

August 8, 2024

**Re: CRES Testing Capabilities**

From: Dan Jia, Ph.D. and Yong-Yi Wang, Ph.D.

1. Small-scale material property characterization
  - a. Tensile test
    - i. Pipe longitudinal tensile
    - ii. Pipe hoop tensile – full-thickness flattened specimen
    - iii. Pipe hoop tensile - non-flattened near-full-thickness tensile<sup>1</sup>
    - iv. All-weld-metal tensile
  - b. Chemical composition analysis
  - c. Charpy V-notch (CVN) test
  - d. CTOD and J-integral test
  - e. Weld macro
  - f. Hardness traverse
  - g. Microhardness mapping
2. Non-destructive examination
  - a. Magnetic particle inspection
  - b. X-Ray inspection
  - c. PAUT
3. Dimensional measurements
  - a. Pipe diameter
  - b. Pipe wall thickness
  - c. Pipe straightness
  - d. Weld high-low misalignment or angular misalignment
  - e. Ovality
  - f. Dent profile
  - g. Corrosion profile
4. Girth weld qualification test
  - a. Visual examination
  - b. NDE
  - c. Charpy V-notch (weld metal and HAZ)
  - d. Hardness traverse

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<sup>1</sup> Unique test designed for the pipeline industry by CRES

- e. Hardness mapping
  - f. Nick break
  - g. Root bend
  - h. Face bend
  - i. Side bend
  - j. Non-instrumented cross-weld tensile
  - k. Instrumented cross weld tensile<sup>2</sup>
5. Failure analysis
    - a. Photographic documentation
    - b. Visual examination
    - c. Fractography
    - d. SEM
    - e. EDS
    - f. Mechanical property testing
    - g. FTIR and XRD analysis
  6. Metallurgical analysis and flaw characterization
    - a. Axial-SCC
    - b. Circumferential SCC
    - c. Other cracks
    - d. Seam weld flaws
  7. Strain-driven low cycle fatigue (ratcheting) test<sup>3</sup>
  8. Room temperature creep test<sup>4</sup>
  9. Curved wide plate test with planar flaws
  10. Mini-curved wide plate test with planar flaws<sup>5</sup>
  11. Full-scale burst test with a variety of anomalies (corrosion, SCC, weld flaws, etc.)

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<sup>2</sup> Unique test designed for the pipeline industry by CRES. Tensile strain capacity (TSC) prediction from the test is possible.

<sup>3</sup> Unique test designed for the pipeline industry by CRES. Useful to characterize material's resistance to low cycle high-mean-stress strain-driven cyclic loading.

<sup>4</sup> Unique test designed for the pipeline industry by CRES, with natural or artificial flaws in pipe body or seam weld. Useful to characterize the propensity of pressure reversal.

<sup>5</sup> Unique test designed for the pipeline industry by CRES. The outcome can be used to evaluate the TSC of welds and TSC models.