Characterization of Pipeline Wall Loss for Strain Capacity Evaluation of Damaged Pipelines Subjected to Ground Movement

SBD-1-4

Contract Number: PR-350-174500

Center for Reliable Energy Systems
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PRCI 2018 Fall TC Meeting

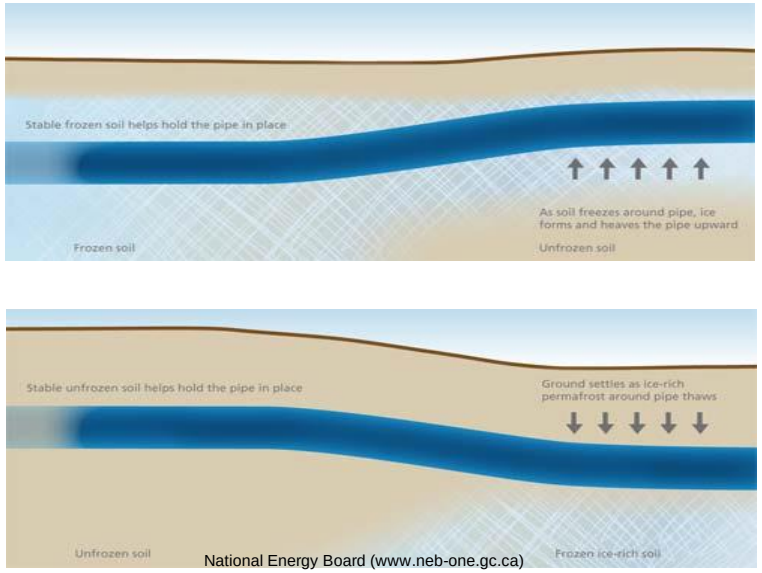
10/23/2018

San Diego, CA

Background and Incentives

- Pipelines experience longitudinal strain during ground movement.
- Appearance of metal loss type corrosion anomalies
  - Reduce pressure containment
  - Reduce longitudinal strain capacity
- Existing integrity assessment methods/tools for corrosion focus on pressure containment, e.g., RSTRENG.
- However, there is no tool available for making integrity assessment decisions related to longitudinal strain capacity.

Lee,E., Fooks,P., and Hart, A., "Landslide issues associated with oil and gas pipelines in mountainous terrain," Quarterly Journal of Engineering Geology and Hydrogeology, vol 49,May 2016



National Energy Board (www.neb-one.gc.ca)

Valor, A., et al., Corrosion Science, vol 101, p.114-131, 2015

Project Status Updates

- The first draft of the integrity assessment tools was uploaded to PRIME on 7/26/2018.
- The first draft final report was uploaded to PRIME on 10/1/2018.
- The final report is under review.

Key Output – Tools with Three Output Options

- Output options
  - Tensile strain capacity (TSC) of pipes with corrosion anomalies
  - Pressure limit of pipes with corrosion anomalies to maintain pre-defined target TSC
  - Size limits of corrosion anomalies to maintain pre-defined target TSC
- Easy-to-use user interface
  - Grouped input parameters
  - Multiple input options for the pipe material and the operating pressure
  - Inputs with different unit options
- Capability of recording and storing the results

Tensile Strain Capacity

- Inputs
  - Pipe geometry
  - Pipe material properties
  - Operating pressure
  - Corrosion anomaly sizes
- Output
  - TSC of pipes with corrosion anomalies

Tensile Strain Capacity Calculation

PIPELINE INFORMATION:	
PREPARED BY:	
DATE:	7/26/2018

PIPE GEOMETRY

Pipe Outer Diameter	32	(•) inch ( ) mm
Pipe Wall Thickness	0.6	(•) inch ( ) mm

PIPE MATERIAL

( ) Use Pipe Grade		
SMYS =	60	(•) ksi ( ) MPa
SMTS =	75	(•) ksi ( ) MPa
(•) Enter Value		
Pipe Yield Strength	90	(•) ksi ( ) MPa
Pipe Tensile Strength	100	(•) ksi ( ) MPa
Calculated Pipe Y/T =	0.9	

OPERATING PRESSURE

( ) Enter Internal Presure	900	(•) psi ( ) MPa
Calculated Pressure Factor =	6.43	
(•) Enter Pressure Factor	0.6	
Calculated Internal Pressure =	2025	(•) psi ( ) MPa

METAL LOSS GEOMETRY

Longitudinal Length	6	(•) inch ( ) mm
Circumference Length	20	( ) inch ( ) mm (•) degree
Depth	0.2	(•) inch ( ) mm ( ) %t

Calculate TSC

TENSILE STRAIN CAPACITY (TSC)

0.81 %

Add to Summary Sheet 1b

Pressure Limit

- Inputs
  - Pipe geometry
  - Pipe material properties
  - Corrosion anomaly sizes
  - Target TSC
- Output
  - Operating pressure limit

Pressure Limit Calculation

PIPELINE INFORMATION:	
PREPARED BY:	
DATE:	7/26/2018

PIPE GEOMETRY

Pipe Outer Diameter	36	(•) inch ( ) mm
Pipe Wall Thickness	0.5	(•) inch ( ) mm

METAL LOSS GEOMETRY

Longitudinal Length	10	(•) inch ( ) mm
Circumferential Length or Angle	15	( ) inch ( ) mm (•) degree
Depth	0.15	( ) inch ( ) mm (•) %t

PIPE MATERIAL

(•) Use Pipe Grade	X65	
SMYS =	65	(•) ksi ( ) MPa
SMTS =	77	(•) ksi ( ) MPa
( ) Enter Value		
Pipe Yield Strength	74	(•) ksi ( ) MPa
Pipe Tensile Strength	85	(•) ksi ( ) MPa
Calculated Pipe Y/T =	0.86	

TARGET STRAIN

Target Tensile Strain Capacity	0.5	%

Note: The procedure has not been adequately valided. It should not be used for making decisions of safe operating pressure.

OPERATING PRESSURE LIMIT

Maximum Pressure Factor	0.72	
Maximum Internal Pressure	1300	(•) psi ( ) MPa

Calculate Pressure Limit

Add to Summary Sheet 2b

Corrosion Size Limits

- Inputs
  - Pipe geometry
  - Pipe material properties
  - Operating pressure
  - Target TSC
- Output
  - Plots of size limits of corrosion anomalies

Metal Loss Limit Calculation	
PIPELINE INFORMATION:	
PREPARED BY:	
DATE:	7/26/2018

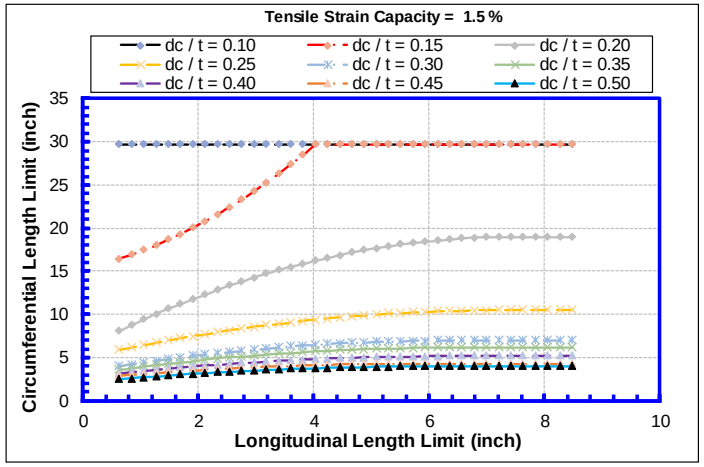
PIPE GEOMETRY		
Pipe Outer Diameter	36	inch / mm
Pipe Wall Thickness	0.5	inch / mm

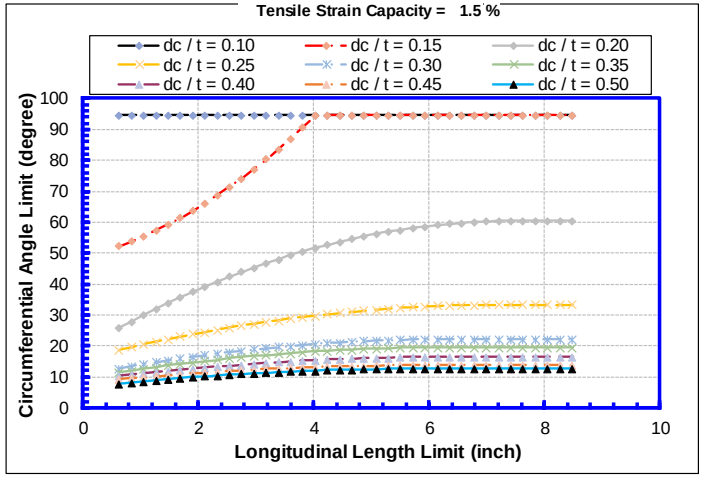
PIPE MATERIAL		
Use Pipe Grade		
SMYS =	0	ksi / MPa
SMTS =	0	ksi / MPa
Enter Value		
Pipe Yield Strength	70	ksi / MPa
Pipe Tensile Strength	100	ksi / MPa
Calculated Pipe Y/T =	0.7	

OPERATING PRESSURE		
Enter Current Internal Presure	1200	psi / MPa
Calculated Pressure Factor =	0.62	
Enter Current Pressure Factor	0.6	
Calculated Internal Pressure =	0	psi / MPa

LIMIT STRAIN		
Tensile Strain Capacity	1.5	%

Calculate Metal Loss Limit





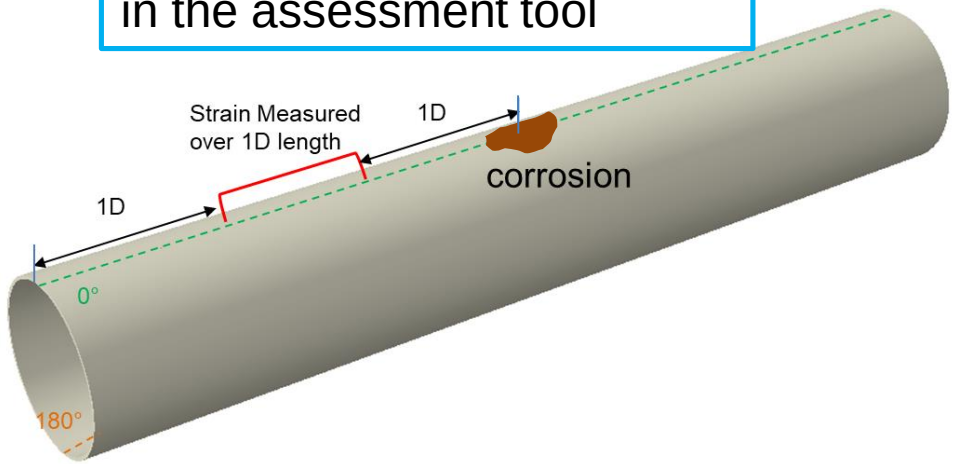
Gaps beyond the Completed Work

- Experimental test data in the subject area are scarce.
  - More data from carefully designed experimental tests are needed to validate the tools.
- Variations in material properties of linepipes are not sufficiently considered.
  - More analysis cases

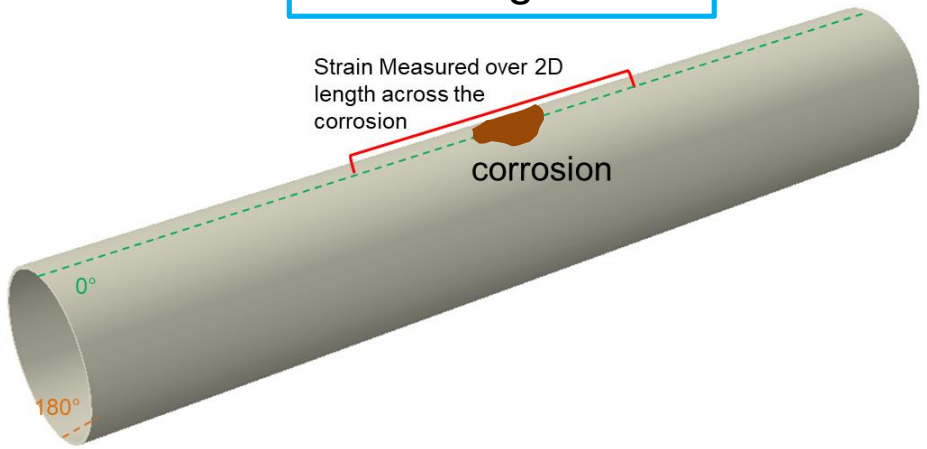
Gaps beyond the Completed Work

- Consistency in measuring and reporting strain demand and strain capacity
- Strain demand
  - IMU: bending strain over a gauge length, e.g., 10 ft or several pipe OD
  - Strain gage: local strain
- Strain capacity
  - Measured strain increases with larger corrosion, if the gauge straddles the corrosion.
  - Measured strain decreases with larger corrosion, if the strain is measured outside the corrosion.

The way of measuring strain in the assessment tool



Alternative way of measuring strain



Future Steps for Confident Use

- Additional analysis to cover more varieties of materials
- More validation tests
- Applications in conjunction with characterization tools
  - Corrosion anomaly
  - Strain measurement

Comments and Questions

- Thank you