Predictive Probability of Detection Curves for Radiography Testing – A Proof of Concept Study

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Probability of detection (POD) curves are a reliable means to evaluate the performance of non-destructive testing methods. Still, their construction requires a significant amount of data from several damaged specimens (at least 30). Recently, so-called predictive probability of detection (P-POD) curves have been developed for large or expensive engineering structures where no data from the damaged state is available. Therefore, the POD curve can be constructed based on undamaged specimens. This article applies P-POD curves to radiography testing for the first time. This reduces the number of scanned specimens from 30 to one, and a single radiographic image, leading to significant economic benefits in form of largely decreased scan time and material waste. Moreover, it allows one to fine-tune the acceleration voltage, current, pre-filter, geometry settings, and other experimental parameters for an optimal radiography result. P-POD methods are based on statistical tests that assume a signal response (intensity or grey values) with Gaussian distribution, unchanged signal variance for several damaged states, and test the significance of changes in the mean value. To predict the POD, a physical model is necessary that links the signal response to varying damage extents, and in this paper, the Beer-Lambert Law is employed for this purpose. For proof of concept, a copper step wedge is analyzed, where the largest thickness is assumed to be the specimen's "normal" state. Steps of decreasing thickness are interpreted as increasing "damage". After outlining an approach on how to calibrate the input parameters for the Beer-Lambert Law, the P-POD curves are constructed based on the normal state. For validation, the POD is evaluated for varying damaged conditions, showing that the empirical POD is identical to the predicted POD. The basic assumptions are verified and critically discussed based on the experimental results.