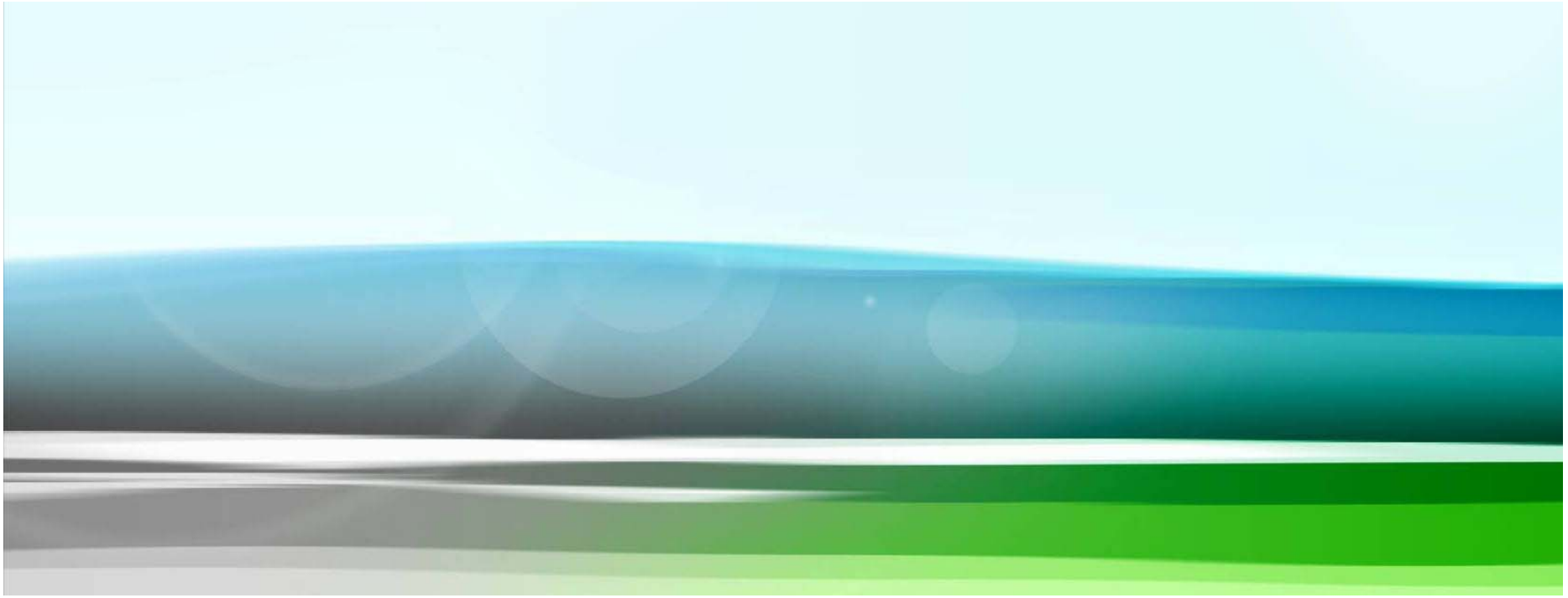

# LFERW
# Seam Weld Challenges

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MANAGING RISK DNV

# Scope of Presentation

- Types of defects found in LFERW line pipe
- Challenges these defects present

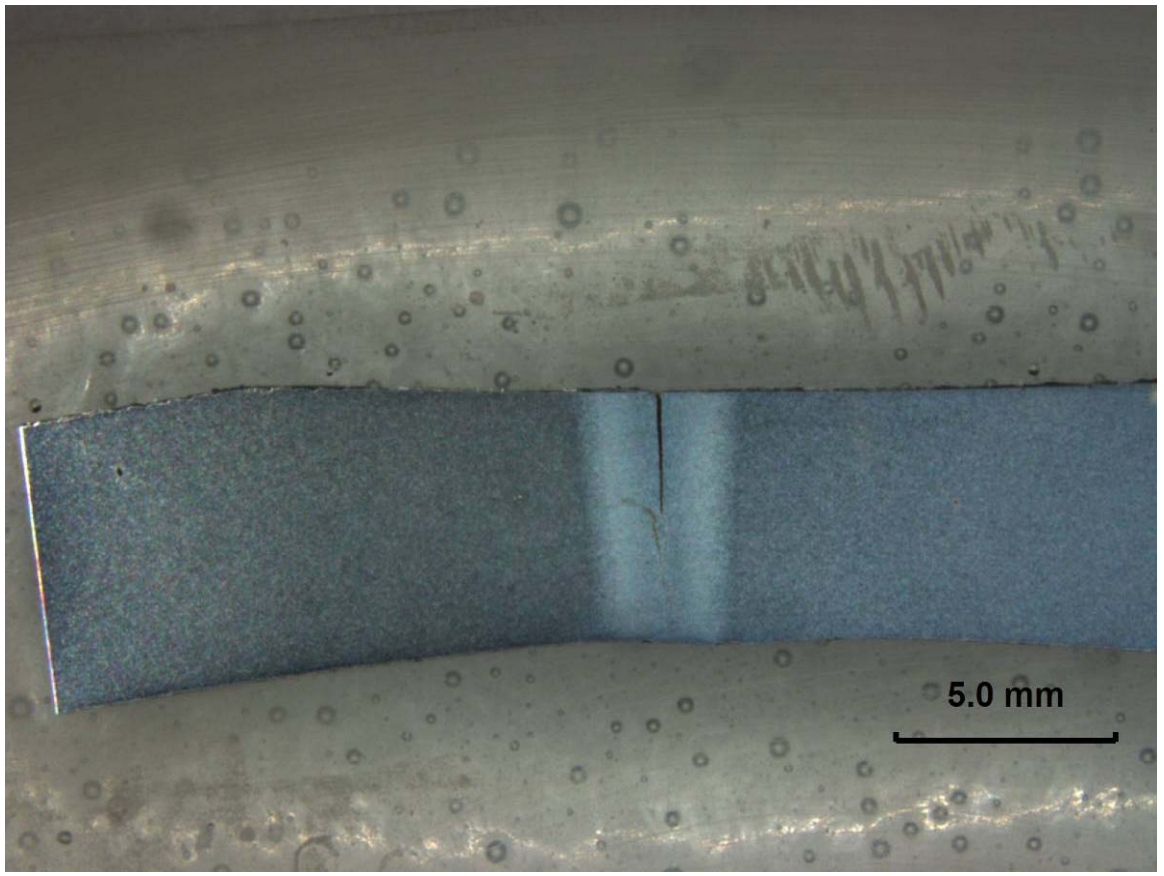
# Defects in LFERW Line Pipe

- Manufacturing defects
  - Cold welds/lack of fusion defects
  - Hook Cracks
  - Contact Marks
  - Trimming defects
  - Offset Plate/Skelp Edges
- Defects that form in service (time dependent)
  - Grooving Corrosion
  - Fatigue
  - Stress corrosion cracking (SCC)

# Lack of Fusion/Cold Weld Defects

- Region of weld with lack of adequate bond strength as a result of insufficient heat and/or weld pressure
  - Separation: lack of fusion defect (incomplete fusion)
    - At the bond line of ERW
    - Generally surface breaking
    - Inside or outside
  - Insufficient bonding: cold weld
    - No obvious metallurgical defect
    - Poor mechanical properties
    - Properties may vary in a periodic fashion (Stitching)
      - Repetitive variation in welding heat input

# LOF Defect




OD

ID

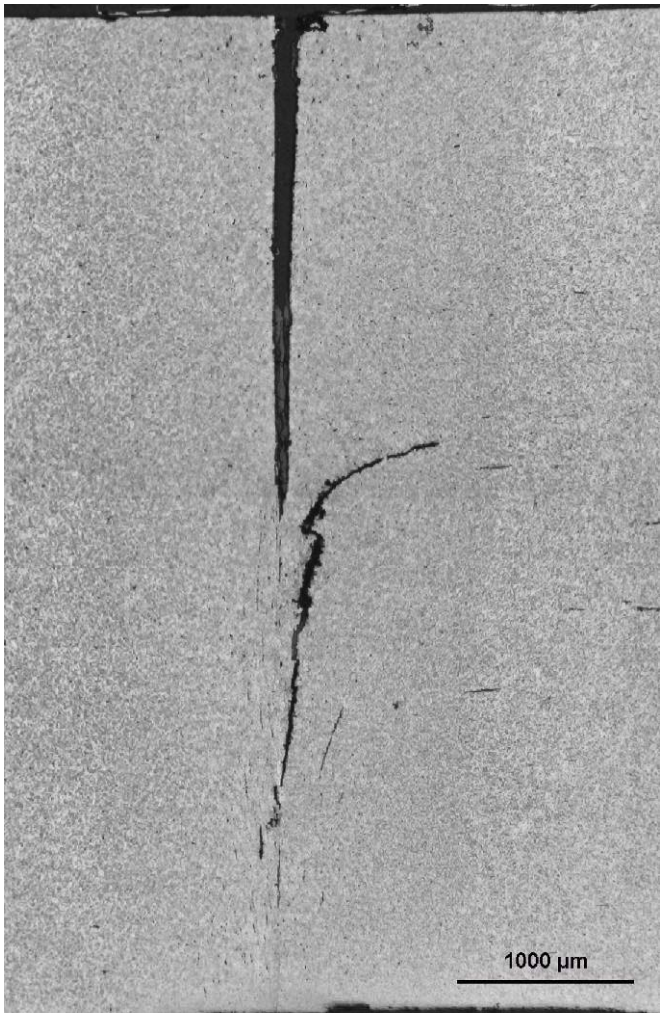
# Challenges (Lack of Fusion/Cold Weld Defects)

- Cold weld (without separation) may not be detectable by conventional ILI
  - No reflector to detect
- LOF defects can grow by pressure cycle fatigue
- Critical flaw sizes can be very small
  - Generally low fracture toughness of seam weld
  - Likely association of LOF defects and cold welds

# Hook Cracks

- Metal separation resulting from imperfections at the edge of the plate or skelp parallel to the surface that turn toward the ID or OD pipe surface when the edges are upset during welding
- Challenges
  - Hook cracks can grow by pressure cycle fatigue
  - Critical flaw sizes can be small
    - Generally low fracture toughness near the seam weld

# LOF and a Hook Crack

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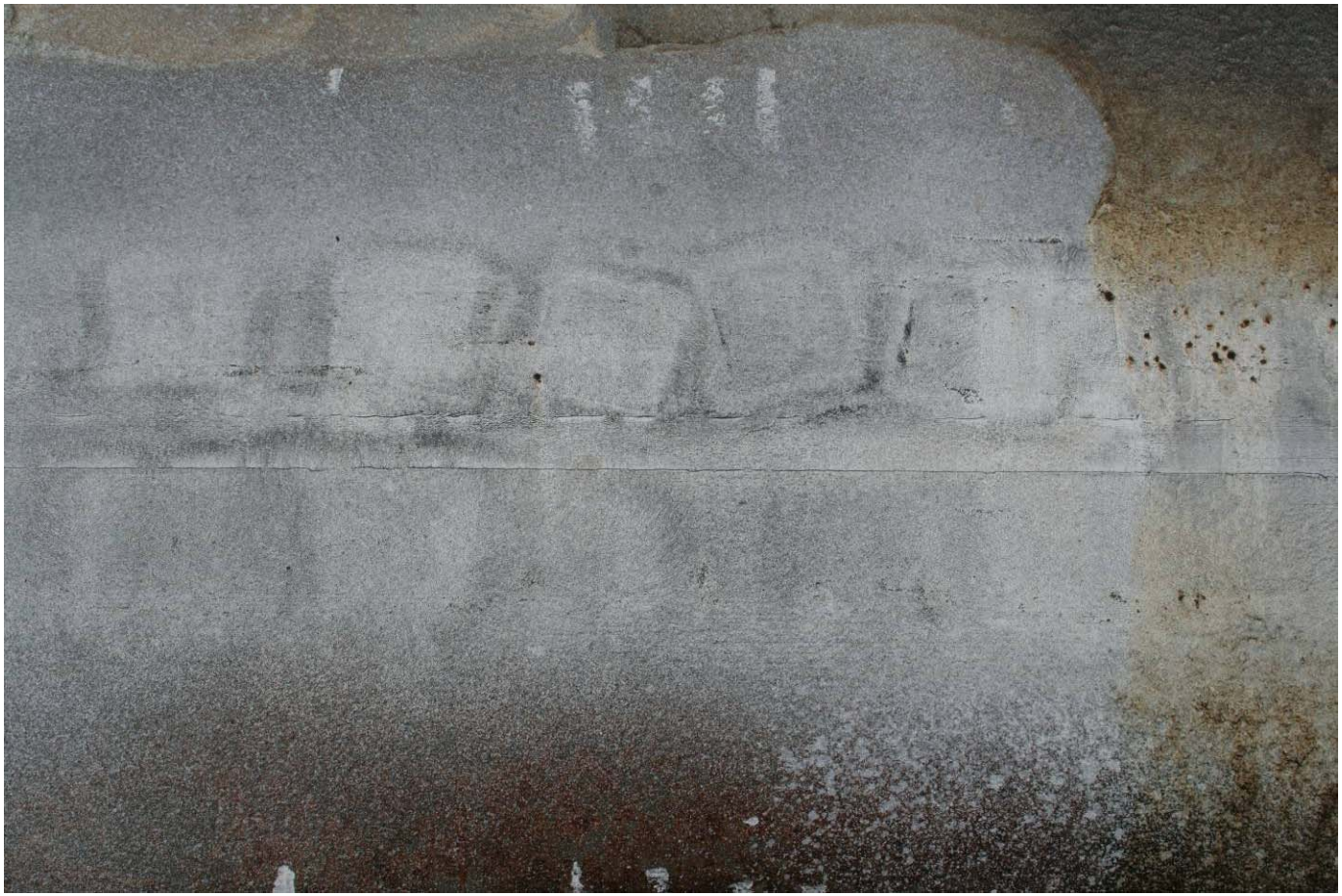
# Contact Marks

- Intermittent marks adjacent to the weld seam resulting from the electrical contact between electrodes supplying the welding current and the pipe surface
  - Altered microstructure as a result of local heating
    - Poor fracture toughness
  - May contain shallow cracks
- Challenges
  - Altered microstructure may be more susceptible to SCC initiation and growth than base metal
  - Affects ability to weld sleeves onto pipe
  - Fatigue of cracks?

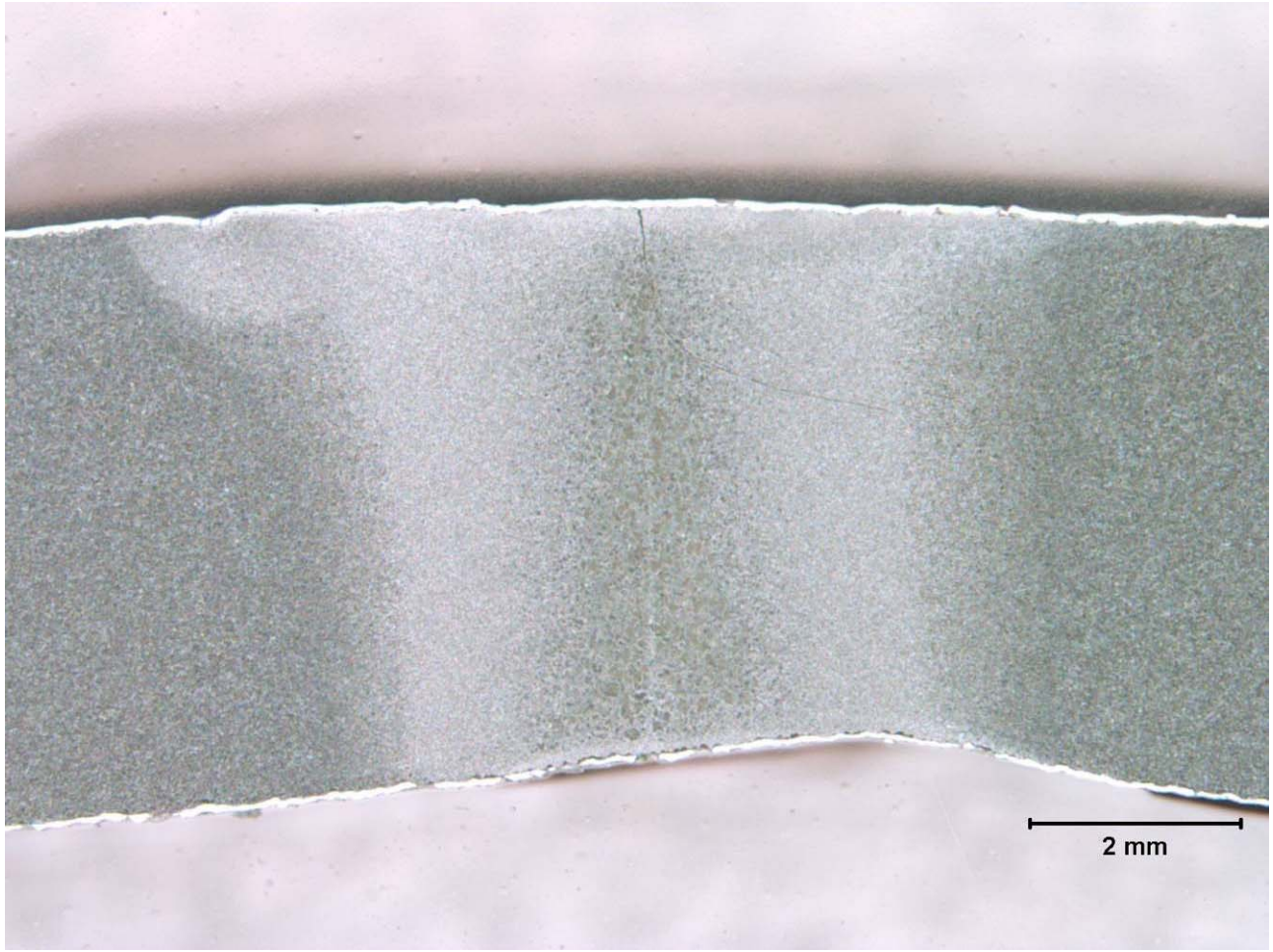
# Contact Marks (MPI)



# Trimming Defects

- Defects introduced during trimming of the weld flash
  - Over-trim
  - Under-trim
  - Tearing from dull tool or too low a trimming temperature
- Challenges
  - Over-trim can increase stress locally and produce stress concentrators
  - Under-trim can produce stress concentrators
  - Tearing can produce shallow cracks

# Over-Trim and Hook Crack



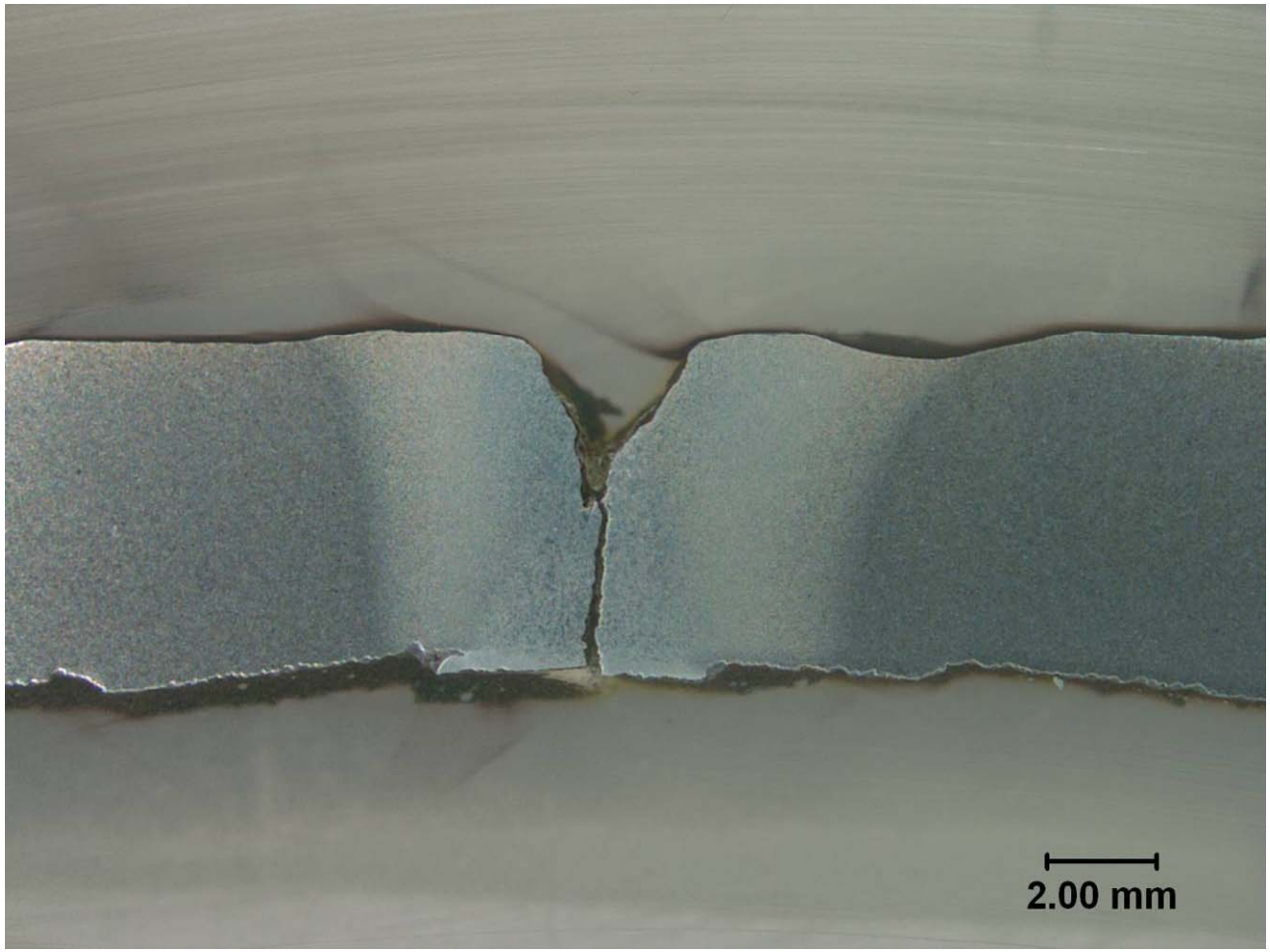
# Offset Plate/Skelp Edges

- Radial offset of plate or skelp edges in weld seam
- Challenges
  - Creates stress concentrator
  - Initiation site for fatigue

# Grooving Corrosion

- Preferential localized attack of ERW seam weld
  - Most commonly on OD
- Challenges
  - Time dependent degradation mechanism that can lead to failure
  - Flaw size can be small because of low toughness
  - Can act as initiation site for fatigue
- Corrosion that is not preferential but is located at the seam can produce failure with small flaw sizes
  - Low seam weld toughness

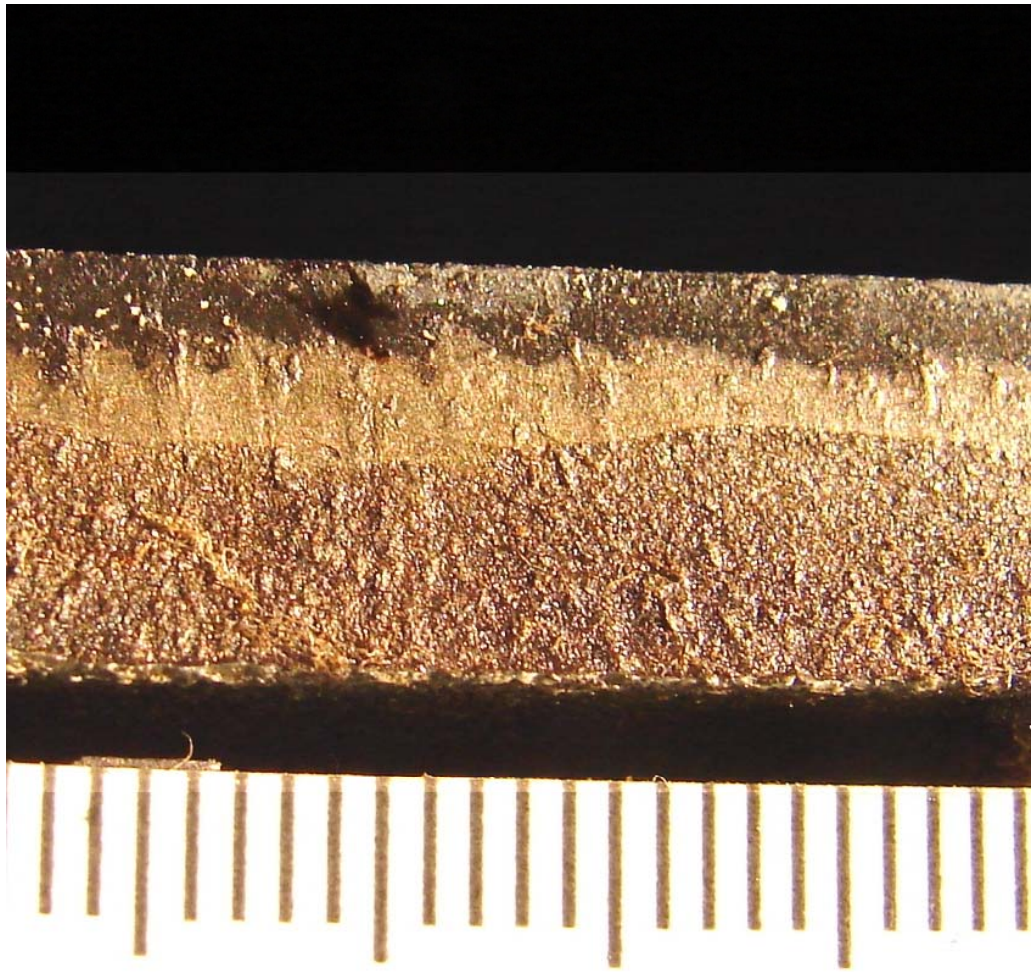
# Grooving Corrosion



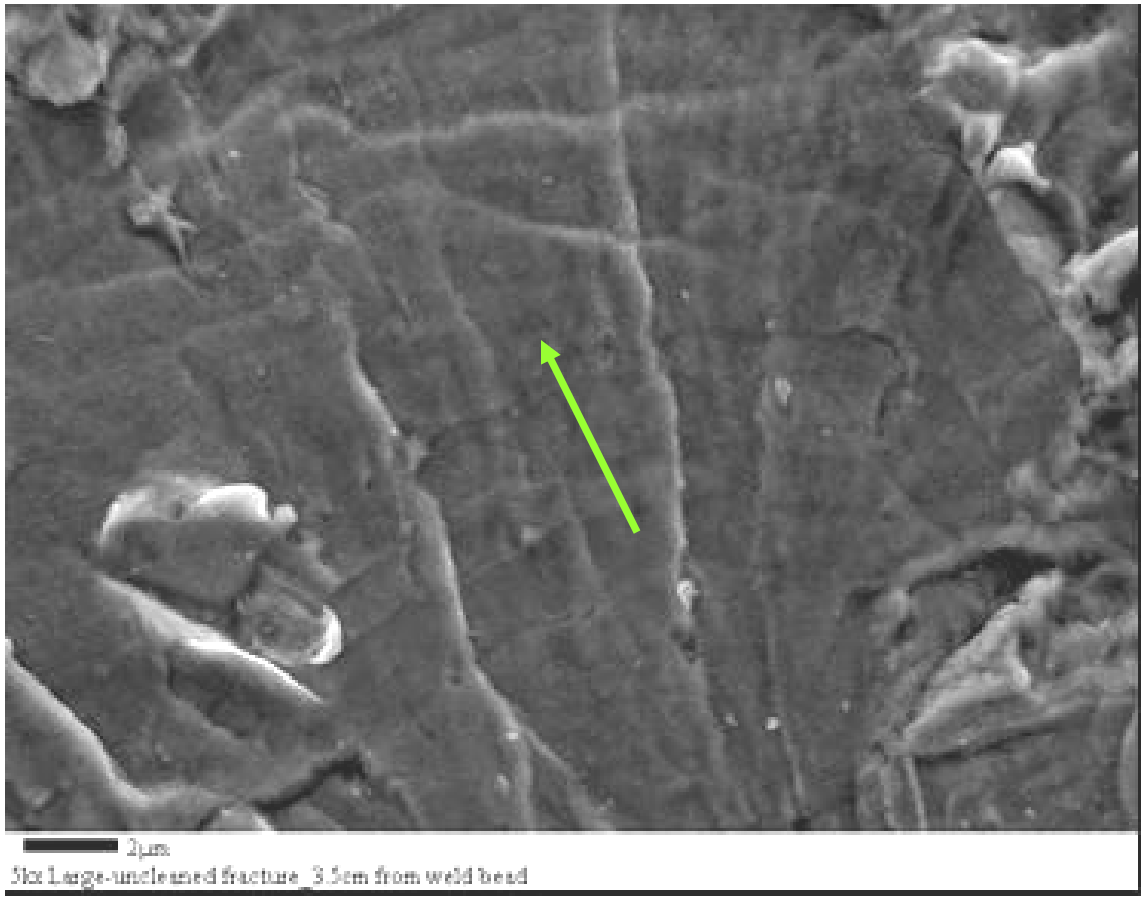
# Fatigue

- Crack growth resulting from fluctuating stress
- Challenges for LFERW seam welds
  - Crack-like flaws at or near the seam weld can grow by pressure cycle fatigue mechanism
    - LOF defects
    - Hook cracks
    - Cracks at contact marks?
      - Typically very shallow
  - Fatigue cracks can initiate at stress concentrators
    - Poor trimming
    - Misalignment
  - Small flaws can lead to failure because of low toughness at or near seam weld

# Fatigue of LOF Defect



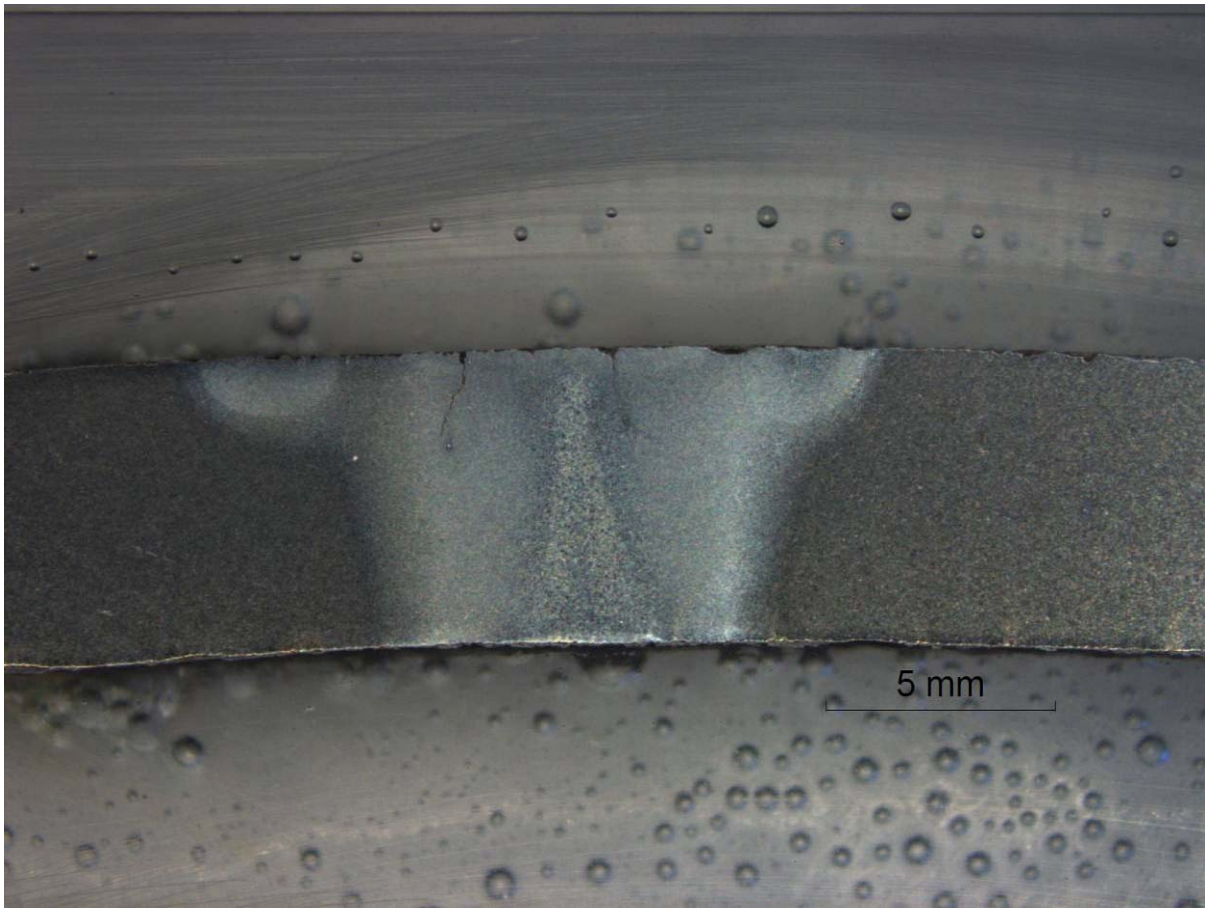
# Fatigue Striations



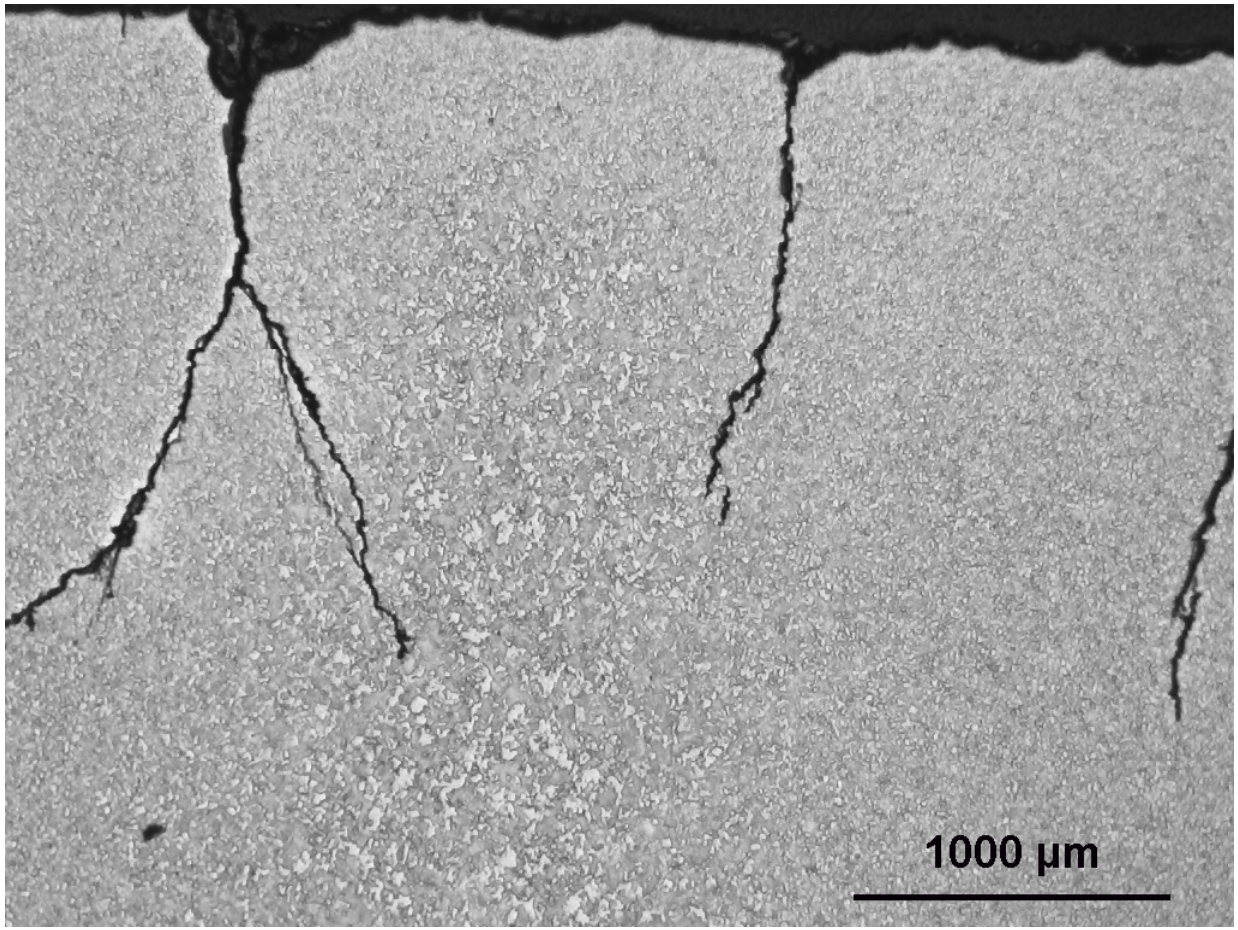
# Stress Corrosion Cracking

- Slow crack growth in normally ductile metal as a result of a susceptible material, tensile stress, and potent cracking environment
- Challenges for LF ERW seam welds
  - SCC colonies that develop at seam weld are more prone to failure than pipe body colonies
    - Smaller critical flaw size at seam weld
    - Possible higher initiation and growth rates

# SCC in ERW Weld



# SCC in ERW Weld



# Safeguarding life, property and the environment

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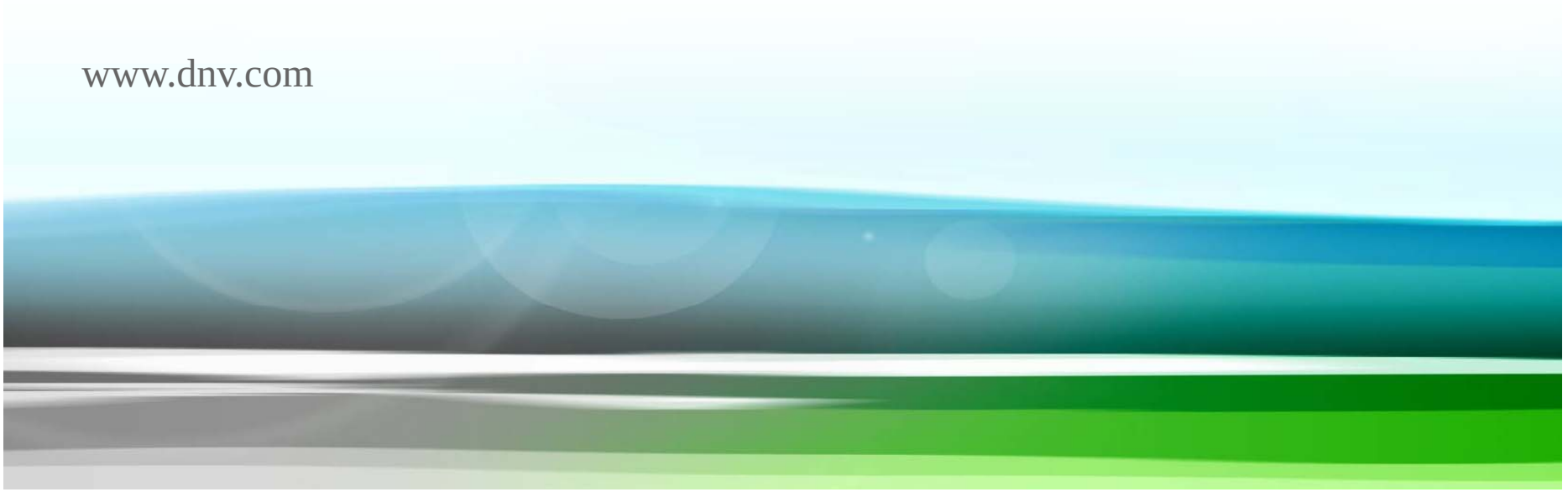

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