

Non-Destructive Examination Techniques of Communication Steel Poles

Brian Reese, PE, CWI

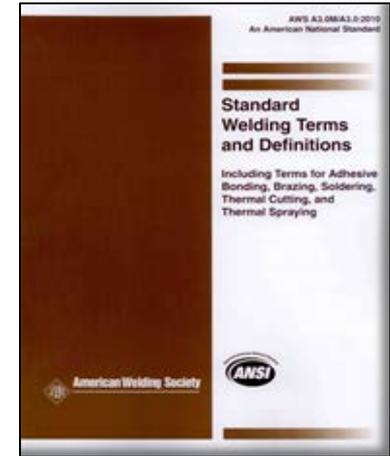
breese@reasetowerservices.com



Reese
— TOWER SERVICES —

What is NDE?

AWS A3.0; Standard Welding Terms & Definitions:



Nondestructive Examination - the act of determining the suitability of a material or a component for its intended purpose using techniques not affecting its serviceability

What is NDT? A nonstandard term when used for nondestructive testing



Why NDE?

- ✓ Base plate connects the pole via the anchor bolts to the foundation
- ✓ Shop fabricated welded connection; non-redundant!
- ✓ Structural adequacy and integrity of this connection is crucial to structure performance; failure catastrophic resulting in collapse
- ✓ Tower owner business model is based on maximizing the load carrying capacity of its structures, thereby adding more load to this connection
- ✓ Known issue in the pole industry

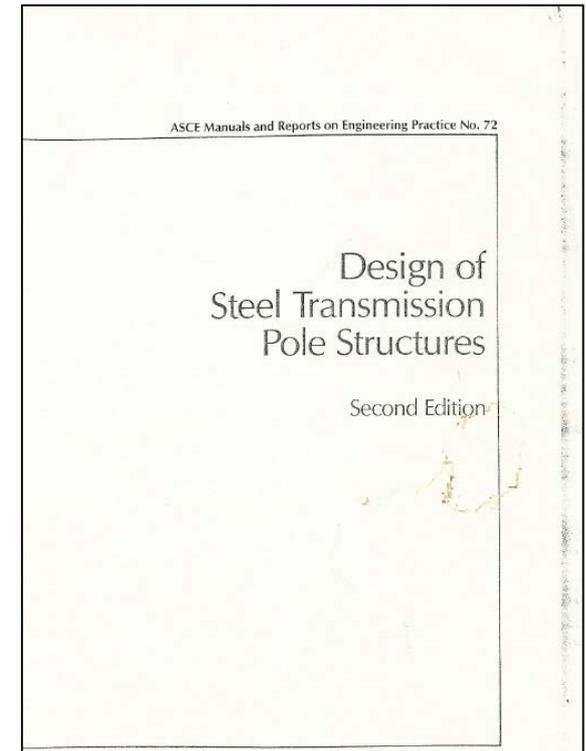
Why NDE?

ASCE Manual 72, 1990:

3.5.3.3 Special Design Considerations

ASTM A143 and A385 as well as reference 308 covers items including material selection, welding, effects on mechanical properties, drainage and venting. These references should be consulted. Several specifics relating to transmission poles are listed below.

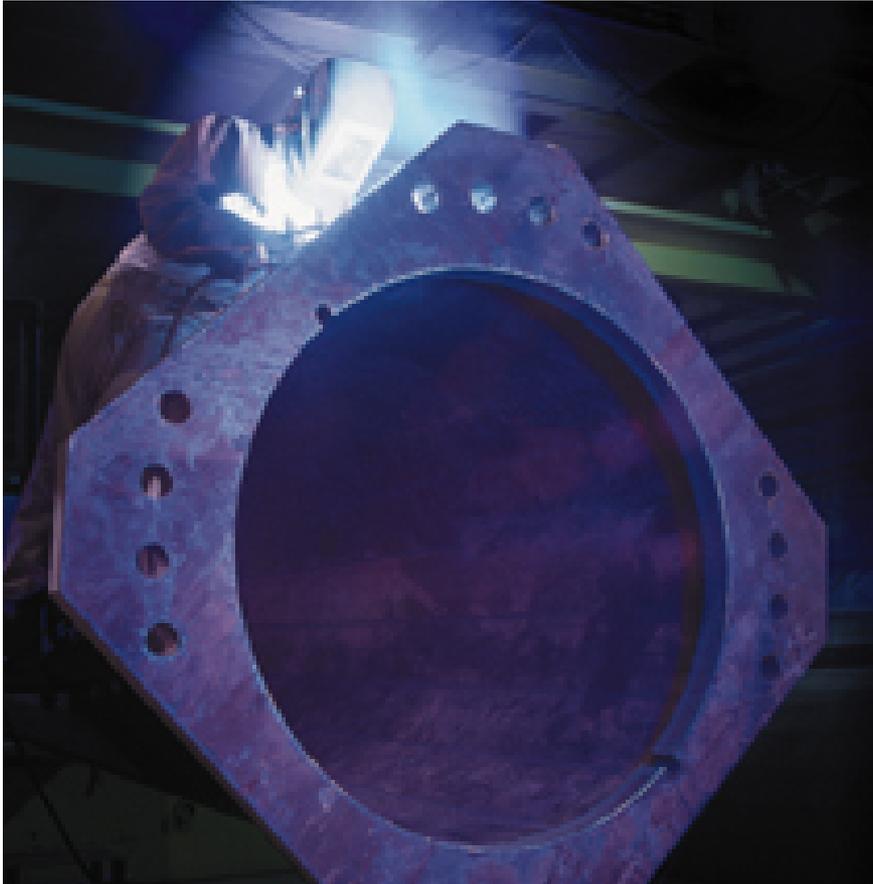
- Steel selection—Refer to section 3.5.3.2.
- Cold working—Reference 308 warns that “cold working is the strongest factor contributing to the embrittlement of galvanized steel” and lists eight precautions involving steel selection, bending and shearing. These have been incorporated in the appropriate sections of this guide.
- Welds—Flux deposits (slag) should be removed prior to galvanizing. The normal pickling associated with the galvanizing process will not remove slag. Some welding processes do not produce slag. Welds that are inaccessible, such as the seam weld on enclosed shapes, should use one of these processes or involve joints where the slag deposits have a width of less than 3/16 in. This is based on the protection provided by the adjacent galvanizing should the slag drop off (in reference 309, AHDGA supports the 3/16 in. maximum dimension).
- Toe cracking of weldments—Toe cracks, around T-joint welds, undetectable prior to galvanizing have been detected after galvanizing. The formation of these cracks appears to be influenced by several factors in the fabrication process (310). Requirements for post-galvanizing inspection should be considered. If the manufacturer can provide historical proof that the practices used do not produce toe cracks after galvanizing, this requirement may be waived.





Why NDE?

- ✓ Improved performance and reduced liability
- ✓ Very inexpensive insurance policy



Why NDE?

Combine any of the following with post-galvanizing toe cracks:

- ✓ Under-designed base plate
- ✓ Overload condition
- ✓ Fatigue
- ✓ Loose anchor rod nuts (including leveling nuts)
- ✓ Extreme weather event
- ✓ No inspection program



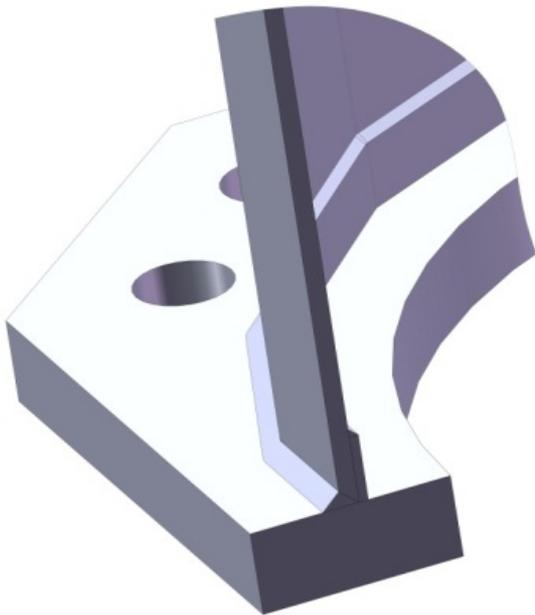


8 10:49 AM



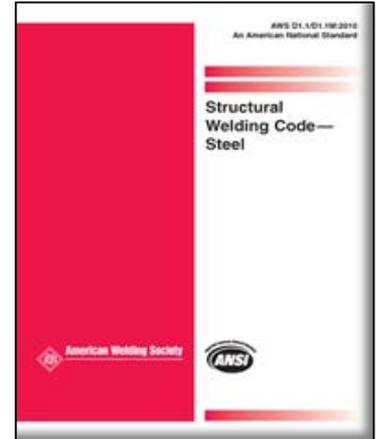
Base Geometry - Connection Types

- ✓ Complete penetration joint (CJP)
- ✓ Socket joint



Defects & Cracks

- ✓ Left in place without repair, cracks may propagate over time and loading and can be very detrimental
- ✓ Cracks can greatly reduce the fatigue strength of a member
- ✓ ***AWS Structural Welding Code D1.1*** does not allow a crack to be left in the weldment after inspection per Table 6.1, Part 1, regardless of size or location



Defects & Cracks

- ✓ Cracks have been found in the pole shaft wall in the toe above the base weld at the bend points
- ✓ Polygonal poles in both CJP and socket connections
- ✓ Field repairs conducted to date show the importance of monitoring and repairing this important connection on an on-going basis



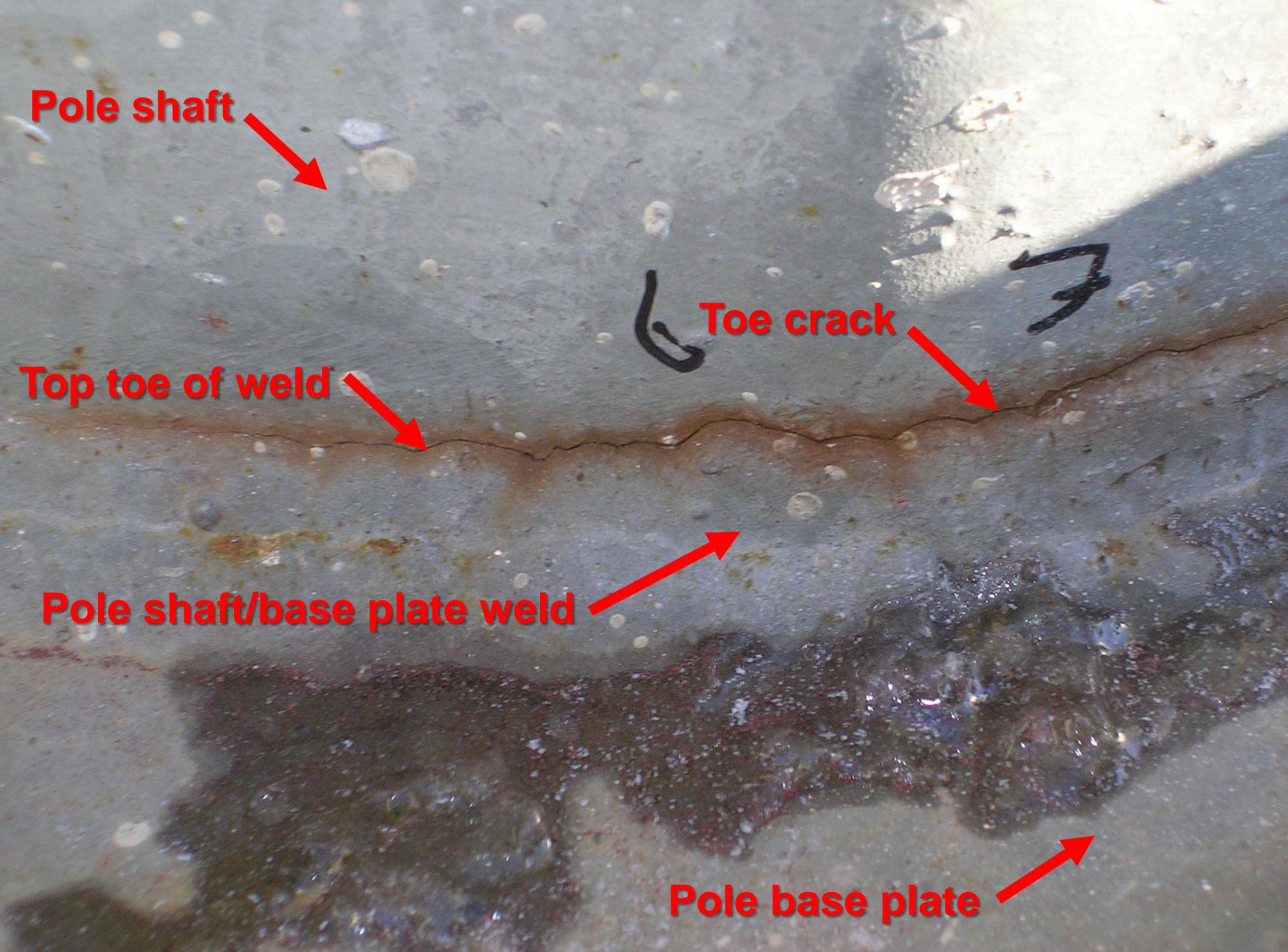
Pole shaft

Top toe of weld

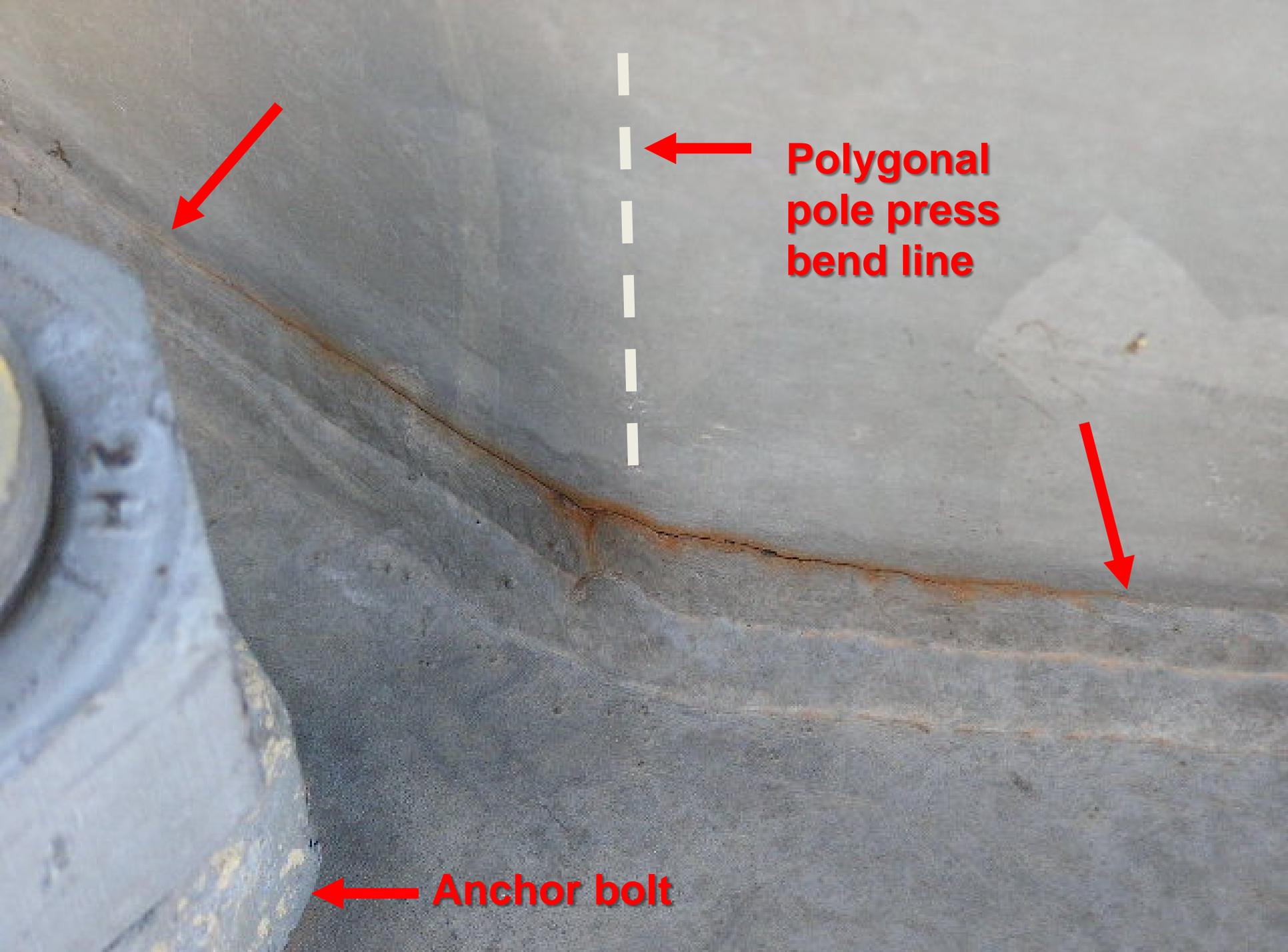
Toe crack

Pole shaft/base plate weld

Pole base plate



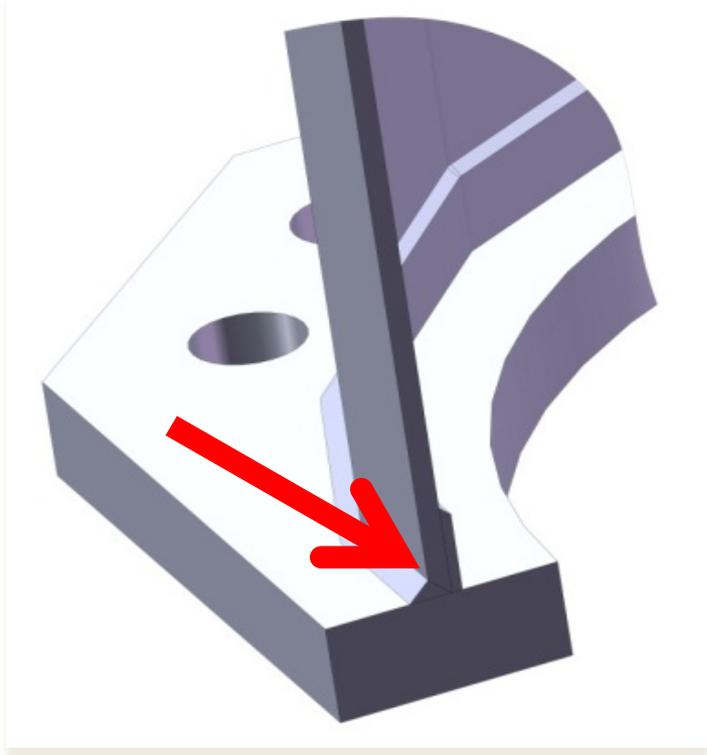




**Polygonal
pole press
bend line**

Anchor bolt

Toe Cracks

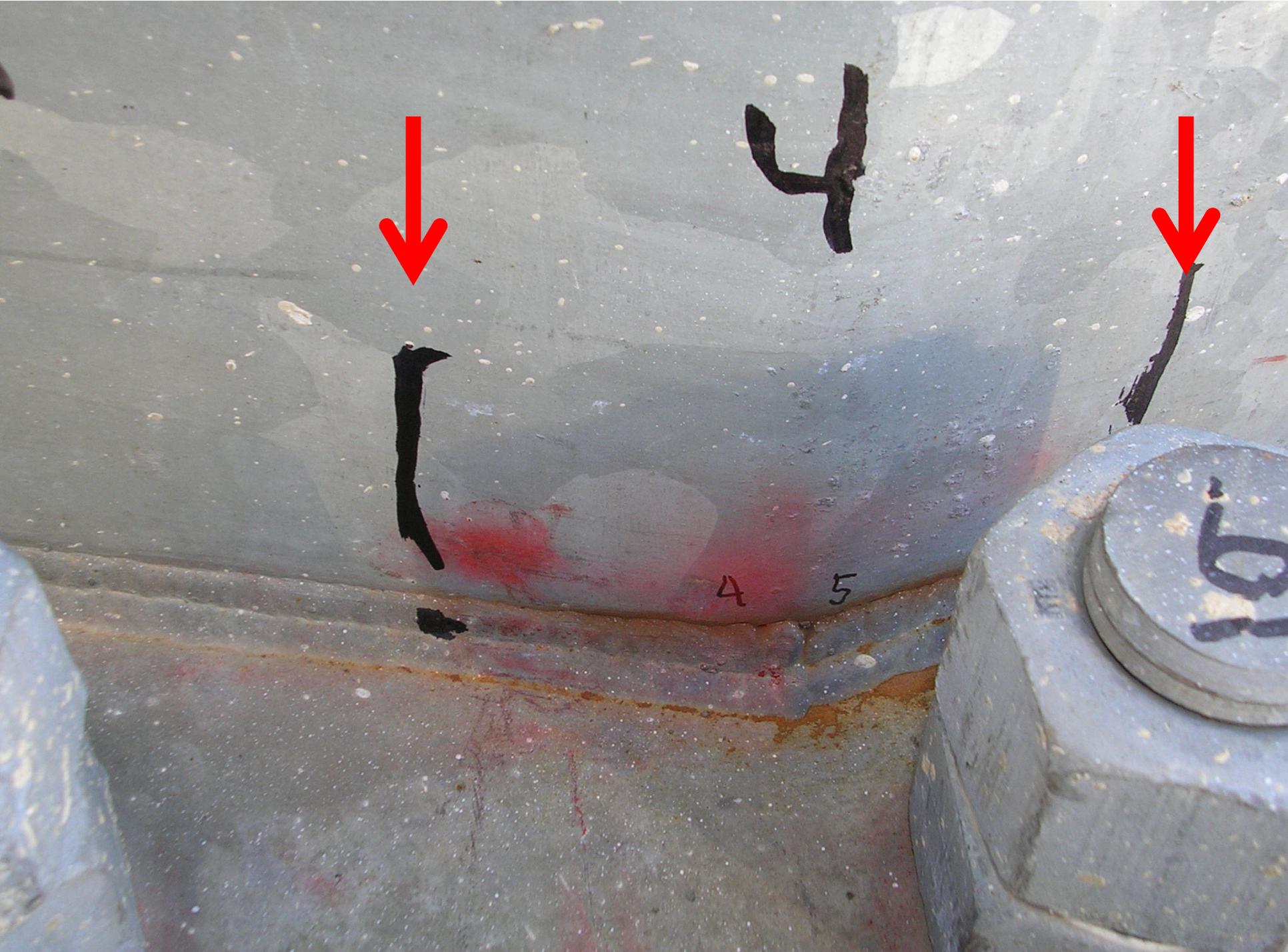


**Pole
Interior**



**Socket
connection**





4

5

6



Pole Base Weld NDE

- ✓ Visual inspection (CWI)
- ✓ Magnetic particle test (MT)
- ✓ Ultrasonic test (UT)

CWI - Visual NDE

- ✓ Visual inspection of all base welds
- ✓ Identify base joint connection detail & other welds to be inspected
- ✓ Goal is to identify any abnormalities in the weld joints to AWS D1.1 Table 6.1 criteria; cracks, weld/base-metal fusion, crater cross section, weld profile, undersized welds, undercut, porosity
- ✓ Inspect any existing welded modifications at the base

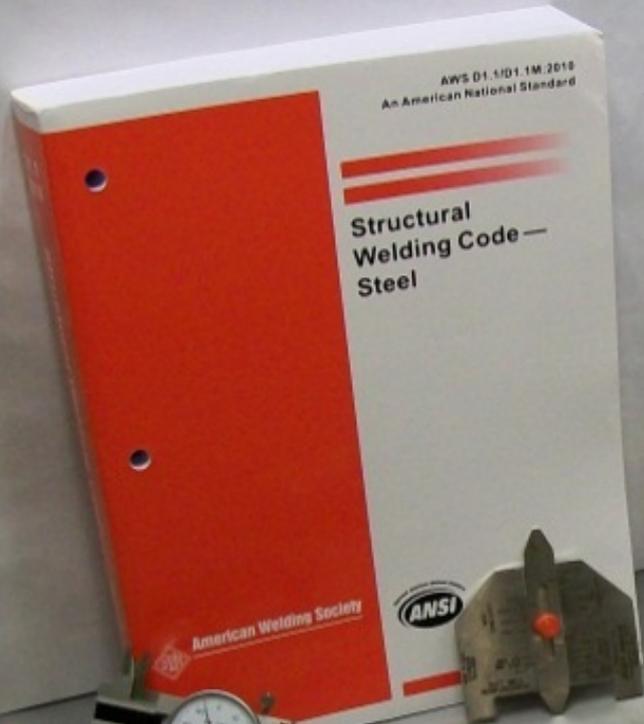


photo source: Lair Industries

Magnetic Particle Testing (MT)

- ✓ MT should be conducted by an inspector with American Society for Non-Destructive Testing (ASNT) Level II Certification
- ✓ MT is conducted by creating a magnetic field in a part and applying iron particles onto the surface of the part
- ✓ Utilized to assess surface and near-surface cracks in welded joints
- ✓ Very reliable and relatively simple to perform



photo source: Lair Industries







Ultrasonic Testing (UT)

- ✓ UT should be conducted by an inspector with ASNT Level II Certification
- ✓ Ultrasonic testing uses high frequency sound waves, well above the range of human hearing, to measure geometric and physical properties in materials
- ✓ The test utilizes ultrasonic waves that are interrupted by any material inconsistency (crack) in the joint and can 'see' through the material
- ✓ Volumetric test – three dimensional

Ultrasonic Testing (UT)

- ✓ UT is not limited to seeing surface defects only; the test is specifically utilized for testing of pole base weld joints that are 100% complete penetration joints (CJP)
- ✓ Determines the presence of any defect in a CJP connection
- ✓ Performed with a transducer and an electric base unit
- ✓ Shear waves, or angle beam transducers, are used for weld evaluation because they transmit sound at an angle avoiding the removal of the weld reinforcement; a 70 degree transducer is commonly used



photo source: Lair Industries







Challenges to Quality NDE

- ✓ Access / geometry
- ✓ Previous structural modifications / obstructions
- ✓ Surface condition – corrosion, moisture, spatter, etc.
- ✓ Inspection over coatings – galvanizing, paint
- ✓ Inspector experience (pole structures)
- ✓ Lack of inspection procedures
- ✓ Weather (MT)



Inspection Over Coatings

- ✓ AWS requires a clean surface for inspection
- ✓ Most poles are typically hot-dip galvanized
- ✓ NDE over existing galvanizing coating
 - Experience / inspection procedures
 - Established procedures by Level III
 - Know weld geometry of joint (CJP vs Socket)
 - Machine calibration (knowing sound path within joint)

Inspection Timetable

- ✓ Recommend minimum five years for steel poles
- ✓ At every structural modification event (loading change) involving welding at the base of the structure



Summary

- ✓ Pole base weld critical, non-redundant joint
- ✓ Toe cracks can cause catastrophic failure
- ✓ Routine weld inspection by qualified personnel critical
- ✓ Issues can be repaired in the field