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" FROM THE FIELD "

Magnetec Inspection, Inc.

Excellence in Eddy Current Inspection Technology & Failure Analysis

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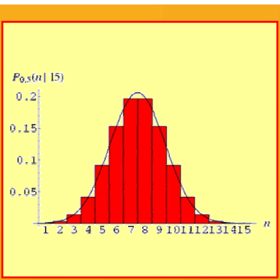

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Subject: POD Analysis

It is believed that PoD curves produced from PoD data are not very well understood by many who use and apply them.

Probability of Detection (PoD)

The low probability of detection is noted as major problem of non destructive testing - this limitation is consistent across the spectrum of techniques which have high attainable flaw sensitivity such as conventional ultrasonic inspection, and is mainly due to the human factors. There is a large amount of 'Probability of Detection' (PoD) data available in the non-destructive and other sensor related industries (automotive, aerospace, medical, etc...). However, it is believed that PoD curves produced from PoD data are not very well understood by many who use and apply them. For example, in producing PoD curves, a certain material and thickness may have been used and yet one can find the same PoD quoted for a range of thicknesses. In other cases, PoD curves may have been developed for pipes, but they have been applied to plates or other geometries. Specific corrosion and defect types tend to lend themselves to either easy detection (eg. large defects in thin walled components) or could push the sensitivity limits

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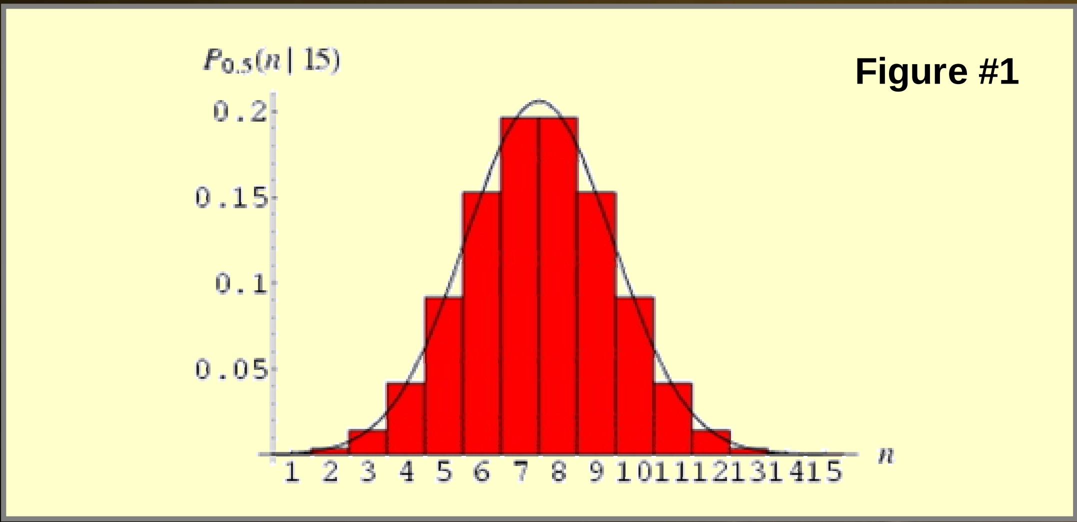
of the equipment and technique. Similarly, PoD curves for one type of weld (eg single sided) have been used to define detection on other weld configurations (eg double sided). PoD data are also highly dependent on the Non-Destructive Testing (NDT) methods used to produce them and these data can be significantly different, even when applied to the same flaws and flaw specimens. It is often assumed that the smallest flaw detected is a good measure of PoD, but there is usually a large gap between the smallest flaw detected and the largest flaw missed. PoD data does not usually fit known distribution curves (Fig. #1 as example) and are highly dependant on defect parameters and orientation.

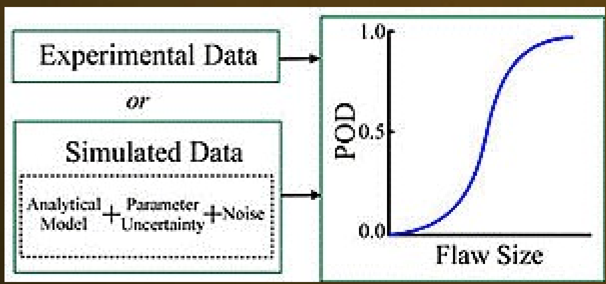


The factor in NDT procedures, and yet it is usually found not to be as important as other operational and physical parameters. Poor inspection environment also tends to reduce PoD due to human interaction, equipment complications or sensor coupling. Irrespective of the basic physics of the method involved, the ability of any inspection technique to reliably detect the presence of integrity affecting defects is subject to a number of parameters. These include; material wall thickness, density & structural composition; defect type, orientation & aspect ratio and application factors which can include surface condition. Many inspection techniques generate thousands of independent signals which must be reduced to flaw information which can put an enormous load on both equipment and inspection personnel. Any inspection technique which generates large amounts of flaw information will be susceptible to PoD failures (eg missed defects, unreported defects, false positives, under/-over called defects, etc...). The detection of all flaws/defects that will impede the reliability of the specific equipment is the primary concern for the applied inspection technique.

Two Ways to Conduct a POD Analysis

1. Experimental – a large number of samples with a range of flaw characteristics is examined by several inspectors

2. Simulated – analytically model the measurement process and run for a range of samples and testing conditions



Reliability is defined as the probability that a system will accomplish its designated mission in a satisfactory manner. The Reliability is modeled using the elements of probability, satisfactory performance, time or mission-related cycle and specified operating conditions.

The reliability of a system depends on selecting certain reliability measures and terms. The reliability is modeled as a function of time.

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$$R = e^{\frac{-t}{MTBF}}$$

Where, t = time period of interest
MTBF = Mean Time between Failures.

Reliability as applied by MTBF is defined by its relationship to a standard test, which measures the value of the test object with failure, denoted by a binary variable, against the value of the object life without failure. By definition, MTBF test errors when its measurement of current condition differs from the measurement of the same quantity with respect to time intervals without assessment of flaw/defect producing phenomena (Corrosion/defect generating event). The application of PoD can be defined by four, possible defect classifications that belong to any measurement: a "false negative" occurs when the test object is not_OK but it is identified as OK by NDT; a "false positive" occurs when the test object is OK but it is identified as not_OK by NDT; similarly, a "true positive" occurs when the test object is not_OK and it is identified as not_OK by NDT and a "true negative" occurs when the test object is OK and NDT identifies it as OK.

Inspection technique's are applied in an attempt to detect defects (e.g., cracks, intergranular corrosion, pits and inclusions) before they can cause structural failure, leaks or other, unfavorable outcomes. The existence of a "probability of detection," corresponding to the probability of a true positive given a true positive OR false negative is more often asserted for these tests than delivered by actual flaw/defect correlations to generated signals. Similarly, the existence of a "probability of false call," corresponding to the probability of a false positive given a false positive OR true negative is more often asserted than delivered.

Defect detection tends to violate Probability theory empirically. Often, a probability of a false call is not defined within the limits of the PoD scenarios and the "probability" of detection and associated parameters are beyond the limits of the specific inspection technique. In these ways, the testing reliability is ill-defined and do not readily correlate with the inspection findings and PoD assessments are skewed. The false impression that the testing reliability is well defined can be established by the use of terms that imply the preservation of probability theory under conditions in which Probability theory is empirically violated. The Eddy Current terms "signal" (true defect) and "noise" (non-relevant electronic impulse) which are generated during a specific test imply that probability theory is unconditionally preserved due to relevant and non-relevant signals being easily classified. In-situ signals are many times a combined effect of “defect signal” and “noise” which can lead to any of the four possible defect classifications.

Some of the consequences of this kind of terminological abuse are:

A) It appears that the testing reliability can be determined when it can't due to complex defect inter-actions.
B) It appears that the expected PoD of testing can be determined when it cannot.
C) It appears that decisions can be made about testing on a basis that is considered rational when actual testing parameters consist of compromised inspection techniques.

Potential and actual users of Defect Detection Tests should also be aware of the fact that the expected results of such a test depends upon:

A) The nature of the statistical populations to be tested.
B) The utilities of the user. As the populations are undefined & the associated PoD vary by user, claims that testing with a particular technology has a greater, expected PoD than testing with another technology should be met with skepticism.

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