Weld Inspection of Transmission Tubular Steel Structures

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Objectives

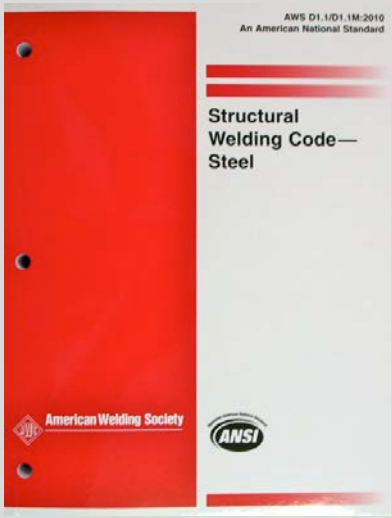
- Framework and shortcomings of AWS D1.1
- Repeatable UT inspection
- NDE metallurgical examinations & validations
- Recommend a standard

History of AWS & D1.1

- 1928- Published First Edition
  - Code for Fusion Welding and Gas Cutting in Building Construction, Code 1 Part A
- 1930, 1937 & 1941 - Revised
  - Given AWS-D1.0 designation
- 1936- Published First Edition of Bridge D2.0
- 1972- D1.0 & D2.0 combined to form AWS D1.1
  - Section 8: Buildings, Section 9: Bridges, Section 10 Tubular

History of AWS & D1.1 cont.

- 1988- Bridges group separated
  - Formed AASHTO/AWS D1.5 – Bridge Welding Code
- 1990's- Section 8 Tubular removed
  - All inspection condensed into Section 6
    - Now Clause 6
    - Change was significant to Pole Structures industry
- Currently- AWS D1.1/D1.1M:2010
  - 5 year rev. cycle



Framework of AWS D1.1

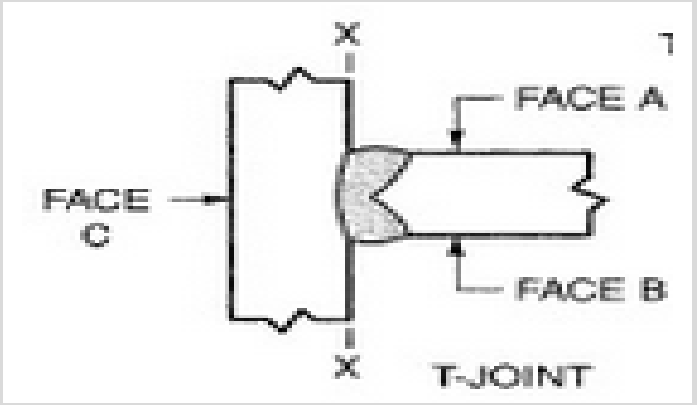
- Known throughout the industry
  - "All Welding per AWS D1.1"
- Qualifies process and people
  - Clause 3 & 4
- Discusses alternative means of UT inspection
  - Annex S
- Inspector Qualification
  - AWS QC1 & ASNT SNT-TC-1A
- Calibration of UT equipment
  - Clause 6 Part F
  - Based on CRT technology

Shortcomings of AWS D1.1

- Very broad; not specific to our industry
  - Pre-Qualified Joints not geared to Pole Industry
- No UT acceptance criteria for CJP's under 5/16"
- Clause 6.8 offers alternative acceptance with very little info on how to document that
- No mention of Galvanizing (& UT)
  - UT is common and necessary on galvanized structures
- Doesn't account for modern technology

Shortcomings of AWS D1.1 cont.

- Evaluation from 1 face (UT)
  - Corner or T- Joint ≤ 1.5 inch
- Needs more consideration
  - CVN
- Identifies all defects
  - Finite Element Analysis (FEA)
  - Should concentrate on critical defects
- Frequency of CJP UT inspection
  - 10% vs. 100%



A Proper Inspection Program

- A good program starts with good VT
- Welding variables defined
  - WPS, Work Instruction, Print
- Inspection before, during, and after
- Inspector qualification
  - AWS, ASNT, CWB, ACCP

A Proper Inspection Program cont.

- If more than VT required
  - VT then UT
- Minimize variation between inspectors (VT & UT)

T&B Destructive Testing Results and Validation of NDE

Figure 1.

A single indication was reported by UT. It was characterized as 2.0"L x 0.12"D. The section containing the defect was sent for metallurgical analysis.

T&B Destructive Testing Results and Validation of NDE cont.

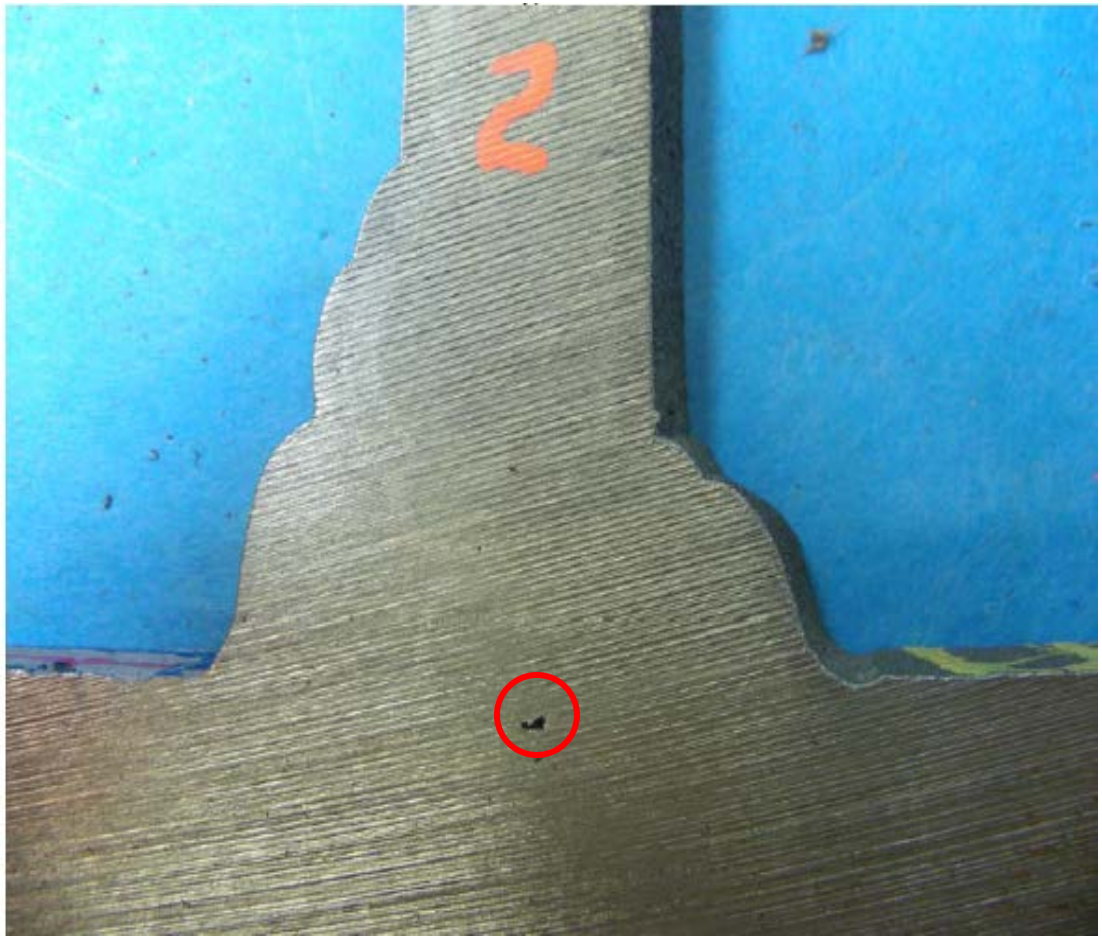


Figure 2.
Examination of the cut slices revealed a defect.

T&B Destructive Testing Results and Validation of NDE cont.

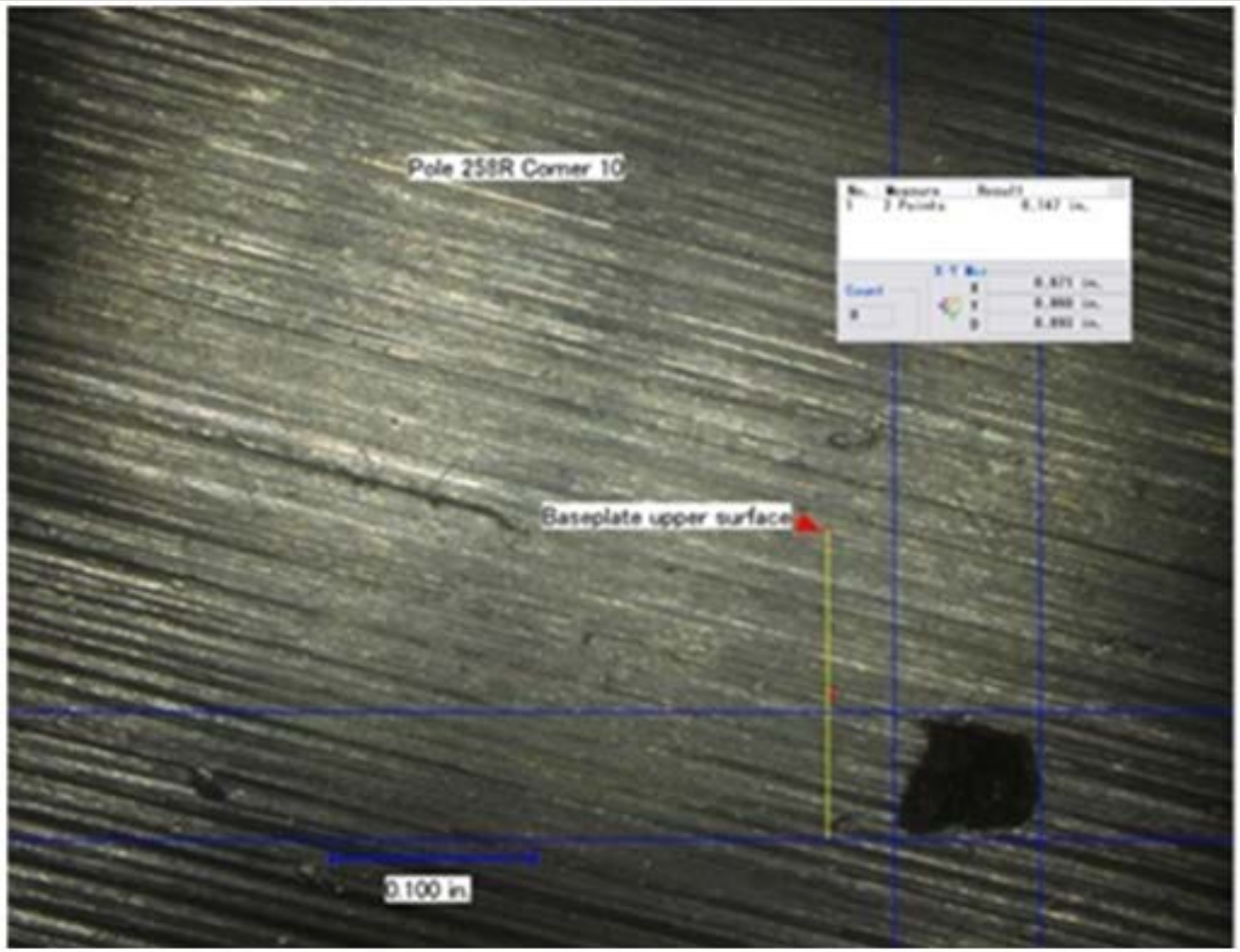


Figure 3.

Under 20X Magnification, the indication exhibited a small slag defect in the center of the weld at the base of the weldment. Actual flaw was less than 0.5"L X 0.1" D.

Results

- Indication rejectable by UT (AWS D1.1)
- Major reduction in size and geometry reported (**UT** 2.0”L x 0.12”D vs. **Actual** 0.5”L x 0.1”D)
- No effect on structural integrity of pole

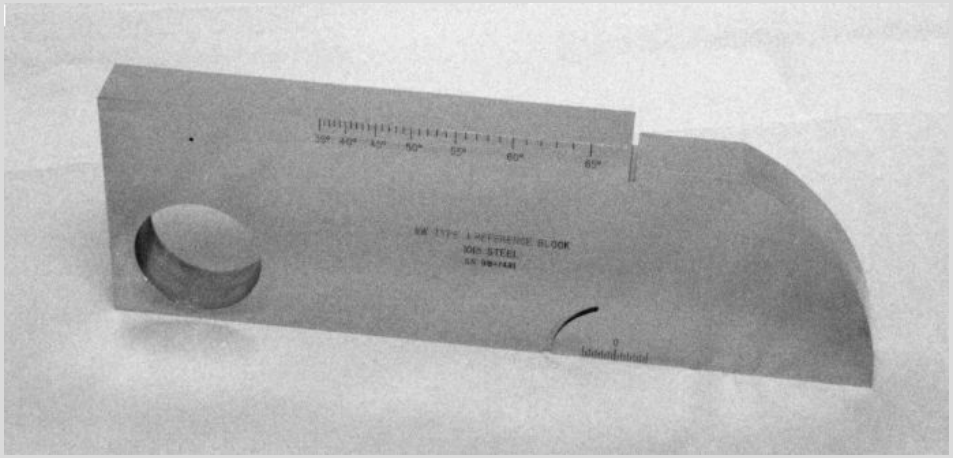
T&B Enhancements to AWS D1.1 for Full Penetration Welds cont.

T&B Enhanced Method

- Calibrate to IIW Block
  - 0.060 Side Drilled Hole to 80% FSH
  - Add 7db
    - Previously add 6db
  - Evaluate at this level

AWS D1.1 Method

- Calibrate to IIW Block
  - 0.060 Side Drilled Hole between 50% to 75% FSH
  - Evaluate at 5-7db's



T&B Enhancements to AWS D1.1 for Full Penetration Welds cont.

T&B Enhanced Method

- Evaluate from Scan Level
  - 80% FSH for 0.060 Hole plus 7db
- 80% FSH - Reject Regardless of Length
- 40% - <80% FSH – Reject after 1 inch of Length
- 20% - <40% FSH – Reject after 2 inches of length

AWS D1.1 Method

- Indication level (a) – Reference Level (b) – Attenuation Factor (c) = Indication Rating
- Compare Rating to Table 6.2
  - Determine Acceptance

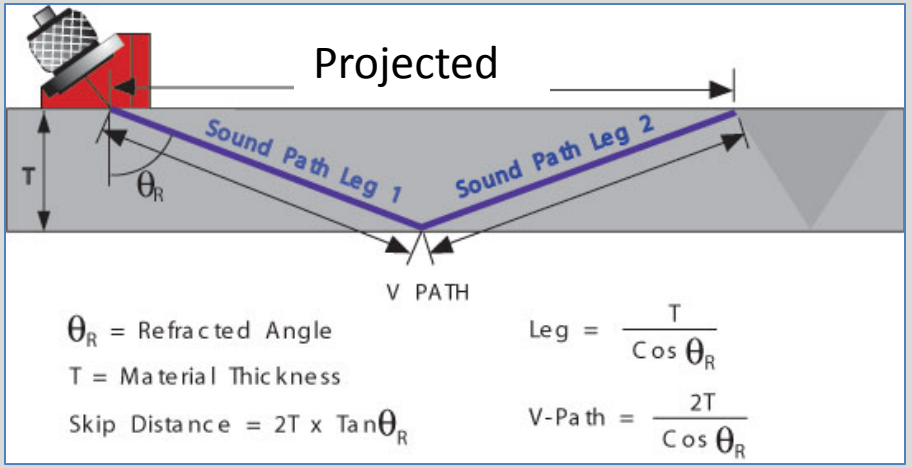
T&B Enhancements to AWS D1.1 for Full Penetration Welds cont.

T&B Enhanced Method

- Add 2db per inch after 2 Inch of Sound Path
  - Was “Add 2db per inch after 5 Inch of Sound Path”
  - Added “Skip Charts” to Standard for easy reference.

AWS D1.1 Method

- Calculated using Sound Path



T&B Enhancements to AWS D1.1 for Full Penetration Welds cont.

T&B Enhanced Method

- Length Evaluation
  - Measured from Center of Transducer
- From Max Indication:
  - Scan Left and Right until indication drops below 10%

AWS D1.1 Method

- Length Evaluation
  - Measured from Center of Transducer
- From Max Indication:
  - Scan Left and Right until indication drops by 50% (6db)
  - This could still be 37.5% FSH
  - This would not be less than 25% FSH

T&B Enhancements to AWS D1.1 for Full Penetration Welds cont.

T&B Advantage

- Meets
  - AWS Requirements
- Exceeds
  - More Critical on Longer Indications
  - Allows Evaluations after 2nd Leg
  - Allows Evaluation with Both a 70° and 45° Transducer

D1.1 Disadvantage

- No Acceptance Criteria for Material Under 5/16 inch
- No Criteria for Coated Material
  - Galvanized
- Evaluation in the 1st and 2nd Legs Only
  - On thinner material the 2nd Leg may not be out from under the transducer

Considerations for a New Standard

API 2X

- Off-Shore Structures
- Same idea as Annex S
- DAC curve; includes Coatings
- Recognize
  - FEA/Fracture Mechanics
  - Certain flaws better left

D1.8 Seismic Supplement

- Designed for strain
- Adequate strength
- Certain defects more critical
- Repairs may result in more harm than good (Example: Figure 1-3)

Conclusions

- The long-term approach for the industry is to work within our industry committees to collectively develop, as AWS D1.1 recommends, a standard suitable specifically for tubular steel transmission structures.
- Refer to Paper, “Baseplate and Flange Weld Inspection of Tubular Steel Transmission Structures”