WG #5 – New Pipeline Construction – Materials Issues

Presentation to the US DOT PHMSA R&D Forum

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Material Testing Issues - Overview

Toughness

1. DWTT Fracture Ductility Testing with Modern High Toughness and Q&T Steels – Ductile v. Brittle initiation
2. Fracture Arrest models' applicability to modern high toughness steels
3. SEN test specimen preparation and test procedures

Tensile

1. Yield Strength Determination in Large OD pipes
2. Weld tension specimens
3. Curved wide plate tension

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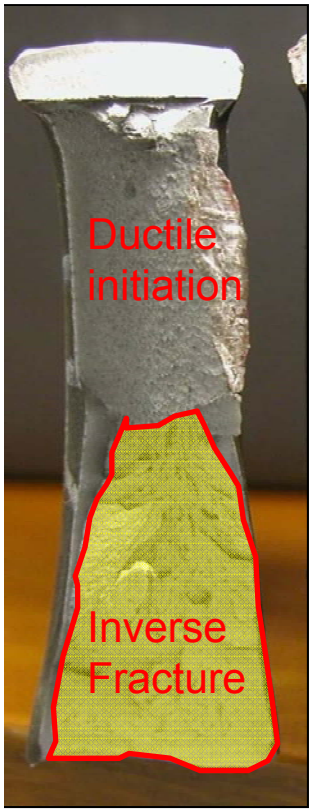
Toughness Testing

1. DWTT Fracture Ductility Testing with Modern High Toughness and Q&T Steels – Ductile v. Brittle initiation



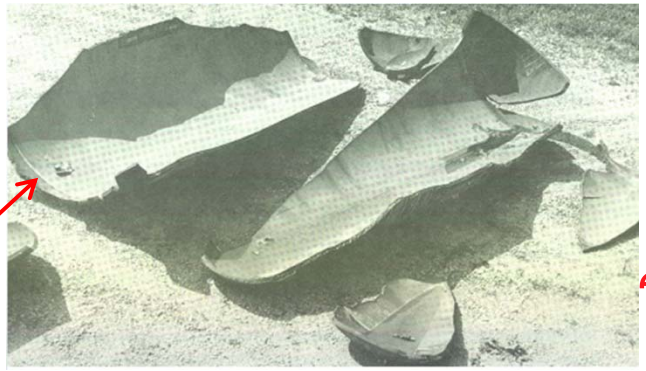
Issues:

- Many DWT tests from materials with high CVN energy returning invalid and not always conservative transition temperature results due to inability to simulate a brittle initiated running fracture
- May not be able to receive valid test for some steels (e.g., Q&T) possibly due to geometric effects.

Actions:

- Fundamental research initiated with ERPG (DWTT), API (approved) and PRCI (MATH 8-1) first to evaluate problem, and then define a course forward.
- Full solution may take >>$1 million

"West Jefferson" (vessel) burst test on 48"
x 1.25" X65 pipe that shattered with 5 to 10% shear area at -30F.



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Toughness Testing -

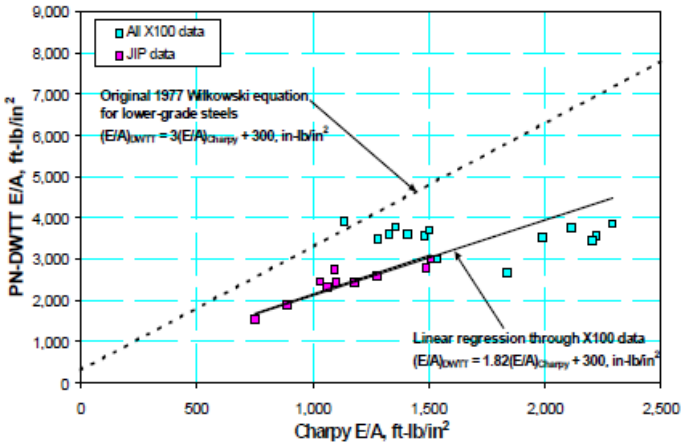
2. Fracture Arrest models' applicability to modern high toughness steels

Issue:

- For modern, high toughness lower strength ≤ X70 steels, full-scale burst test correlations to CVN toughness based on historical correlations may be non-conservative as they behave more like X100 steels.

Action:

- PRCI program may investigate subject (MATH-8-1)
- Upper-shelf energy measurement may require use of DWTT-type specimen rather than Charpy specimen to measure fracture resistance energy.[1]



[1] Wilkowski, G.: "Concerns on Fracture Toughness Measurements on Modern Low Grade (< X70) Line-Pipe Steels", presentation to JTM of PRCI, May 19, 2011.

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Toughness Testing -

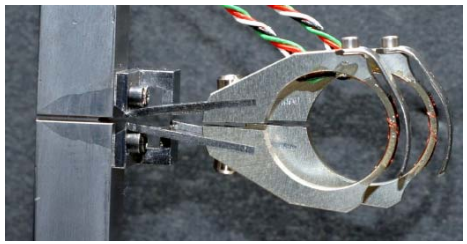
3. Single Edge Notch Tension [SEN(T)] test specimen preparation and test procedures

Issue:

- CTOD may be overly conservative for some analysis. The SEN(T) as it is a more realistic test for girth welds loaded in tension and results in increased toughness and greater accuracy
- SEN(T) procedures have been developed in the industry but they need to be converted into recommended practice for industry-wide application so that SENT data from different testing facilities can be considered comparably

Action:

- Develop standardized SEN(T) specimen preparation and test protocols (PRCI API-2-1)



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Tensile Testing

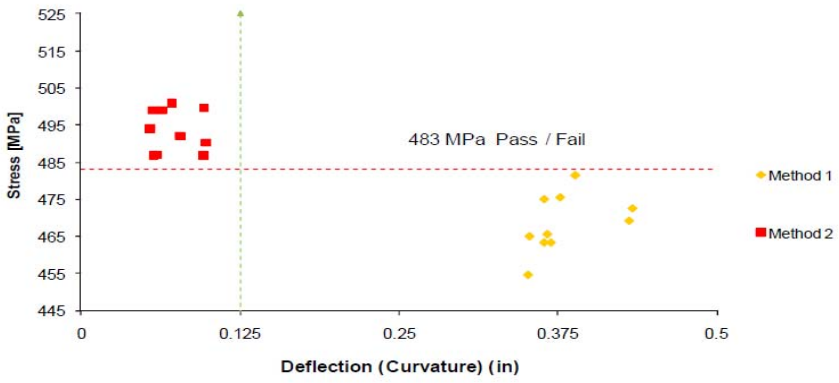
1. Yield Strength Determination in Large OD pipes

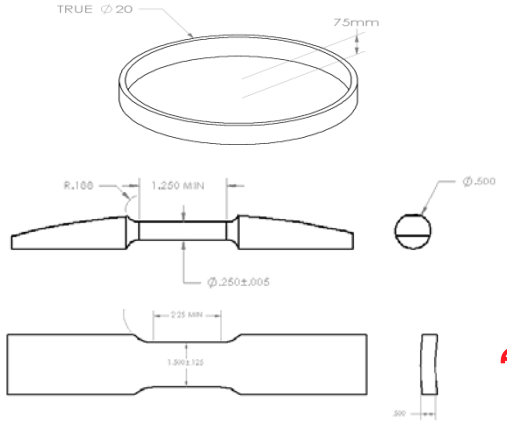
Issues:

- The various tension test specimens (Flattened Strap, Round Bar, Ring Expansion) give different yield strength responses due to Bauschinger and other effect.
- Many crucial sample preparation, flattening, and testing procedure components are experiential in industry and these are not in public standards.

Action:

- JIP on subject initiated in 2012 with aim of identifying affects of test specimen and developing a recommended practice or standard update.





Tensile Testing

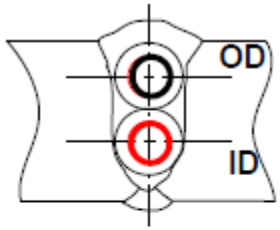
2. Weld tension specimens

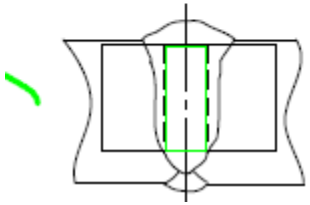
Issue:

- Round Bar SAW tension specimens sample only small cross-section of weld

Action:

- Consider full-section rectangular weld specimen developed with PRCI (MATH-1)
- Institute specimen in standards





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Tensile Testing

3. Curved wide plate tension

Issue:

- Gauge length of some specimen sizes may not be long enough

Action:

- Investigate issue and standardize specimen preparation and testing protocols.

Priority:

DWTT fracture testing sample preparation and testing protocols

Issues:

- Potential safety issue with modern steels as DWTT results may be non-conservatively giving lower ductile transition temperatures – may fail in brittle mode.
- A modified specimen and test protocol may be capable of measuring fracture energy to also address fracture arrest energy measurement.
- This issue has already been identified, budgeted and work initiated within EPRG, PRCI and API groups but costs may be in millions to develop test correlations to full-scale burst tests.

Thanks

- Questions?

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