Recent Hanford Inspection Studies

Allan F. Pardini PNNL
Dennis R. Weier PNNL
James M. Alzheimer PNNL
Wesley H. Nelson AREVA
August 26, 2009

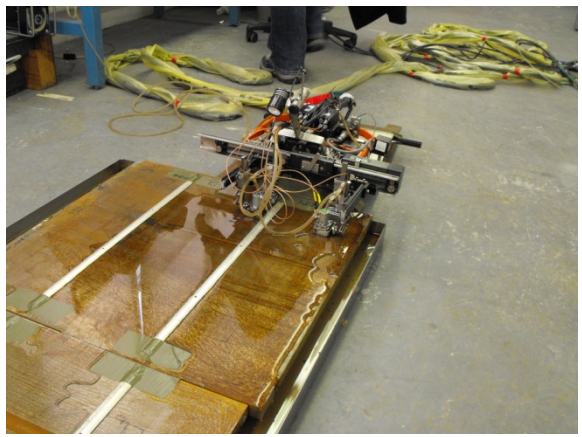
Topics Covered

- **Background Information**
- **Studies that PNNL and AREVA are conducting**

Background Information

•Ultrasonic Inspection Program for the DSTs

- Ultrasonic inspections (in the annulus) are performed by AREVA Federal Services
- Inspectors are qualified through a PDT given by PNNL



Background Information

•Requirements Documents

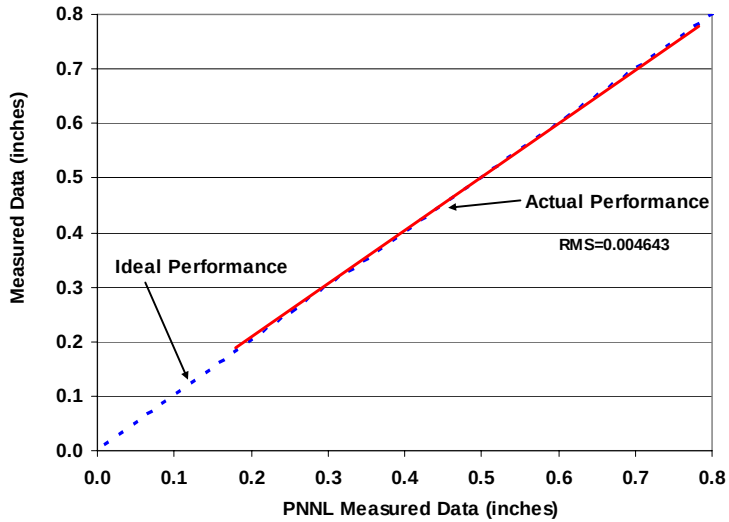
- RPP-PLAN-38332, Rev. 2 Task Plan for the Ultrasonic Inspection of Hanford Double-Shell Tanks – FY 2009 WRPS
- WHC-SD-WM-AP-036 Acceptance Criteria for Non-Destructive Examination of Double-Shell Tank WHC
- BNL-52527 Guidelines for the Development of Structural Integrity Programs for DOE High-Level Waste Storage Tanks - TSIP

- PDT Wall Thinning Criteria

  Subcontractor to size the thickness within 0.020 inch accuracy.

Background Information

- **Typical PDT**



Inspector RMS Values (Same Plate)

0.006254 0.002427 0.012428 0.008138 0.006683 0.004643 0.009545

All better than the 0.020” requirement.

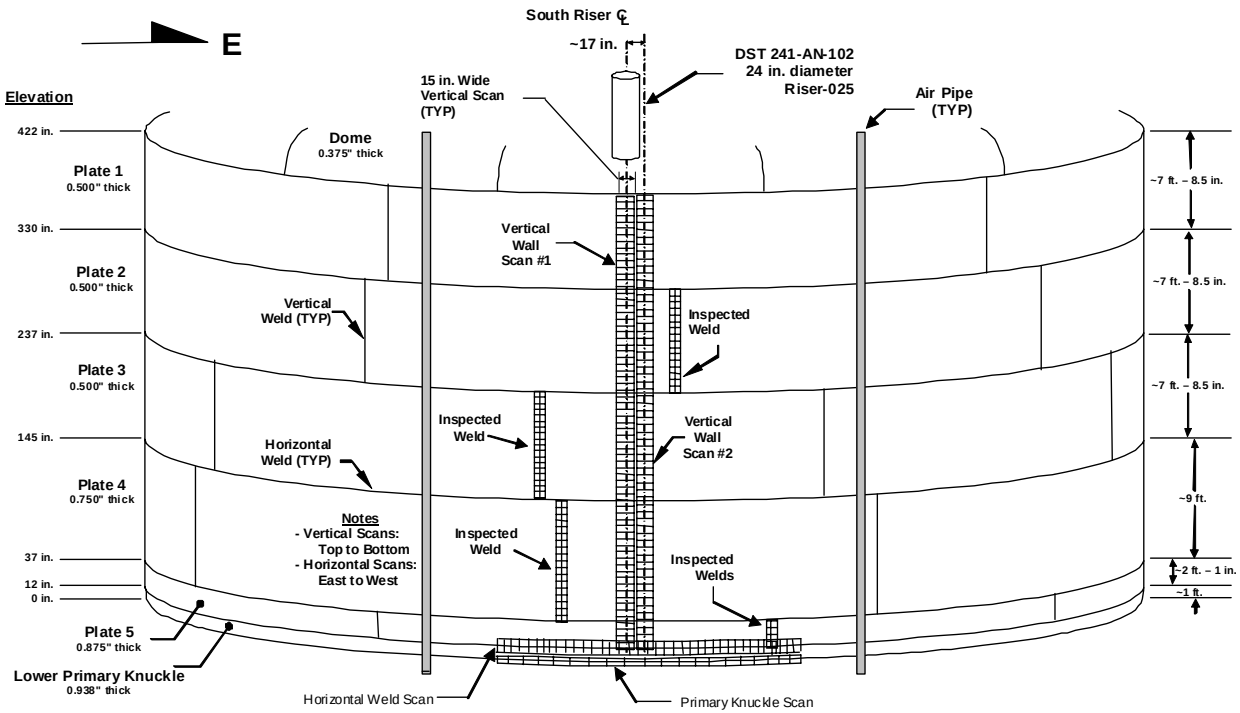
Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle *Since 1965*

Background Information

DST Tank Inspections

- Inspect multiple paths of primary tank from separate annulus risers
- Inspecting for wall thickness, vertically oriented cracks in tank wall, and cracks oriented perpendicular and parallel in the HAZ of some vertical and horizontal welds

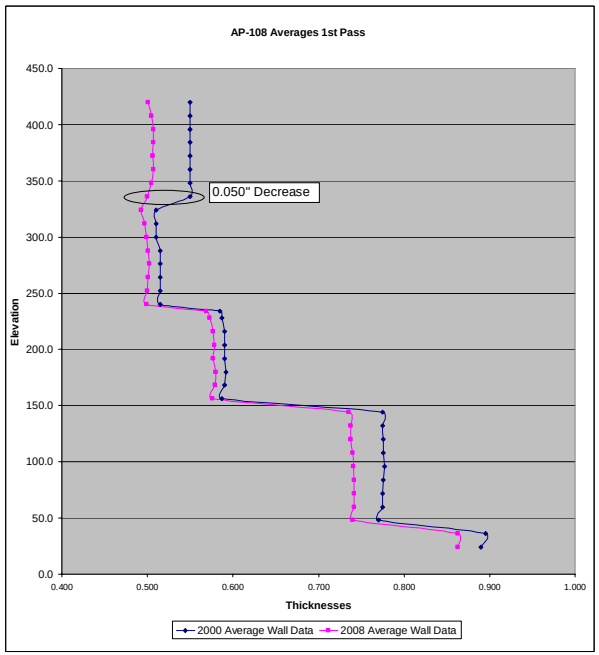


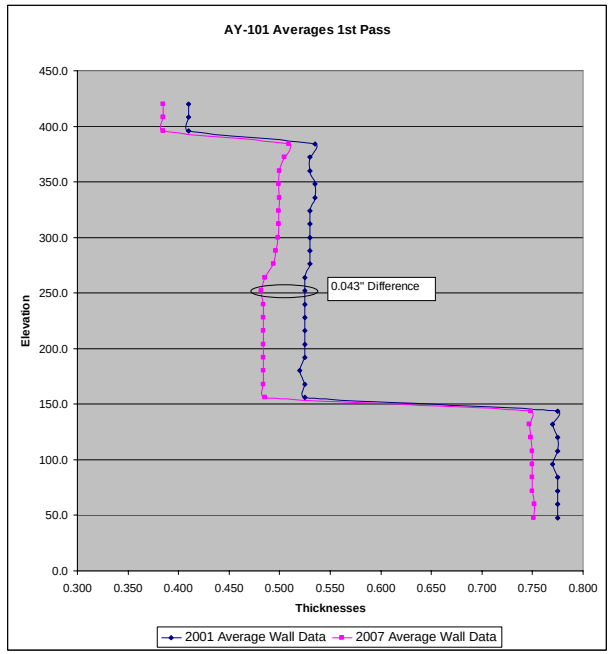
Pacific Northwest
NATIONAL LABORATORY

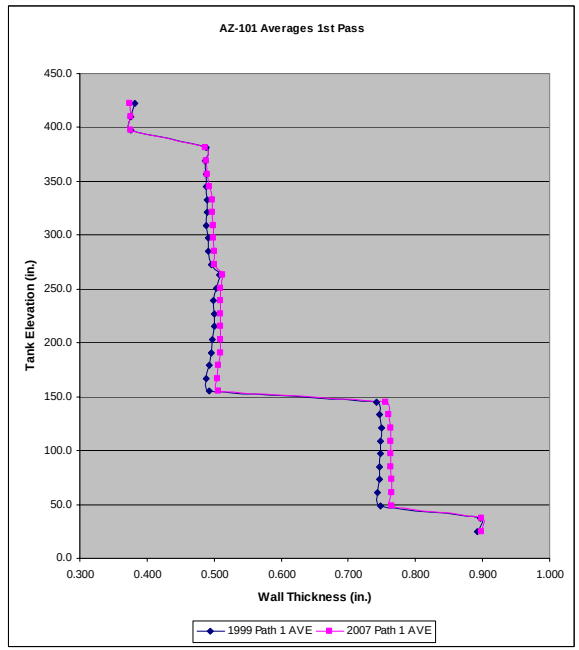
Background Information

DST Tank Inspections

- Since measurement inception in 1997, 12 tanks have been examined twice.
- Most have shown slight decreases in wall thickness. AY/AP tanks a little more.
- A couple of tanks showed areas where the wall thickness actually increased.







Pacific Northwest
NATIONAL LABORATORY

Background Information

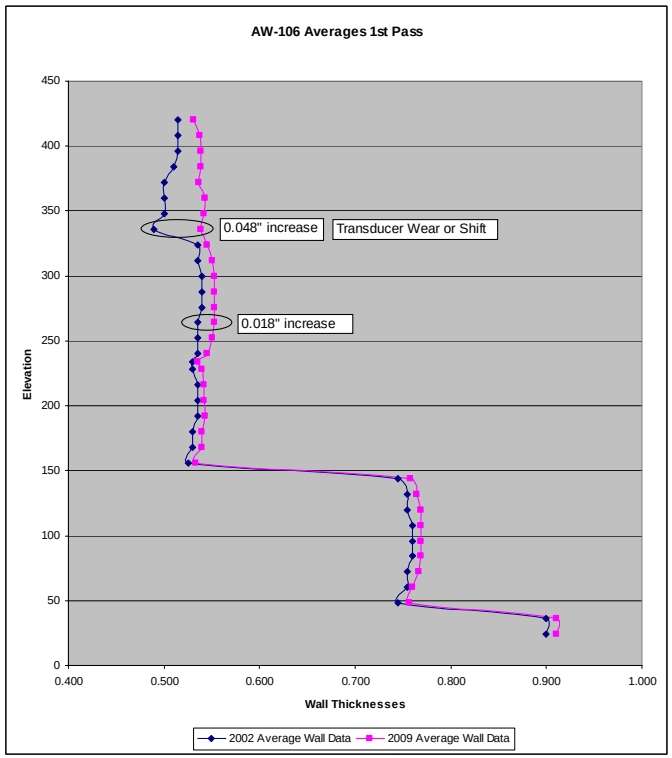
DST Tank Inspections

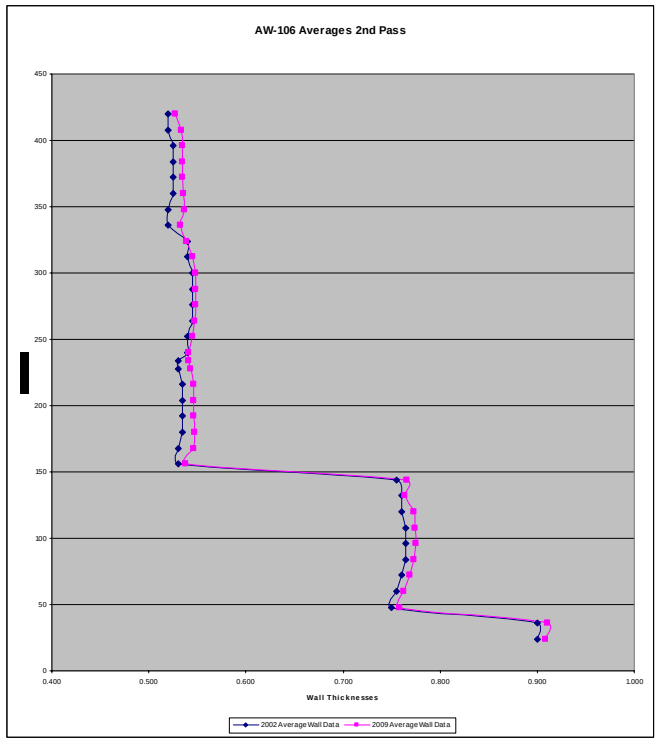
- Initial reviews of these two comparable data sets and comparison to ongoing corrosion probe studies indicated a need to investigate if there was any UT measurement variation that was not understood. This variation could be a result of actual wall thinning occurring on the waste tanks walls, or some other unexplained anomaly resulting from operator setup error or equipment error.

Background Information

DST Tank Inspections

- And recently Tank 241-AW-106 was scanned and showed an increase in wall thickness over the entire tank .





- WRPS has contracted with the Pacific Northwest National Laboratory (PNNL) to assist AREVA in understanding why this variation exists and where it stems from.
- PNNL developed a study plan to address this issue.

Pacific Northwest
NATIONAL LABORATORY

Planned Studies

- Historical Study - Data Review

  Evaluate ultrasonic measurement method used in previous years and compare to what is used now. Compare Peak/Peak-Edge/Edge

- Mockup Study

  Evaluate specific parameters such as:

  Calibration

  Wall Cleaning

  Point Measurement vs Scanning

  Couplant - Tank Wall – Calibration Standard Temperatures

  Single Element vs Dual Element Transducers

  Multiple Operator/Instrument/Transducer Repeatability Scans

- Tank Study

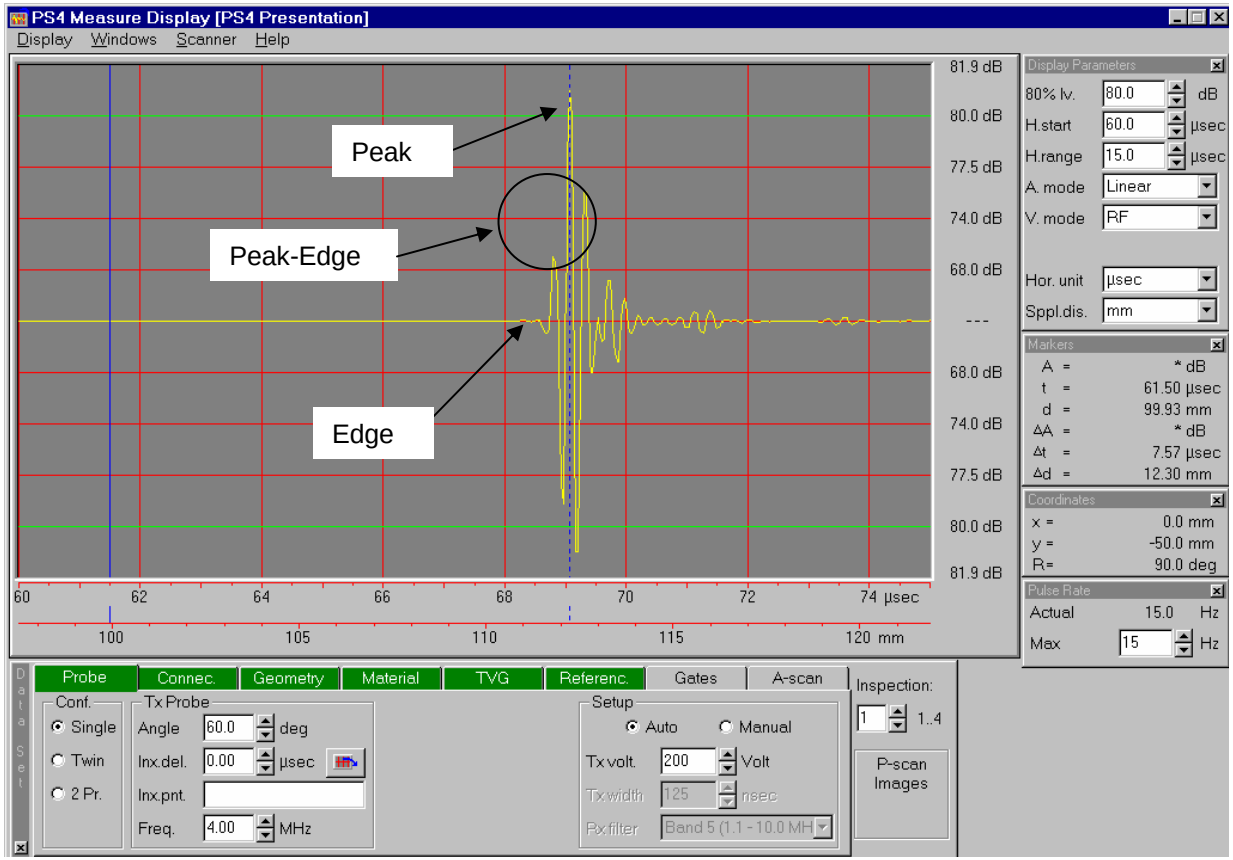
  Evaluate specific parameters such as:

  Multiple Operator/Instrument/Transducer Repeatability Scans

  Point Measurement vs Scanning

Planned Studies

Edge/Peak-Edge/Peak Study Results



Planned Studies

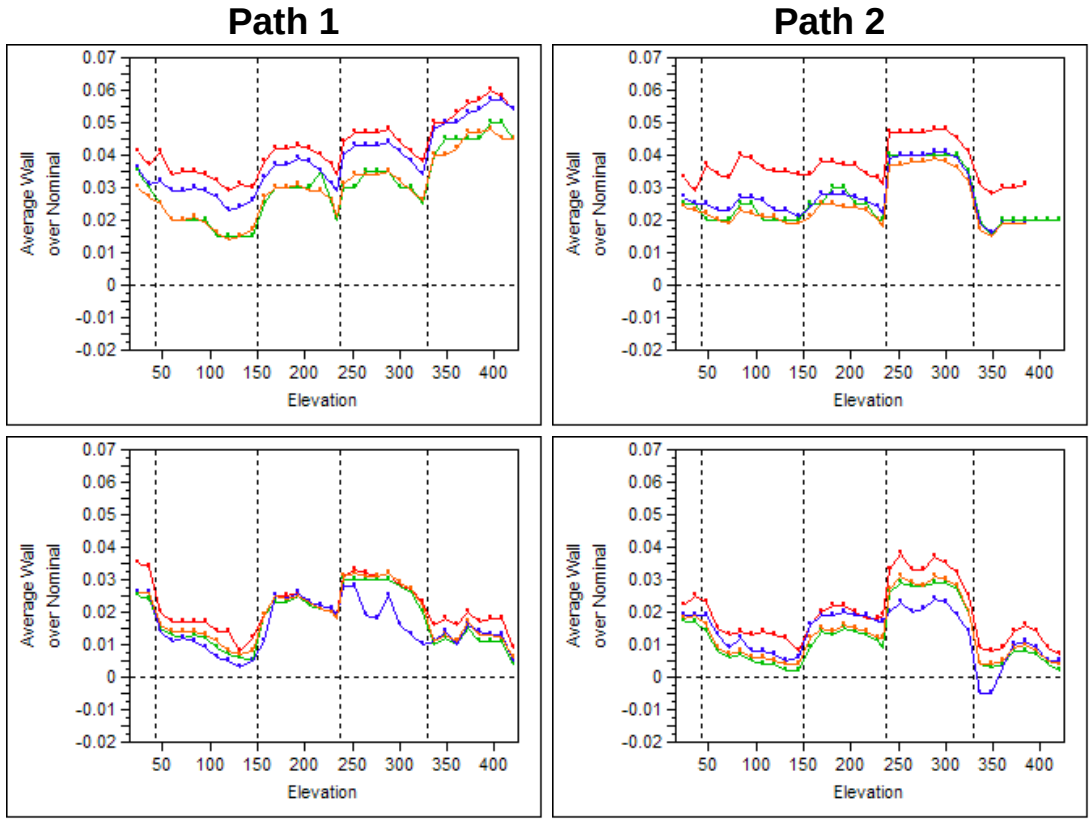
Edge/Peak-Edge/Peak Study Results

- Calibration of the system is the method used to verify that the system is measuring correctly. The portion of the signal that you are using whether it is the edge, peak/edge, or peak is calibrated using a known material of a specific thickness.
- The question posed was; during the initial first set of scans, was there a consistent evaluation performed (i.e. did you analyze all data to one specific mode)? Historical evidence indicates that the desire in the early stages of the program was to provide the best ultrasonic signal that could be analyzed (work around the noise spikes caused by surface roughness) and not much attention was paid to which of the 3 methods was used.
- In an effort to discern whether this could affect measurement variability, a study was proposed to evaluate the original data in these 3 methods and compare them to recent data on the same tanks to estimate effects.

Planned Studies

Edge/Peak-Edge/Peak Study Results

Tank AN-102



Year - 2001

Year - 2008

Edge
Original
Peak
Peak/Edge

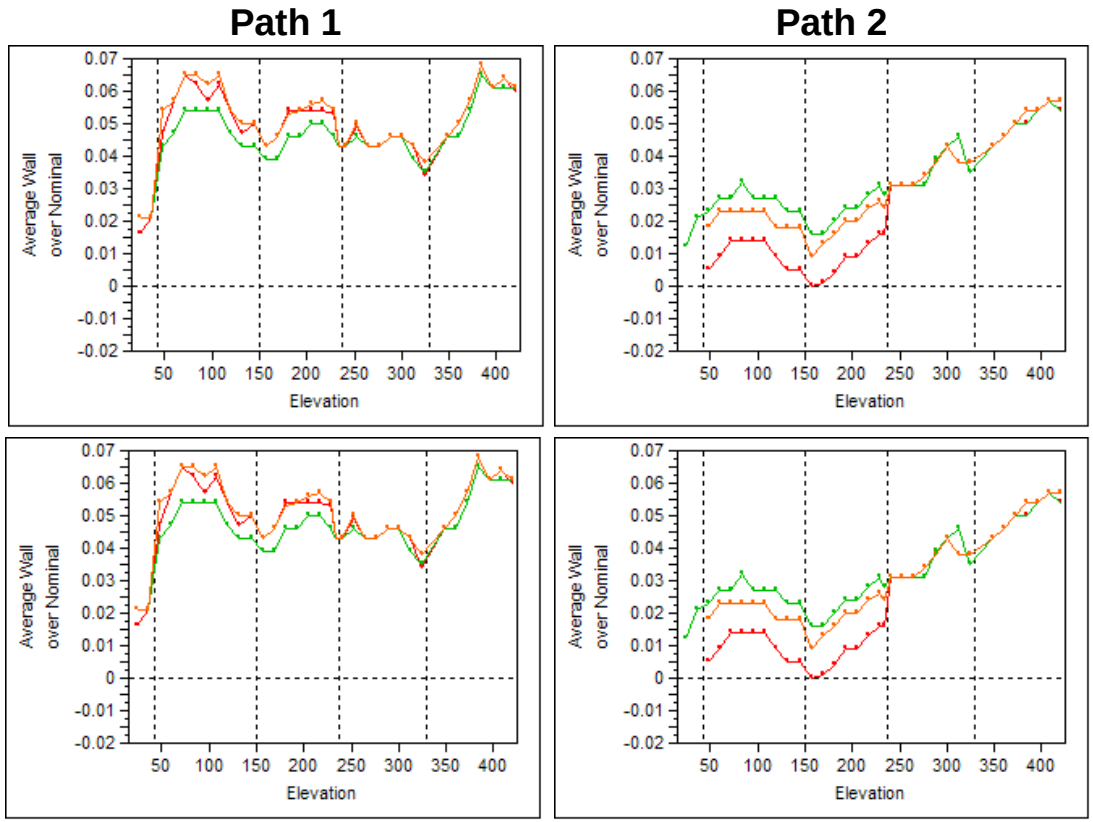
Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle *Since 1965*

Planned Studies

Edge/Peak-Edge/Peak Study Results

Tank AN-107



Year - 2001

Year - 2008

Edge
Original
Peak
Peak/Edge

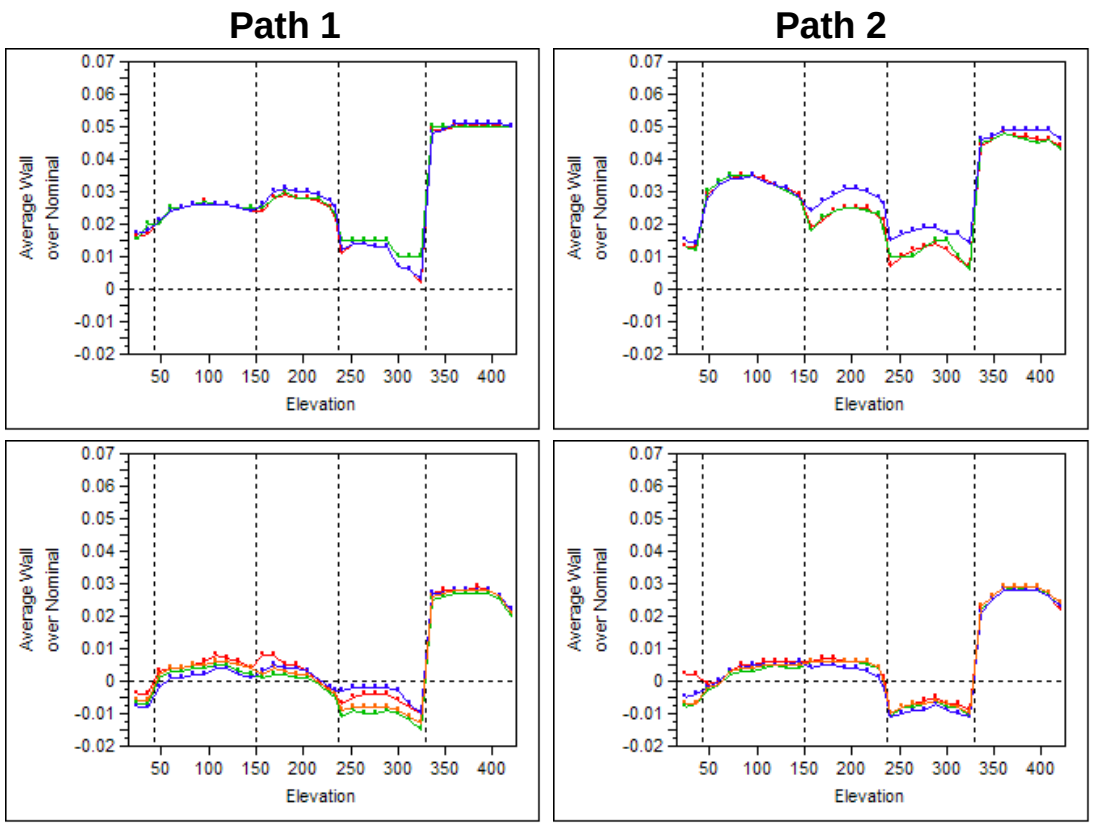
Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle *Since 1965*

Planned Studies

Edge/Peak-Edge/Peak Study Results

Tank AP-108



Year - 2001

Year - 2008

Edge
Original
Peak
Peak/Edge

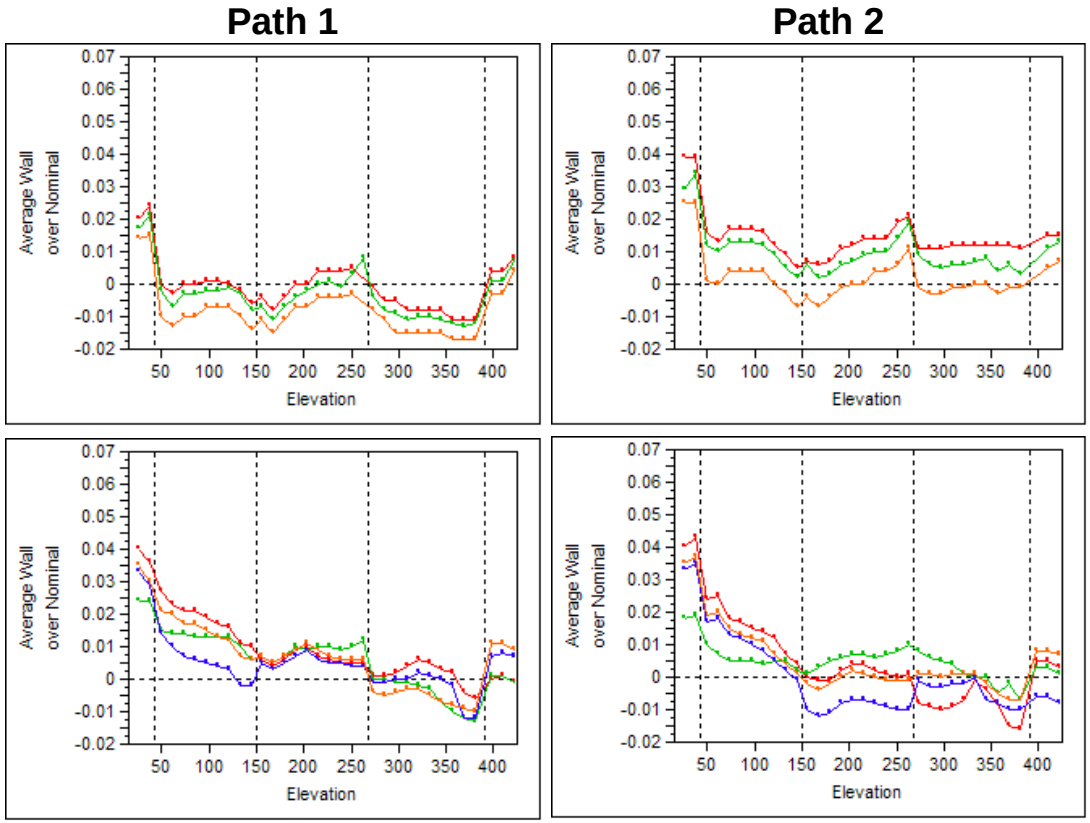
Pacific Northwest
NATIONAL LABORATORY

Proudly Operated by Battelle *Since 1965*

Planned Studies

Edge/Peak-Edge/Peak Study Results

Tank AZ-101



Year - 2001

Year - 2008

Edge
Original
Peak
Peak/Edge

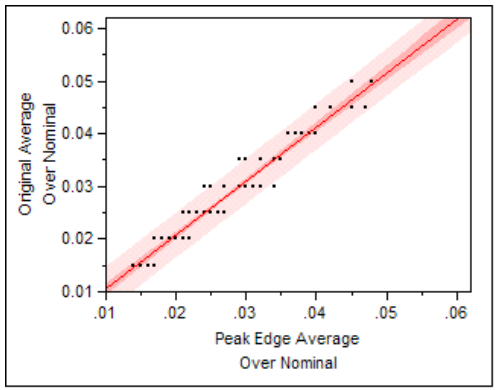
Pacific Northwest
NATIONAL LABORATORY

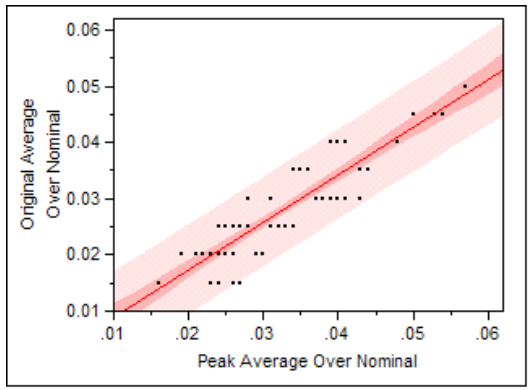
Proudly Operated by Battelle *Since 1965*

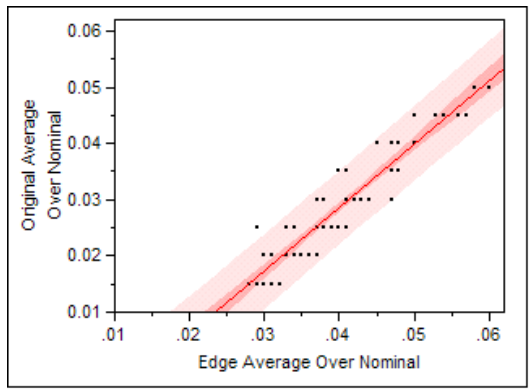
Planned Studies

Edge/Peak-Edge/Peak Study Results

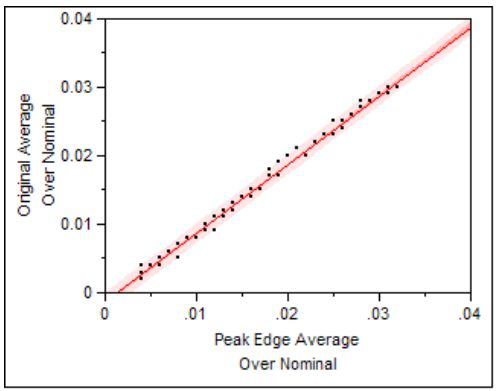
Tank=AN-102, Inspection=Old

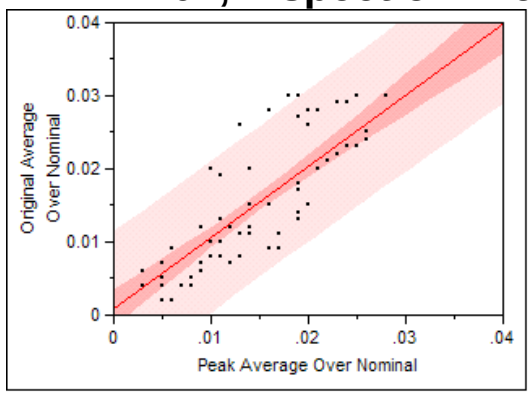


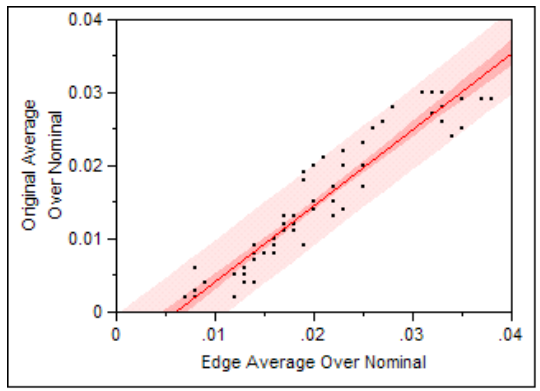




Tank=AN-102, Inspection=New







Dark pink is confidence band for regression line; light pink is confidence band for individual values.

Planned Studies

Edge/Peak-Edge/Peak Study Results

Method	Mean
Edge	0.021978
Peak	0.018635
Peak/Edge	0.017559

- Over all tanks these average differences from nominal were observed

- Thus if old to new comparisons are made (to be discussed in a later presentation) the change in methods from old to new inspections should be considered

- We'll see this in the later discussion where old to new went from Edge to Peak-Edge, which according to the above results might introduce a 0.0044 in. bias

Planned Studies

Mockup Study

- Currently working on the mockup studies

Pacific Northwest
NATIONAL LABORATORY

Planned Studies

Tank Study

- **Operator / Transducer / Instrument**

  Three each of the factors operators, transducers, and instruments were used to generate UT scans in two tanks so the variability due to each of the three factors could be examined

- **Point Measurements**

  Average UT measurement results are compared between the usual moving crawler results and stationary point measurements

Planned Studies

Operator/Instrument/Transducer

Instrument	Transducer	Operator
A	1	W
A	2	J
A	3	B
B	1	B
B	2	W
B	3	J
C	1	J
C	2	B
C	3	W

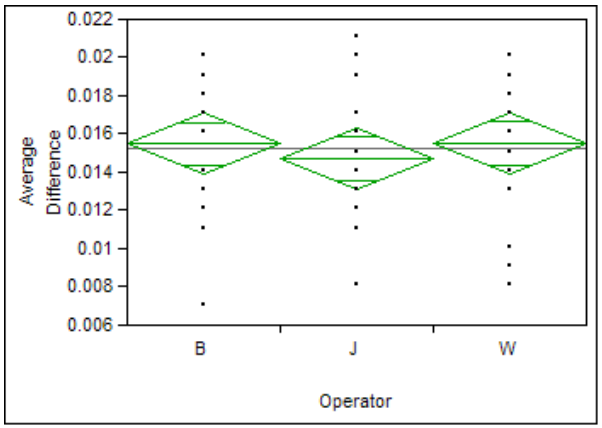
- For each combination of factors five 12 x 15 inch UT images were generated in Plate 3 and two in Plate 5 for a total of seven

- A full factorial design would require 27 such combinations. Instead the indicated Latin Square design was used which permitted the examination of the three factors with only 9 combinations

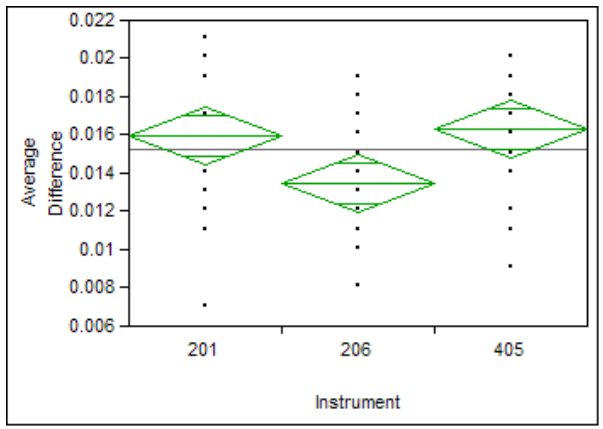
Planned Studies

Operator/Instrument/Transducer Results

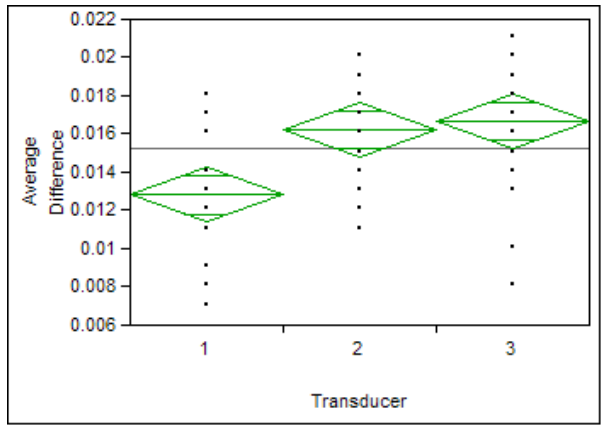
Operator Results



Instrument Results



Transducer Results



Plotted points are wall thickness differences from nominal; each column has 21 such values

Operator Means		Instrument Means		Transducer Means	
B	0.0154	201	0.0160	1	0.0128
J	0.0147	206	0.0135	2	0.0162
W	0.0155	405	0.0163	3	0.0167
Significance	0.5439	Significance	0.0019	Significance	<0.0001

Pacific Northwest
NATIONAL LABORATORY

Planned Studies

Operator/Instrument/Transducer Results

Previous slide treats the factors as “fixed effects”. That is, interest is in the differences in these specific operators, instruments and transducers. In this case the means for each are considered.

Alternatively they could be treated as “random effects”. That is, each set of three operators, instruments, or transducers is simply a random sample that represents the variability among larger groups of operators, instruments, or transducers. In this case variance components or standard deviations for each factor are considered.

Component	Var Component	% of Total	Plot%	Sqrt(Var Comp)
Instrument	0.00000192	12.6		0.00138
Transducer	0.00000403	26.6		0.00201
Operator	0.00000000	0.0		0.00000
Within	0.00000922	60.8		0.00304
Total	0.00001517	100.0		0.00389

Planned Studies

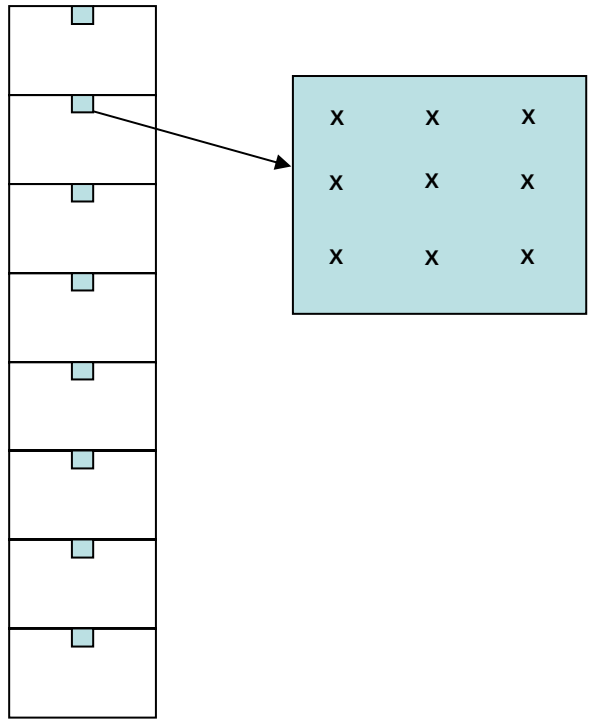
Point Study

• Figure indicates a vertical scan consisting of eight 15 by 12 inch UT images generated in the usual manner with a moving crawler.

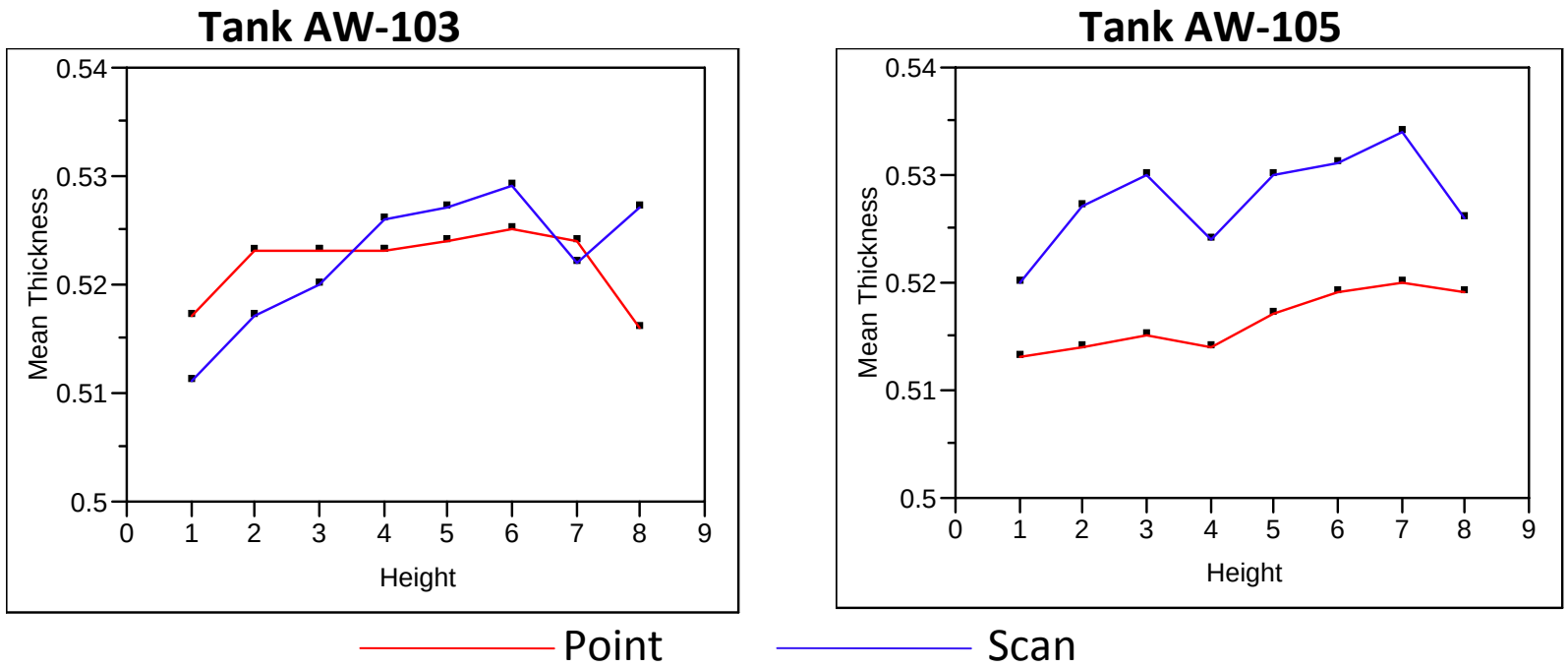
• The blue square with x's indicate 9 points which were then measured with the crawler stationary. Note that about 7500 pixels were measured within this square in the vertical scan.

• The mean of the 7500 "scan" measurements was compared to the mean of the 9 "point" measurements.

• The study was done both in Tanks AW-103 and AW-105.



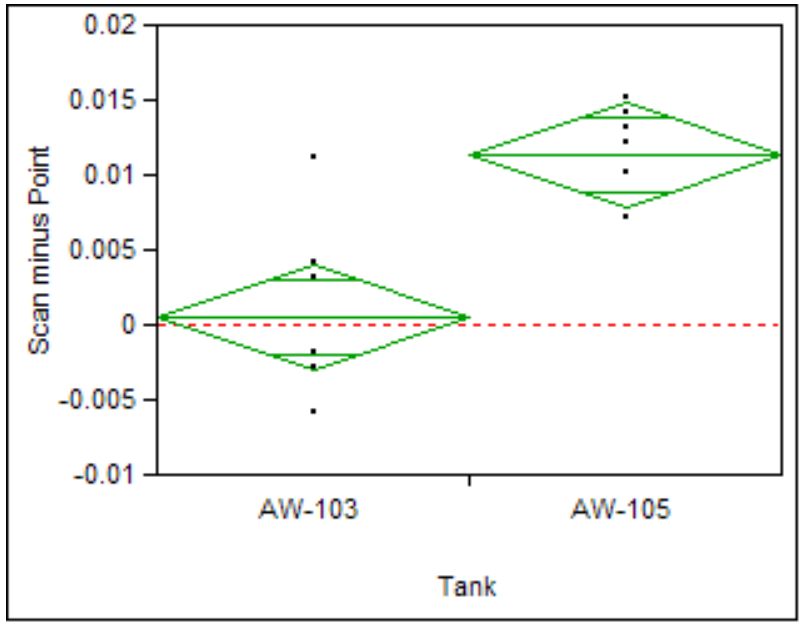
Point Study Results



For Tank AW-103 little difference is shown on the average between the scan and point results.

For Tank AW-105 a persistent difference is indicated with the scan measurement averages exceeding the point measurement averages.

Point Study Results



AW-103 “scan minus point” mean difference is 0.0005 in.

AW-105 “scan minus point” mean difference is 0.0114 in.

Visual Crack Detection Study

- Study the feasibility of using remote visual inspection techniques to characterize cracks in the concrete dome of the single shell tanks
  - Description of surfaces to be examined
  - Results of experimental study in the laboratory

Visual Crack Detection Study

Why Look for Cracks in the Dome Surface?

- 1/16 inch wide cracks in the concrete are indicative of permanent rebar deformation
- If we can find 1/16 inch wide cracks, then we can determine if such permanent deformation of the rebar has occurred

Visual Crack Detection Study

Description of Surfaces to be Examined

- Dome surfaces were not fabricated with crack detection in mind
- Lots of seams from concrete forms
- Surface anomalies from repair of voids during initial concrete pour
- Surface changes due to environmental affects

Visual Crack Detection Study

Tank Domes Showing Form Seams and Access Risers

Pacific Northwest
NATIONAL LABORATORY

Visual Crack Detection Study

Construction Repair To Single Shell Tank Dome Concrete

Pacific Northwest
NATIONAL LABORATORY

Visual Crack Detection Study

Laboratory Investigation

- Prepared cracked concrete samples
- Took a series of digital photos to investigate:
  - Required camera resolution
  - Effects of lighting types and lighting angles
  - Effects of angle between camera and surface
  - Ultraviolet and Infrared imaging
  - Polarizing filters
  - Application of various imaging filters

Visual Crack Detection Study

Samples of cracked concrete used for photographic studies

Visual Crack Detection Study

Characteristics of Concrete Cracks

- Cracks on dome surface would be due to tensile failure of concrete
- Cracks of 1/16 inch width indicate permanent rebar deformation
- Cracks will likely have missing chips at multiple locations along their length

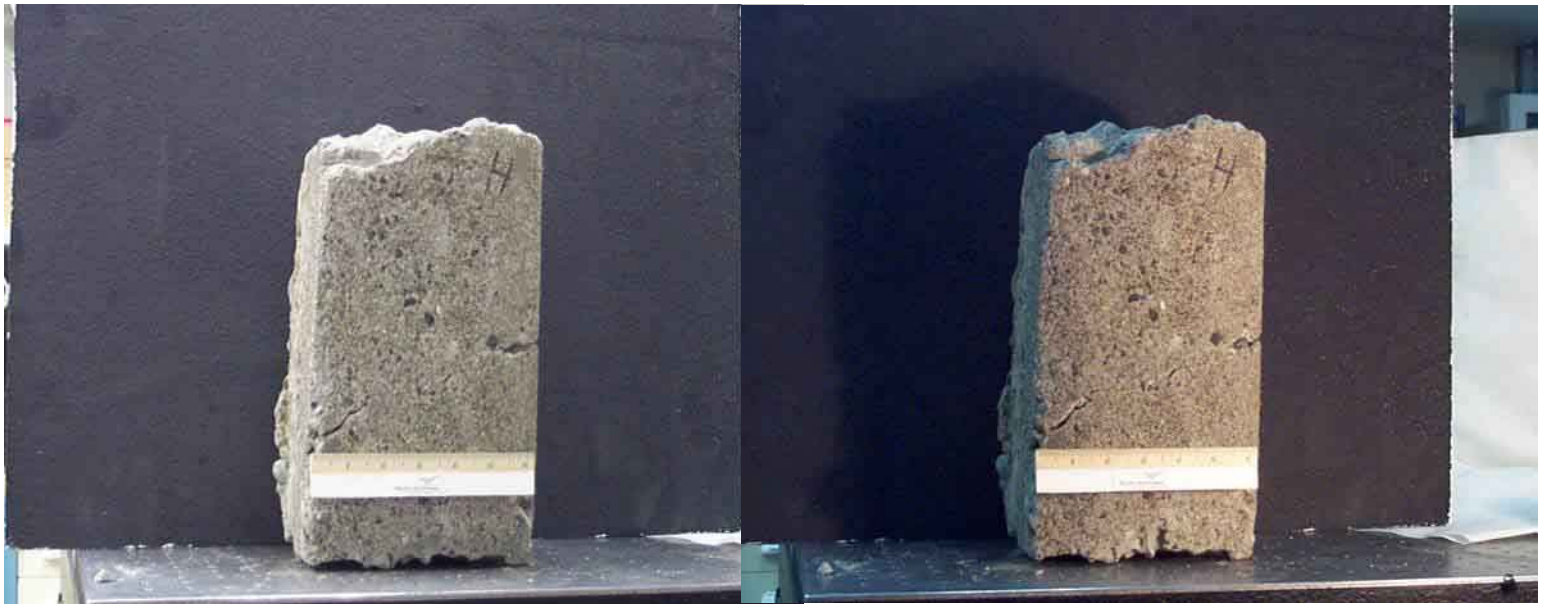
Visual Crack Detection Study

Chips along cracks at tensile surface

Pacific Northwest
NATIONAL LABORATORY

Visual Crack Detection Study

Effect of Lighting Type on Crack Detection

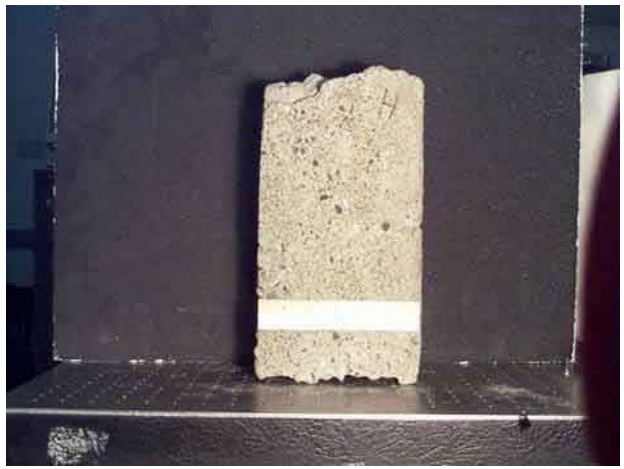


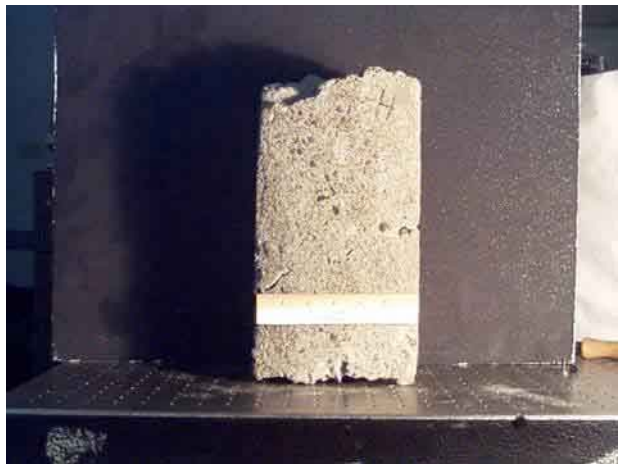
Diffuse Fluorescent Light

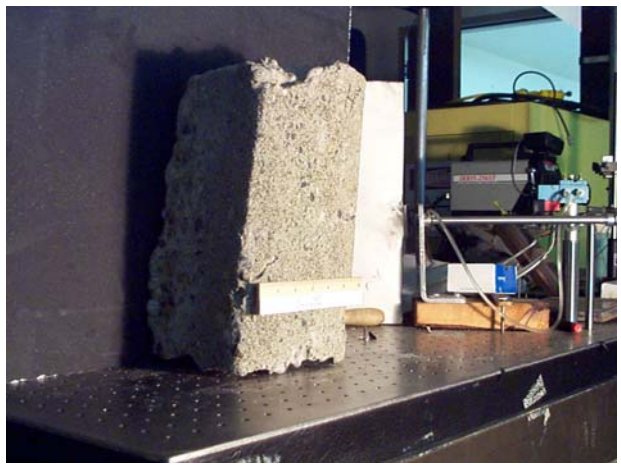
Tungsten Light Source

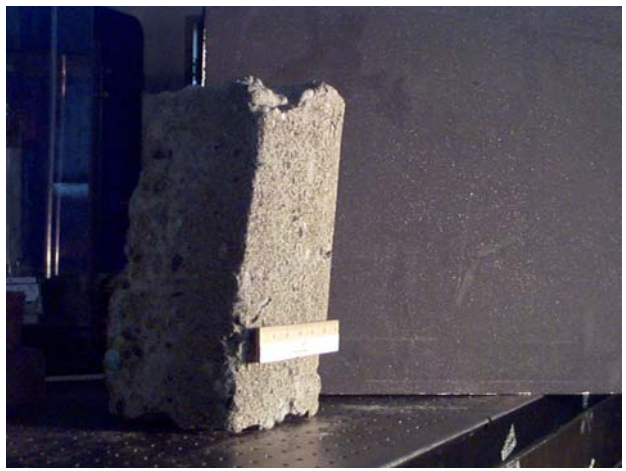
Visual Crack Detection Study

Variations in Light Source and Camera Angles





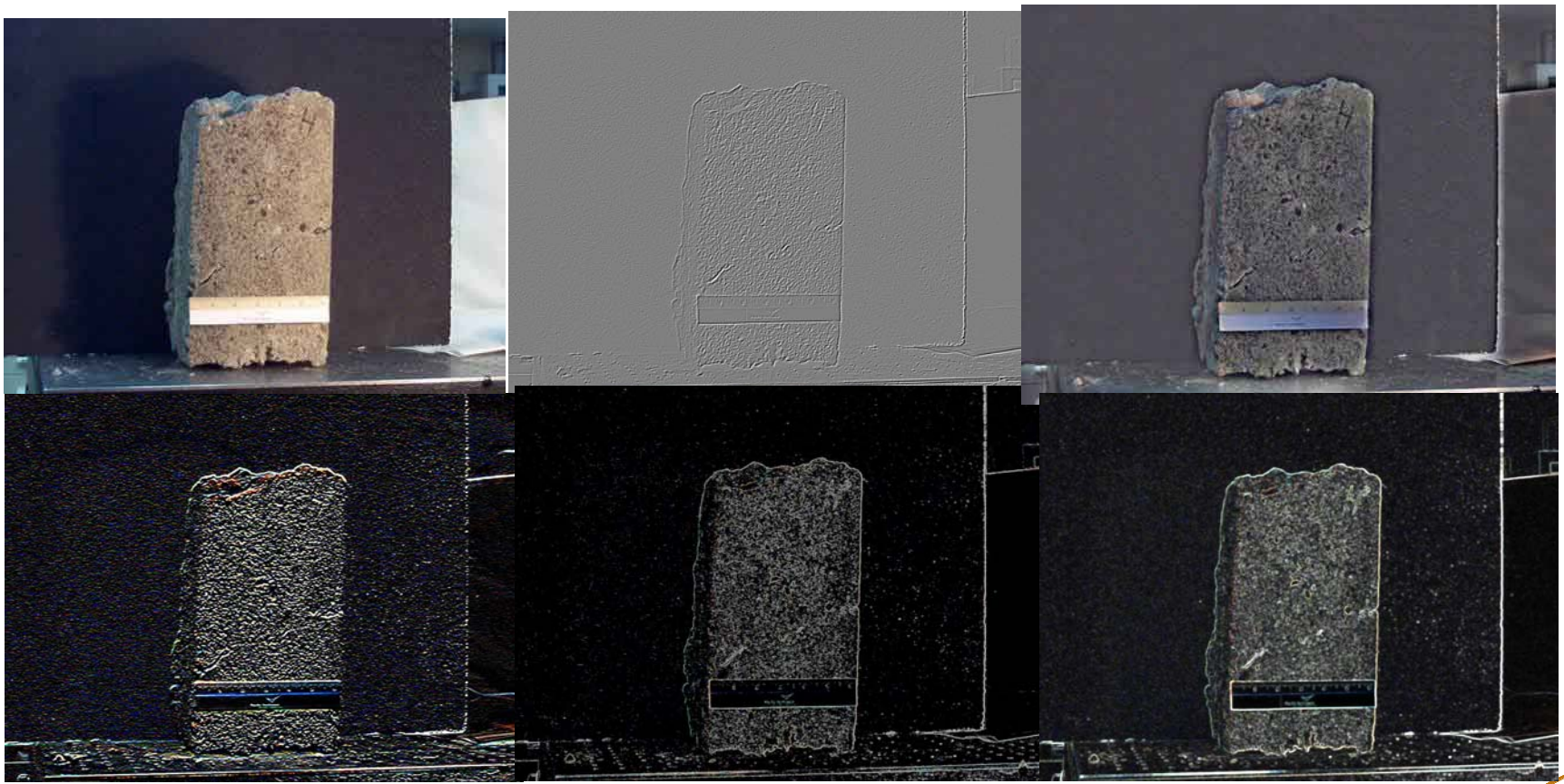




Pacific Northwest
NATIONAL LABORATORY

Visual Crack Detection Study

Application of Various Imaging Filters



Visual Crack Detection Study

Insights on Imaging to Date

- Detection of 1/16 inch wide cracks appears challenging but achievable with available cameras
- Proper lighting is critical to any crack detection
- Changing lighting angles may aid in detection
- Ultraviolet and infrared imaging did not improve detection
- Polarizing filters did not improve detection
- Imaging filters deserve further investigation
- Getting the camera and lights close enough and at the optimum orientation of the dome surface will be challenging