

## Study of Special Challenges for NDT-Methods on Nuclear Structures

Stefan MAACK<sup>1</sup>, Björn THUNELL<sup>2</sup>, Herbert WIGGENHAUSER<sup>1</sup>

<sup>1</sup>BAM, Bundesanstalt für Materialforschung und -prüfung, Unter den Eichen 87, 12205 Berlin, Germany,  
Phone +493081044246, Fax: +493081041447, e-mail: stefan.maack@bam.de, herbert.wiggenhauser@bam.de

<sup>2</sup>Scanscot Technology AB, Emdalavägen 10, SE-22369 Lund, Sweden,  
Phone +462765233, e-mail: thunell@scanscot.com

### Abstract

The special design of buildings, constructed for nuclear power plants is a particular challenge for the non-destructive testing in the building industry. In particular the major component thicknesses, the degree of reinforcement and surface coating systems make the application of NDT methods difficult. The studies first steps were undertaken to determine to which extent established applications of these techniques are useable in the field of infrastructure buildings. Methods have been evaluated that are already state of the art. So for example the ground penetrating radar was used for locating metallic mounting parts. Furthermore, the low-lying internal structure of the containment was investigated with the ultrasonic method.

**Keywords:** non-destructive testing, ground penetrating radar, ultrasonic, nuclear structures, pulse echo technique

## 1. Introduction

Applied at infrastructure buildings, the non-destructive testing have already impressively demonstrated their performance. With these methods, questions about the localization of tendons or the determination of the thickness of components can be answered very well. Building structures of the nuclear industry often show such constructive elements. However, in contrast to infrastructure buildings, the construction design of NPP's has special characteristics. So the concrete covers are usually much larger. Furthermore, most of the concrete surfaces of the inner construction have coatings, in order to allow easy and fast cleaning (Figure 1).



Figure 1: Overview of measuring areas for non-destructive testing at the outer side of the containment [1][3]

The goal of the research is to show how far non-destructive testing can be implemented technically at these structures. In this investigation state-of-the-art techniques were applied. This includes the detection of metal parts with the ground penetrating radar and the ultrasonic

echo method for locating low-lying elements such as the liner. In addition to the results presented here, further investigations were carried out which go beyond the state-of-the-art and constitute the state of science and research. A detailed documentation of these results is shown in [1][3]. Figure 1 shows the study areas on the outer containment of the power plant.

## 2. Results

### Ground penetrating radar

With the radar method an excellent technique is available for the professional to detect metallic fixtures within concrete structures [7][8]. The radar investigations were carried out manually with a measuring grid of 5 cm with vertical and horizontal measuring lines with a 2.6 GHz antenna. The results of the measurement Field 1 are presented in (Figure 1). The measuring area has a width of 3.5 m and a height of 2.5 m. All measurements shown are reconstructed with the SAFT algorithm [4][5][6]. The slight curvature of the surface of the containment can be neglected in the SAFT-algorithm due to the large radius.

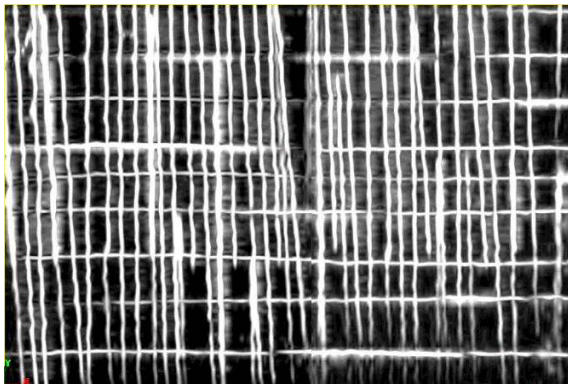


Figure 2: Time slice of a reconstructed radargram at a depth of 8,0 cm

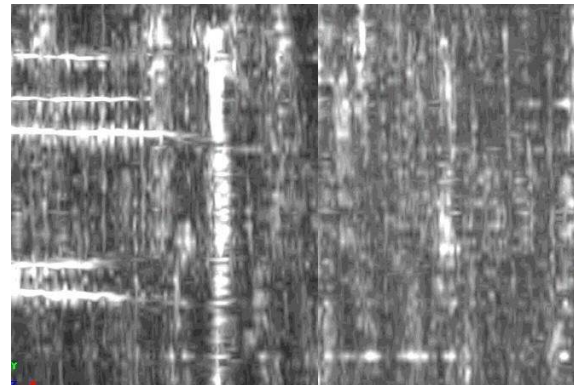


Figure 3: Time slice of a reconstructed radargram at a depth of 18,0 cm

The results of the tests are shown in Figure 2 and Figure 3. Figure 2 shows the C-scan at a depth of 8 cm. The horizontally and vertically extending conventional reinforcement is recognizable very well. In Figure 3 the C-scan of the reconstructed data at a depth of 18 cm can be seen. On the right side of the C-scan the horizontal tendons are visible. Due to the different depth of in this section, they can be seen first. In the central area a vertically running mounting for the horizontally tendons is well identifiable. The liner, which is located at a depth of about 74 cm, can not be detected by ground-penetrating radar because of the high density of near-surface reinforcement. The surface coating has no impact on the measurements with this method.

## 3. Ultrasonic

For the ultrasonic measurements an automatic scanning system was used. This scanner has been developed at BAM and enables a high number of measurement points with a high precision of measurement [1][3]. The results presented here were recorded at the measuring area field 01 (Figure 1). The measuring area was investigated with a measurement point offset of 2 cm in both scanning directions. The middle frequency of the transversal wave probe is 60 kHz, which was determined in preliminary studies. Additional results of the tests are documented in [1] and [3].

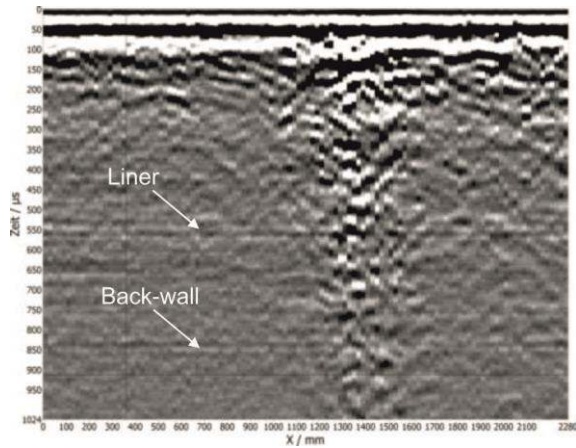


Figure 4: B-scan from the test measuring field recorded with an middle frequency of 60 kHz [3]

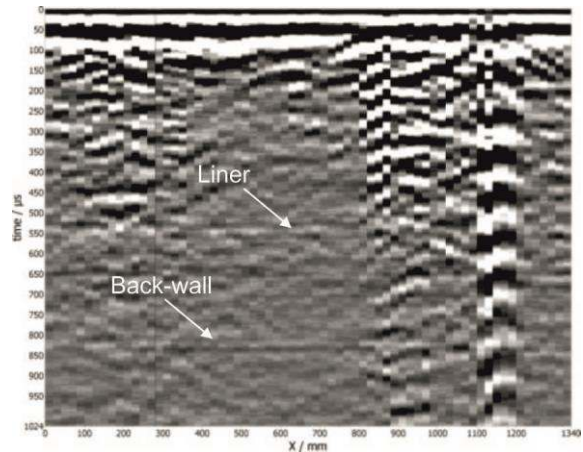


Figure 5: B-scan from the test measuring field recorded with an middle frequency of 30 kHz [3]

The images Figure 4 and Figure 5 show two B-scans taken at the measuring field 01. Here it was investigated, with which frequency the optimal results can be achieved. There were no significant differences for the B-scans. In both images, the liner at a depth of 74 cm and also parts of the back wall of the containment at a depth of about 100 cm can be detected. Therefore, further studies with a mean frequency of 60 kHz were performed.

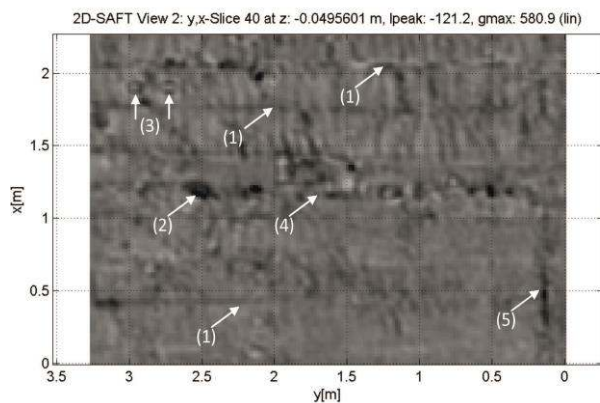


Figure 6: C-scan of ultrasound measurement field 01 in a reconstructed depth of 5,0 cm, recorded with a middle frequency of 60 kHz ((1) – reinforcement bars, (2)/(3) – single reflector, (4) - different coating/ crack, (5) - crack)

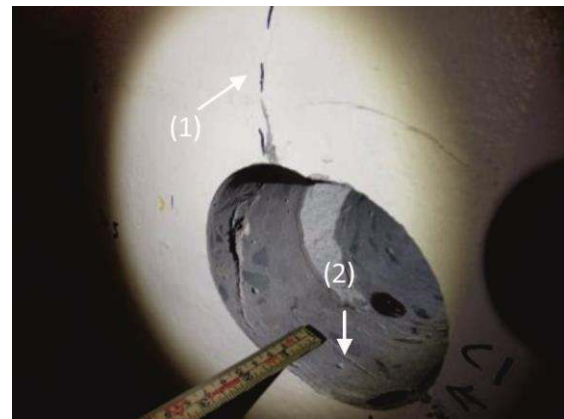


Figure 7: Crack path indicated by a drilling core taken in measuring area the ultrasound investigations (marking – (1), crack – (2))

Figure 6 shows the C-scan of a reconstructed ultrasonic data set at a depth of 8 cm. In the C-scan, different features are emerging in the image signal. Especially the cracks near the surface (Figure 7) hinder a detailed examination of the internal structure significantly. The coating of the containment concrete affect the results only slightly. In areas where this coating has been removed, the signal amplitude is significantly greater (Figure 4, Figure 5). This leads to artifacts in the SAFT-reconstruction of ultrasound data.

#### 4. Conclusions and outlook

In summary it can be stated for the radar investigations that the reinforcement can be detected very well. With the antennas used, it is possible to detect metallic elements to a depth of about 23 cm. Underlying objects cannot be determined due to the dense near-surface reinforcement.

The process technology is well suited for this inspection task due to its high recording speed of several square meters per hour.

In the ultrasound examinations the liner in a depth of about 74 cm and the back wall can be detected at a depth of about 100 cm. Due to the near-surface cracks a detailed resolution of the internal construction is not possible. A continuous surface coating affects the measurements only to a small extent. Only in areas where the coating has been removed, an overdrive of the ultrasonic signals occurred and made the analysis here very complex. The ultrasonic method is much slower compared to the radar method. But it delivers information from greater depths of the construction. Therefore, such investigations should be carried out with the ultrasonic method. Here it must be ensured that cracks on the surface do not hinder the measurements.

## 5. References

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