REX2024
PRCI Research Exchange

An Operators Experience Managing the SCC threat using Electromagnetic Acoustic Transducer (EMAT) In-line Inspection (ILI)

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Debartha Bag, Hena Rehman, Gary Vervake,

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PRCI LEADING PIPELINE RESEARCH

Pipeline Research Council International

Overview

- Enbridge US and Canada GTM System
- SCC Management Evolution
- EMAT Tool Performance Evaluation
  - Tool Run, Data Analysis and Response, Bell Hole Assessment
- Reinspection
- EMAT Tracker
- EMAT SCC Findings
- Conclusions & Overall Recommendations

US and Canada GTM System

Enbridge Gas Transmission Systems is nominally comprised of large diameter pipes: 24”, 30”, and 36” OD.

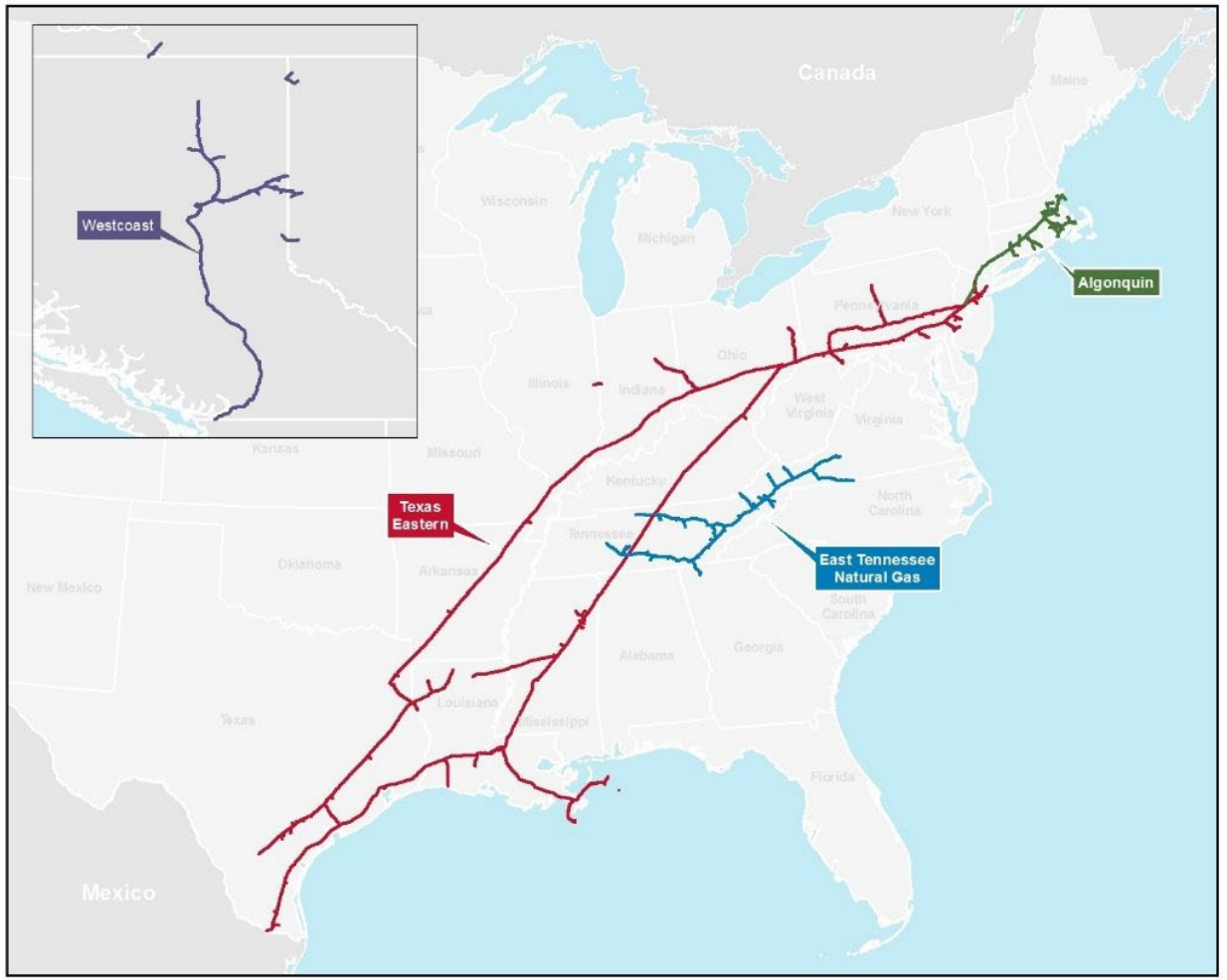
Susceptible Pipeline Characteristics:

US GTM System:

- Nominally 30” OD and 24” OD, Class 1 (0.321”, 0.375” WT), 1950’s vintage pipe.
- Grandfathered pipe operating: 77% or 80% SMYS
- Coating Composition – mostly coal tar coating and FBE (Fusion-Bonded Epoxy)
- High pH SCC.

Canadian GTM System:

- Large diameter transmission system [30” (762 mm) and 36” (914 mm), Class 1 (NWT 0.375”/9.5mm, 0.390”/9.9 mm), X52 and X60
- Coating Composition – mostly coated with tape, with some asphalt.
- Nn-pH SCC.

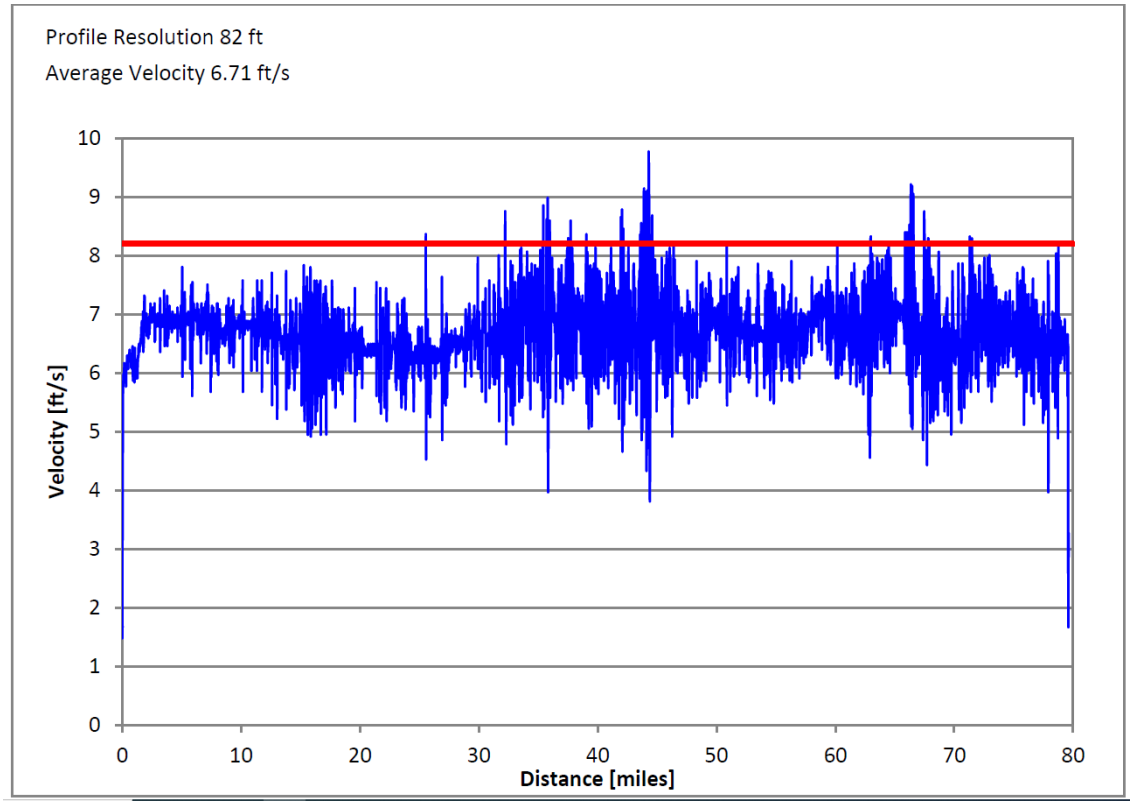


Evolution of SCC Management on the Enbridge GTM System: From Legacy Approaches to Advanced EMAT Inspection

- Legacy Measures:
  - SCC Direct Assessment (SCCDA) for low to moderate risk segments.
  - Hydrostatic test program for high-risk segments and segments with significant SCC history managed via hydrostatic testing.
- Introduction of MT Program:
  - In 2004, magnetic particle test (MT) program introduced for excavated pipelines at SCC risk
- Transition to EMAT ILI Inspection:
  - 2018: Commitment to assess SCC susceptible piggable lines with EMAT ILI inspection.
  - Aim: Provide quantitative threat management and employ risk and reliability methods for line suitability.
- EMAT Technology Advancement:
  - Provides quantitative assessments supporting Engineering Assessments, IMP enhancement, and further technology development.
  - Facilitates Risk and Reliability assessment for service and pressure restriction decisions.

Implementation Process of EMAT ILI Tools

- Pre-Assessment Planning and Coordination:
  - Involves ILI vendor, company integrity staff, and gas control.
  - GIS pipeline data provided to vendor.
  - Cleaning runs conducted, and pipe configuration reviewed for potential tool launch, receiving, and passage challenges.
- ILI Run and Data Assessment:
  - After ILI run, data quality assessed, and tool inspected for damage.
  - Pipeline Integrity Engineers evaluate and accept Data Quality Analysis (DQA).
  - Overspeed or data quality issues identified and rectified before acceptance.



Just-Missed-Flaw Analysis Overview

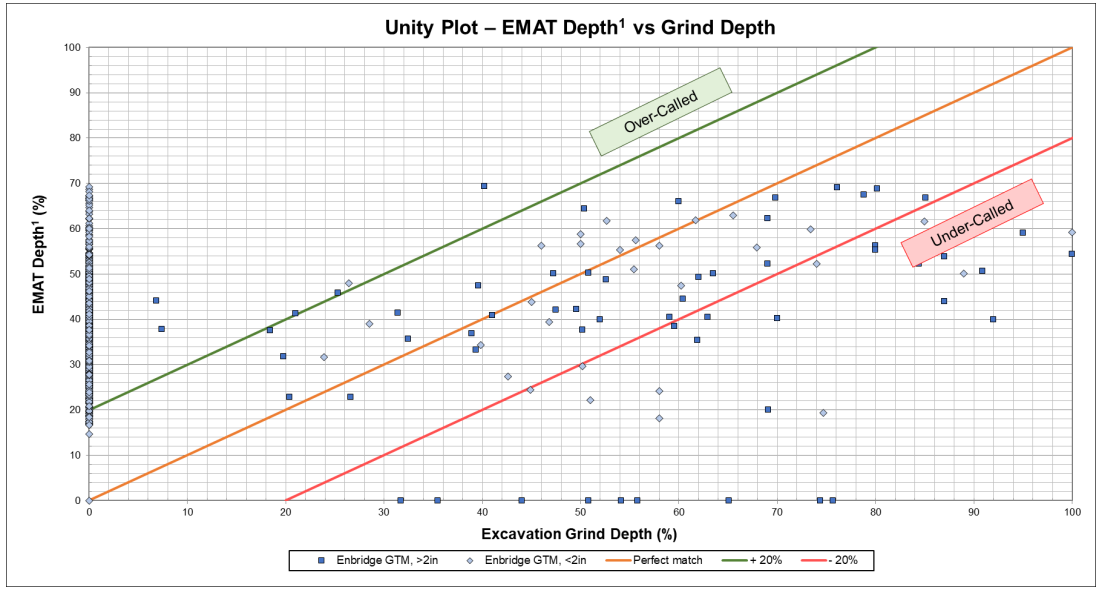
- JMF analysis involves evaluating features just below EMAT ILI reporting threshold.
  - The purpose is to manage re-inspection intervals to prevent flaws from reaching critical size.
  - JMF Size: Determined by ILI specification, typically around - 20 mm deep x 50mm long].
  - Time for JMF to reach a Failure Pressure Ratio (FPR) of 1.00 (MAOP).
  - Re-inspection Interval: Considers JMF and ILI calls, growing to FPR of 1.25.

- Adjustments in 2022:
  - Method: JMF-Option 1 considers failure rate, consequence, time since reversed flow, historical SCC findings.
  - Growth Rates: Specified for different coating types based on pipe properties.
  - SF: Safety Factor between 1 and 2 applied to JMF-Option 1.

- Reassessment Interval:
  - Average: 4 years after baseline run.
  - Further reinspection after 2nd EMAT inspection and excavation validation program.

- Risk-Informed Program:
  - Considers risk-based reinspection interval and JMF-Option 1 interval.
  - Decision Process: Considerations from Risk and Reliability group.

EMAT Tracker Integrity Tool



EMAT Tool Performance, US GTM Unity Plot - SCC Depth

EMAT Tracker in Assessing SCC Feature Characteristics

- Monitors and evaluates SCC feature characteristics.
- Correlates features with EMAT tool performance for accuracy and reliability.
- Validates observed features in the ditch, aligning with initial detection.

Analysis and Implications

- Tracks feature development over time, including predictive failure pressures and growth.
- Considers pipe characteristics for a comprehensive understanding (SMYS, wall thickness, diameter, coating type, toughness).

Assessing EMAT Tool Performance

- Methodical data reporting characterizes successes (true positives) and areas needing improvement (false positives and negatives).
- Essential for refining detection algorithms and enhancing tool efficiency and precision.

Collaborative Effort

- Generate unity plots and share excavation findings with ILI vendors.
- Fosters continuous improvement, refining detection and enhancing tool effectiveness in reliably identifying features within the system.

EMAT SCC Results

- EMAT Program was first launched on our West Coast systems in Canada in 2014.
- For US GTM, the program started in 2018 and ramped up from 2019 onward.
- Baseline runs for all susceptible piggable lines were finalized for the West Coast in 2021, and ongoing reassessment runs are currently in progress.
- For the US-GTM area, baseline runs are nearing completion as of 2023, marking the start of reassessment activities.
- Out of nearly 10,000 miles covered by EMAT runs, approximately 5,000 miles were conducted on non-susceptible pipe segments in both the US and Canada.
- Almost 1,200 miles of reassessment runs were performed in 2023.

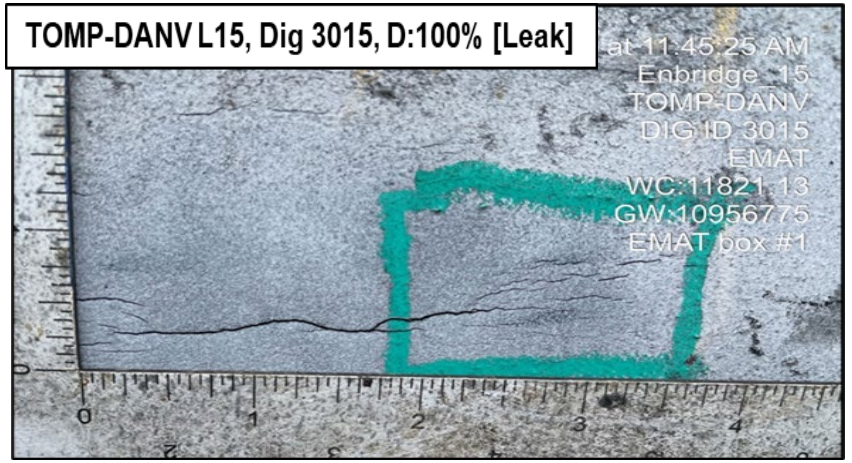
Year	Region	# of Tool Runs	Mileage Covered
2014	West Coast	2	113
2015	West Coast	2	51
2016	West Coast	1	57
2017	West Coast	2	94
2018	West Coast	5	217
	USA	1	69.4
2019	West Coast	23	973
	USA	24	1342
2020	West Coast	8	294
	USA	37	2039
2021	West Coast	5	175
	USA	37	1850
2022	West Coast	8	321
	USA	22	871
2023	West Coast	11	591
	USA	14	708
Total	**Canada**	**67**	**2886**
	USA	**135**	**6879.4**

EMAT Dig Results, US GTM vs. Canada West Coast

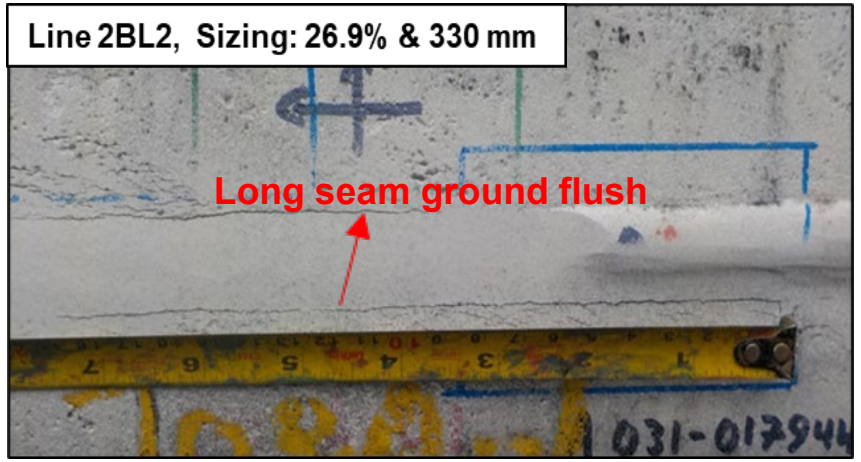
- SCC (longitudinal) Susceptibility Criteria (ASME B31.8S-A4 and Enbridge SCC Threat Response guidance (TRGD)
  - Pipe Age > 10 years
  - MAOP > 60% SMYS
  - Susceptible Coating (non-FBE or non-liquid epoxy)
  - Distance from Compressor Station ≤ 20 miles (only for high-pH SCC)
  - Operating temperature > 100° F (only for high pH SCC)

- For West Coast EMAT excavations, total 62 EMAT call outs have been confirmed as SCC features in the digs.

- More than half of the excavated SCC features from west coast digs were for EMAT call outs with seam weld interaction, and several of them were found at the toe of the LSW. For comparison, this differs from most of the high pH SCC features noticed for the US GTM in the pipe body with coal tar coating.



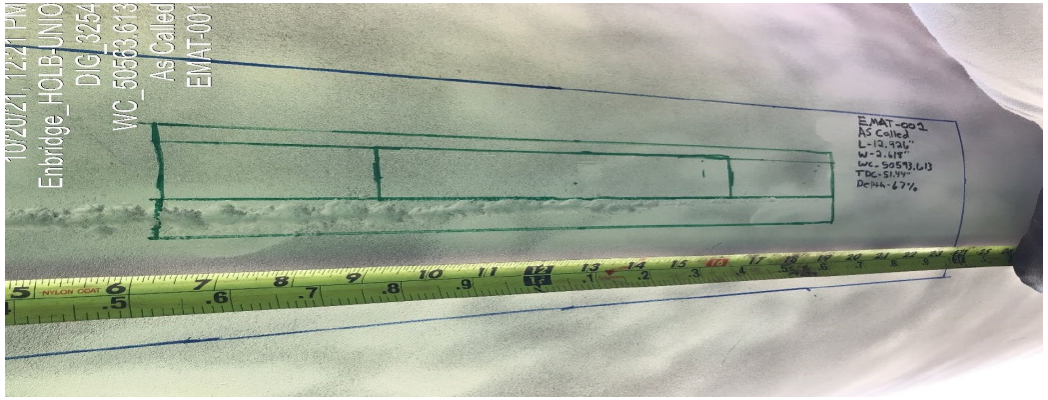
Typical high-pH SCC in pipe body (US-GTM)



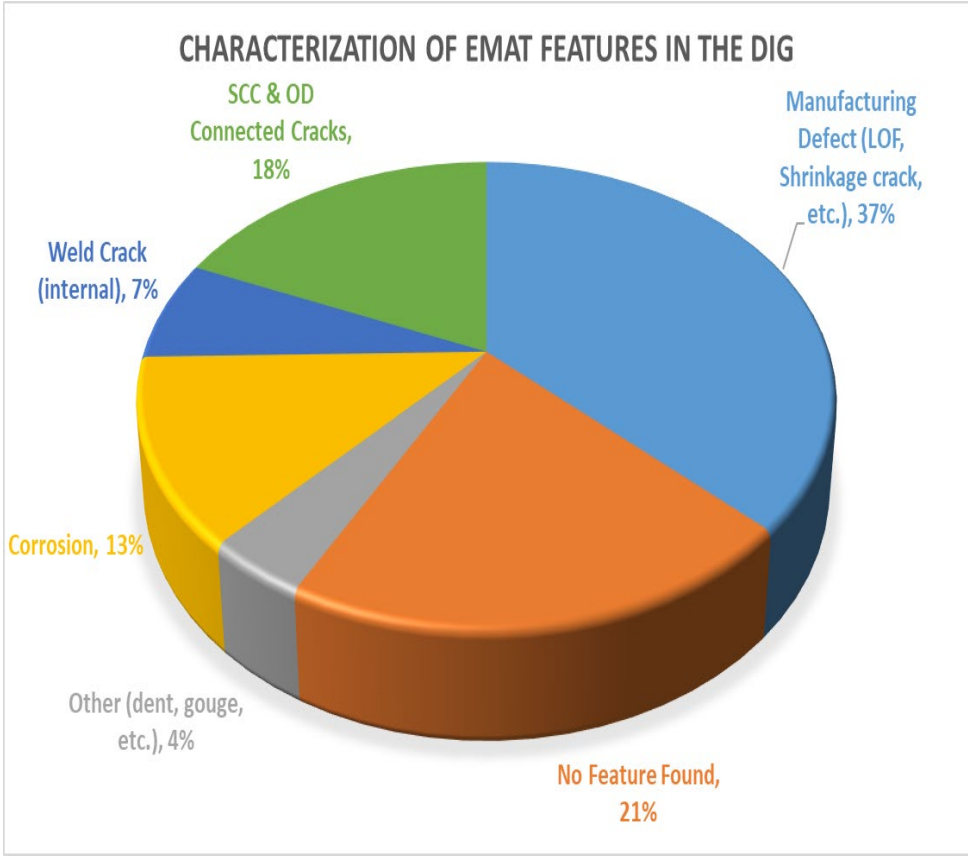
Typical nn-pH SCC at the toe of the LSW (West Coast)

EMAT Dig Results, US GTM

- Over 1,000 EMAT features were assessed in 600 excavations.
- Approximately 18% of these features were verified as either SCC or OD-connected cracks.
- <1% of the features turned out to be false negatives, meaning SCC was not reported by EMAT.
- Nearly 80% of EMAT features turned out to be false positives. Among these, 37% were attributed to manufacturing defects such as lack of fusion and ID-connected shrinkage cracks, while 21% were determined to be non-existent features, categorized as true negatives.
- All SCC instances in the US were identified as high pH SCC occurring in coal tar-coated pipes.

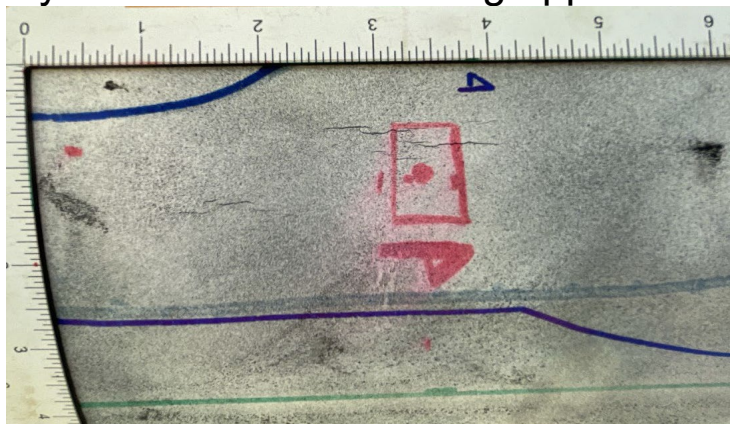


EMAT call- 68% deep axial crack in the base metal, resulting in an immediate dig. External corrosion (25% deep) noticed in the field with no reported linear indication (no MT and PAUT indication found)



EMAT Effectiveness in Finding Deep Cracks

- Year over year, 50% or deeper cracks identified by EMAT and confirmed & repaired in the ditch.
- 2019 through 2023, 60 out of the 65 cracks which were 50% or deeper have been identified by EMAT and subsequently repaired in the ditch.
- Cracks identified during reassessments were not called out during baseline.
- There have been few false negatives (<8% of all the SCCs confirmed in the field) which were not called out by EMAT but found during opportunistic digs.



EMAT Dig Year	# of 50% or Deeper Crack Features Confirmed in the Field	Field Repair	Comment
2023	7	All Type B Sleeve	4 features were associated with re-runs. No SCC found in 2023 reassessment were reported during baseline
2022	9	4 cutouts and 5 B sleeves	
2021	26	18 cutouts and 8 B sleeves	3 False negatives, (not called out by EMAT).
2020	8	All cutouts	
2019	15	All cutouts	2 False negatives (not called out by EMAT)

EMAT Findings- Baseline vs Reassessment

- Re-assessment EMAT features confirmed as SCC in the ditch- not reported during baseline.
- Some of these features were found to be short and below tool reportable spec.
- In-ditch assessment confirmed them as high pH SCC, some of them almost through-wall.
- None of these features were reported in baseline run. Findings reported to ILI vendor for further assessment.

Baseline ILI	Re-assessment ILI Year	Segment & Line	Feature Length (in) ILI	Feature Depth (%) ILI	Feature Length (in) Field	Feature Depth (%) Field	Field Characterization
Not reported	2022	Segment 1, Feature 1	1.6	52	2.75	100	Severe SCC
Not reported	2022	Segment 1, Feature 2	1.5	62	2.25	50.4	Severe SCC
Not reported	2021	Segment 1, Feature 3	0	0	1	30	Moderate SCC
Not reported	2021	Segment 1, Feature 4	5.5	61	1.758	85	Severe SCC
Not reported	2022	Segment 1, Feature 5	1.5	54	1.75	50	Moderate SCC
Not reported	2023	Segment 2, Feature 1	2.7	46	1.75	60.2	Severe SCC
Not reported	2023	Segment 3, Feature 1	0.5	36	2.5	42.3	Moderate SCC
Not reported	2023	Segment 3, Feature 2	1.5	48	2.25	81.7	Severe SCC
Not reported	2023	Segment 3, Feature 3	1.9	48	12	36.5	Moderate SCC
Not reported	2023	Segment 4, Feature 1	1.9	42	1.5	39.2	Moderate SCC

Conclusions

- The EMAT ILI and bell hole confirmation data are essential for assessing SCC Risk and Reliability evaluations, Engineering Assessments and Integrity Management Programs.
- EMAT ILI has proven effective in detecting significant SCC that pose rupture threats, thereby mitigating potential leaks or ruptures.
- EMAT is effective for addressing both high pH SCC and nn-pH SCC mechanisms.
- The efficiency of EMAT ILI has been challenging, as evidenced by the high percentage of false positives and the inefficiency in identifying true positive SCC features below the vendors sizing criteria. These areas are opportunities for improvement and further research and development.
- Several short deep cracks detected in Reinspection EMAT runs, which were not detected during baseline runs. These findings have been reported to ILI vendors for further assessment and explanation, and Enbridge PI Engineering is studying the conditions further.
- EMAT ILI program will continue to be improved with focus on SCC feature sizing and characterization accuracy and efficiency. This includes ongoing collaboration with ILI vendors, implementing advanced data analysis techniques, and considering data from field excavations to enhance tool performance and reduce false positives

thank you

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