An International Round-Robin Test of NDE Reliability for PWSCC

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Structural Mechanics in Reactor Technology
(SMiRT 19)
August 12-17, 2007
Toronto, Canada

Sponsored by: The U.S. NRC, Office of Research
Carol Moyer and Iouri Prokofiev, Project Managers

Battelle

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Presentation Outline

- Introduction to the International Cooperative
- PWSCC Morphology from Service Degraded Components
- Eddy Current Responses from PWSCC
- Manufactured Cracks
- Dissimilar Metal Weld Test Blocks
- Bottom Mounted Instrumentation Nozzle Test Blocks
- PINC Atlas Database
- Summary

International Cooperative Program for Inspection of Nickel-alloy Components (PINC)

- Objectives of PINC
  - Quantify PWSCC Morphology and distinguish it from fabrication conditions
  - Record NDE responses associated with PWSCC
  - Assess NDE effectiveness for nickel alloy components
  - Manufacture realistic simulations of PWSCC
  - Recommend changes to codes and standards

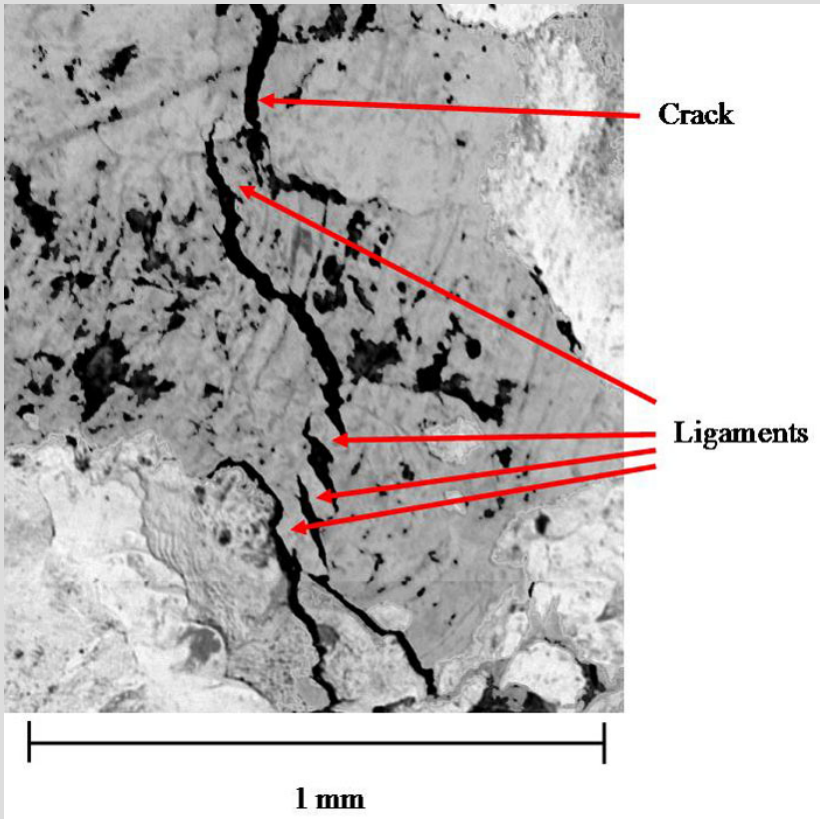
International Cooperative

- Program for Inspection of Nickel-alloy Components (PINC)
- Five nations: Sweden, Japan, Finland, South Korea, USA
- Regulators, NDE qualification institutions, research organizations, and industrial companies
- Two task groups
  - PWSCC morphology/NDE atlas group
  - NDE technology assessment group – quantification of NDE procedure effectiveness
- PWSCC/NDE database developed in Atlas group

International Cooperative NDE Technology Assessment

- Include current industry inspection practice
- Incorporate NDE research from university programs
- Describe and develop test blocks for circulation to international inspection teams

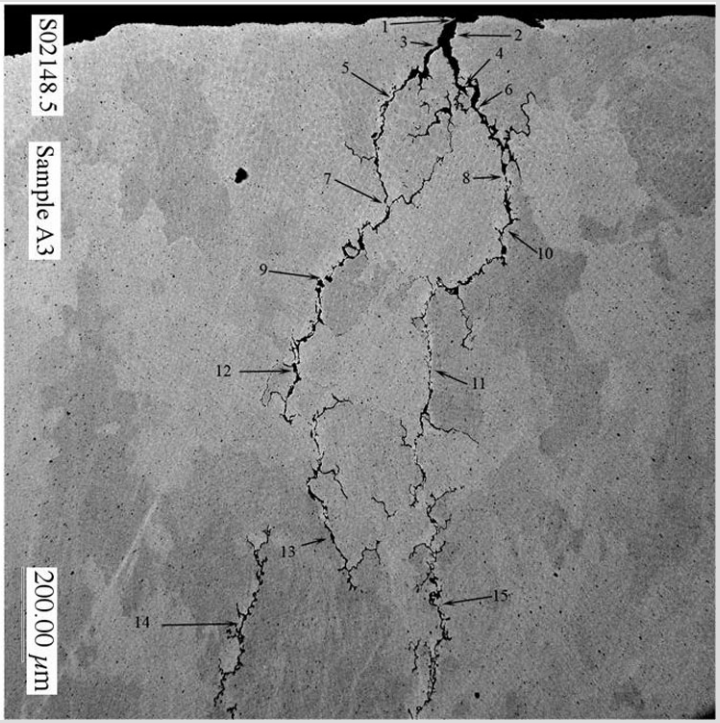
PWSCC Morphology from Service Degraded CRDM Components



- Crack has ligaments of metal across the crack
- This electrical contact along the crack length reduces eddy current response

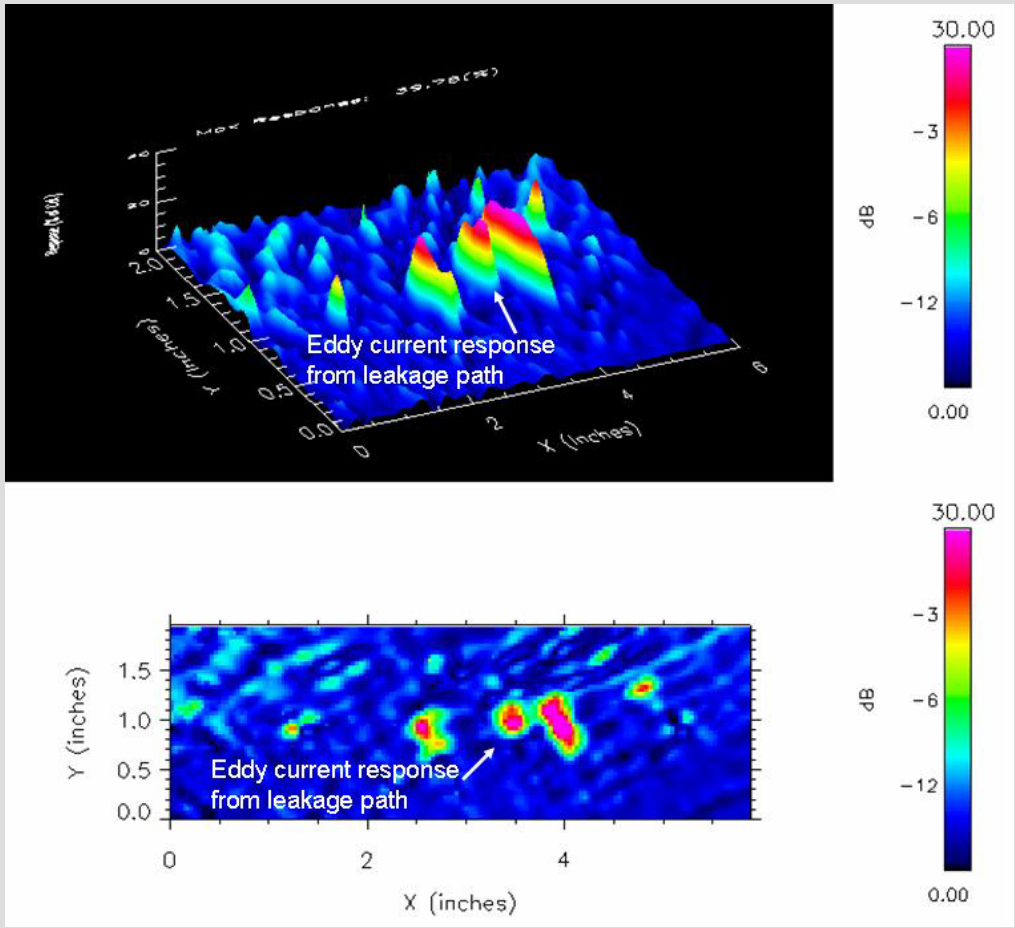
PWSCC Morphology from Service Degraded CRDM Components

Location	COD (μm)
1	10
2	29
3	6
4	2
5	6
6	6
7	2
8	Closed
9	Closed
10	4
11	2
12	9
13	7
14	3
15	2



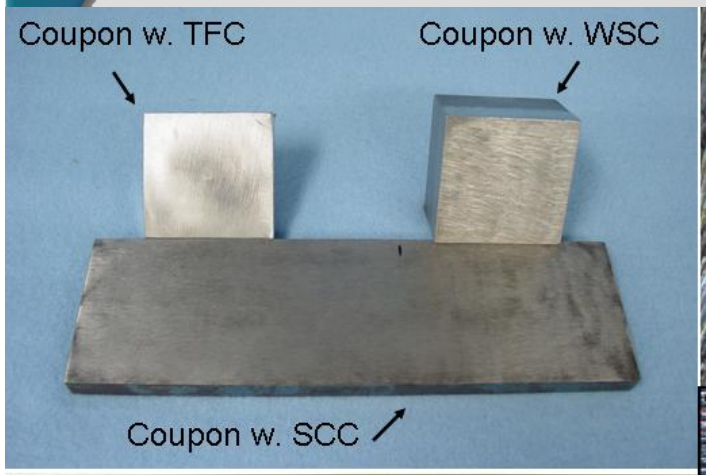
- The crack is open at the surface (10-30 microns wide)
- The crack is tight below the surface (less than 9 microns wide)
- The crack is branched and follows the weld grains

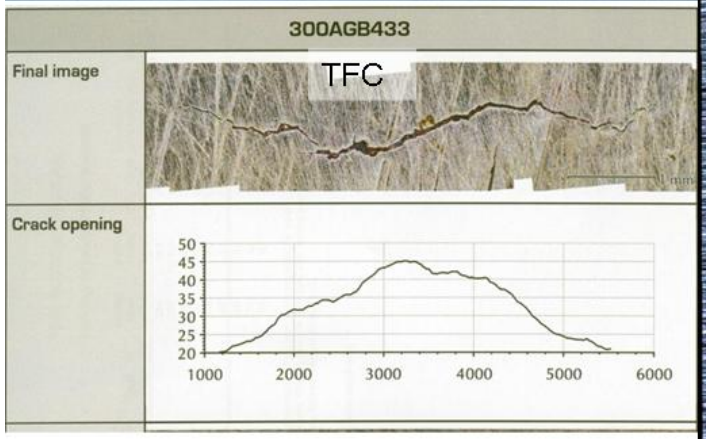
Eddy Current Responses from PWSCC

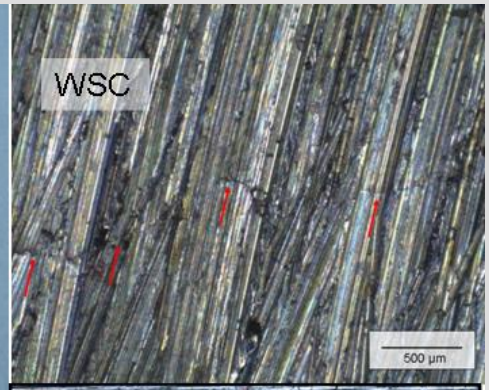


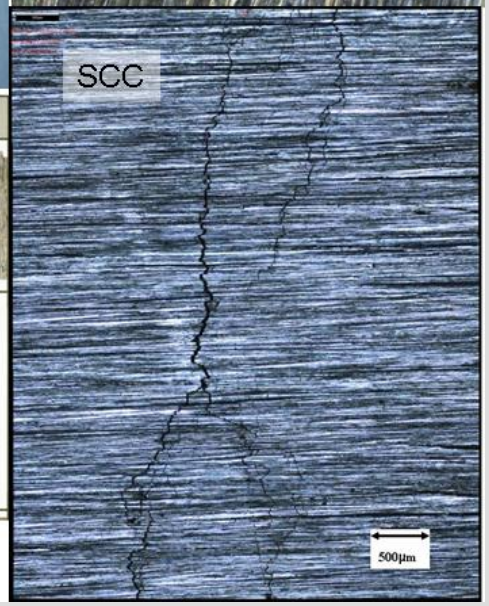
- Eddy current was an effective technique for detecting PWSCC
- PNNL was able to find the leakage path in CRDM
- Surface of the crack was too tight to detect by bare metal inspection and visual testing using replicant

Manufactured Cracks for Simulating PWSCC



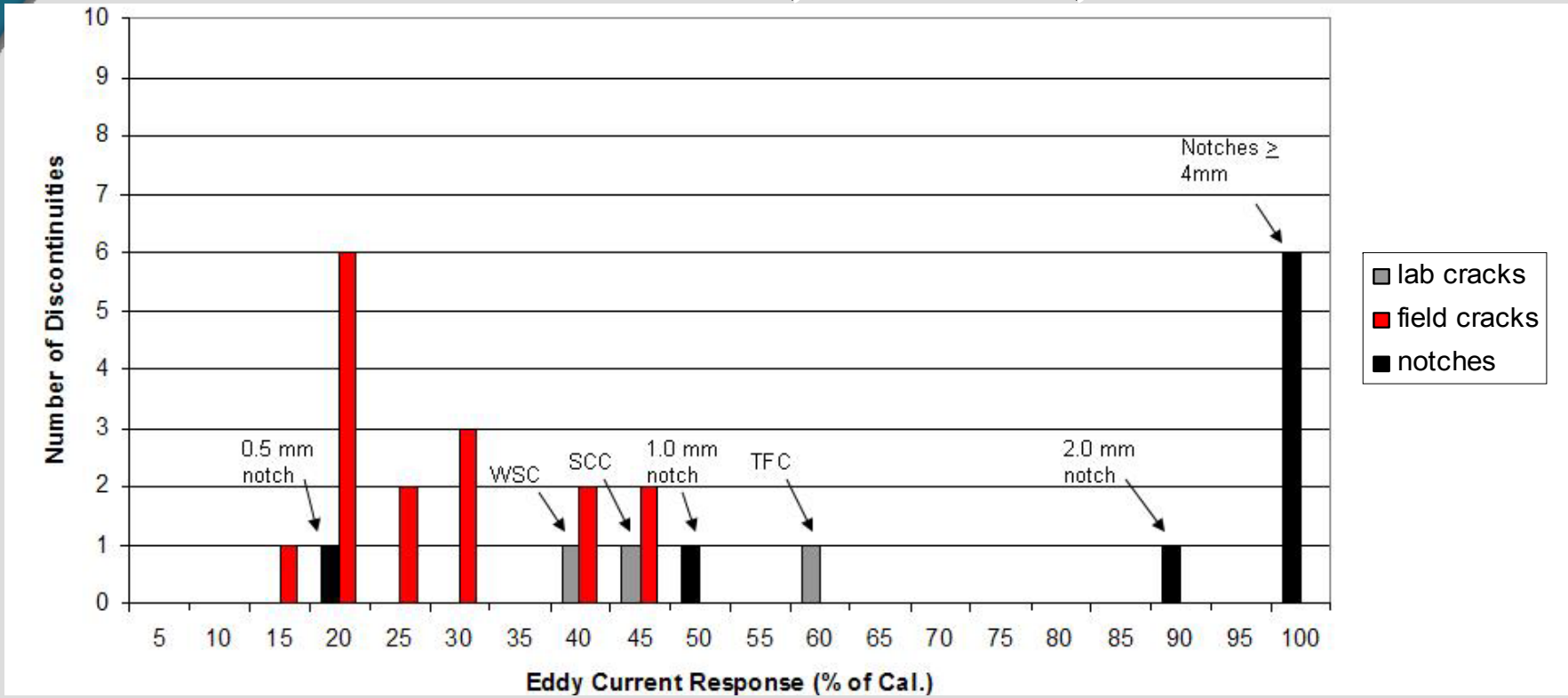






- Manufactured cracks are being evaluated to simulate PWSCC
- Cracks are being introduced into alloy 182 weld metal
- Thermal fatigue cracks
- Weld solidification cracks
- Lab grown stress corrosion cracks

ECT Responses from Manufactured Cracks, PWSCC, and Notches

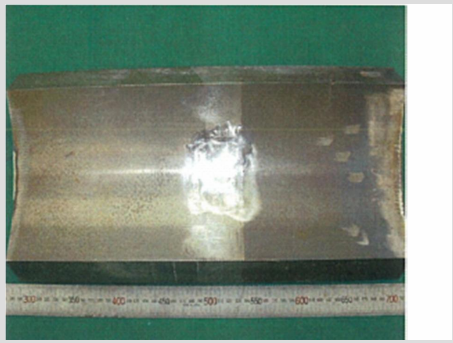


- PWSCC eddy current indications
- EDM notches between 0.5 and 4.0 mm deep
- Manufactured crack responses

Test Blocks for PINC RRT

Mid Thickness Dissimilar Metal Welds

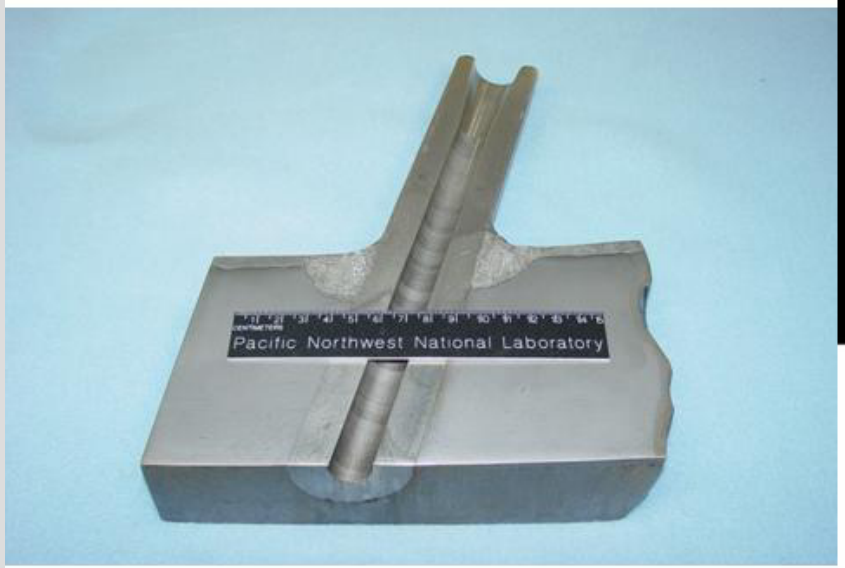
- 9 Test Blocks
- 6 meters of weld
- Cracks in 4 size ranges
  - 1-9% through-wall
  - 10-30% through-wall
  - 31-60% through-wall
  - 61-100% through-wall



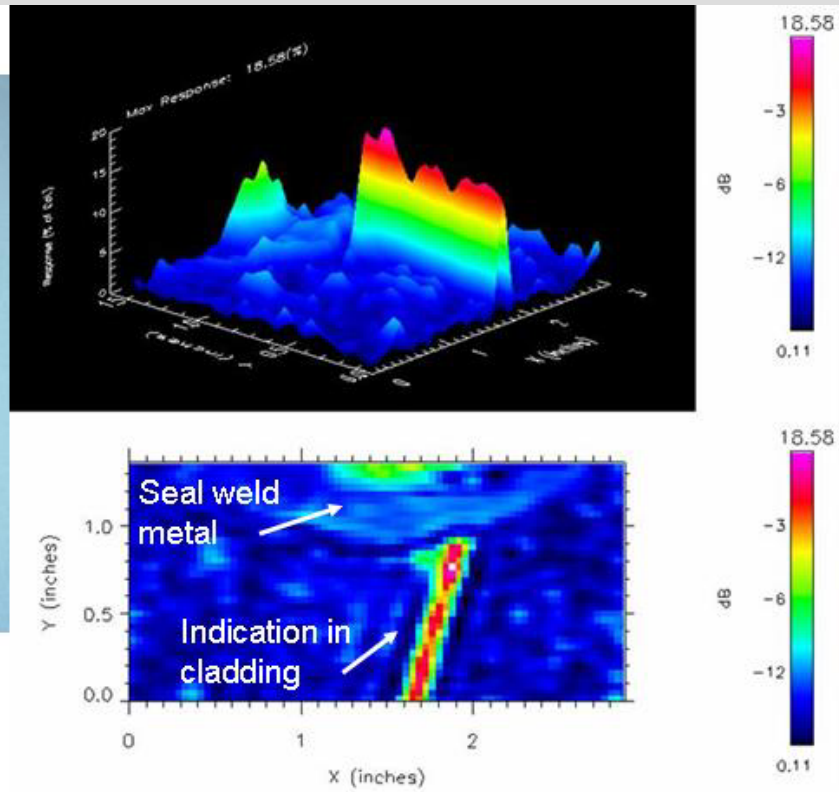
Bottom Mounted Instrumentation Nozzle Test Blocks

- Bottom head specimens removed from U.S. cancelled PWR vessel
- 6 BMI nozzle test blocks removed. Installed WSC and TFC in test blocks for round robin test

Bottom Mounted Instrumentation Nozzle Test Blocks



Test blocks do not have buttering

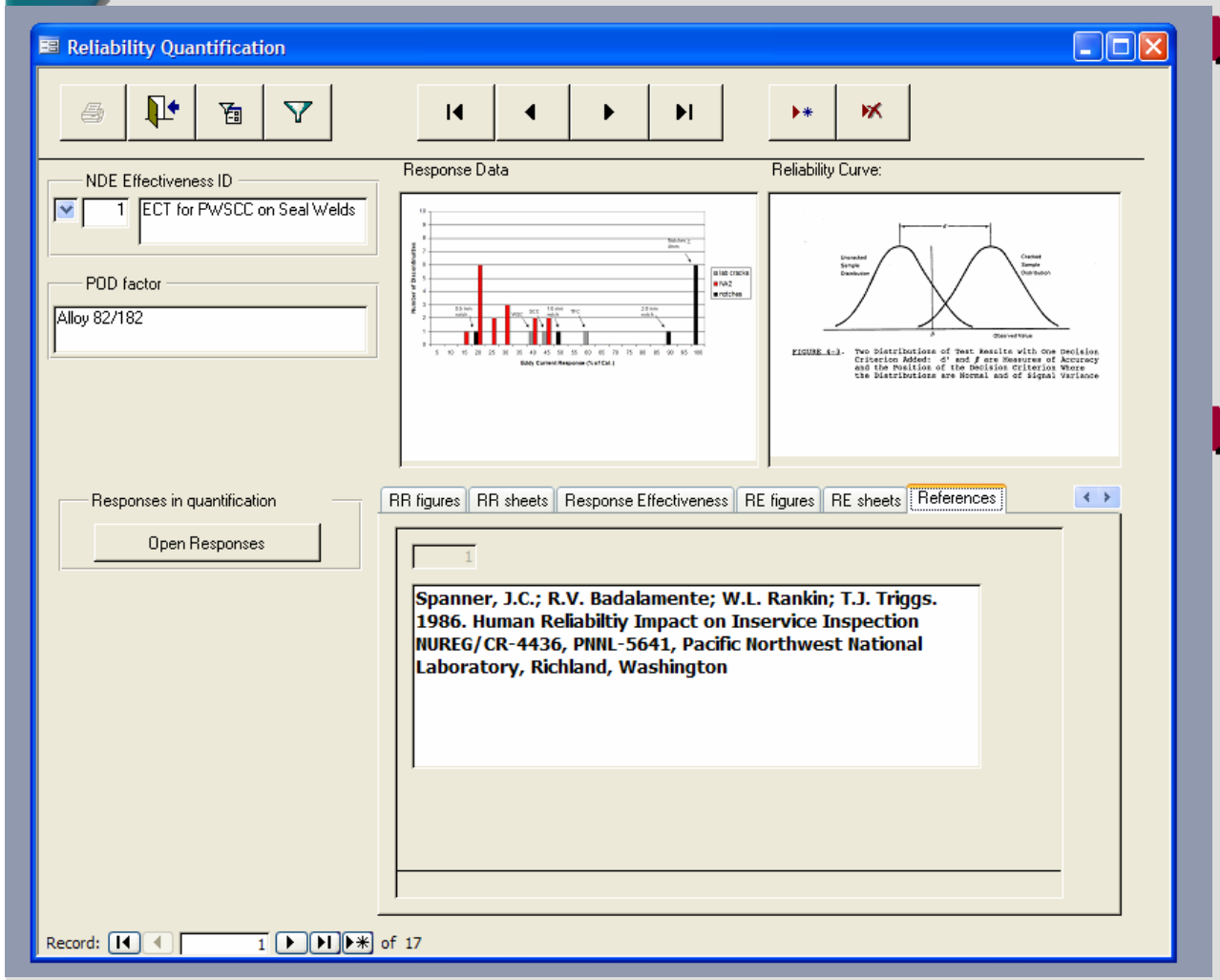


Test blocks have realistic fabrication conditions

PINC Atlas Database

- Contains all published information of NDE responses of PWSCC and crack morphology
- PINC participants providing new unpublished data for Atlas database
- All NDE technology assessment data going into Atlas database
- Database designed to provide PINC participants with an interactive source of available NDE responses on PWSCC and crack morphology

PINC Atlas Database Example



- PWSCC morphology quantification in the Atlas database
- Use of NDE response information in the Atlas database and in PINC for reliability quantification

Summary

- International cooperative program in progress
- PWSCC morphology being quantified using service degraded components
- Calibrated eddy current response obtained from PWSCC
- Manufactured cracks being evaluated for realistic simulation of PWSCC
- Round robin test blocks being circulated for inspections
- Atlas database of quantified NDE effectiveness being assembled