DEFECT ASSESSMENT METHODS
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DEFECTS THAT COULD AFFECT PIPELINE INTEGRITY

- Corrosion-caused metal loss
- Longitudinally-oriented cracks
- Circumferentially-oriented corrosion
- Circumferentially-oriented cracks
- Dents
- Dents with reduced wall & damage
METHODS USED TO EVALUATE FLAWS IN PIPELINES

**Corrosion-Caused Metal Loss**
- ASME B31G
- Modified B31G
- RSTRENG
- KAPA
- PCORR
- COR-LAS™
- PAFFC
- API RP 579
- DNV RP F-101

**Cracks (axial)**
- SURFFLAW
- KAPA
- COR-LAS™
- PAFFC
- API RP 579
- BS 7910

**Cracks and Blunt Flaws (circumferential)**
- API STD. 1104, Appendix A
- CSA Z662, Appendix K
- API RP 579
- BS 7910
METHODS USED TO EVALUATE FLAWS IN PIPELINES

Plane Dents
API Publication 1156
B31.8
API 579
PRCI PR-218-9405 Fatigue Rating Shallow Unrestrained Dents
PRCI PR-218-9822 Guidelines for the Assessment of Dents on Welds

Dents with Gouges
API 579
Dent-Gouge Fracture Model (EPRG)
Patch to Ductile Flaw Growth Model (PRCI-Battelle)
Empirical Q-factor Model (PRCI)
STATUS OF MODELS FOR EVALUATING CORROSION-CAUSE METAL LOSS

• Mature technology
• Most of the models are based on Maxey’s Surface Flaw Equation
• Comparisons show that the models give similar predictions and all have been validated against PRCI’s Database of Corroded Pipe Tests
  – Any of the models can be used with confidence, but ASME B31G tends to give excessively conservative predictions
• Further research is being carried out to better address multiple defect interaction and varying axial stress
• Little or no need to pursue this in the future
STATUS OF MODELS FOR EVALUATING AXIAL CRACKS

• Log-secant equation (a.k.a. NG-18 surface flaw equation) is empirically based
  – Can be used without the need for special software and utilizes Charpy energy (upper shelf) to represent material toughness.

• PAFFC and CorLas™ are based on J-integral and tearing modulus theory.
  – Can use Charpy energy correlations for toughness.
  – Are implement in software packages.

• API RP 579 Level II and BS 7910 methodologies are based on the FAD methodology.
  – Can be used without special software and can accommodate toughness based on Charpy energy.

Kiefner & Associates
STATUS OF MODELS FOR EVALUATING AXIAL CRACKS CONTINUED

• These models have been validated against PRCI full-scale test results and other data.
• Comparisons show that the models give similar predictions.
  – Log-sec equation tends to give excessively conservative predictions for flaws with depth/thickness ratios less than 0.3.
• Further research is being carried out to develop a “new” model for axial cracks.
• The weak link in fracture mechanics based models are fracture toughness correlations.
• The existing methods work well, so further effort beyond the on-going work on a new model is probably not necessary.
STATUS OF MODELS FOR EVALUATING ROCK DENTS AND PLAIN DENTS

• API 579 has dent radius criteria
  – requires radius > 15 x remaining wall
• B31.8
  – Maximum strain <6% (4% in ductile welds) calculated from curvature
• Calculation based on caliper or in the ditch readings
  – Kiefner methodology – trace & compare
• Need to better understand the effect of length and membrane strain on fatigue life
STATUS OF MODELS FOR EVALUATING DENTS WITH METAL LOSS OR CRACKS

- **ASME B31.8** –
  - Evaluate dent and metal loss independently
  - Grind out cracks
  - Not ideal, needs validation
- **Dent & Gouge Fracture Model**
  - Conservative
  - Requires high toughness
  - Curvature limited to >5t
  - Length not included
- **API 579 Level 2**
  - Uses Q factor
  - Limits cyclic stresses
- **Q Factor** – not recommended
- **R&D overlaps mechanical damage (dents with gouges)**
STATUS OF MODELS FOR EVALUATING DENTS WITH GOUGES

• The current dent-gouge fracture model results in better predictions if the depth of cracking from re-rounding of the dent is added to the gouge depth in the model.
• Patch to ductile flaw growth model has not been codified or fully validated.
• The empirical Q-factor model is not recommended.
STATUS OF MODELS FOR EVALUATING DENTS WITH GOUGES CONTINUED

• This area is the focus of much current research:
  – Dent and Gouge Fracture Model (FAD) approach is being extended by AF&A with KAI (improved burst test prediction) and Advantica (time dependent model)
  – Patch to the Ductile Flaw Growth Model will be extended by Battelle (time dependent model)
STATUS OF MODELS FOR EVALUATING DENTS AND DENTS WITH GOUGES CONT.

• Further FEM & full scale testing research is being carried out to validate a range of models for fabricated gouges and dents.
  – Most existing test data on gouge and dent defects may not simulate the behavior of real gouges and dents.
  – Are a starting point for dents with gouge damage, but there is still a need for more realistic mechanical damage.

• Consideration should be given to developing a realistic mechanical damage test method to validate new and existing models.
Questions?
SURFACE FLAW

Sharp Flaw

Blunt Flaw
Length and depth determination
Maxey’s Surface Flaw Equation

\[ S = S_0 \left[ \frac{1 - A/A_0}{1 - (A/A_0)(1/M)} \right] \]

\[ A = Ld \quad \text{(for a rectangular defect)} \]

\[ A_0 = Lt \]

\[ M = \sqrt{1 + \frac{0.8L^2}{Dt}} \]
API RP 579 Level II Assessment
Failure Assessment Diagram Approach

Failure Assessment Diagram (FAD)