# Application of NDE Simulations to Estimate Probability of Detection

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# **Components of Probability of Detection**

Equipment variability

inherent filtration of x-ray tube eddy current lift off and coil tilt broad band center frequency

# Setup variability

placement of the central axis of the x-ray tube orientation of the UT probe scan variation in lift off and probe tilt

Signal Noise

#### Flaw morphology effects

size shape position in the part orientation in the part

#### Visual acuity – human variability of the eye cracks pores

effects of complex images

#### Human factors

mood training environment **Need for 2D Detectability criteria** 

Increased use of scanned data in inspections

X-ray, ultrasonics, eddy currents

1D scans2D raster scans2D imaging arrays3D computed tomography

scans offer multiple measurements of a flaw



# 2D Data Detectability

# Both flaws are easily detected.



SNR=0.675

#### Signal to Noise Ratio

$$SNR = \frac{\left| D_{background} - D_{flaw} \right|}{\sigma}$$



# **Automated Detectability Scans**

#### binomial hypothesis test

- Given a signal mean and noise distribution
- What is the probability of a noise fluctuation producing the observed histogram of measured signals in the 2D area?
- Threshold for the test is a 5% false call

#### Large flaw

POD Mo	idel			8
ROIS	election ROI H andard Area	listogram POD Cur Select Clear	/e   Operation   Filt Testing Area	er   Select   Clear
	Top: 272	Bottom: 345	Top: 201	Bottom: 264
	Left 234	Right: 305	Left 233	Right: 304
н	leight: 73	Width; 71	Height: 63	Width: 71
Min	nimum; 2.958 1	Maximum: 3.319	Minimum: 2.862	Maximum: 3.277
3	Mean: 3.128	STD: 0.045	Mean: 3.124	STD: 0.049
	☑ Low Intensit Result	y Defect	POD F	Show Threshold
	Possibility of De	tection (POD) is 99.7	%. 9 160	<u>^</u>
	Nw = 12.63%,	Pw = 8.76%		×

Green region standard

Red region test area

Probability 99.7%

#### No flaw region

Flaw_003.grd( 1.0:1)	
	ROI Selection  ROI Histogram  POD Curve  Operation  Filter    Standard Area
	Top:      278      Bottom:      347      Top:      133      Bottom:      183        Left:      233      Right:      300      Left:      231      Right:      304        Height:      69      Width:      67      Height:      50      Width:      73        Minimum:      2.936      Maximum:      3.296      Minimum:      2.972      Maximum:      3.293
	Mean:  3.130  STD:  0.045  Mean:  3.129  STD:  0.046    Image: Constraint of the state
	Nw = 56.93%, Pw = 55.35%

Green region standard



Probability 7.8%

#### **Small flaw**



Green region standard

Red region test area

Probability 0.9%

## Simple shapes versus real flaws



Large contrast

low KVp

Low contrast

#### Simple shapes versus real flaws

# Effect of Defect Morphology on Signal same crack size, different signal



optimal orientation

poor orientation



Flaw Size in mm

Note: inclusion is not detectable

## Effect of Flaw Morphology, Composition and Orientation



POD

**Flaw Size** 

# Conclusions

- Detectability criteria for scan data
- Application of NDE simulations Simple shapes versus real flaws