# Observer POD for Radiographic Testing

Daniel KANZLER*, Christina MÜLLER*, Marija Bertovic*, Jorma PITKÄNEN**
* BAM Bundesanstalt für Materialforschung und -prüfung, Berlin, Germany
** Posiva Oy, Eurajoki, Finland

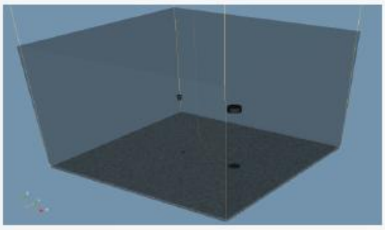
**Abstract**

The radiographic testing is an important non-destructive testing method, especially in industrial areas where people could be injured in case of failing of a component. There it is a mighty method to find volumetric defects. As bigger the penetrated length of the defect in the component is, as bigger is the radiographic contrast. The detectability of volumetric defects in its turn is not only depending on the contrast but also on the noise, the defect area and its shape, . The currently applied POD approach uses mostly only the contrast and the noise as detection threshold. This does not reflect accurately the results of evaluations by human observers. A new approach is introduced, using the widely applied POD evaluation and additionally a detection threshold depending on the area of the defect. The presentation shows the process of calculating the POD curves with simulated data by the modeling software aRTist and with artificial reference data. This approach was developed within a joint project with the company POSIVA, which is constructing a final depository for high active nuclear fuels in Finland. Radiographic testing is one of the NDT-methods they use to test the electron beam welds of the copper canisters. The copper canisters will be used in the depository as a corrosion barrier within the waste management concept.

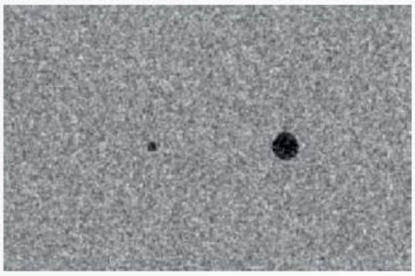
# Evaluation of RT Systems with an Observer-POD

D. Kanzler, C. Müller, M. Bertovic (BAM, Berlin) and J. Pitkänen (Posiva, Eurajoki, Finland)

## In a typical POD evaluation of a RT system only a small part of the information is used!

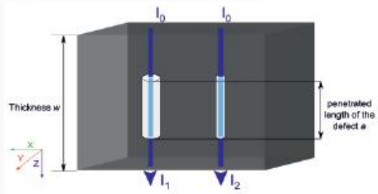


Simulation model of two defects with same penetrated length but different diameter.
Simulationsoftware aRTist:
Testing object: 19mm thick block of iron
Defects: flat bottom holes with different sizes
Source: X-ray tube with 200 kV
Detector: Film D4



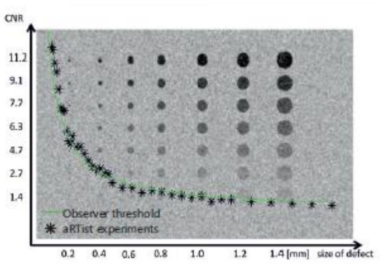
Typical radiographic image of two indications with different diameter the same contrast noise ratio.

In the conventional a vs. â approach for the POD the area of the radiographed defect does not influence the POD. Only the penetrated length is important.

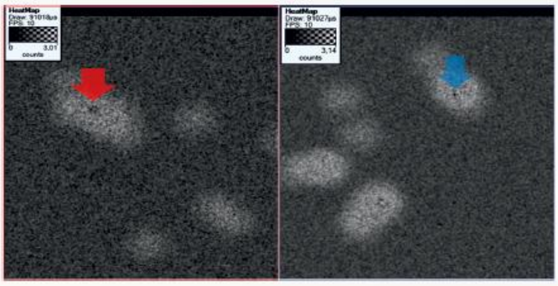



Information used for a conventional POD approach: the maximum penetrated length evaluated through the cut at the biggest part of the defect.

## Experiments to quantify the detection threshold for RT indications depending on the diameter




A human operator is able to detect bigger defects better than smaller ones with the same CNR. The experiment with one observer with simulated defects results in this threshold curve. The indications in the background give an idea about the size of tested defects.




A pre-experiment (pilot study) with an eye tracker and 4 observers: The images show a gaze opacity map, where the bright areas illustrate areas with eye fixations. These areas show us the indication search patterns of the observers before they detected the indication. The first results indicate that the bigger indication (red) is easier to be found than the small indication (blue).

## Observer threshold with diameter dependency

$$POD_{hole} = f(Th_{dec}, a_{RT})$$

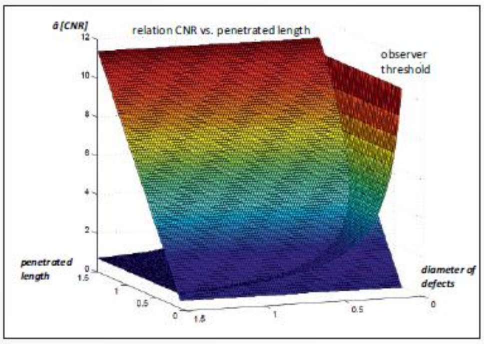
The POD in radiography for holes is depending on the detection threshold ($Th_{dec}$) and the penetrated length of the defect.

$$Th_{dec} = f(diameter_{hole}, \hat{a})$$

The detection threshold depends on the diameter.

$$CNR_{min} = \frac{PT \cdot SR_b^{image}}{diameter_{hole}}$$

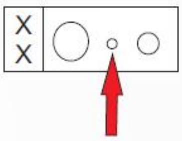
For the minimal distinguishable contrast to noise ratio (CNR) an equation with the basic spatial resolution ($SR_b^{image}$) in the image and of the diameter can be found. The PT (perception threshold) factor in the experiment equals 12.




The POD is a function of the CNR and the observer threshold. The detectable indications are lying above both graphs.

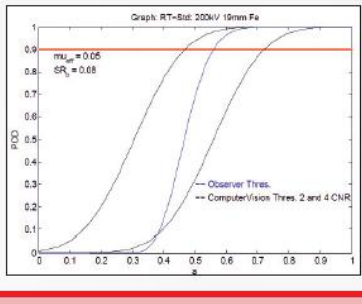
The graph was created by the experiments.

## Observer POD for T1:




Step hole IQI for volumetric defects ASTM E1015 / EN ISO 19232 - 2

To create a dependency between a and the diameter, the ASTM reference defect T1 was chosen. For that defect the penetrated material thickness of the defect equals the diameter of it.




**Result:**
The use of a fixed high threshold (based on small defects CNR 4) underestimates the POD. The use of a fixed low threshold (based on bigger defects CNR 2) overestimates it. The observer POD contains the dependency of the detection treshold on the diameter and does not provide neither an over- nor an underestimation. Furthermore, with the use of the detection threshold the POD is steeper than the POD using a fixed threshold.
(the POD is model based and does not have a confidence band, because of absence of real experimental data.)

## References: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