

# **LOW COST METHOD OF SIGNIFICANTLY IMPROVING THE RELIABILITY OF INSTRUMENTED NDT PROCEDURES**

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# Probability of Detection (POD)

- **Introduced in 1970's to quantify nondestructive testing(NDT) / inspection(NDI) / assessment(NDE) CAPABILITY as a necessary input to fracture analysis and control**
- **Statistical rigor was incorporated to provide a confidence level in the CAPABILITY quantification**
- **POD is one element of NDT RELIABILITY**

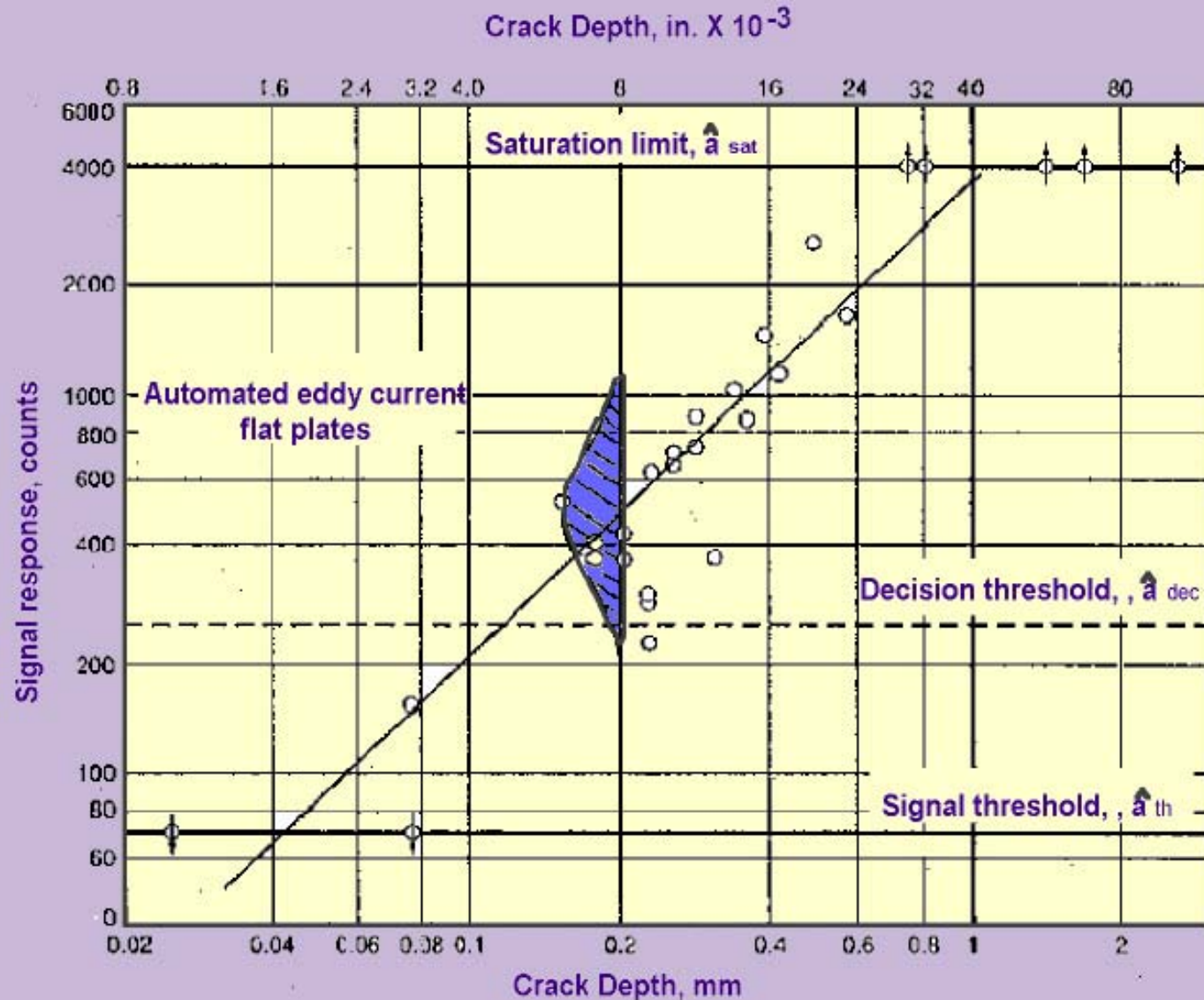
# POD ANALYSES

Based on a causal relationship established by:

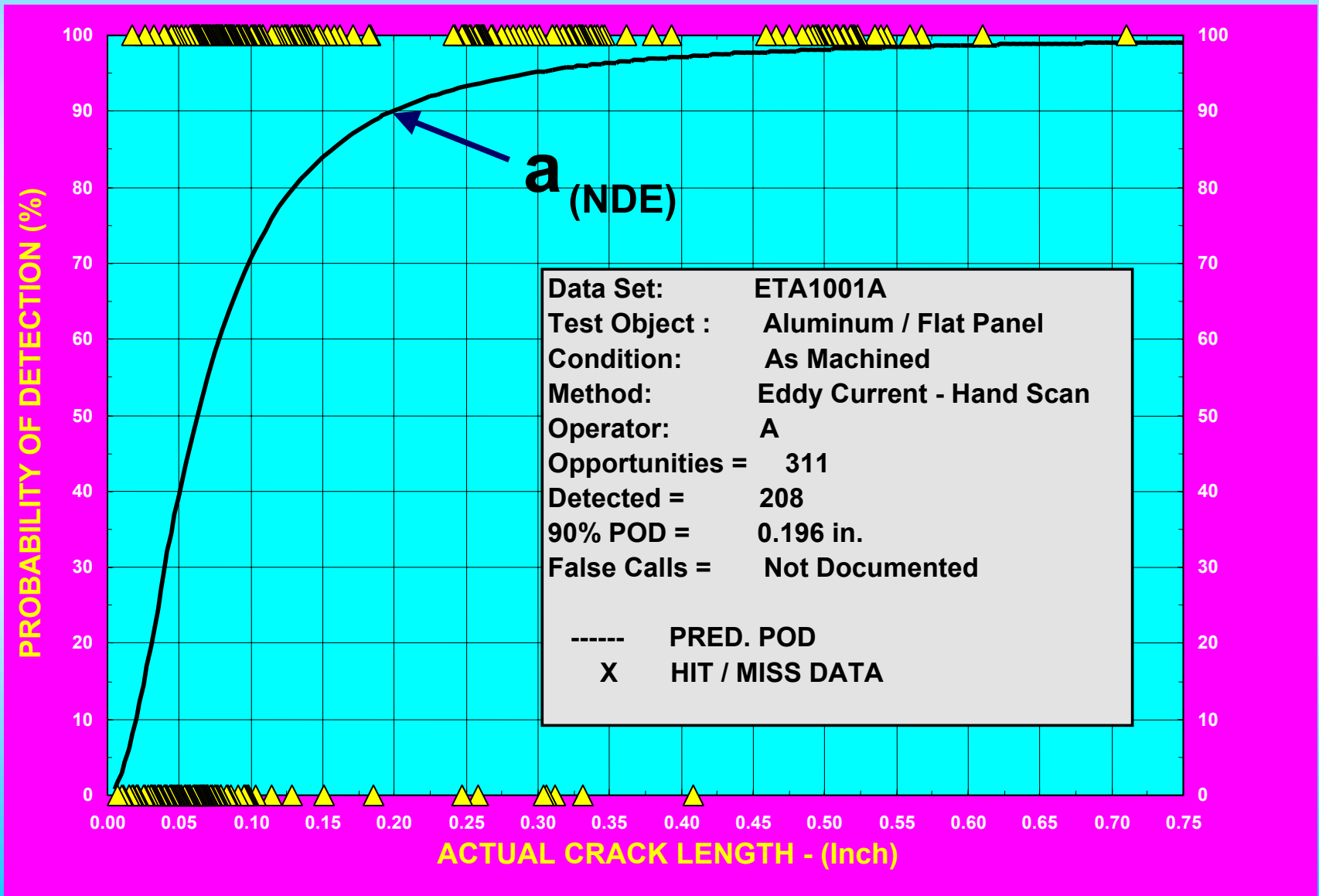
- **Hit / Miss sampling, or**
- **Quantified NDT measurements known at the  $a$  versus  $\hat{a}$  method**
- **Fitting the data to a log logistics model as developed by Berens\***

\*Berens, A.P. and Hovey, P.W. (1984), "Flaw Detection Reliability Criteria, Volume I- Methods and Results." AFWAL-TR-84-4022, Air Force Wright Aeronautical Laboratories, Wright Patterson, Air Force Base, Ohio, April, 1984

# Berens Causal Relationship



# Berens POD Model Output



# POD is Dependent on:

- **Flaw (Artifact) Variables**
- **Test Object Variables**
- **NDT Method Variables**
- **NDT Materials Variables**
- **NDT Equipment Variables**
- **NDT Procedure Variables**
- **NDT Process Variables**
- **Calibration Variables**
- **Acceptance Criteria / Decision Variables**
- **Human Factors**

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# INSPECTION RELIABILITY

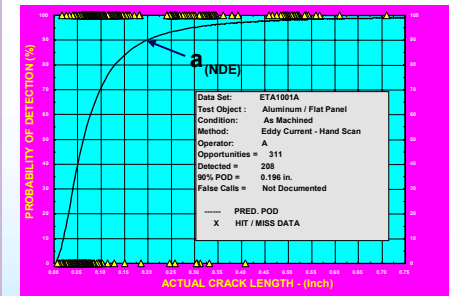
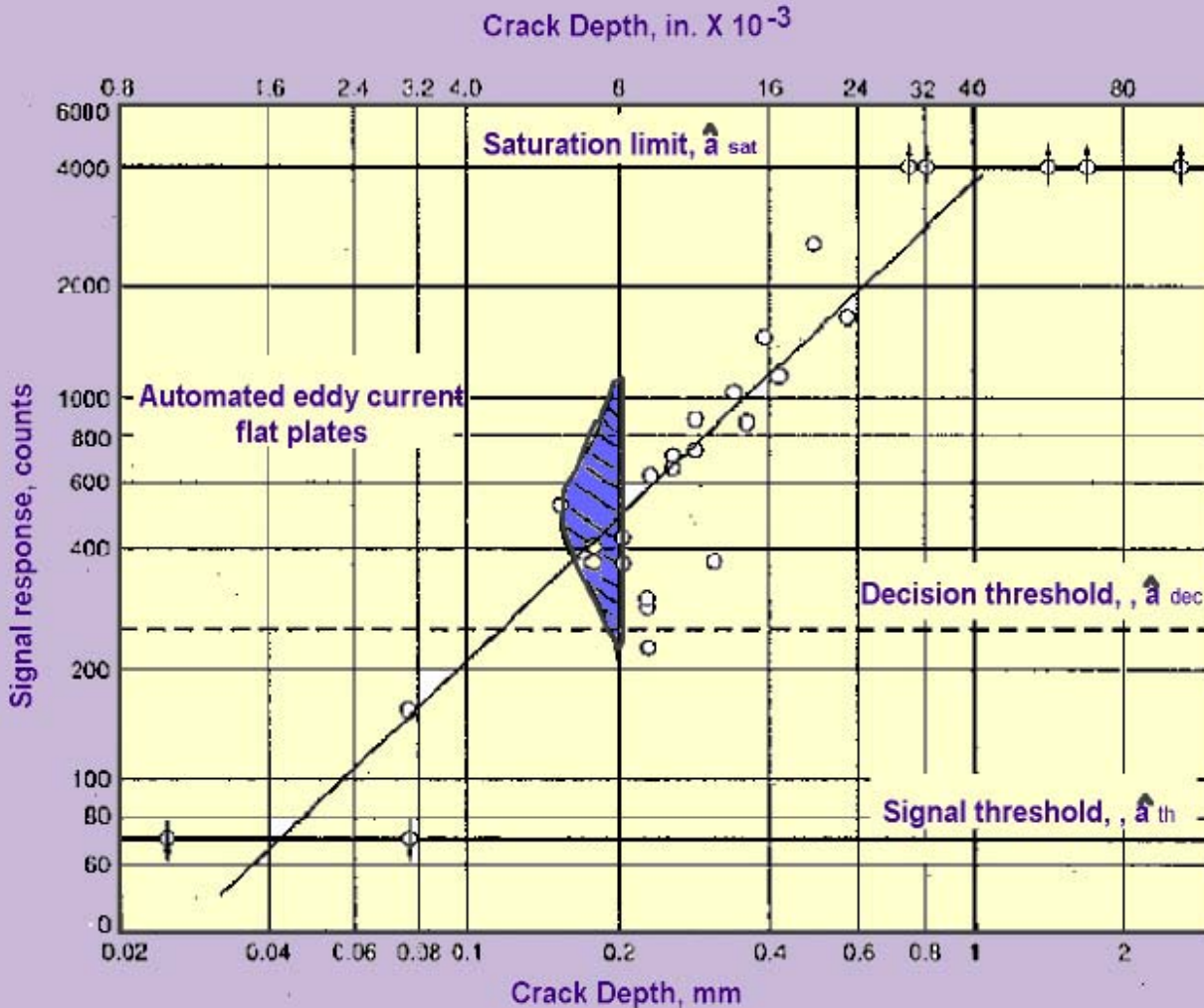
- **Capability (POD)**
- **Reproducibility (Calibration)**
- **Repeatability (Process Control)**



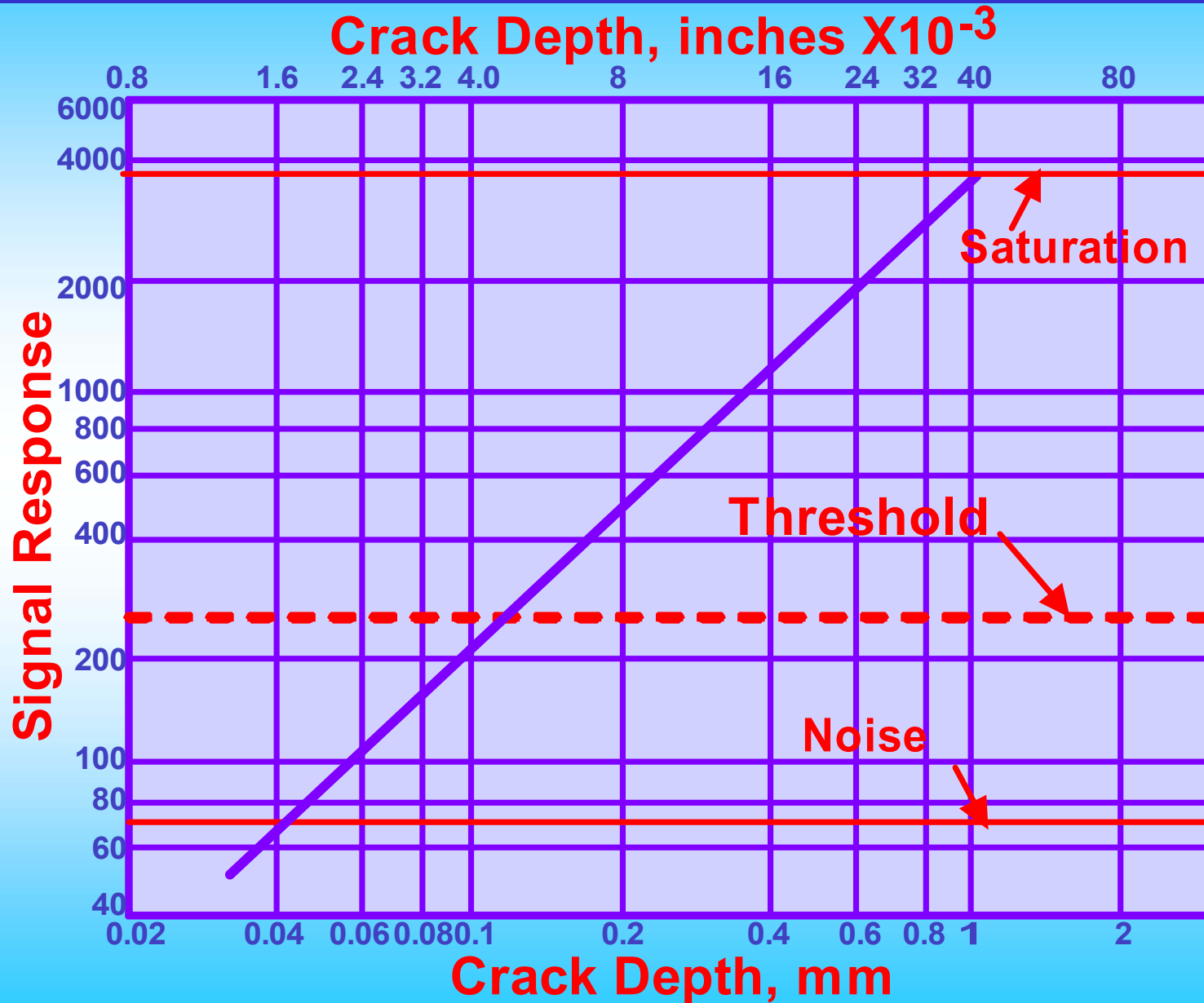
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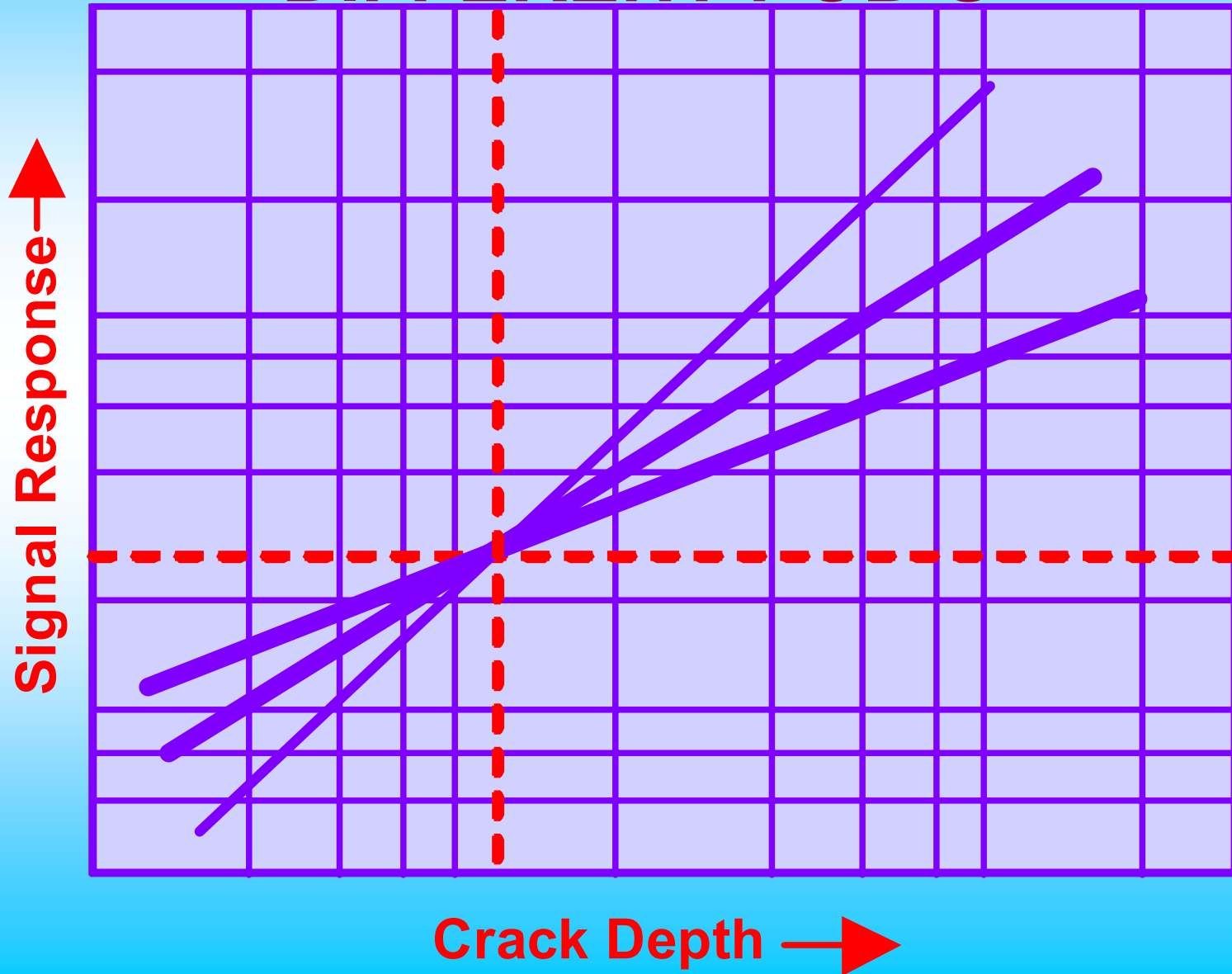
# Calibration Must Reproduce Berens Causal Relationship

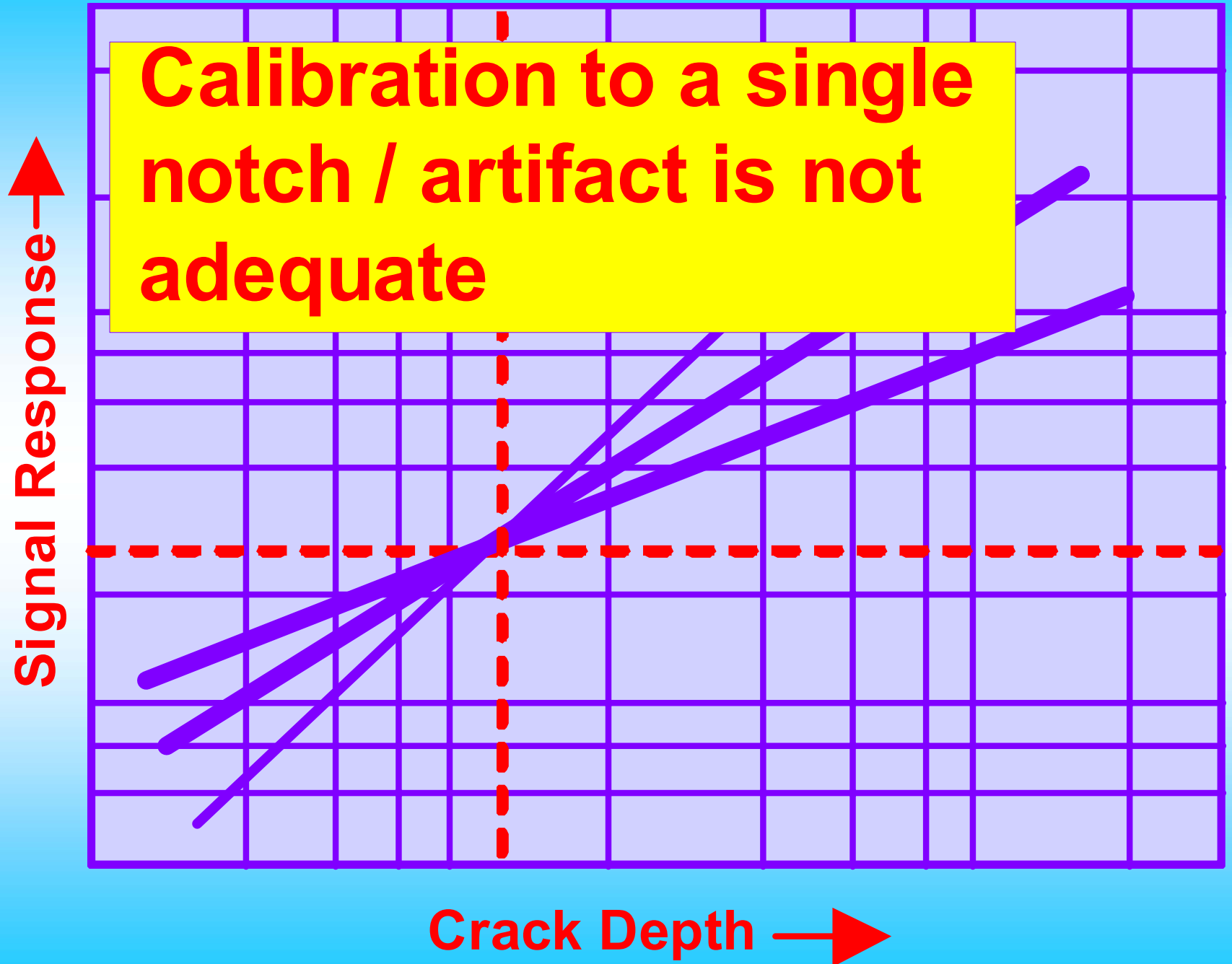


# IDEAL RESPONSE

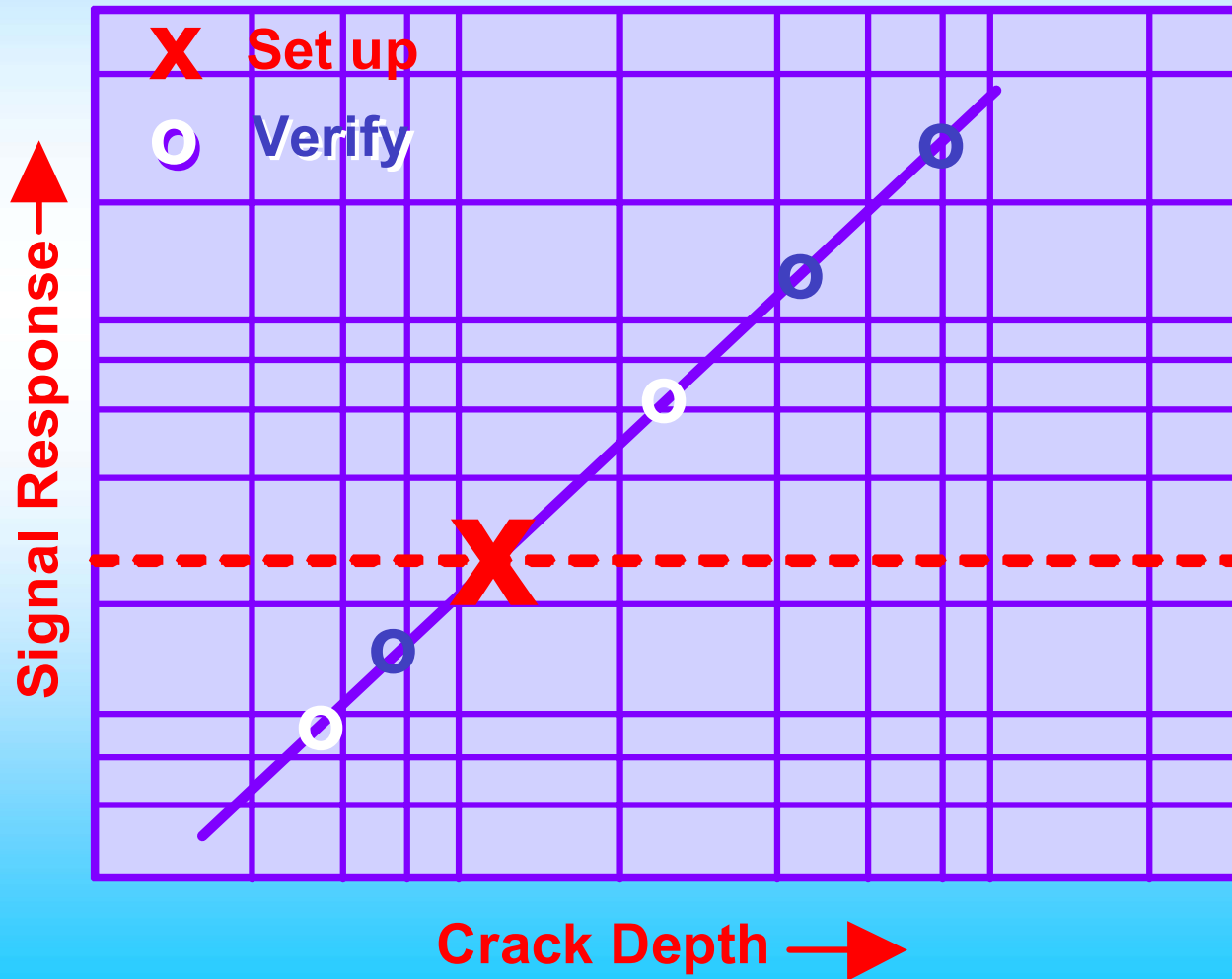


# SAME "CALIBRATION" DIFFERENT POD'S

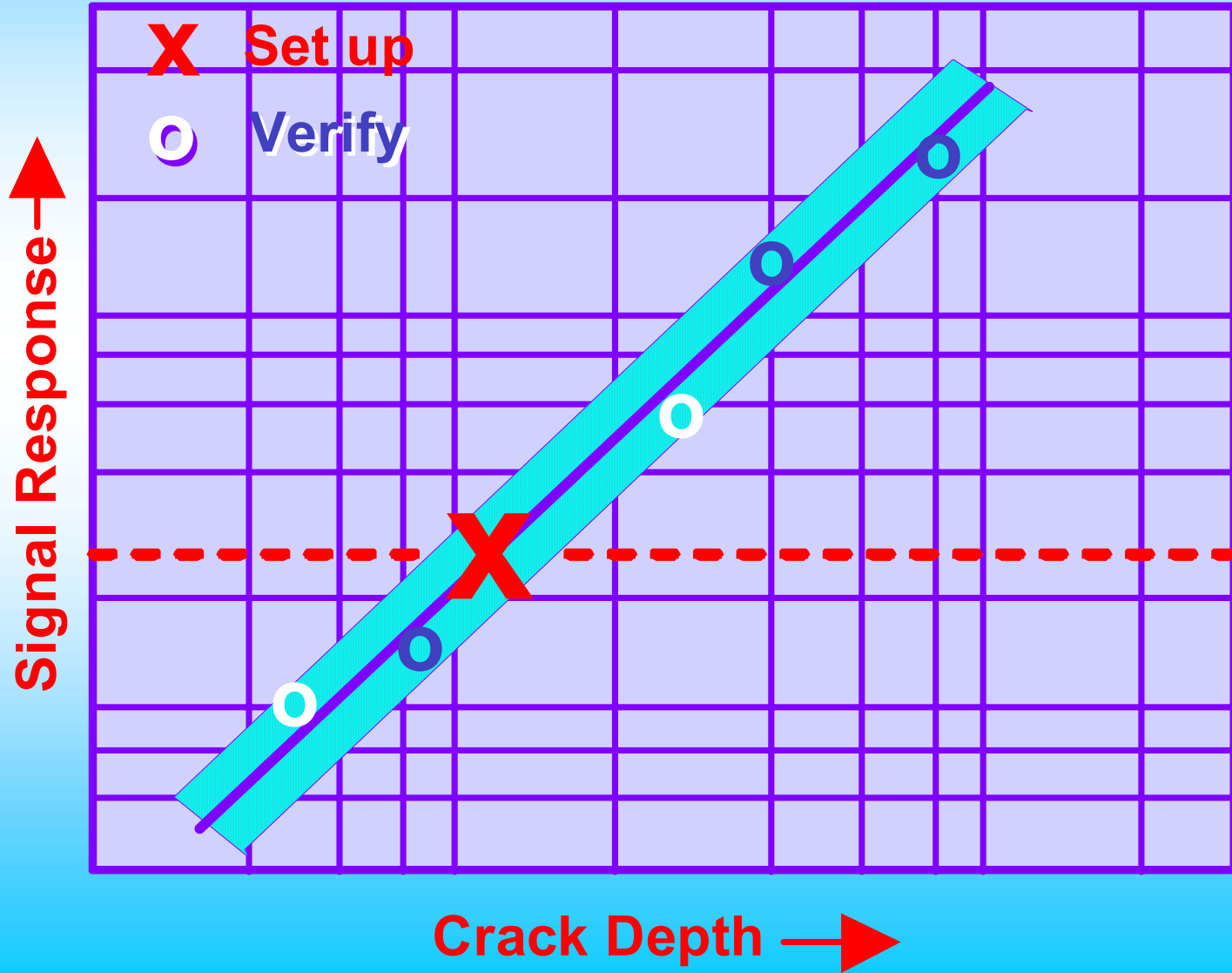




# MULTIPLE POINT CALIBRATION DATA ESSENTIAL TO PROCEDURE VALIDATION



# ALLOWABLE CALIBRATION VARIANCE (Response and S/N)

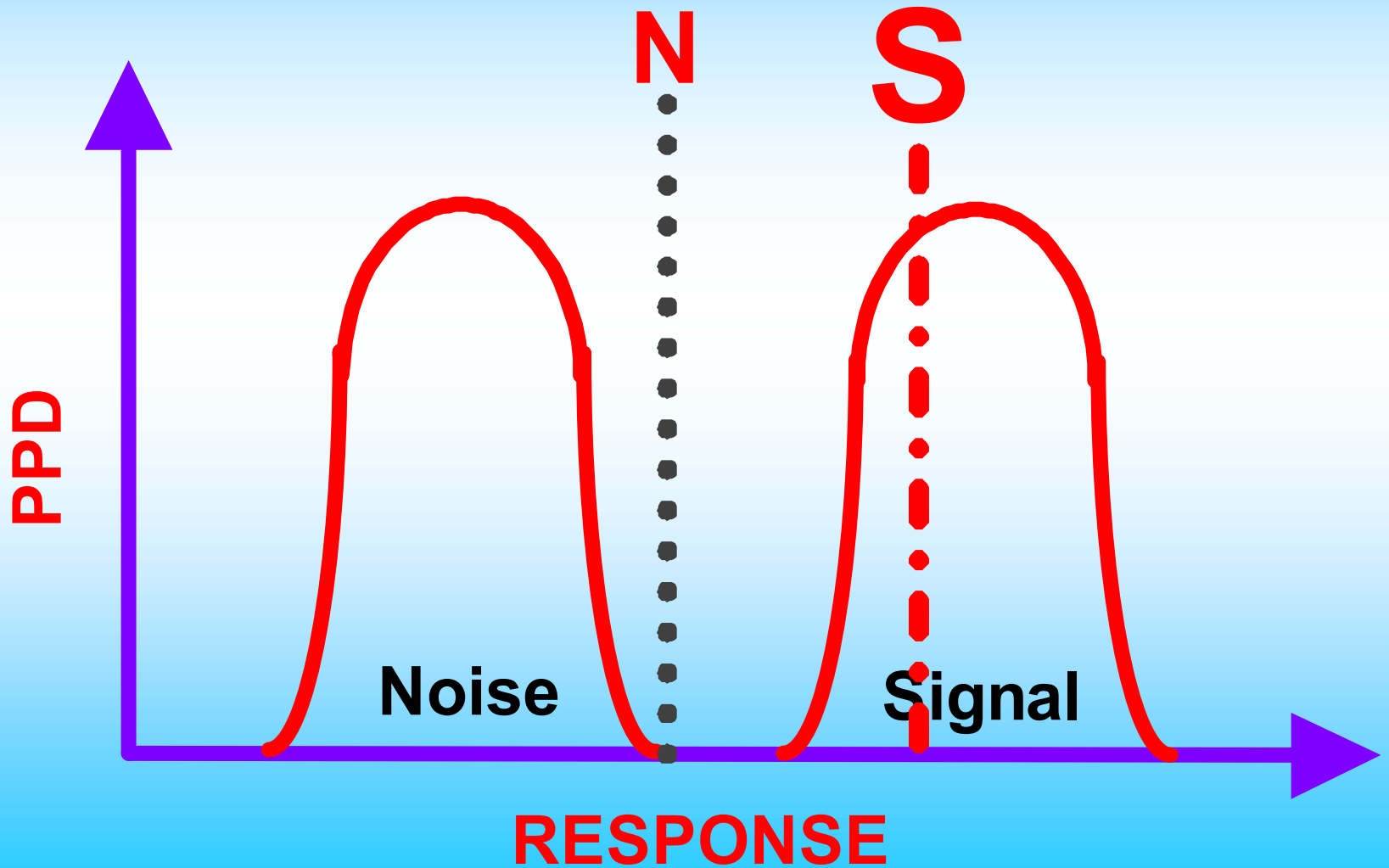


# MEASUREMENTS REQUIRED FOR PROCEDURE VALIDATION

- Multiple measurements on “calibration” artifacts to establish measurement variance / bounds
- Measurements of signal / noise relationship on each “calibration” artifact to establish part / measurement variance / bounds



# SIGNAL / NOISE (S/N) RESPONSE



# MULTIPLE POINT CALIBRATION IS

- **REQUIRED FOR PROCEDURES THAT ARE TRACEABLE TO POD**
- **REQUIRED FOR RELIABLE NDE PROCEDURES APPLICATIONS**
- **NOT CURRENTLY REQUIRED BY MANY SPECIFICATIONS, STANDARDS AND CODES**
- **MASTER GAGING IS REQUIRED FOR MULTIPLE APPLICATION SITES**

# **BUILD ON WHAT WE HAVE**

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- **Good news – flat bottom holes / notches of different sizes are (usually) adequate for multiple point SYSTEM “CALIBRATION”**
- **Transfer to a part also requires measurement and acceptance of a signal / noise relationship for inspection**

# SUMMARY

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- **The POD Metric**
- **POD methodology is mature**
- **Stable system requires / change in “CALIBRATION”**
- **Multiple point calibration is minor change in application cost with major benefits**
- **NDE procedure validation specific to each application**