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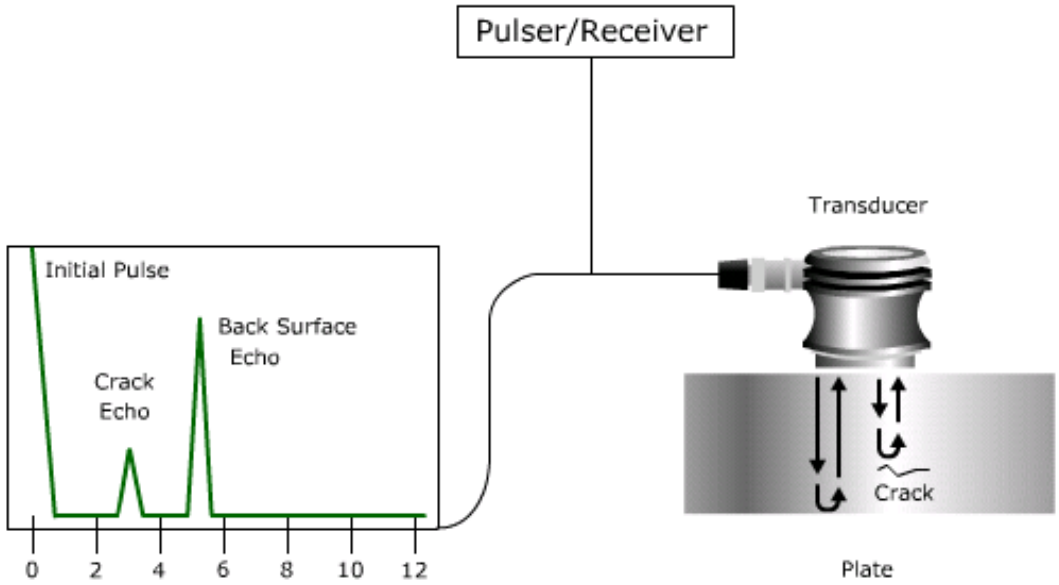
Ultrasonic Inspection of adhesively bonded Joints

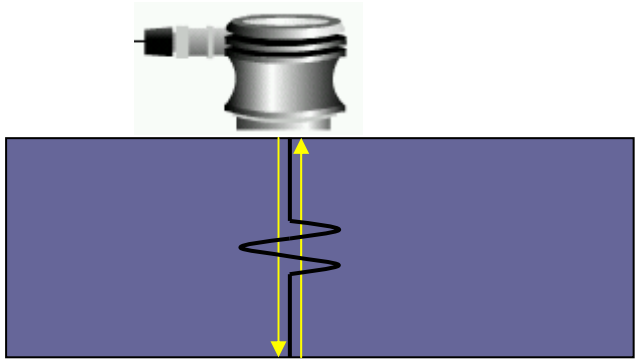
M. Kaack, Th. Orth

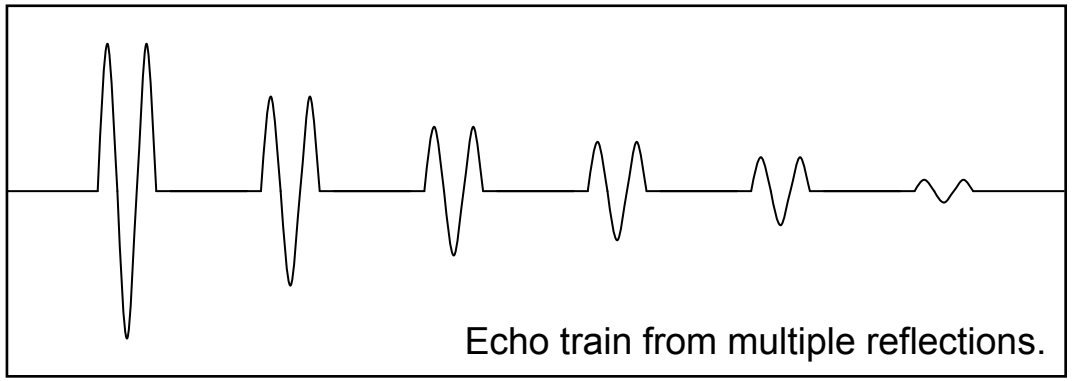
Duisburg , 2nd / 3rd December 2009

Ultrasonic Inspection Techniques for adhesively bonded joints
Perpendicular Inspection



- Ultrasonic wave is generated by piezoelectric transducer supplied by some 100 volts.
- Coupling by oil or immersion technique.
- Reflections from interface layers.
- Ultrasonic wave runs several times through the sample.
- Wave is attenuated.





Ultrasonic Inspection Techniques for adhesively bonded joints
Different defect types

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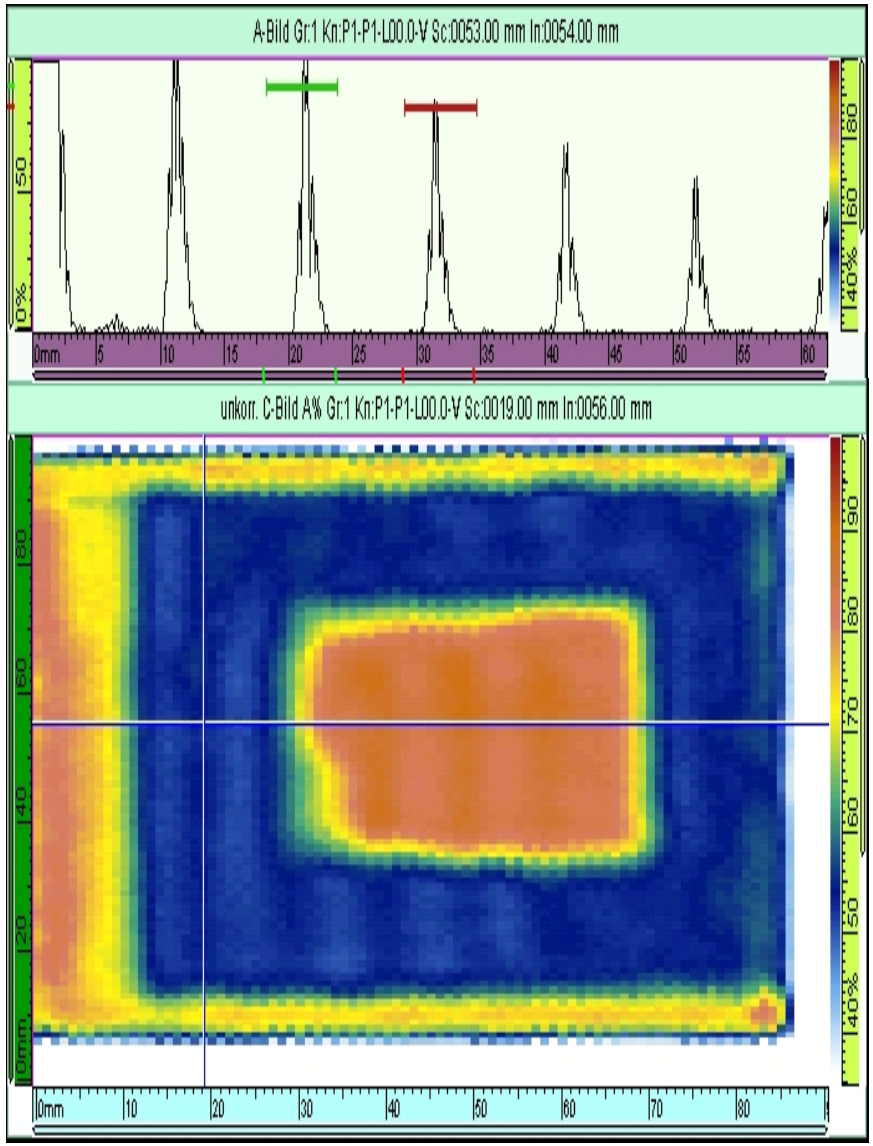
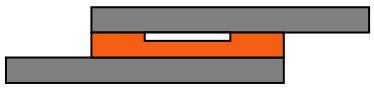
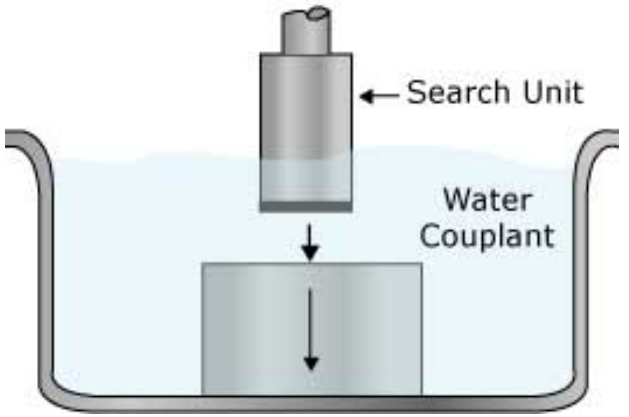


- Amplitudes of third backwall echo was recorded by automated scanning the sample.
- Immersion technique in water bath was used.
- Circular void is clearly visible!
  (scaling on x- and y- axis different)

Teflon strip on inner interface





Ultrasonic Inspection Techniques for adhesively bonded joints
Real adhesively bonded samples

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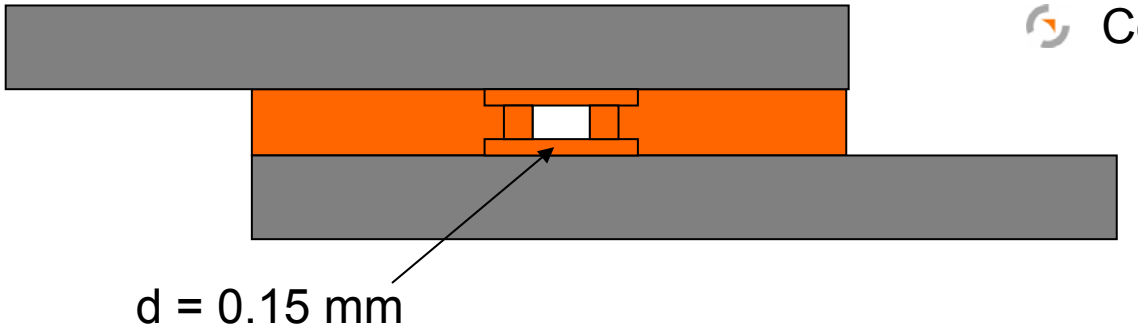
- In real samples a thin adhesive layer is present around an air void.
- Comparable test defects were made.



Ultrasonic Inspection Techniques for adhesively bonded joints
Frequency dependence

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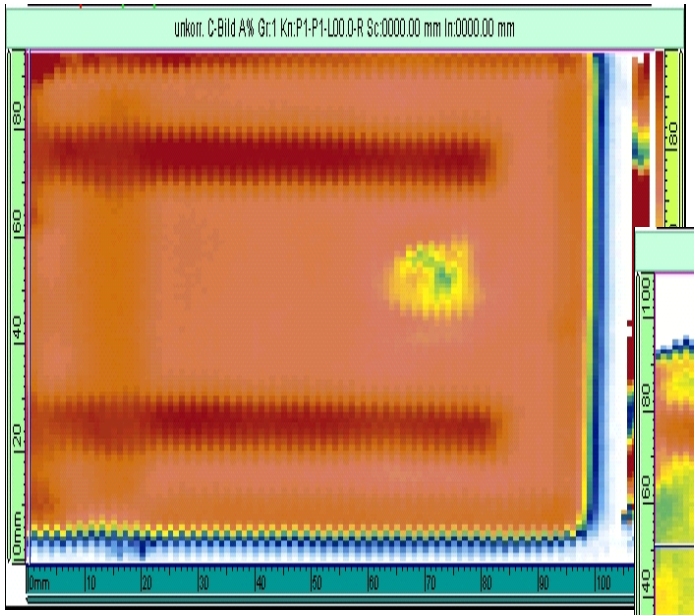
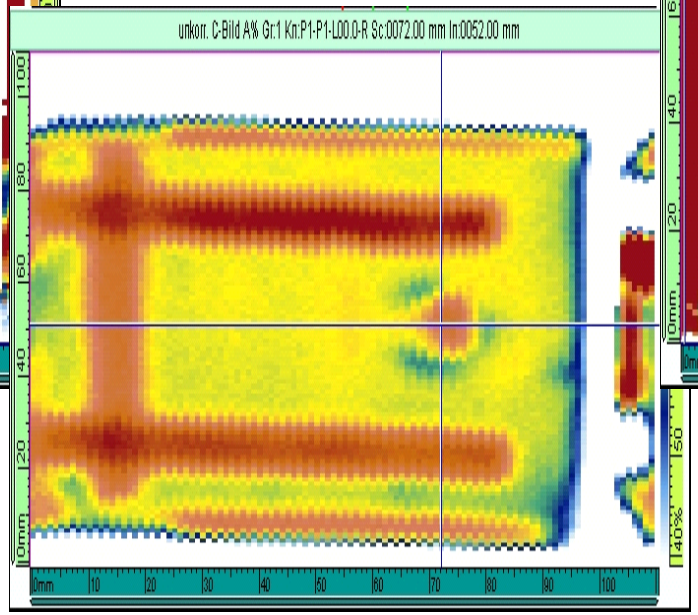
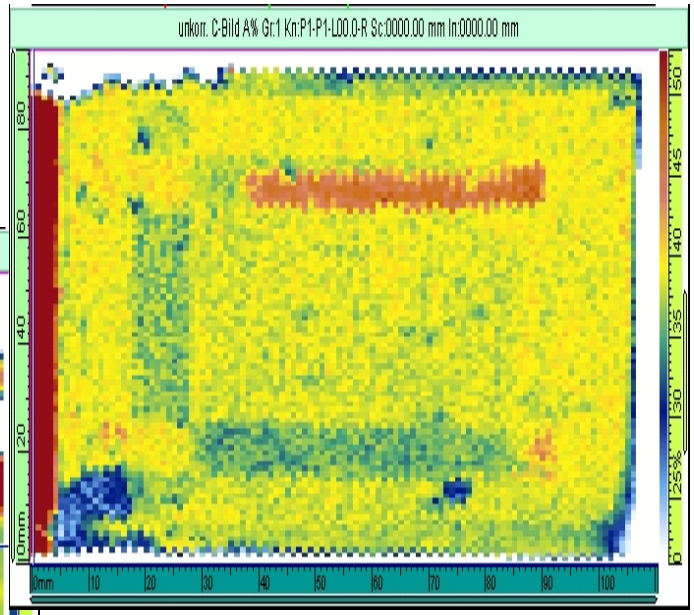


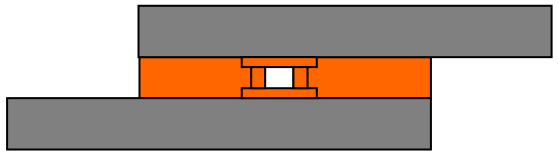
LBL, 2 MHz



LBL, 5 MHz



LBL, 20 MHz



- Significant dependence on frequency particularly for high frequencies.

Ultrasonic Inspection Techniques for adhesively bonded joints
Piezoelectric Transducer Heads

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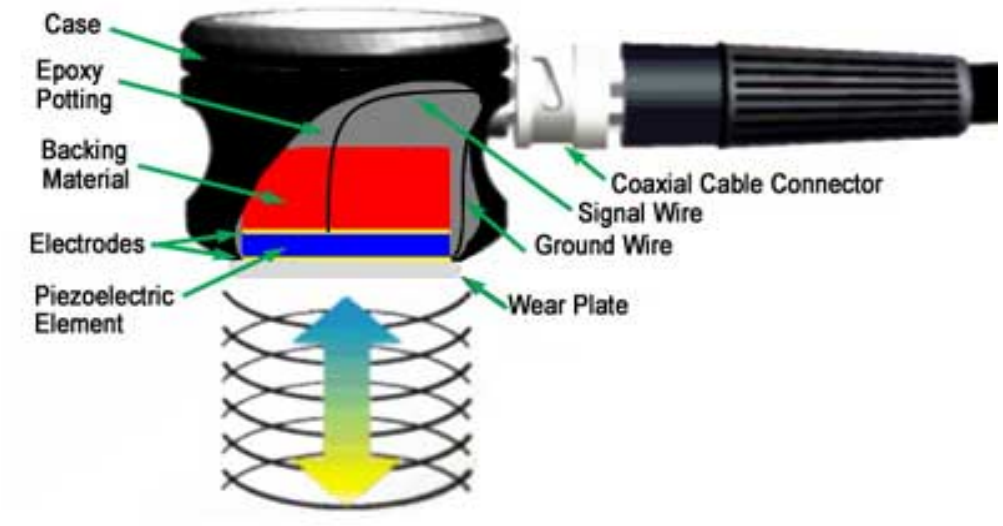

- Ultrasonic heads are equipped with a piezoelectric device (transducer).
- Typical frequencies: 0.5 MHz to 25 MHz
  Typical voltages : a few 100 V
- Depending on orientation longitudinal or transversal waves can be generated.

Ultrasonic Inspection Techniques for adhesively bonded joints
EMAT-Technique

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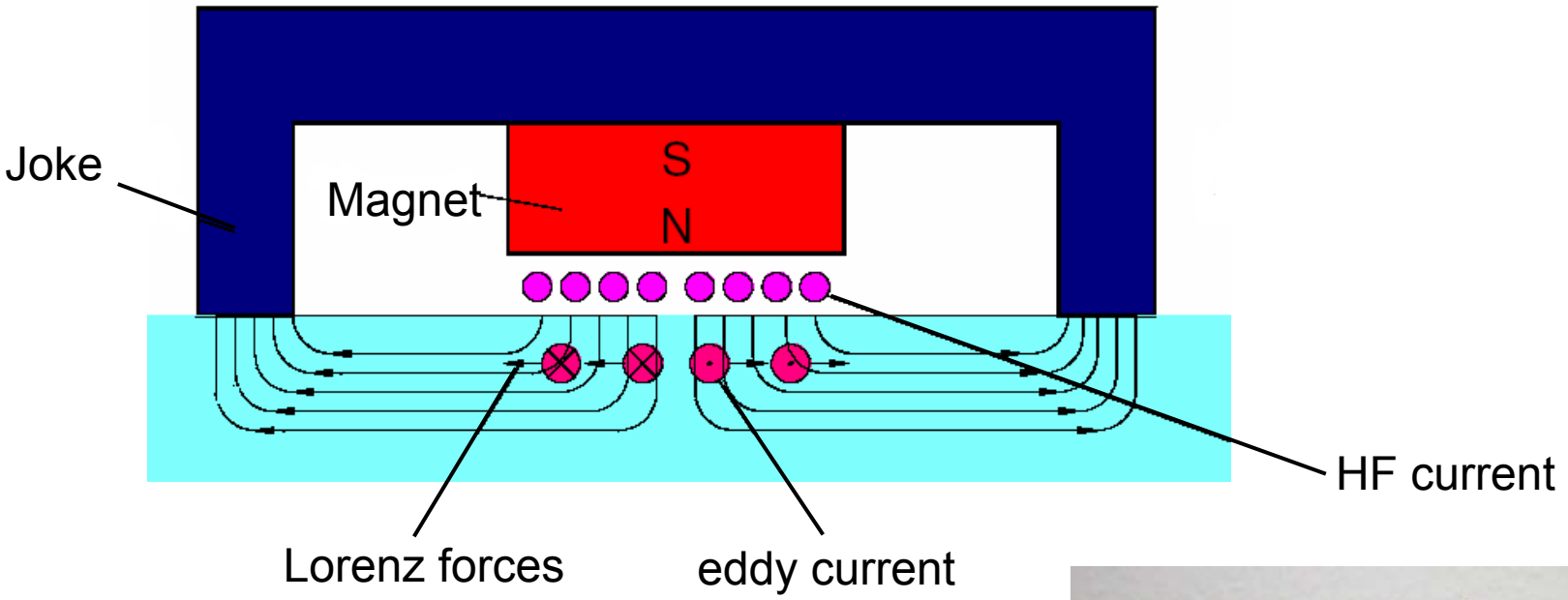

Properties of EMAT-inspection:

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

Ultrasonic Inspection Techniques for adhesively bonded joints
Piezo <-> EMAT-Technique

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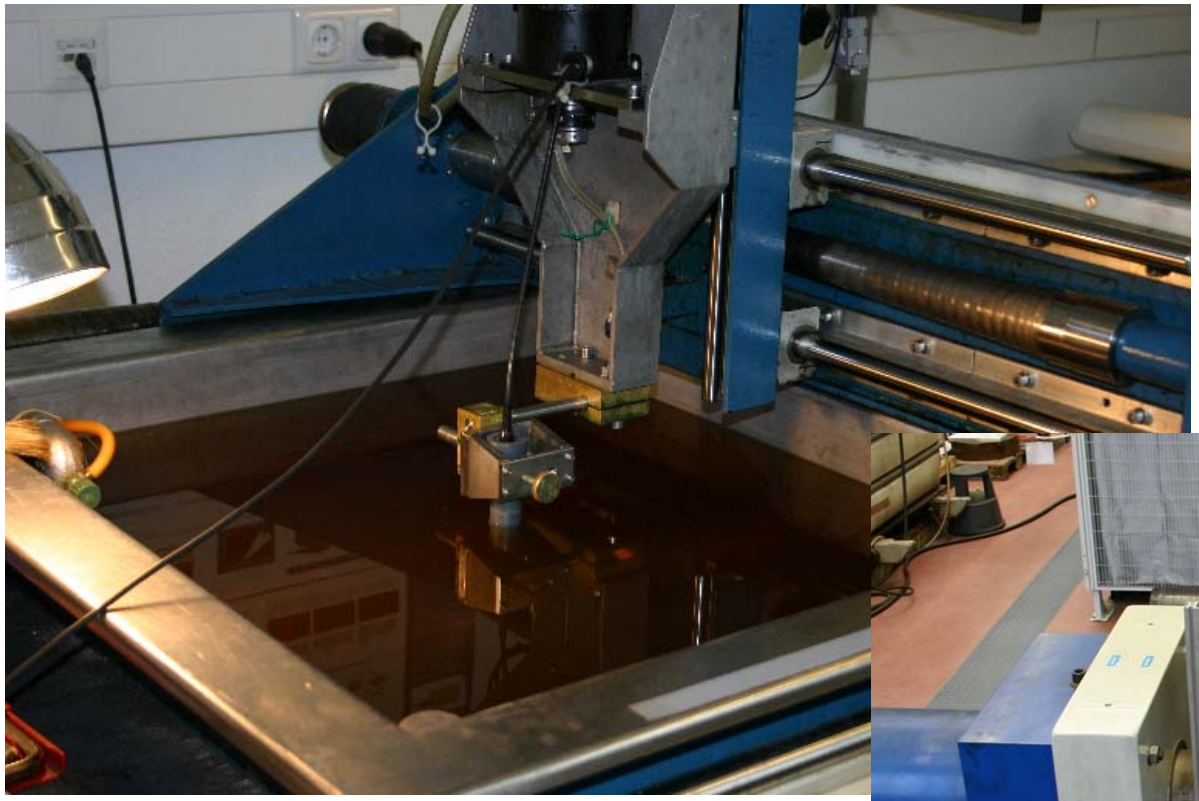
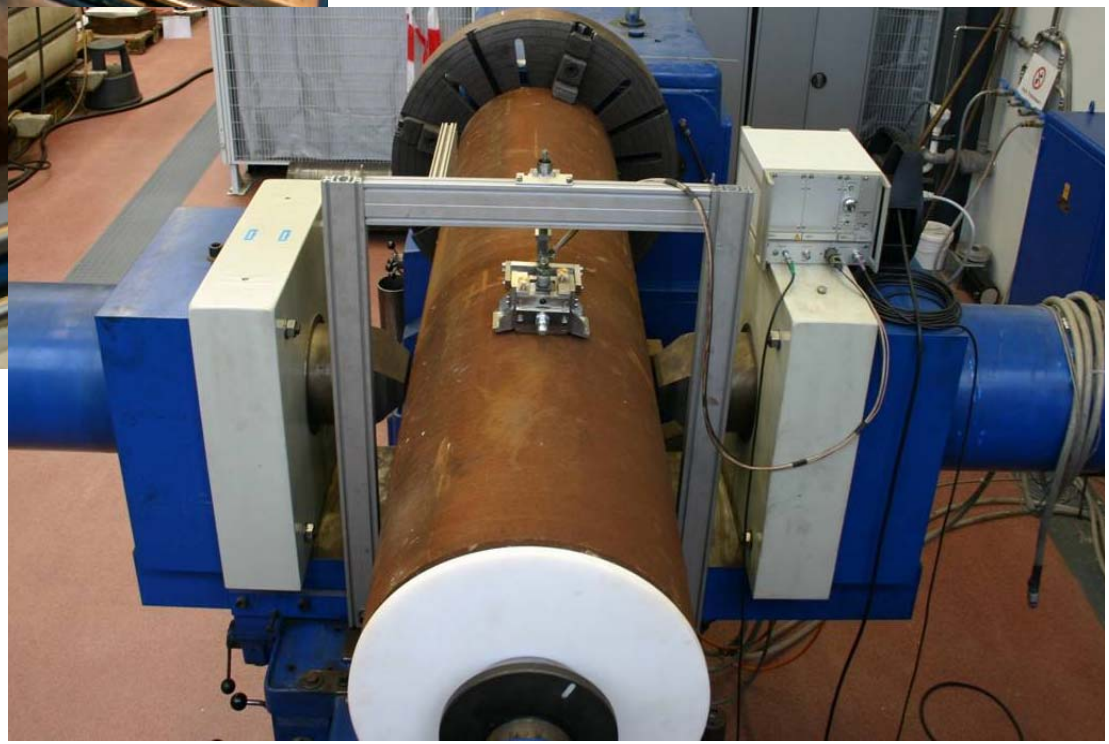


- Typical setup for Piezo - Testing
- Limitation in size of specimen



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

Ultrasonic Inspection Techniques for adhesively bonded joints
Artificial air voids

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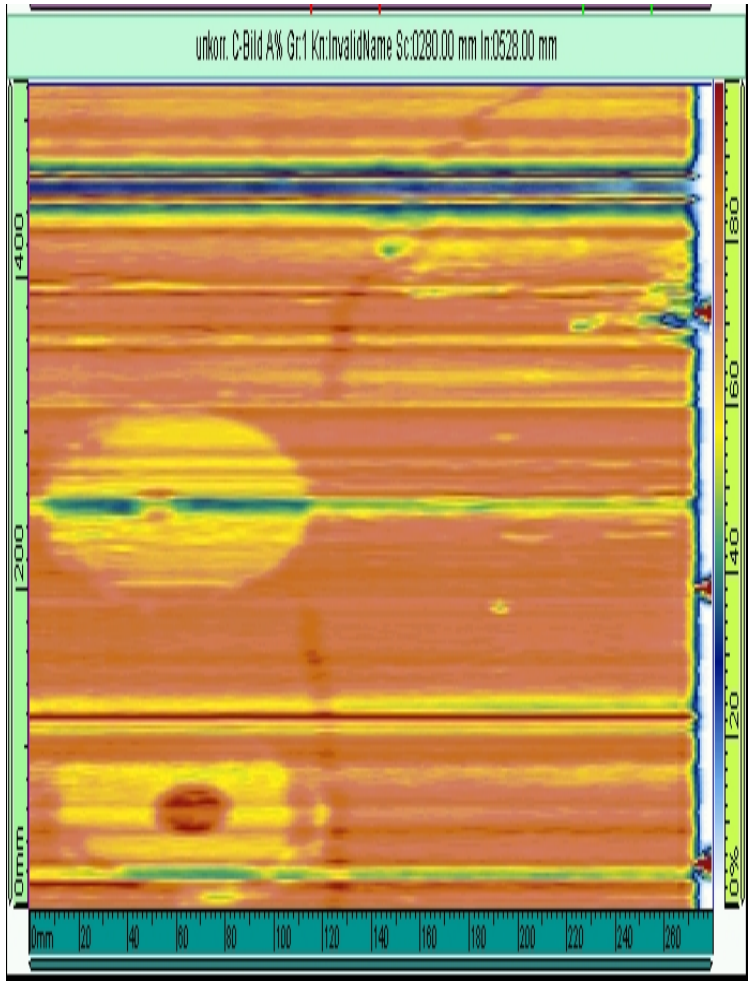
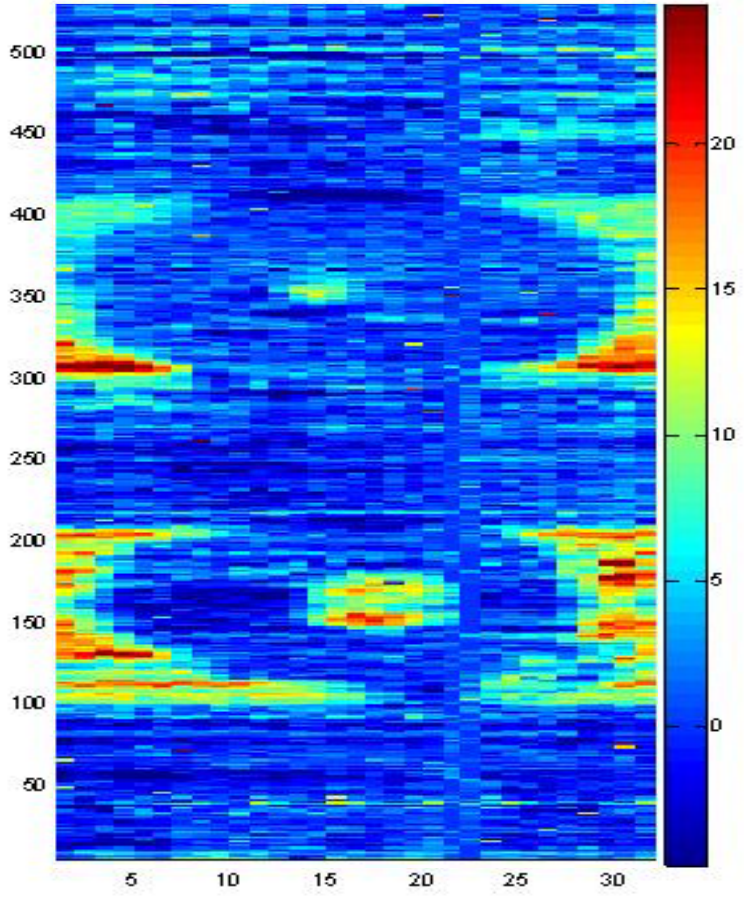


Piezo technique



EMAT technique
data processing

Ultrasonic Inspection Techniques for adhesively bonded joints
Investigation of sleeves

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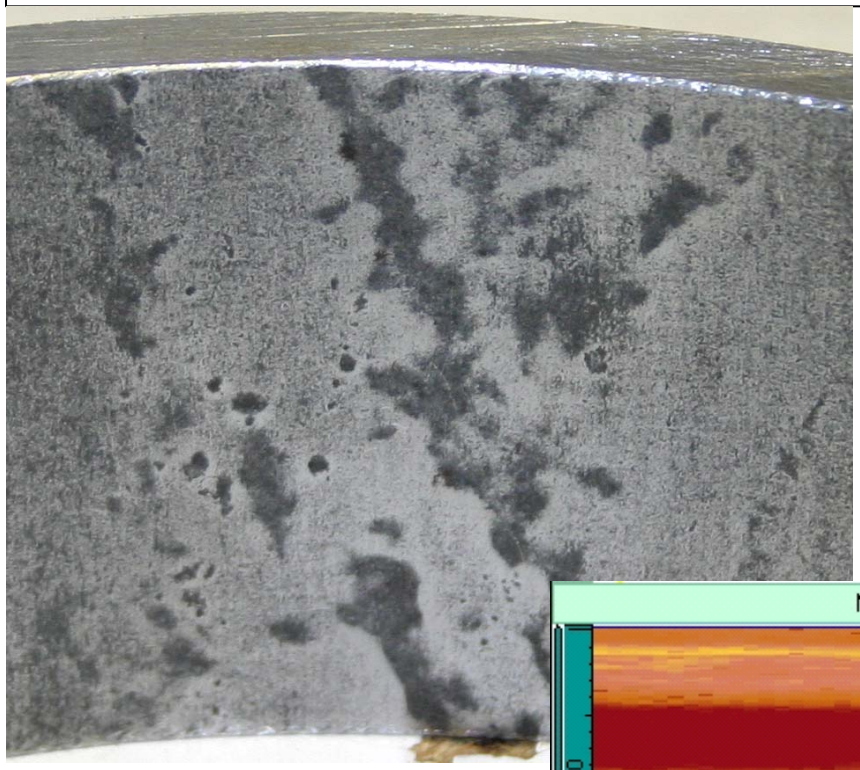
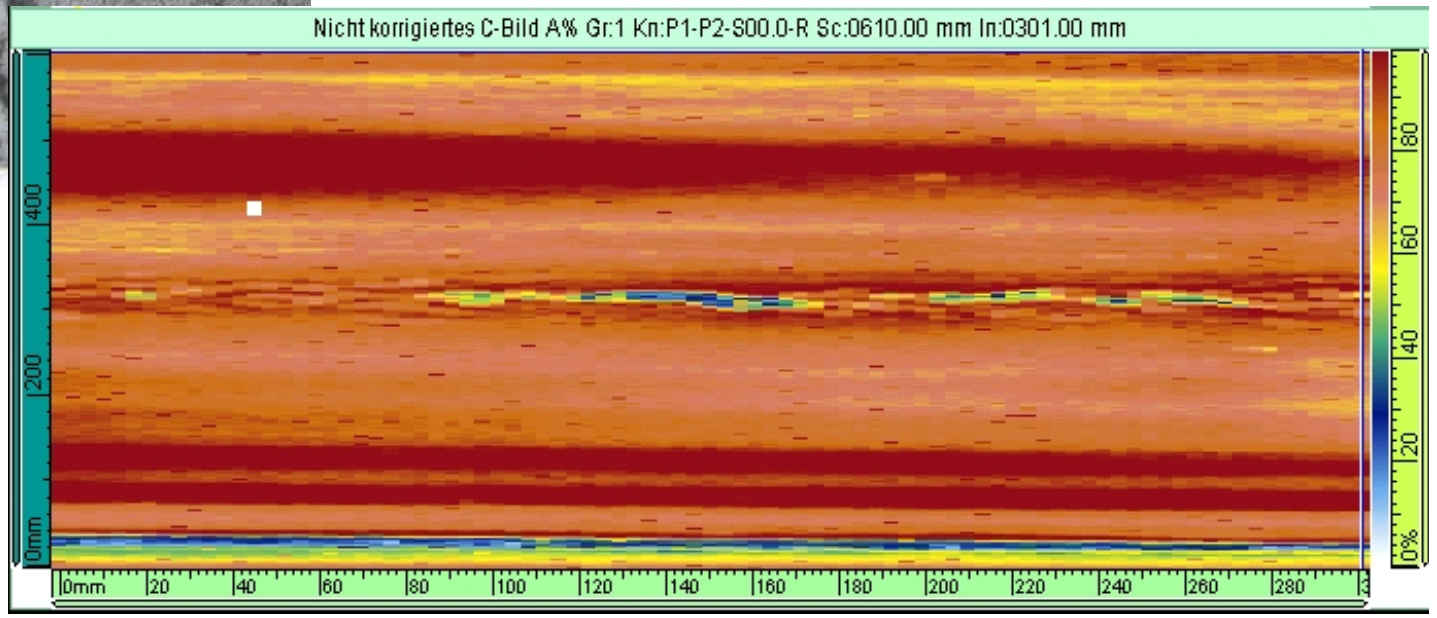
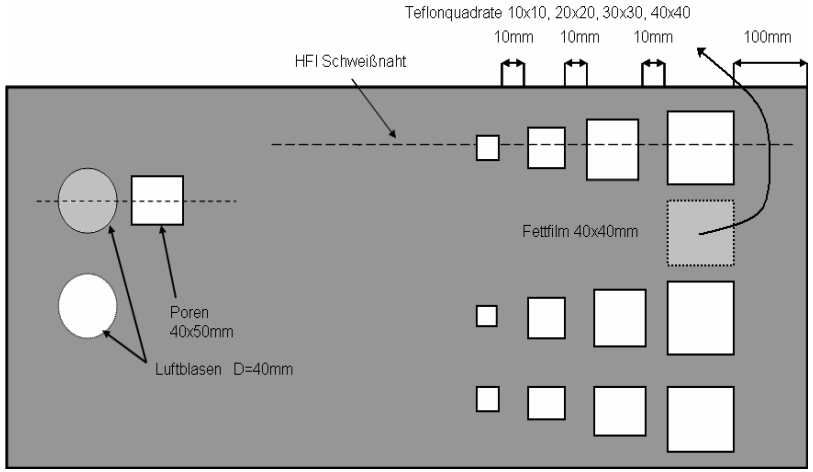


- Sleeves for 168 mm tubes have a ‘corrosion line’ opposite to the weld seam.
- These both lines lead always to UT-indications!

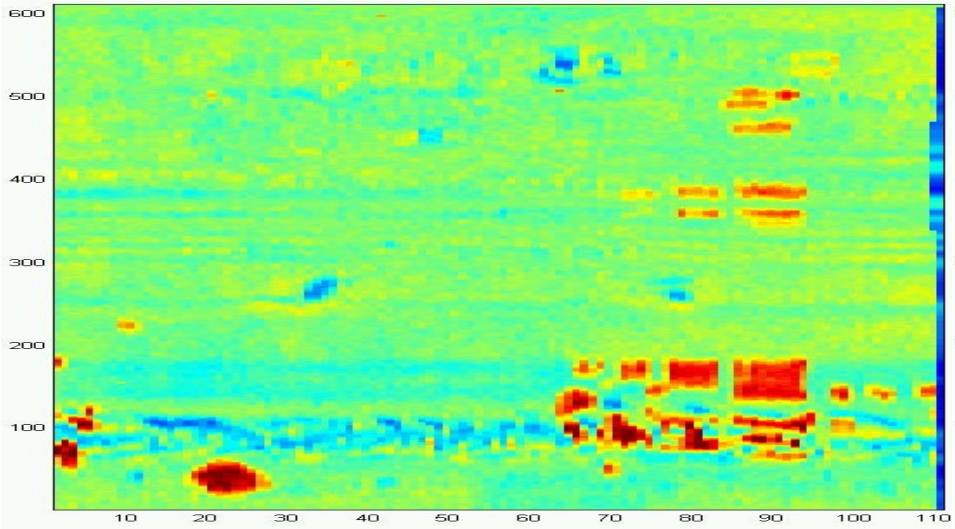


- To be placed in 3 o’clock and 9 o’clock positions.

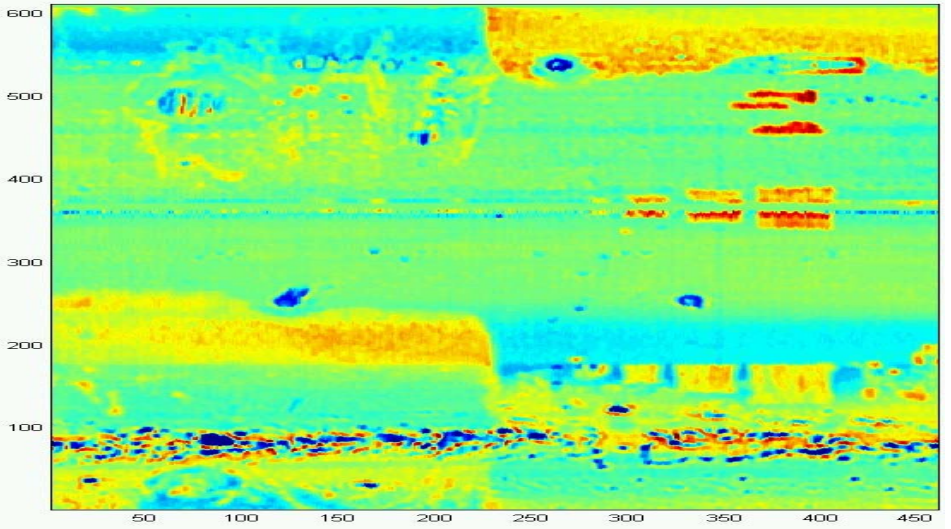
Ultrasonic Inspection Techniques for adhesively bonded joints
Prepared test tube



- A test tube was prepared in Salzgitter (Dr. Flügge) with several characteristic artificial defects.
- The relevant defects could be detected.
- Difficult to detect air voids on inner interface.



Result from EMAT- testing



Result from Piezo- testing

Ultrasonic Inspection Techniques for adhesively bonded joints
Detection of ‚natural' air voids in bonded joints

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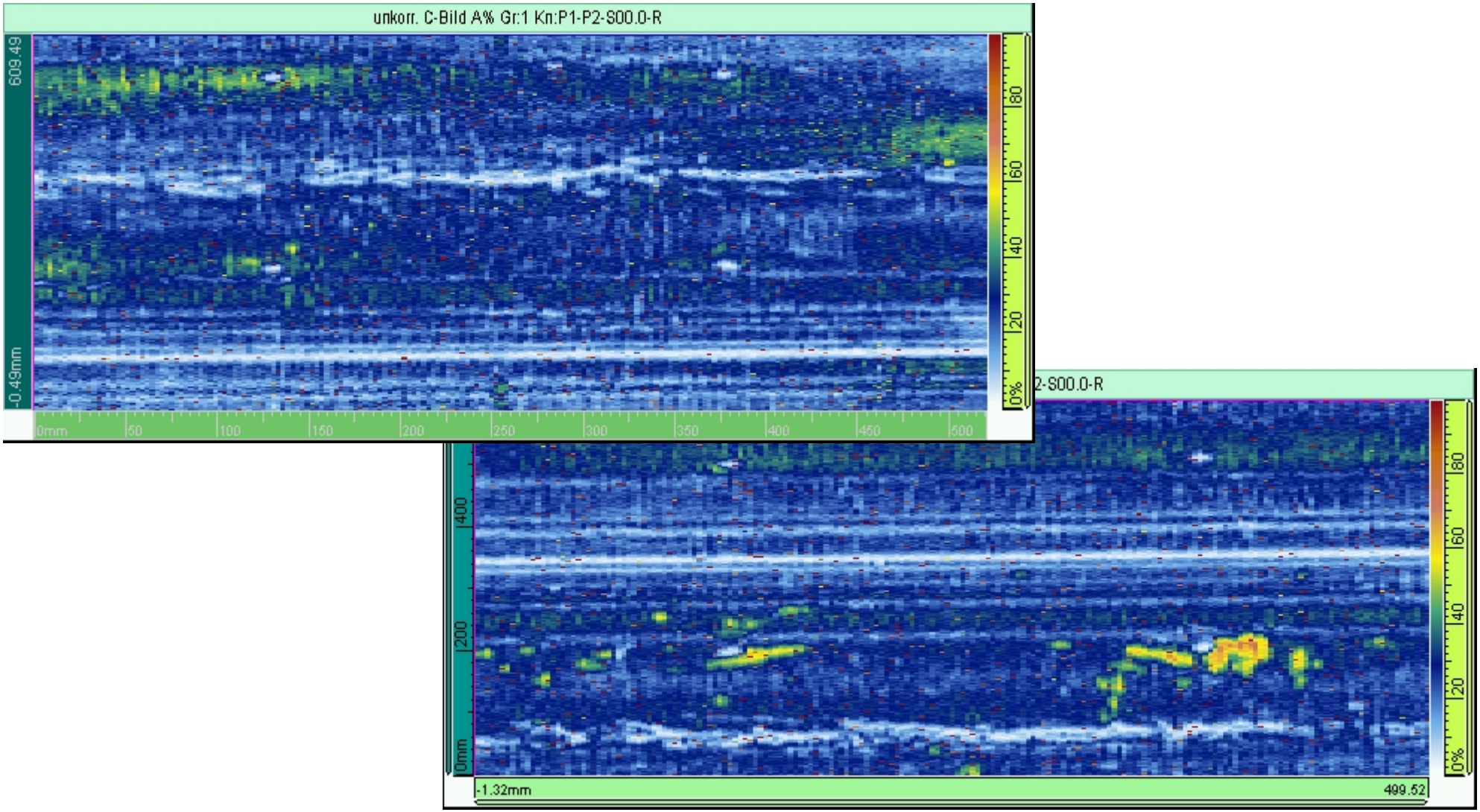

- Results of inspection of bonded joints (168 mm tubes) before destructive testing.

Ultrasonic Inspection Techniques for adhesively bonded joints
Detection of ‚natural' air voids in bonded joints

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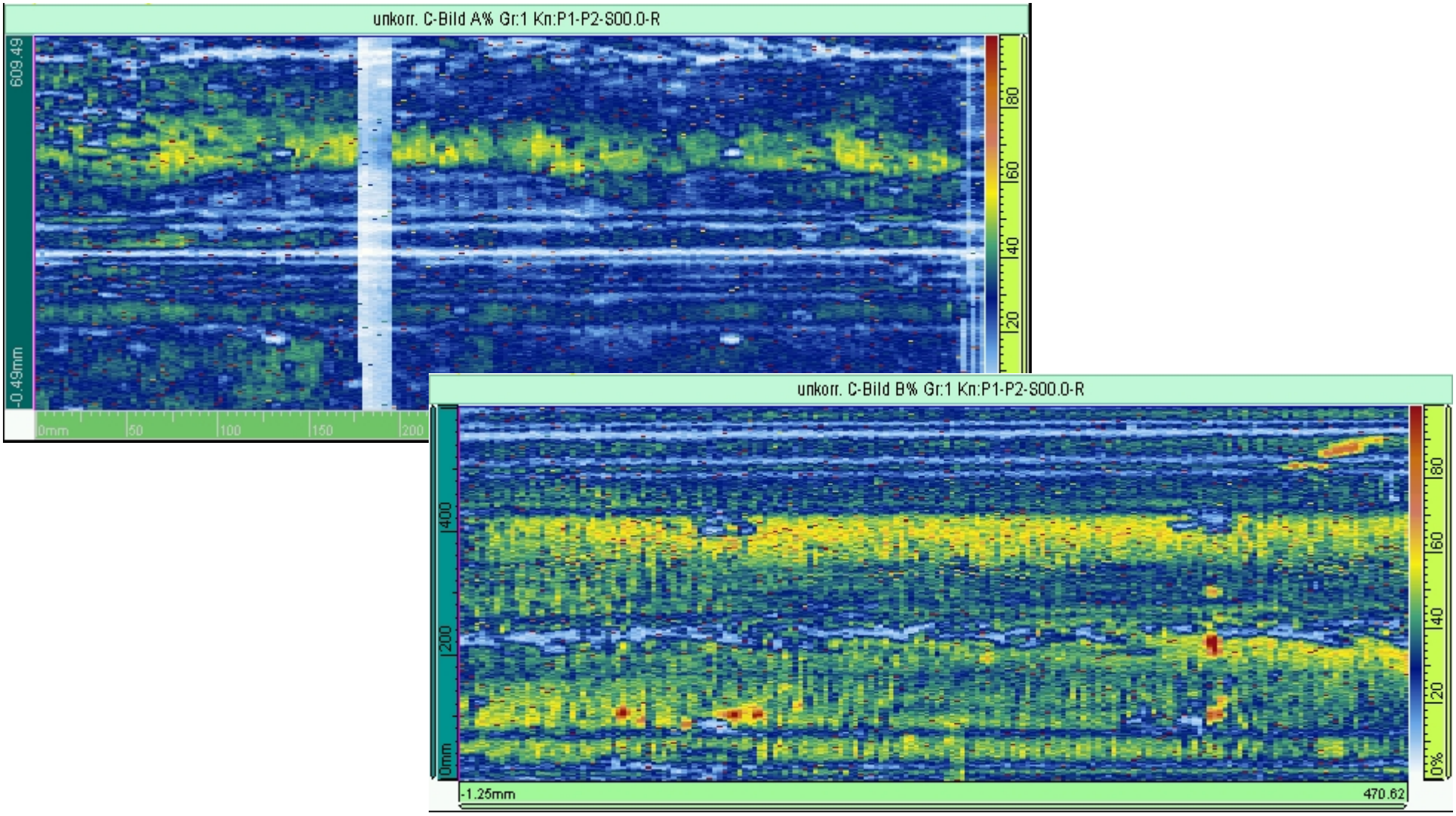

- Results of inspection of bonded joints (168 mm tubes) before destructive testing.

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Results from tubes

- Piezo- and EMAT- technique can be used for inspection.
- EMAT has advantage in the field as coupling is easier, but more sensitive to disturbances.
- Weld seam cannot be inspected → 3 o'clock position.
- Sleeves with corrosion line on inside show always indication there.
- Relevant defects in test tube could be detected.
- Voids on inner side of gap are difficult to detect.
- Natural defects in bonded joints were found.
- Patent application.

Next steps

- Inspection of large diameter bonds.
- Transfer of technique to field application (mechanics !).