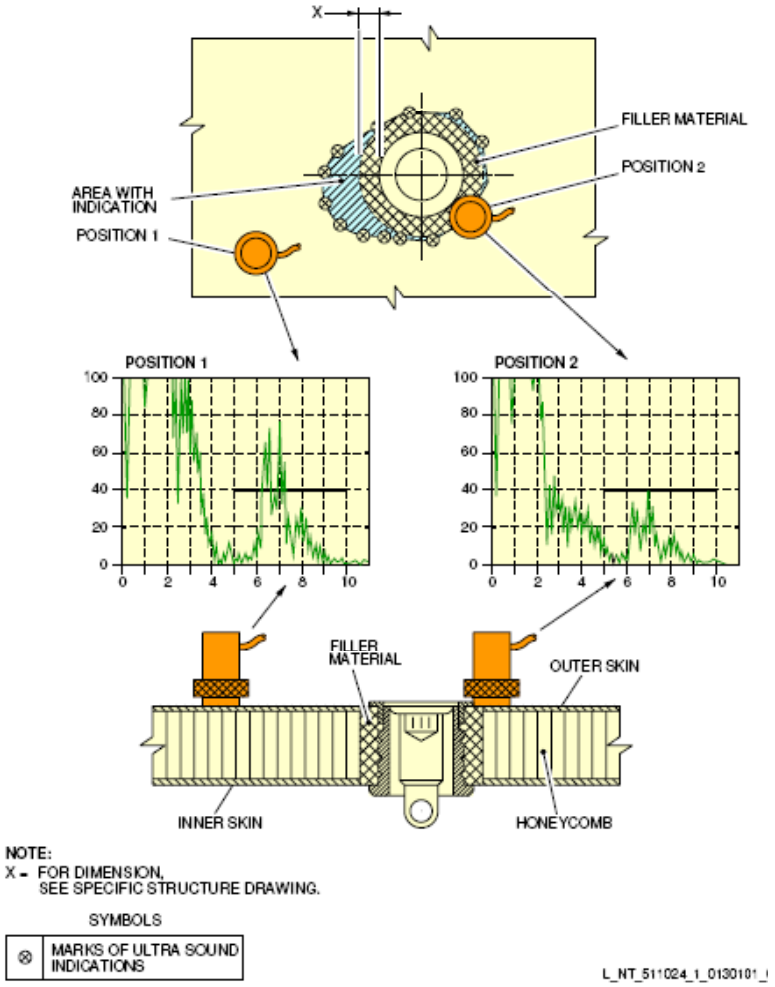






Ultrasonic Impulse Echo Inspection

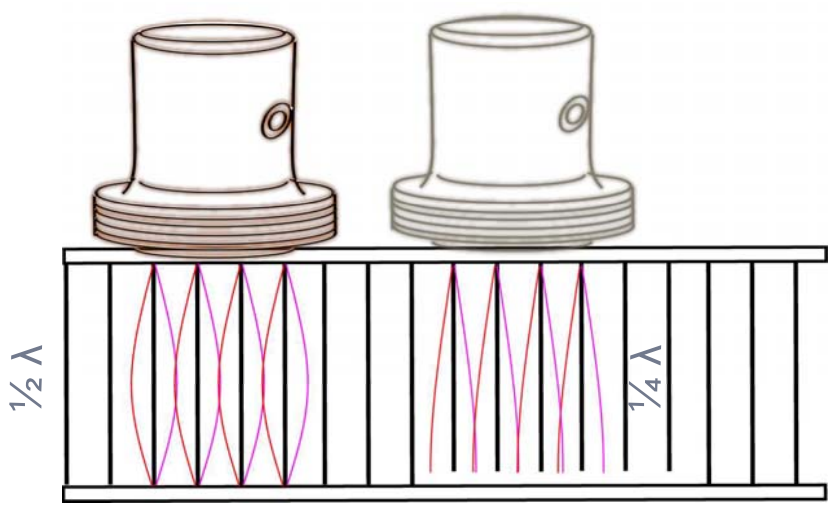
Detection of delamination on the outer composite skin, outer / inner skin disbonding, cracked honeycomb core, crushed honeycomb core and fluid ingress (outer skin thickness up to > 5 mm, > 25 x 25 mm detectable damage size, sandwich thickness up to > 40 mm)



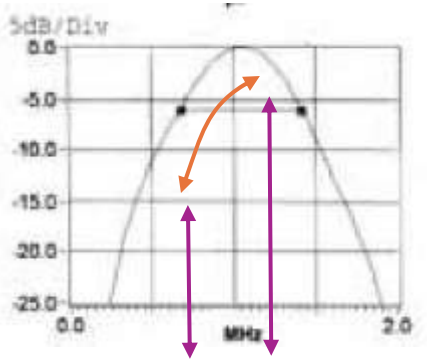
Ultrasonic Impulse Echo Inspection Principle

The UT Impulse Echo Procedure uses a kind of guided waves.
The System must be tuned to the core height (membrane length = ½ λ)

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.



Amplitude reduction
by resonance change



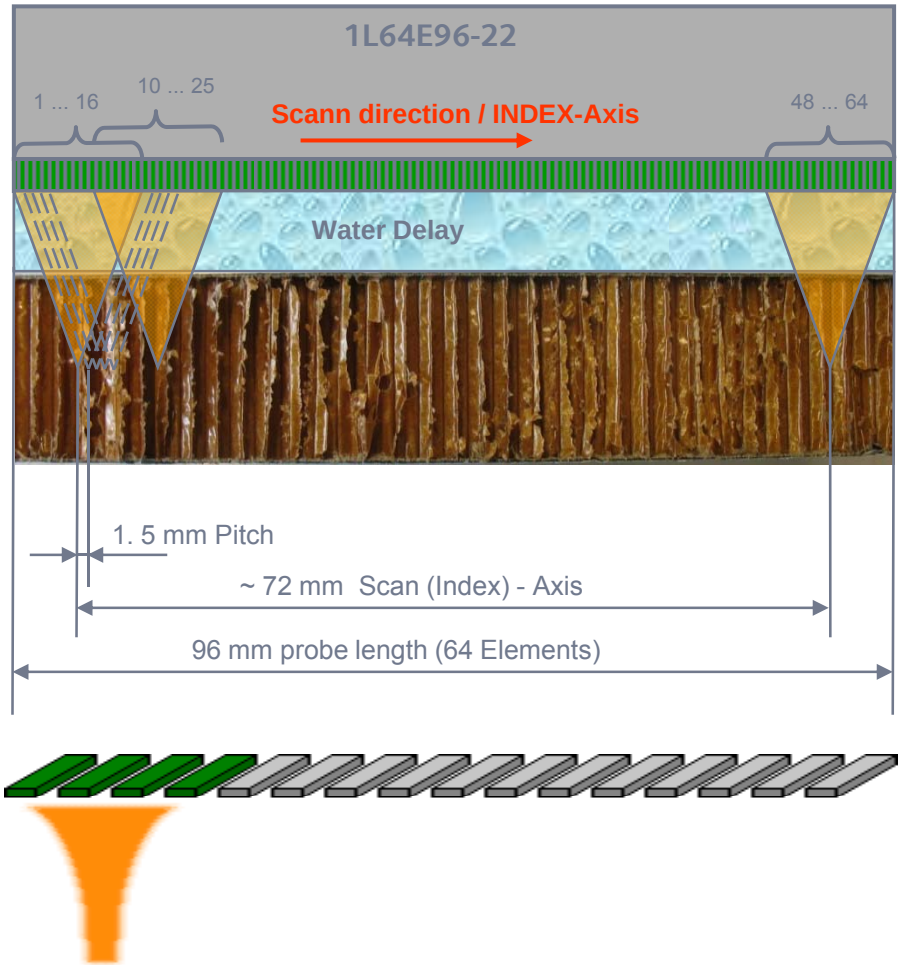
Ultrasonic Phased Array Impulse Echo Inspection

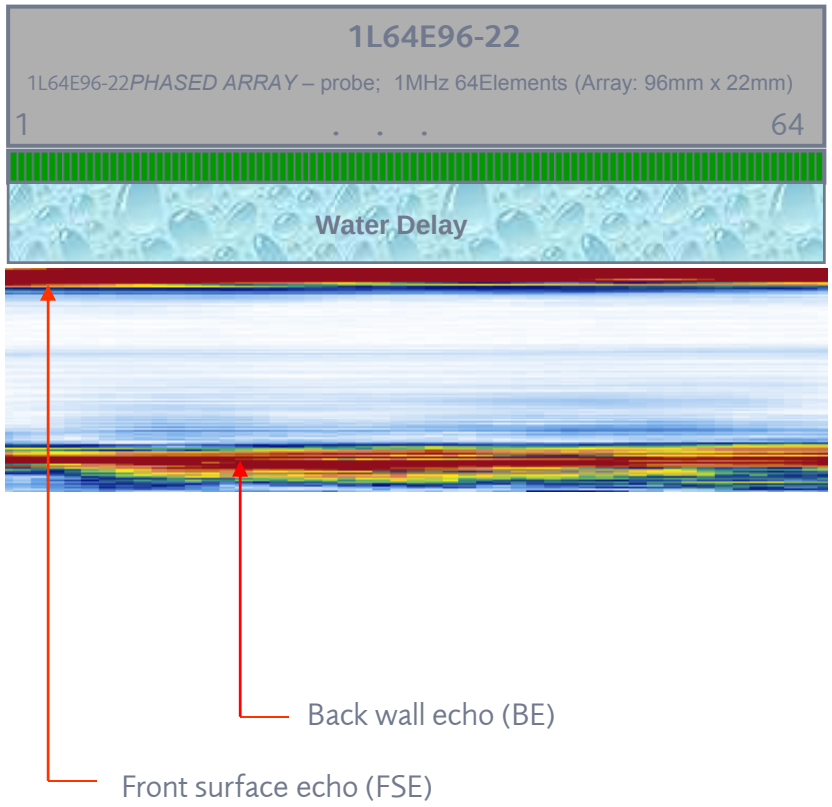
Impulse Echo Ultrasonic Phased Array (PAUT) scan configuration. (PAUT equipment, 1 MHz probe with water delay and wheel encoder)

It is possible to inspect moderate tapered areas by adapted ultrasonic beam forming.

Principle of linear electronic scanning

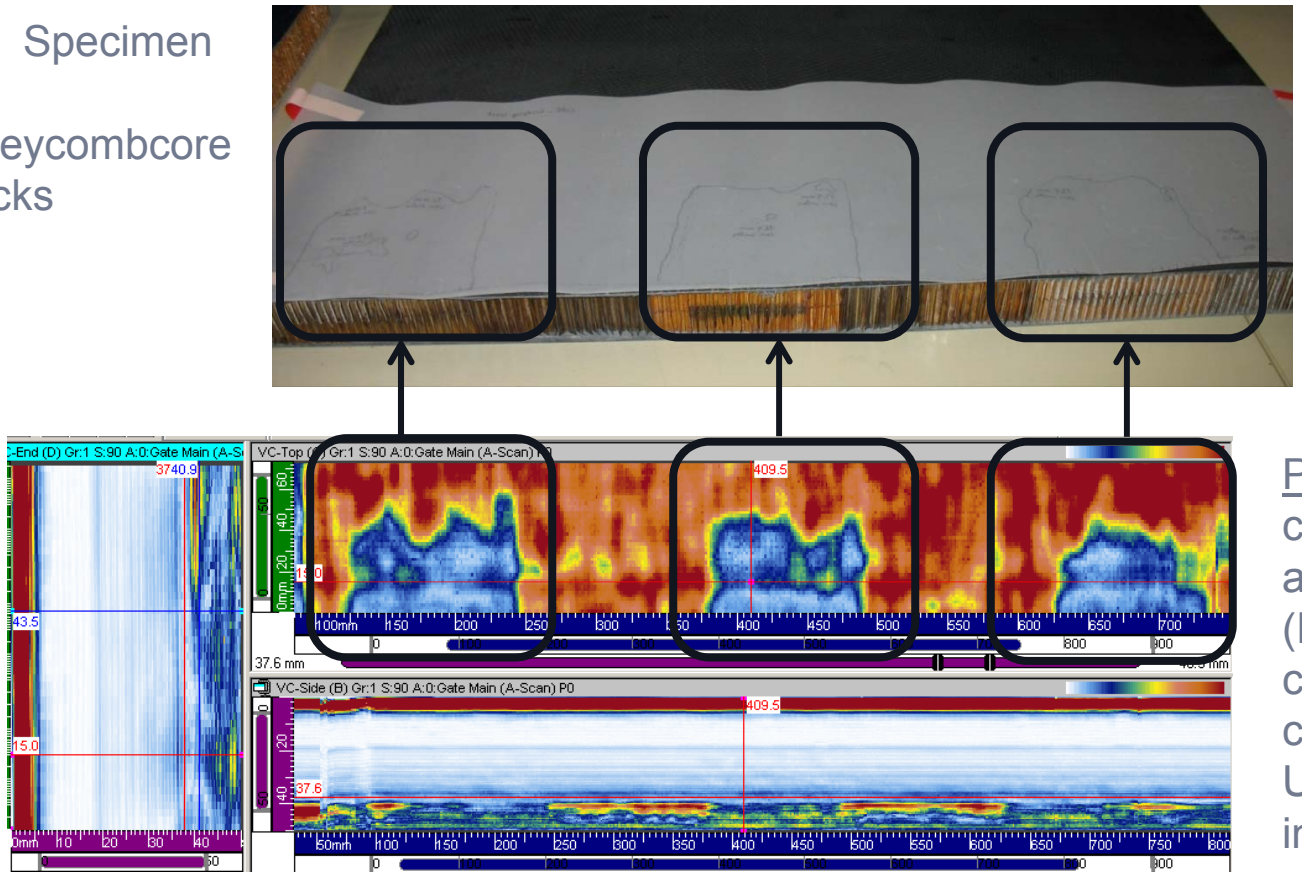
The linear scan is achieved by multiplexing of a single , constant *Focal Law* along a Linear-Array





Ultrasonic Phased Array Inspection Results

Test Specimen with Honeycombcore Cracks



PAUT Results: clear indication of affected areas (Results also confirmed with conventional single UT probe inspection)

Conclusion

• UT & ELCH were developed to detect disbonded or cracked core of the far side of the sandwich structure under maintenance conditions with the required level of inspection sensitivity.

• New NDI Infra Red Thermography method and training was established to detect fluid ingress and repairs.

• These new NDI procedures guarantee the airworthy condition of the inspected parts.