



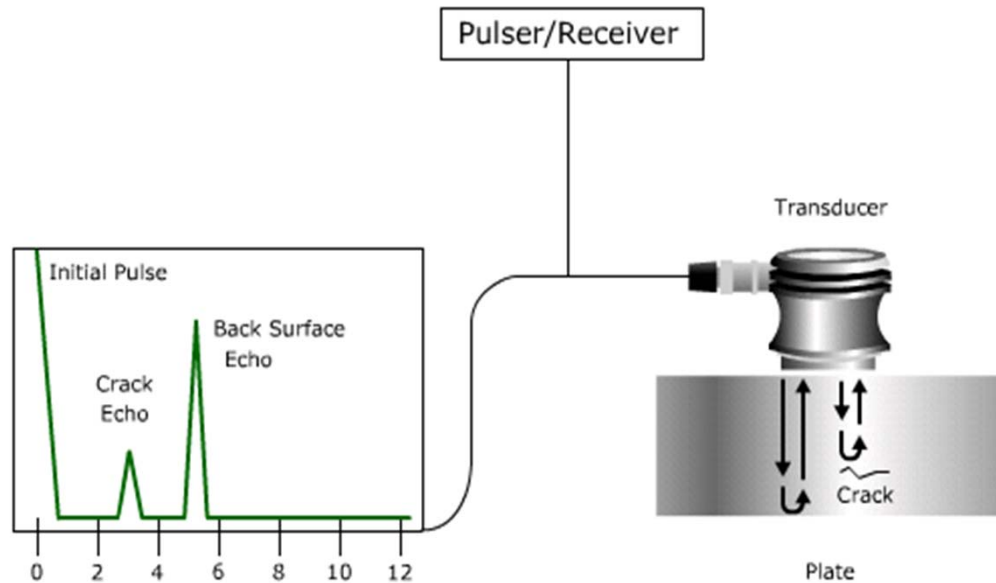
Ultrasonic Inspection of adhesively bonded Joints

M. Kaack, Th. Orth

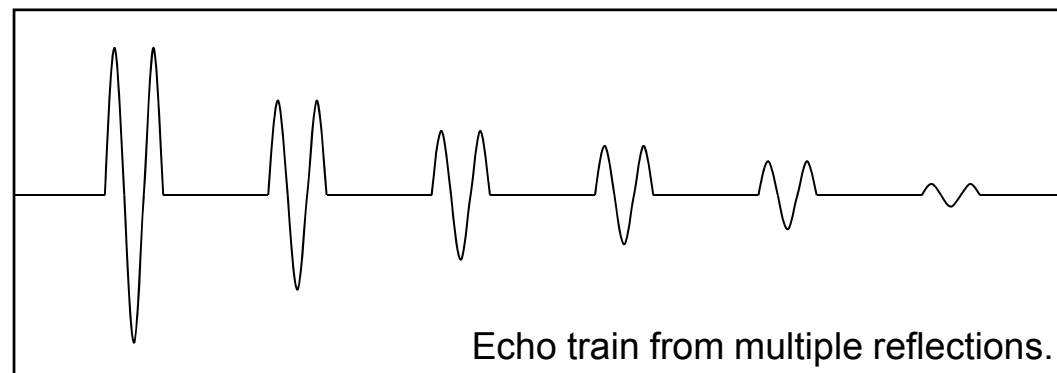
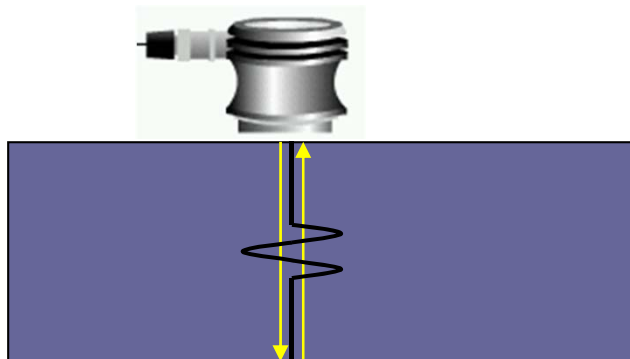
Paderborn , 26th / 27th of May 2010

Ultrasonic Inspection of adhesively bonded Joints

Perpendicular Inspection

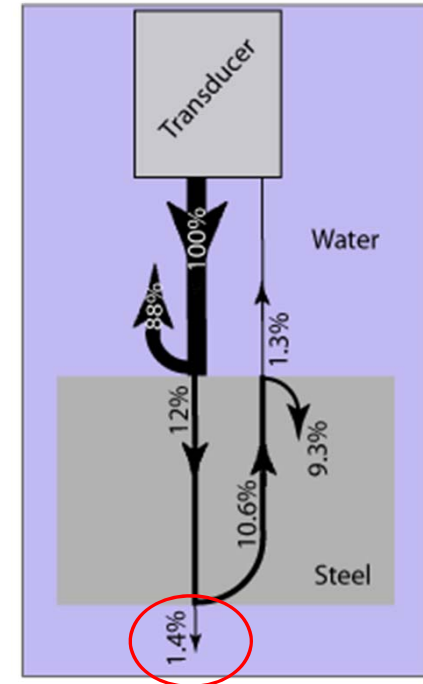
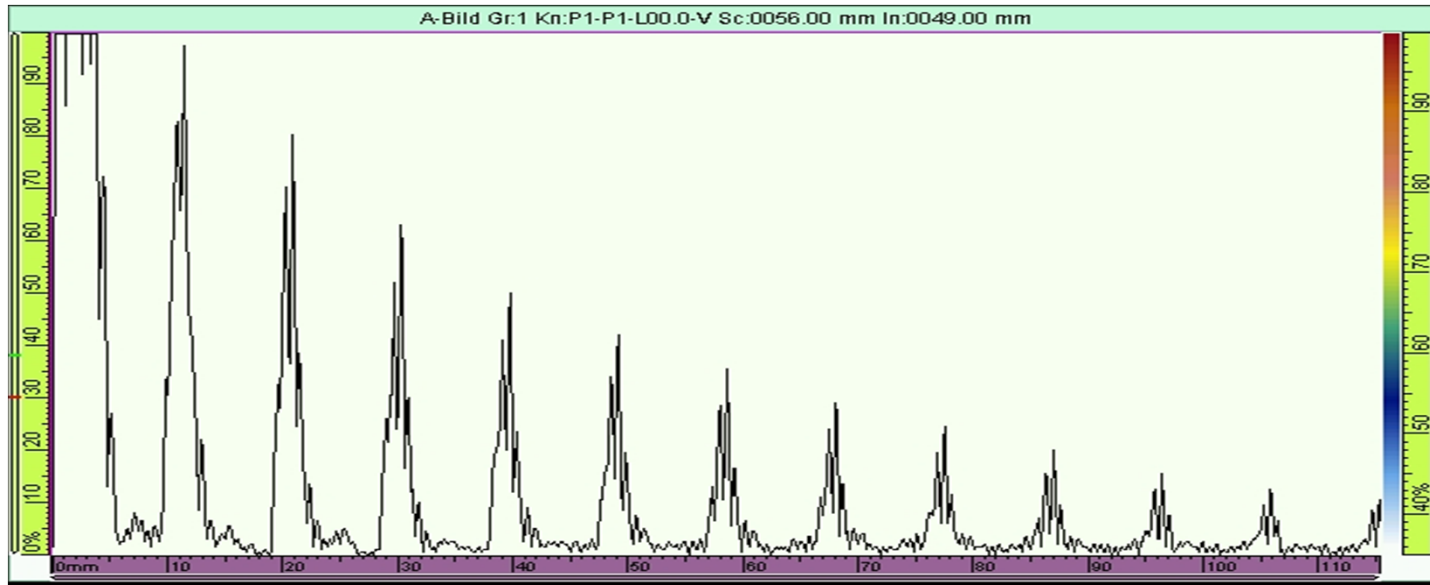


- Ultrasonic wave is generated by a transducer head and coupled **perpendicularly** to the sample.
- Coupling by oil or immersion technique.
- Ultrasonic wave runs several times through the sample.
- Typically **echo-position** is evaluated.
- Not possible here due to high attenuation in adhesive.

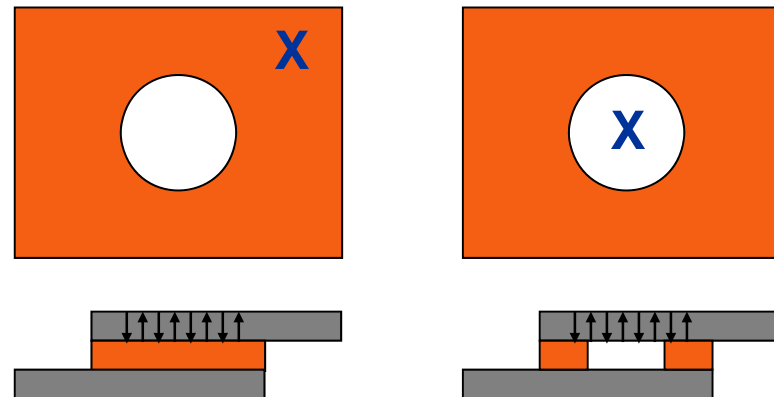


Ultrasonic Inspection of adhesively bonded Joints

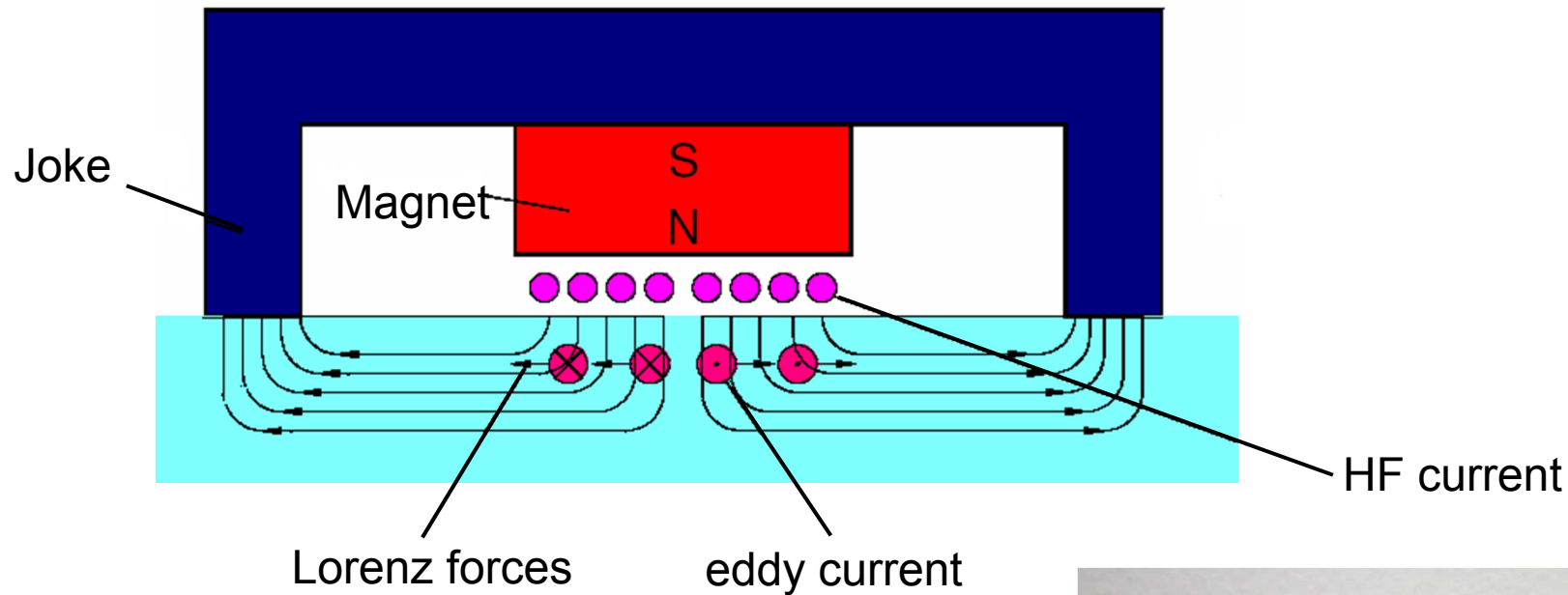
Attenuation in steel layer



- Here echo-amplitudes have to be evaluated.
- Echo trains at locations of void and adhesive are compared.
- Significant differences in attenuation is found!

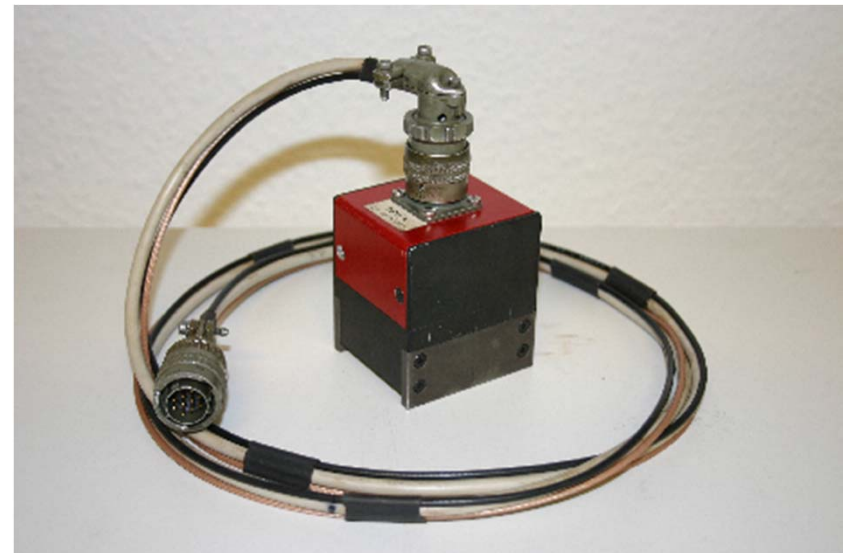


Ultrasonic Inspection of adhesively bonded Joints EMAT-Technique



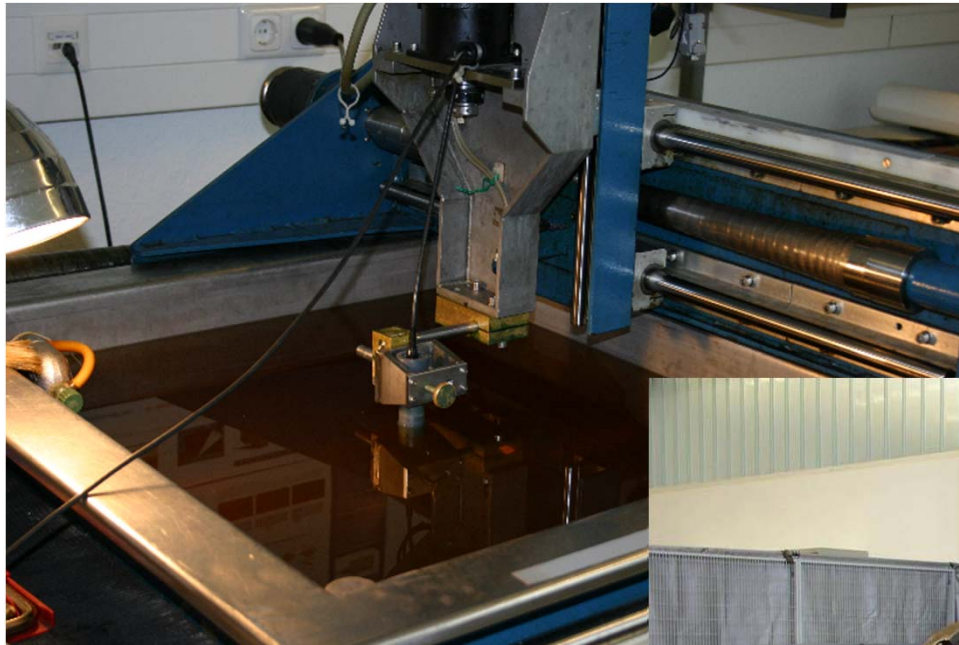
Properties of EMAT-inspection:

- No coupling medium required.
- More sensitive to disturbances.
- Generation of transversal waves.



Ultrasonic Inspection of adhesively bonded Joints

Piezo <-> EMAT-Technique



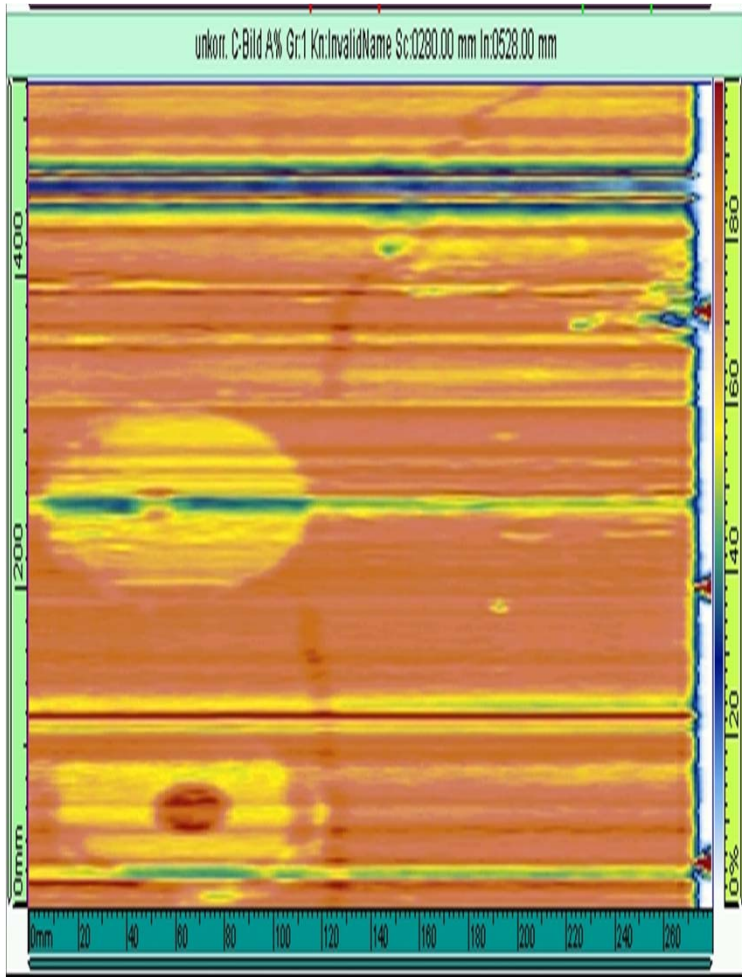
- Typical setup for Piezo - Testing
- Limitation in size of specimen

- Typical setup for EMAT - Testing
- Easy handling due to dry coupling

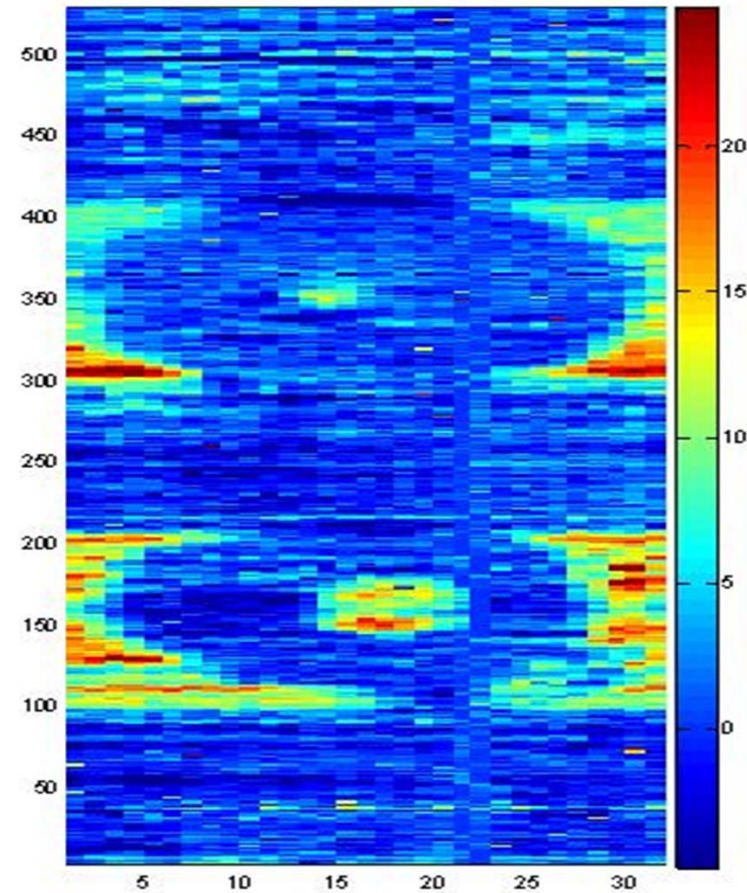


Ultrasonic Inspection of adhesively bonded Joints


Artificial air voids



Piezo technique

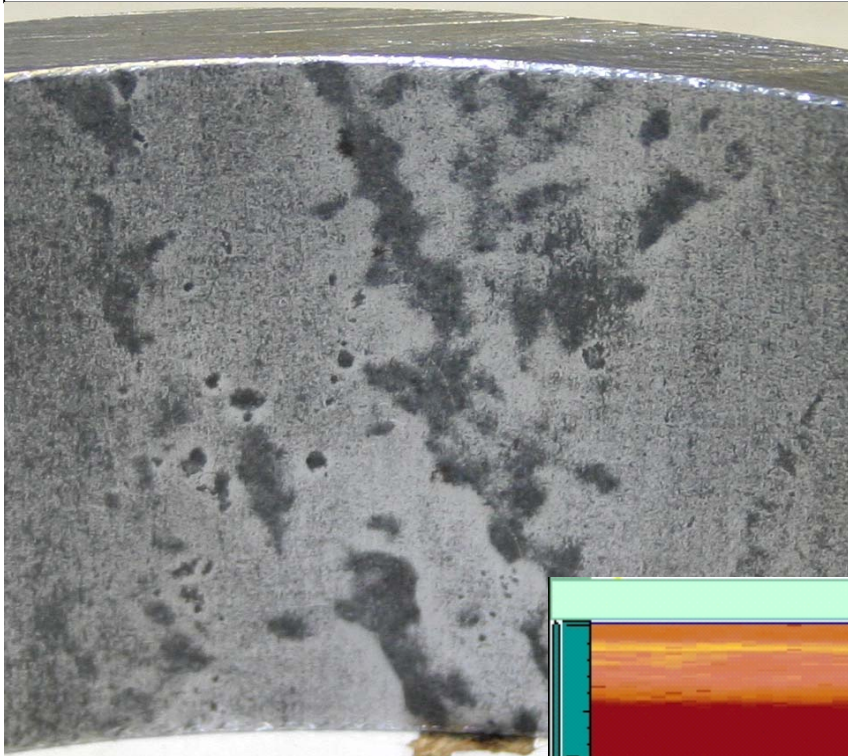


EMAT technique

 In both techniques detection of the artificial defects is possible.

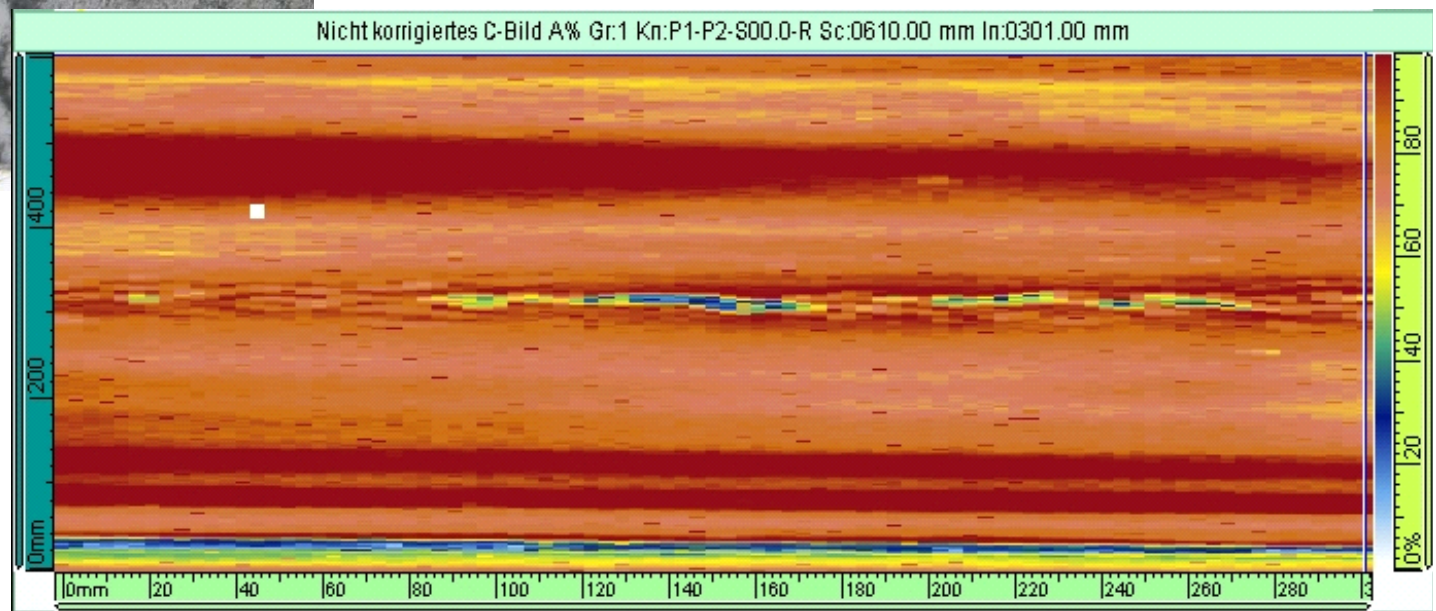
Ultrasonic Inspection of adhesively bonded Joints

Investigation of sleeves

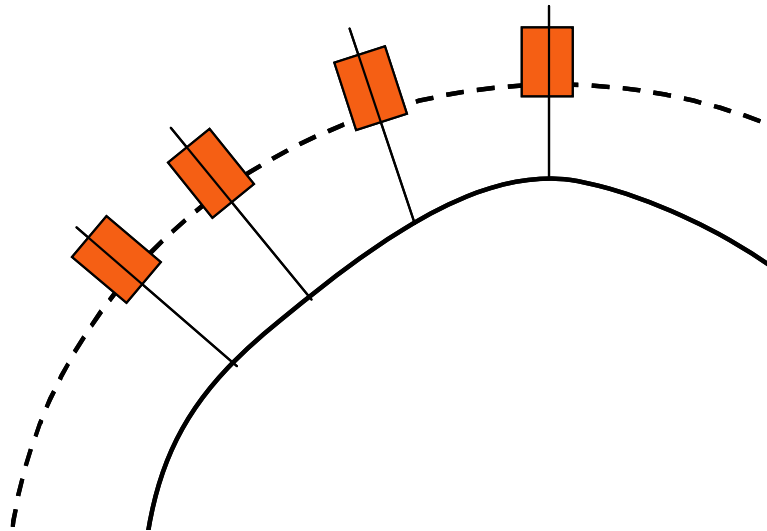


- Sleeves for 168 mm tubes have a 'corrosion line' opposite to the weld seam.
- These both lines lead always to UT-indications!

- To be placed in 3 o'clock and 9 o'clock positions.

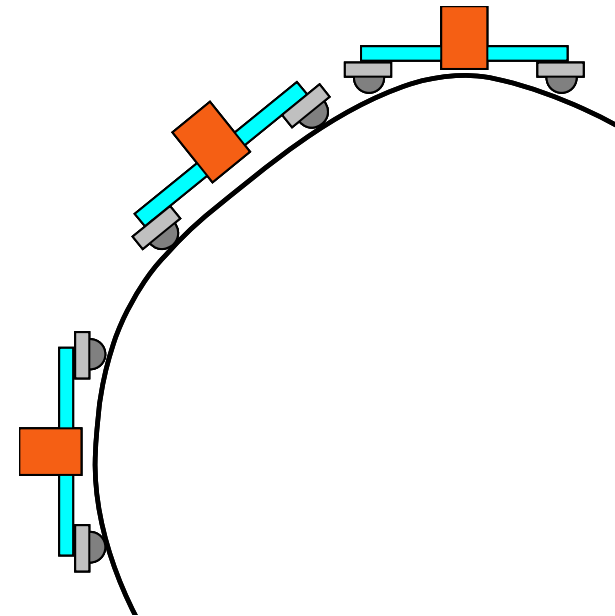


Ultrasonic Inspection of adhesively bonded Joints Tubes with out-of-roundness



Piezo technique:

- Head ↔ surface distance is changing.
- Angle of incidence is changing.



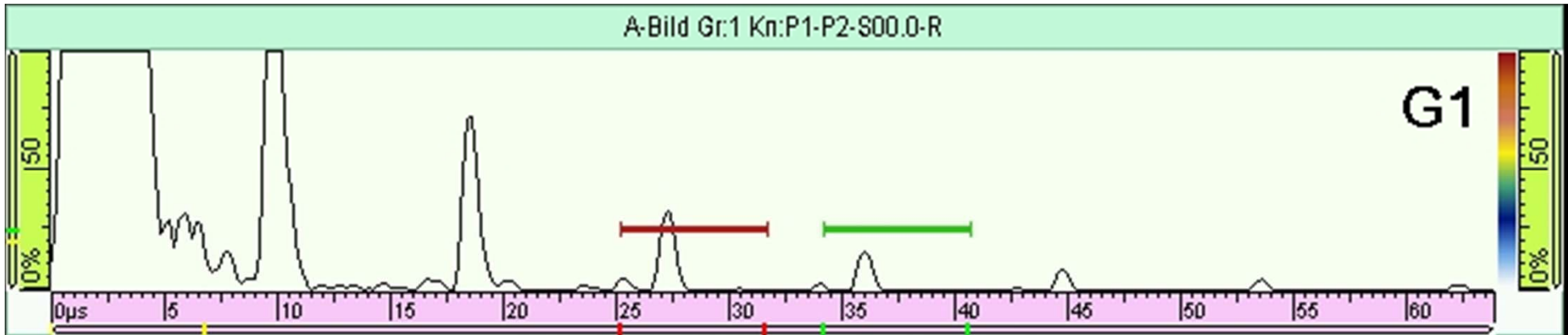
EMAT technique:

- Head ↔ surface distance is changing !!
- Double influence: magnetic forces and strength of eddy currents.

 Quality of the sleeve (roundness and smooth surface) are critical for the inspection!!

Ultrasonic Inspection of adhesively bonded Joints

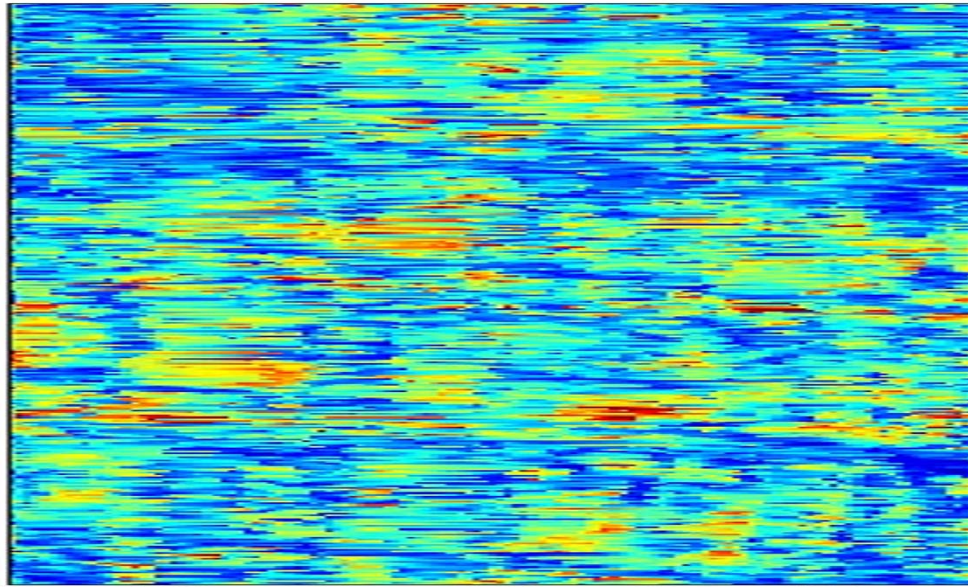
Results Joint I



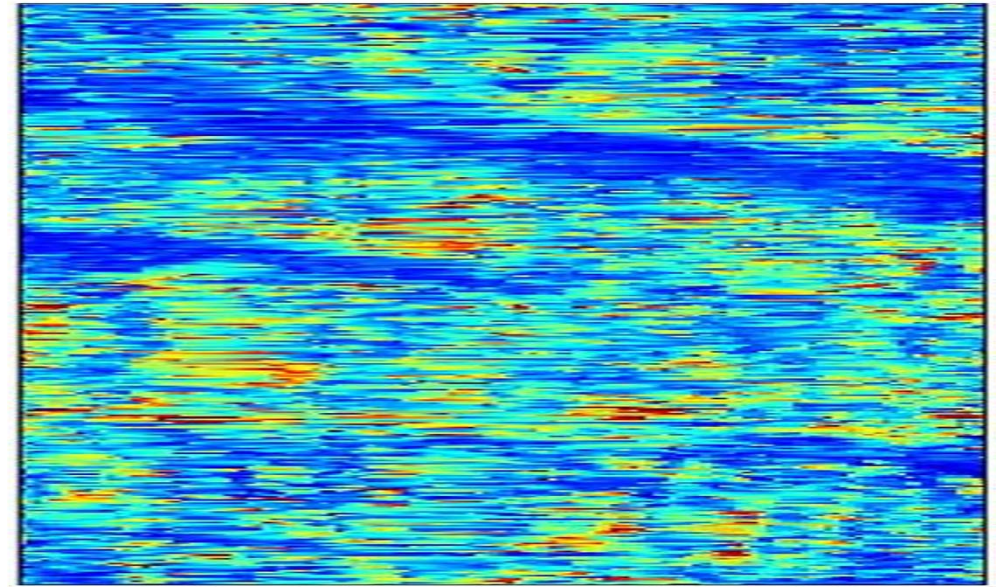
- For the inspection of the large diameter joints, the 3rd to 6th echos were used.
- Typically higher echo number gives better contrast.
- Geometry of the sleeves was not perfect: seamless tube produced in a hot Pilger-process
- Wall thickness variations, ovality, excentricity,...led to variations in the echo amplitudes
- Absolute value of wall thickness is larger for this sleeve.

Ultrasonic Inspection of adhesively bonded Joints

Results Joint III



Echo No. 3



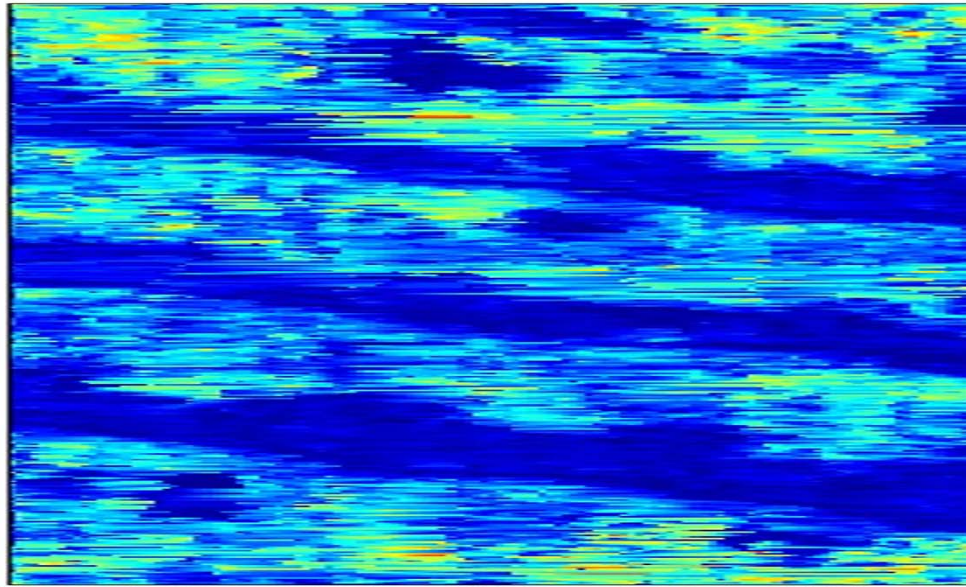
Echo No. 4

- Done by manual inspection.
- No indication for air void found.
- No liquid adhesive found.

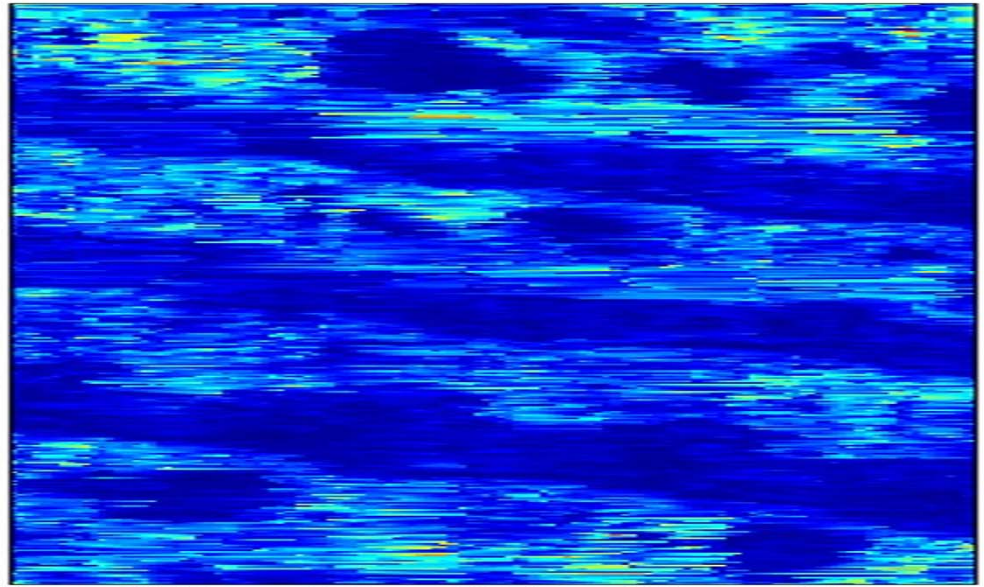
- A reference defect would have been necessary to evaluate the technique under the changed conditions.

Ultrasonic Inspection of adhesively bonded Joints

Results Joint VI



Echo No. 3

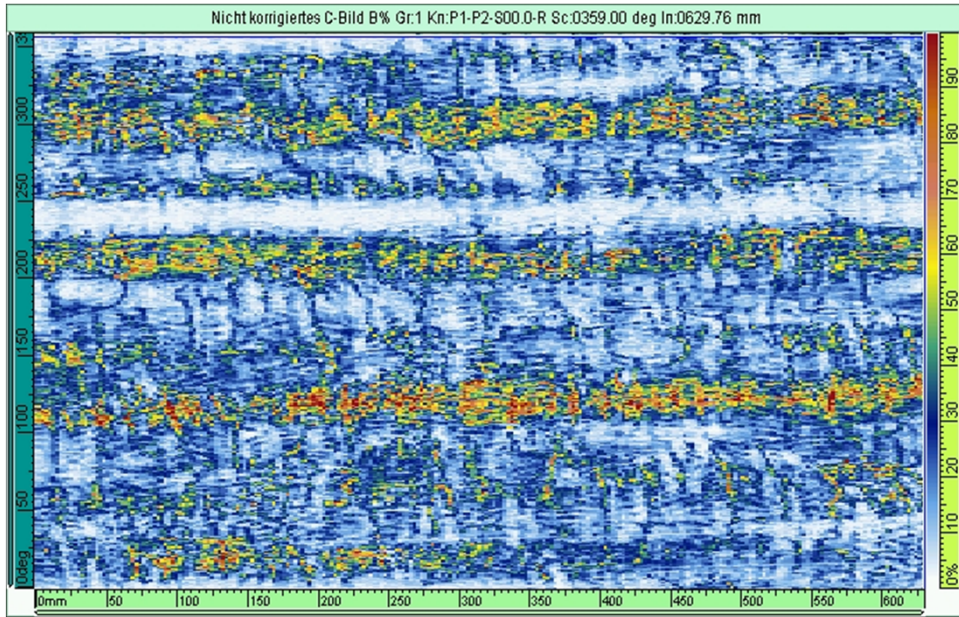


Echo No. 4

- Done by manual inspection.
- No indication for air void found.
- No liquid adhesive found.

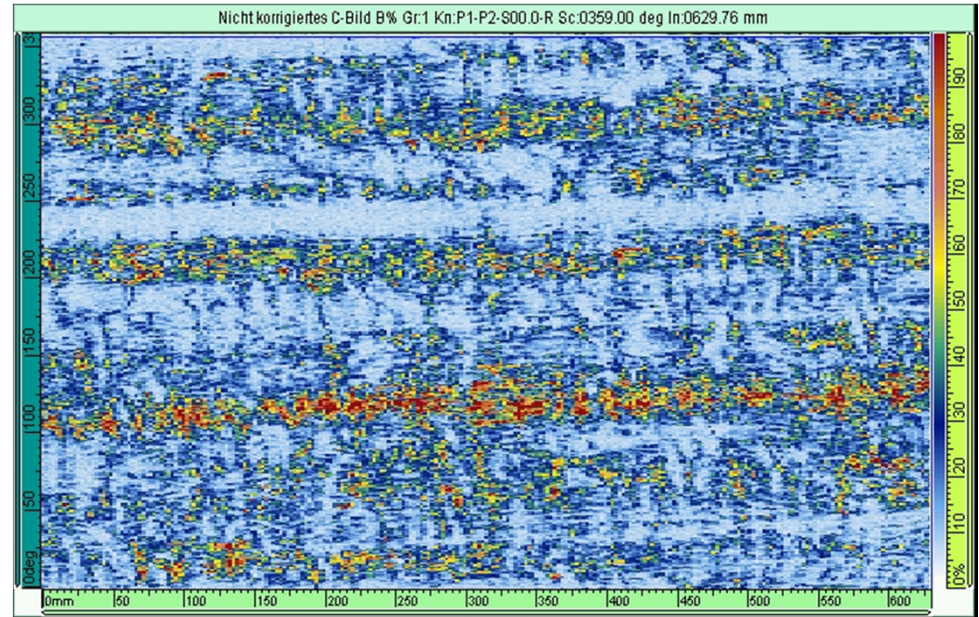
Ultrasonic Inspection of adhesively bonded Joints

Results Joint I



Echo No. 4

- Done by **automatic inspection**.
- No indication for air void found.
- Liquid adhesive found.

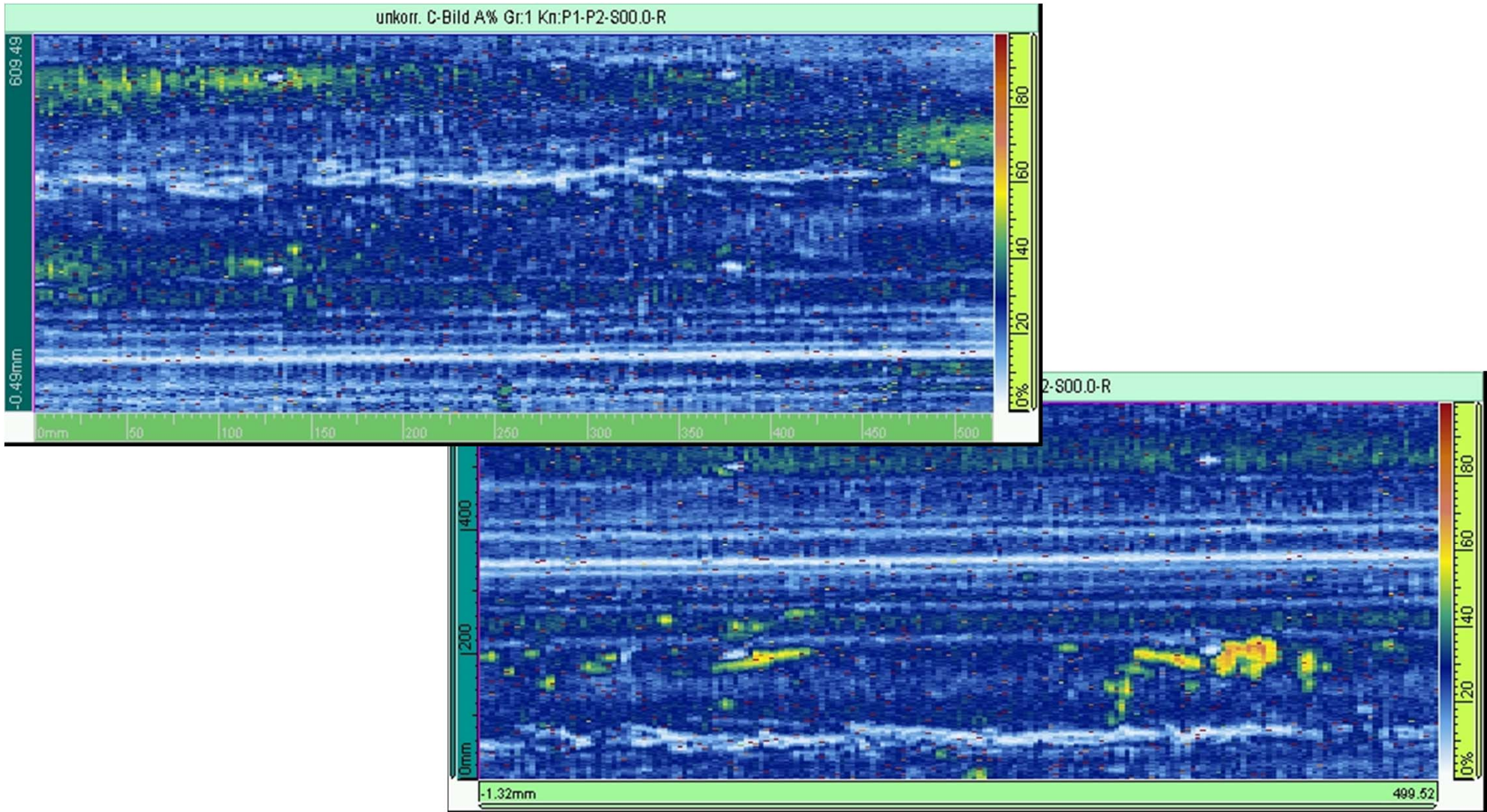


Echo No. 6



Ultrasonic Inspection of adhesively bonded Joints

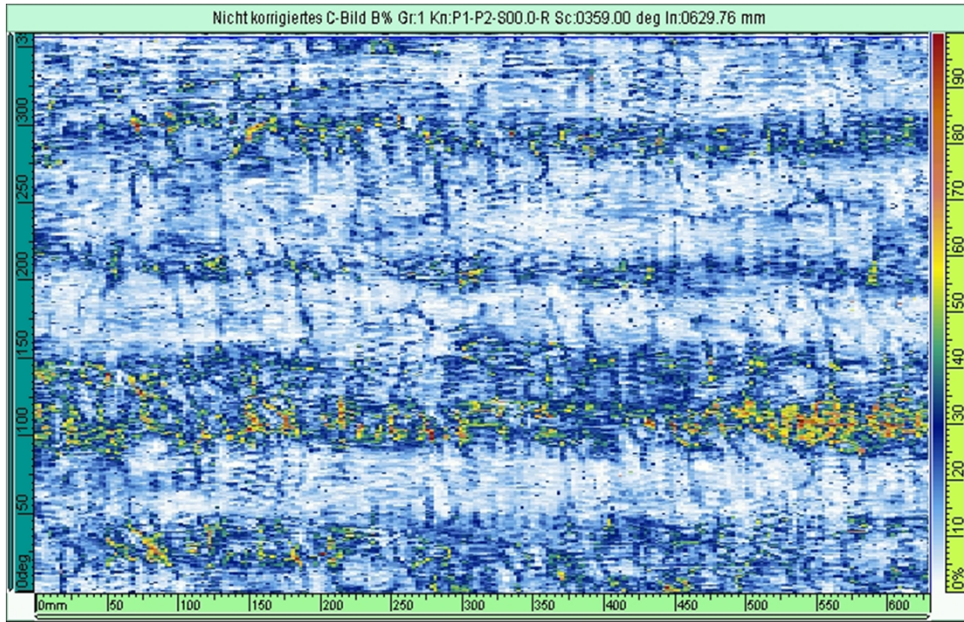
Detection of ,natural' air voids in bonded joints



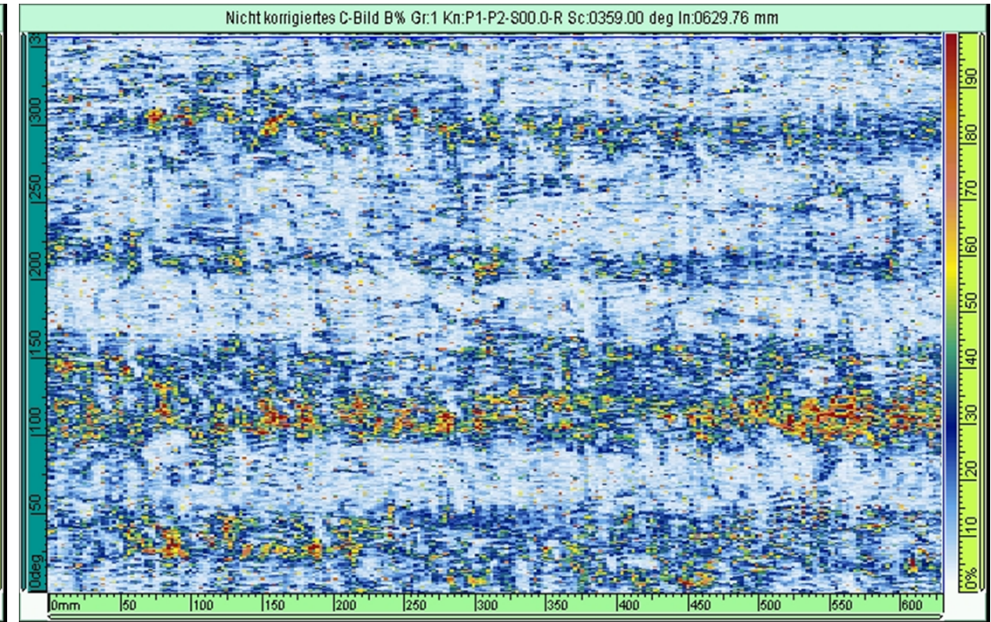
Results of inspection of bonded joints (168 mm tubes) before destructive testing.

Ultrasonic Inspection of adhesively bonded Joints

Results Joint II



Echo No. 4

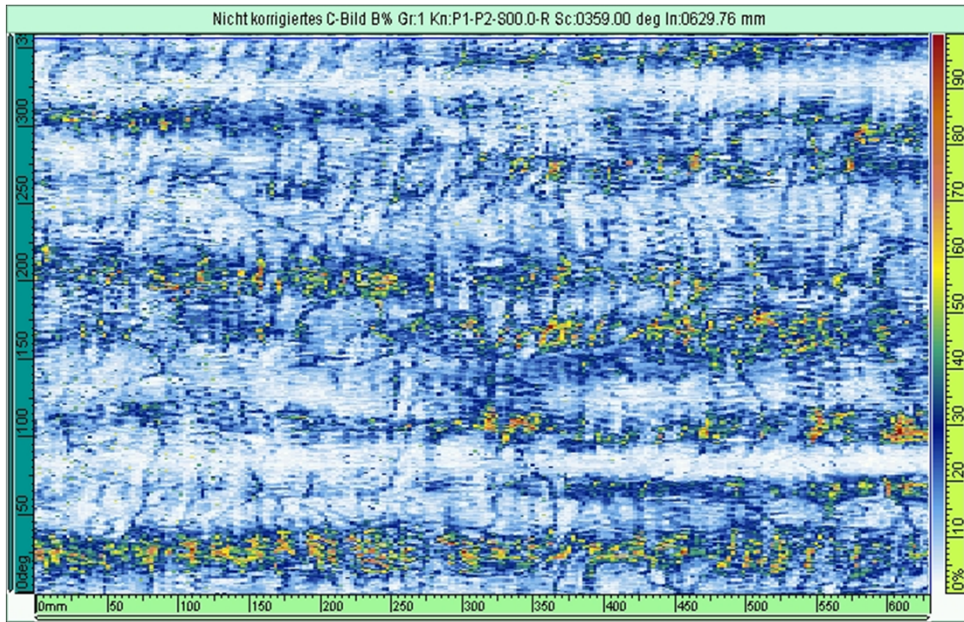


Echo No. 6

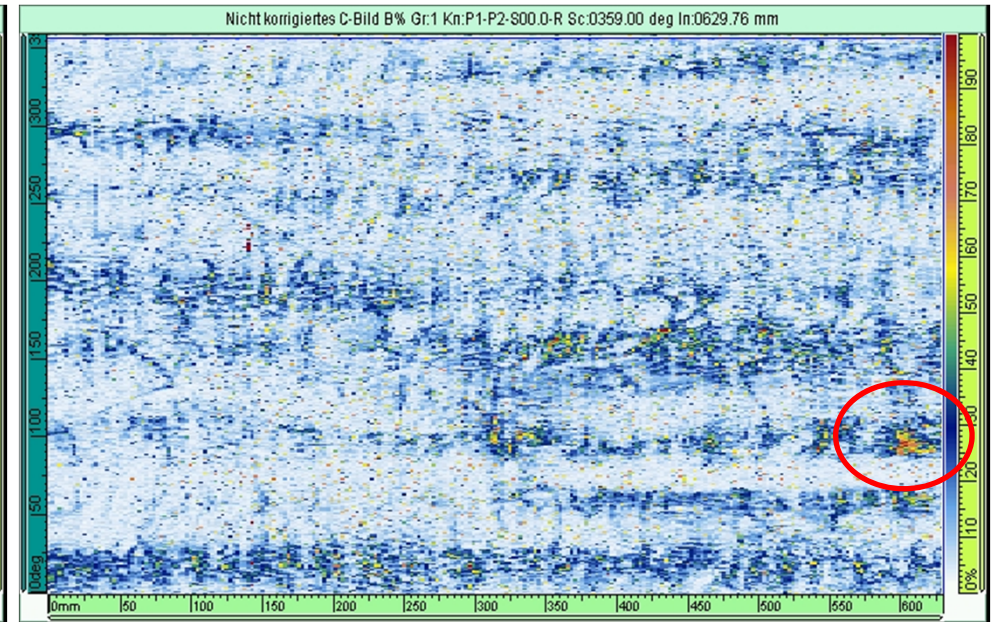
- Done by automatic inspection.
- No indication for air void found.
- Liquid adhesive found.

Ultrasonic Inspection of adhesively bonded Joints

Results Joint IV



Echo No. 4

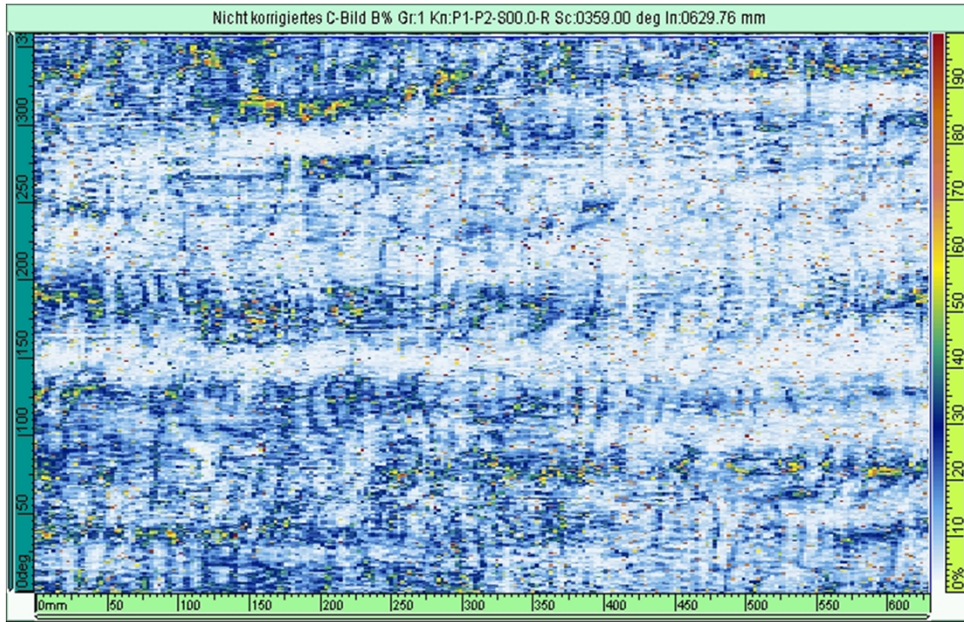


Echo No. 6

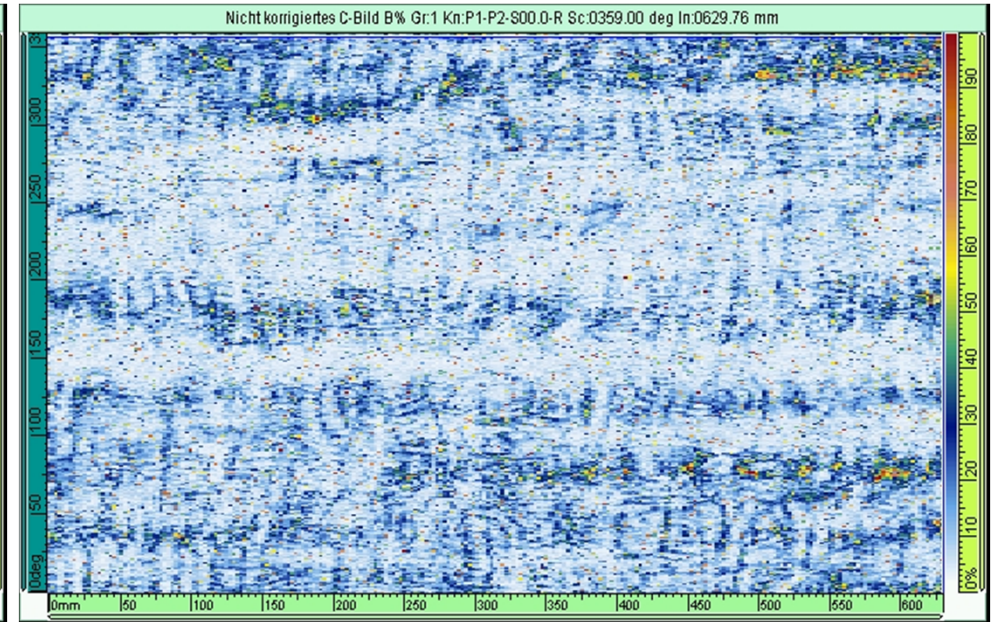
- Done by automatic inspection.
- Indication for air void found in the position of the filling holes. → *Feedback*
- No liquid adhesive found.

Ultrasonic Inspection of adhesively bonded Joints

Results Joint V



Echo No. 4

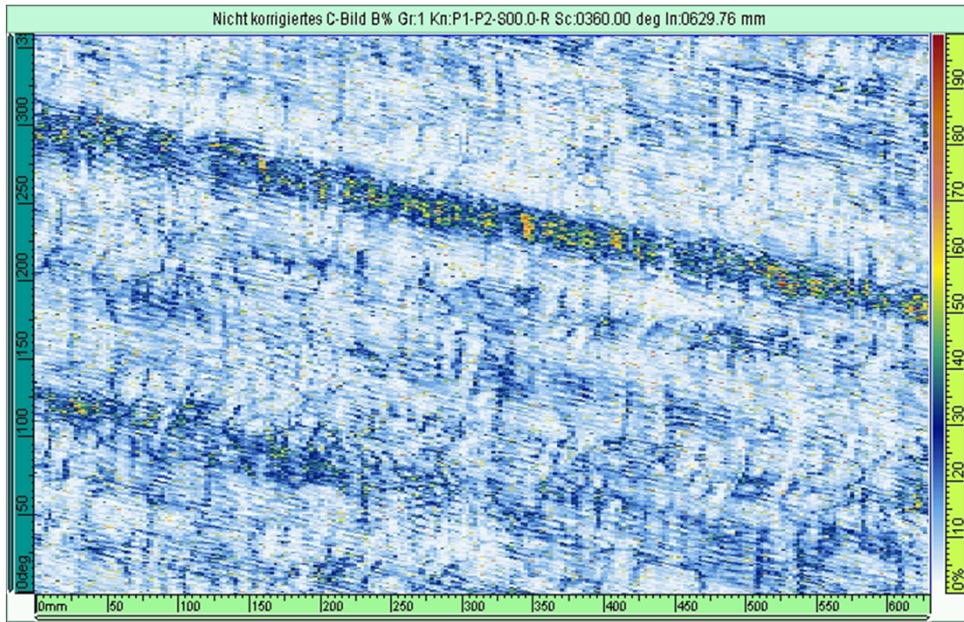


Echo No. 6

- Done by automatic inspection.
- No indication for air void found.
- Liquid adhesive found.

Ultrasonic Inspection of adhesively bonded Joints

Results Joint VII

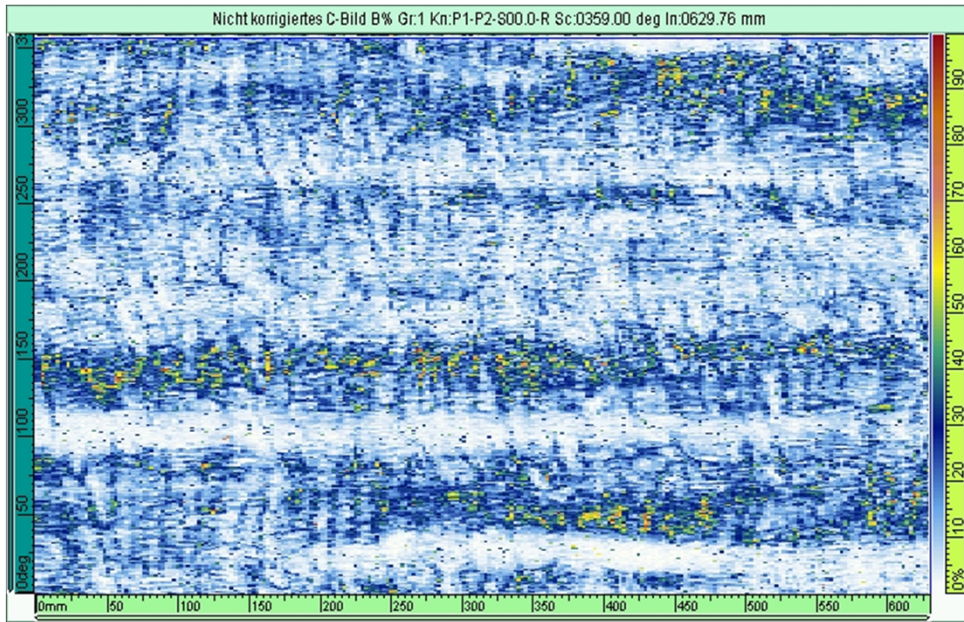


Echo No. 4

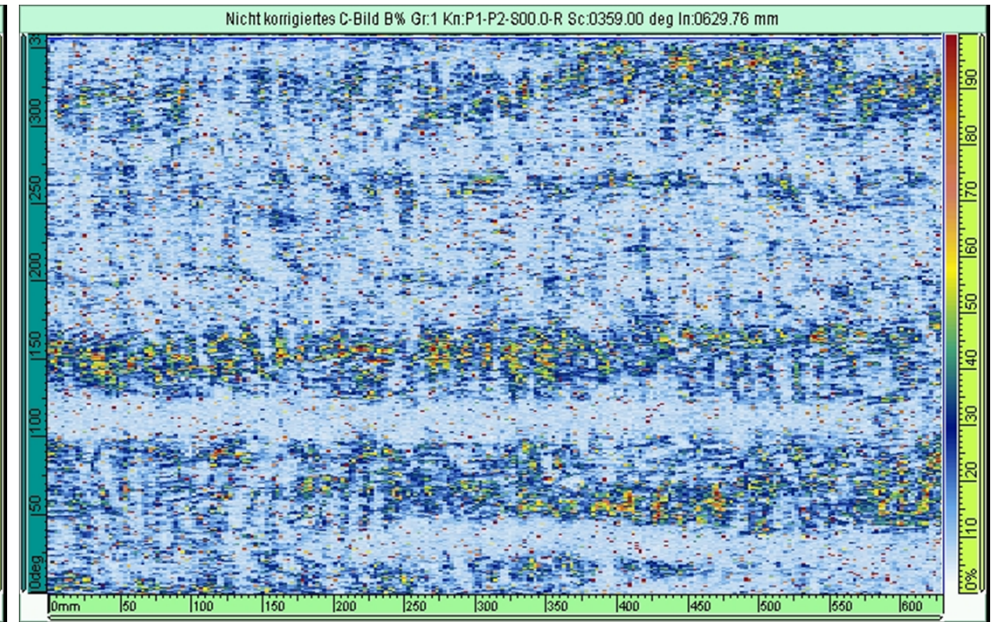
- Done by automatic inspection.
- No indication for air void found.
- Liquid adhesive found.

Ultrasonic Inspection of adhesively bonded Joints

Results Joint VIII



Echo No. 4



Echo No. 6

- Done by automatic inspection.
- No indication for air void found.
- No liquid adhesive found.

Results from tubes

- Mechanics were set up to do inspection.
- Inspection of large diameter bonds was difficult due to geometry of the sleeve.
- One possible indication for an air void was found.
- If adhesive is liquid or not cannot be detected by UT.
- **For a reliable inspection good geometry quality of the sleeve is necessary.**