Pressure-Testing Technical Challenges

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Pressure Test Overview

- Liquid Pipeline guided by 49 CFR 195 Subpart E
- Gas pipelines guided by 49 CFR 192 Subpart J
- Minimum requirements
  - 1.25 MAOP for 8 hours
  - Gas Pipelines utilize a 1.37 MAOP spike test (often tests are conducted at 100 or 110% SMYS)
    - Spike test period is a variable from 30 minutes to 1 hour.
- Testing to pressure much higher than MOP eliminates all critical flaws (on the verge of failure or close to failure)
  - Impact on sub-critical flaws is unclear (depends on kind of flaw)
  - Tearing of certain sub-critical flaws is a possibility
  - Blunting of certain critical flaws is a possibility
- Demonstrates immediate serviceability
- No information is derived on the subcritical defects
- Lack of effective ILI technology renders this as the only alternative

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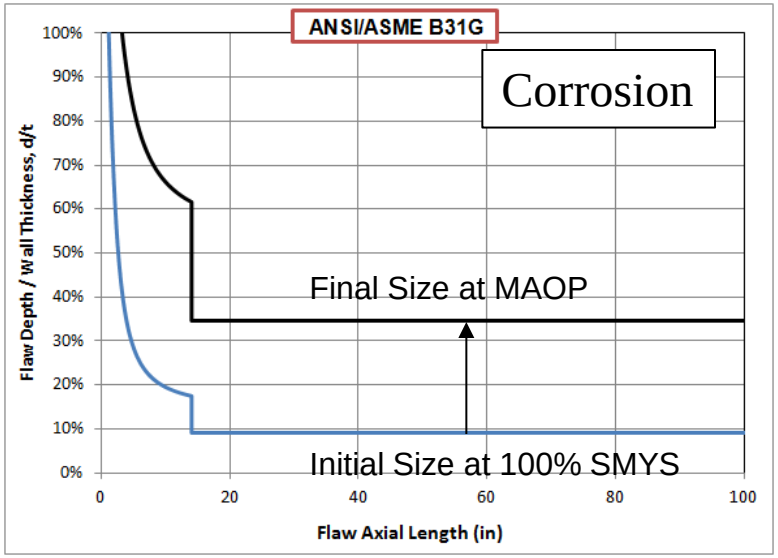
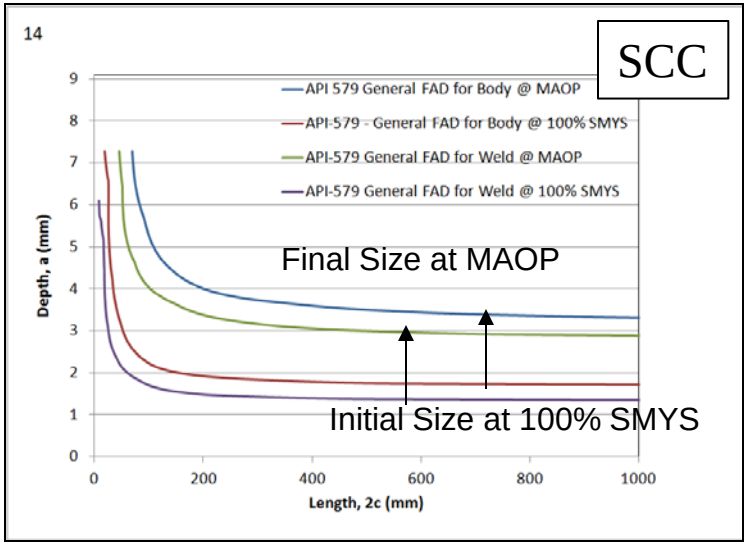
Pressure Test Interval

- Toughness / Strength Based Sentence Plot approach
  - Integral to this is the crack growth rate (mechanistic model or field empirical data)
- Empirical Approach specifically to SCC (Fessler)
  - Short early intervals followed by progressively longer intervals more effective and less costly than uniform intervals





Pressure Test Interval drives reliability

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Pressure Test Reliability

- Pressure reversals: features were not detected by HT but failed later shortly at MOP or a pressure lower than HT pressure:

$$\text{Pressure reversal} = \frac{P_{HT} - P_{failure}}{P_{HT}} \%$$

  - **POF at MAOP is 1x 10^{-9} if pressure test at 1.25 MAOP for a 20% pressure reversal**

    ***Keifner** prediction

Modern day Pressure testing appears to have better control on reversal issues

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Pressure Test Reliability

- Premature Failure: failure occurred at MOP/MAOP before the scheduled pressure test. (Limited data) – Gas Pipelines

(data from JIP 1 SCC)

  - 38 valve sections: High pH SCC (% valve section with no in service failures)
    - Pressure test > 100% SMYS
      - » 3 years (100%), 6, 7, 9 years interval (96%)
    - Pressure test > 90% SMYS
      - » 3 years (97%), 9 years (84%)
  - 11 valves sections: Low pH SCC
    - Pressure test > 100% SMYS
      - » 3 years (100%), 6 years (91%), 7 years (90%), 9 years (78%)
  - 132 valve sections – no failure

Mechanism, Pressure Levels and other factors impact Reliability.

POF's (for certain valve sections) approach 1x 10^{-2} depending on interval

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Technical Challenge - 1

- What is the Reliability of Pressure Testing?
  - For SCC (high and low pH)
  - For weld defects (ERW/EFW) as a function of low/high toughness
    - Dormant defects/ Growing defects
  - For dents with coincident cracks

- What is Overall reliability of pressure testing? Extensive data existed but not evaluated and/or quantified.
- Need/Value - Pressure testing vs ILI new technologies – e.g., EMAT for gas pipelines, USCD, TFI
  - How to assess ILI reliability, Guidelines?
  - When is a technology

Function of pressure levels, test duration, test intervals

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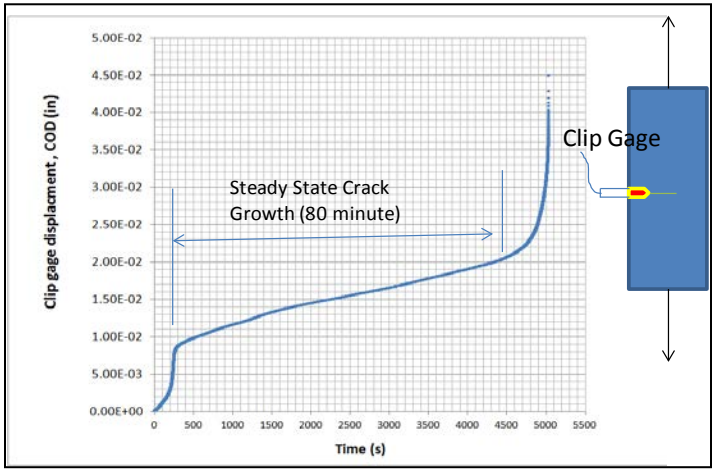
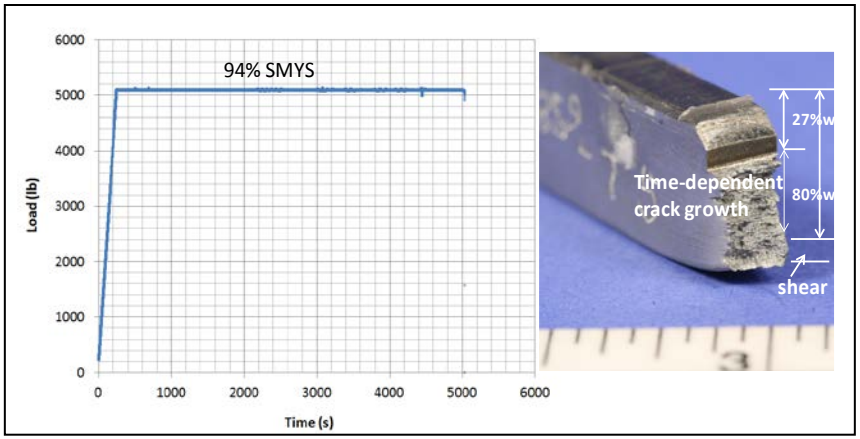
Testing Approach (Duration, Spike, Pressure Reversals)

Time Dependent Plasticity Induced Crack Growth

Recent work





- **1983, Wilkowski and Maxey of Battelle**: evaluated the effect of sustained load on gouge and dent defect in natural gas transmission pipe. Significant crack growth by slow ductile tearing under sustained load, and eventually the crack extended through the wall thickness resulting in a leak, ASTM STP 791, pp II-266-II-294
- 1983, Ingham et al of UK Nuclear Power Development Laboratories: time to failure after holding a crack at constant load decreases with increasing load level, and attributed it to the time dependent plasticity induced ductile crack growth, ASTM STP 803, pp I-721-I-746
- **1992, Leis et al. of Battelle:** Studied Hydrotest Strategies for gas transmission pipelines based on ductile-flaw-growth considerations under PRCI funding support. PRCI, NG 18-18 Report 194, 1992
- **2004, Andrew Cosham and Phil Hopkins**: failures have been observed during hydrostatic test hold periods, during operation and under laboratory conditions., IPC 2004, Paper 84

Pressure Test Duration a large impact on test reliability & frequency

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Technical Challenges - 2

- Drivers that increase Reliability
  - Pressure Level / Spike test plus Leak Test
  - Test Duration / Spike and/or Leak Test
  - Test Interval establishment as a function of the cracking mechanism (Type of threat)
    - SCC, ERW, Dents with cracks, etc.
  - SCC crack coalescence and its impact on pressure testing frequency

Implication

- Would a longer holding time for spike be beneficial and remove all near critical flaws?
- Would a longer holding time for leak remove all near critical flaws?
- Would a longer holding time for both spike and leak be benefit to minimize Pressure Reversal and increase reliability over a set interval?

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Other Technical Challenges

- Pressure testing differences as a function of fracture toughness
- Pressure testing differences as a function of yield/microstructure

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