EPIL
Pipeline Infrastructure Limited

Integrity Assessment of Non-Piggable Pipelines

Divakar Kunapareddy & Kokila Shah

28th June 2024

Speakers Profile

 **Divakar Kunapareddy** **PIL**	Head – Field O&M Vice President - Pipeline Infrastructure Limited (PIL) B.E. – Mechanical, MBA (Marketing) Started his career with IFFCO followed by GAIL, Reliance and PIL. In his tenure of 30+ years of experience in Oil & Gas sector, he has been involved in Construction, Commissioning and Operation & Maintenance of cross-country pipelines and has formalized many innovative measures to safeguard the integrity of pipeline assets.
 **Kokila Shah** **PIL**	Lead Cathodic Protection General Manager - Pipeline Infrastructure Limited (PIL). B.E. – Electrical Started her career with Mahanagar Gas Ltd followed by PIL. She has an experience of 15 Years in Cathodic Protection and Pipeline Integrity of Natural Gas Pipelines

Content

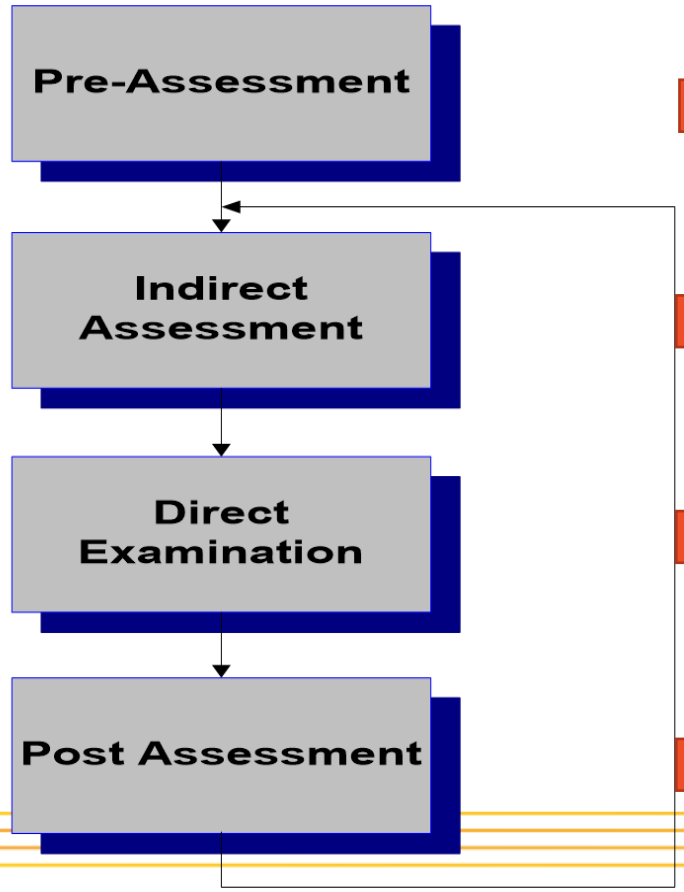
Pipeline Infrastructure Limited

01	Introduction to integrity assessment of non piggable pipelines	02	PIL Asset information	03	Pre-assessment details
04	In-direct inspection details	05	Direct Assessment details	06	Case study – Spurline in Andhra Pradesh
07	Case Study – Spurline in Maharashtra	08	Results & Conclusions	09	Way Forward

INTEGRITY ASSESSMENT OF NON-PIGGABLE PIPELINES

Done through ECDA / ICDA and SCCDA

ECDA / ICDA / SCCDA takes into account the threats of external corrosion, internal corrosion and Stress corrosion cracking.



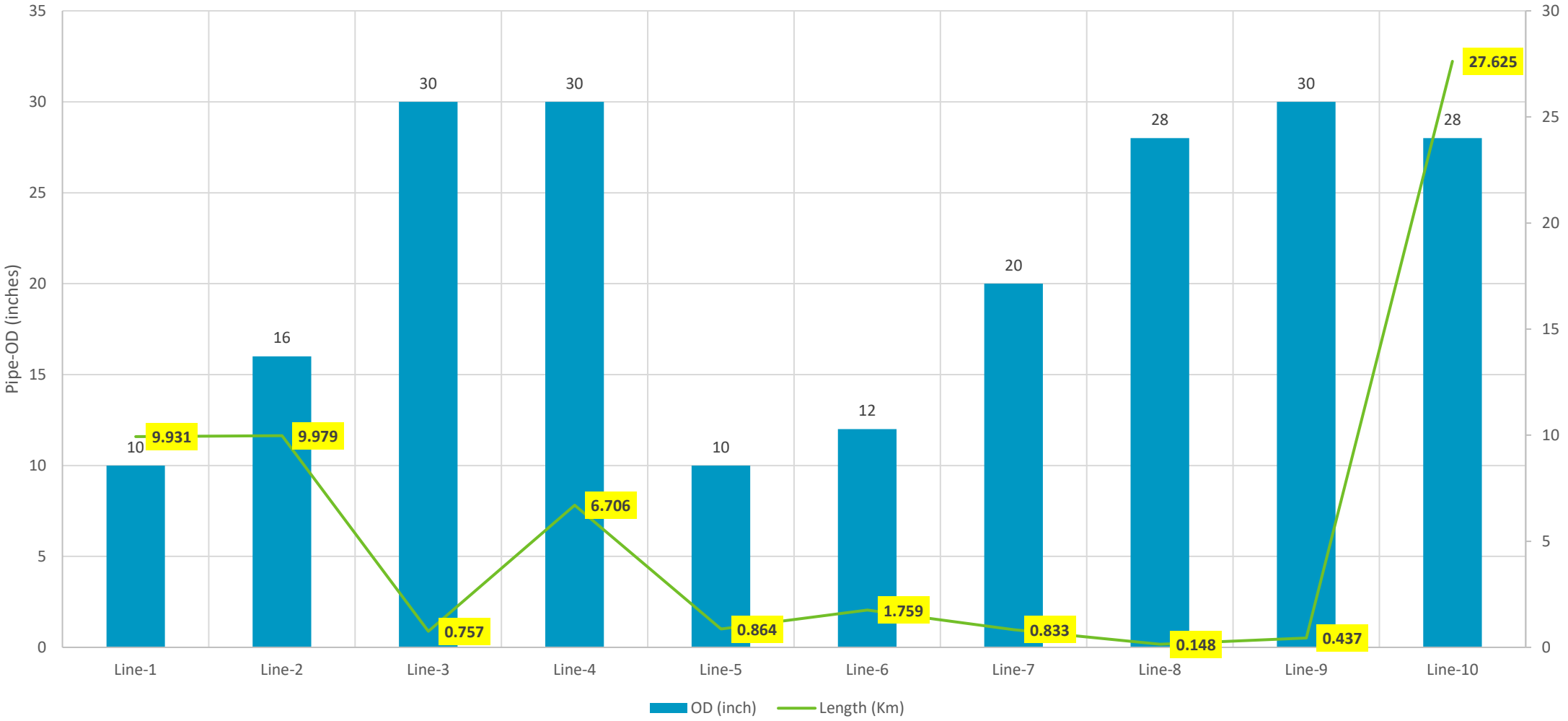
Data collection and assessment, Corrosion/ leak History, Scrutinizing Data & Audit Visit, Selecting DA regions, Appropriate IDI tools, Susceptibility

Above ground inspection CP/ Coating/ Terrain (EC & SCC)/ Corrosion modeling (ICPM), future threat areas, potential corrosion locations

In the ditch investigation, Coating assessment, Environment classification, Corrosion deposits and areas, NDE, Remaining Strength

Reassessment Intervals, Remaining Life, DA effectiveness & Health assessment

PIL Asset information – ECDA / ICDA / SCCDA carried out

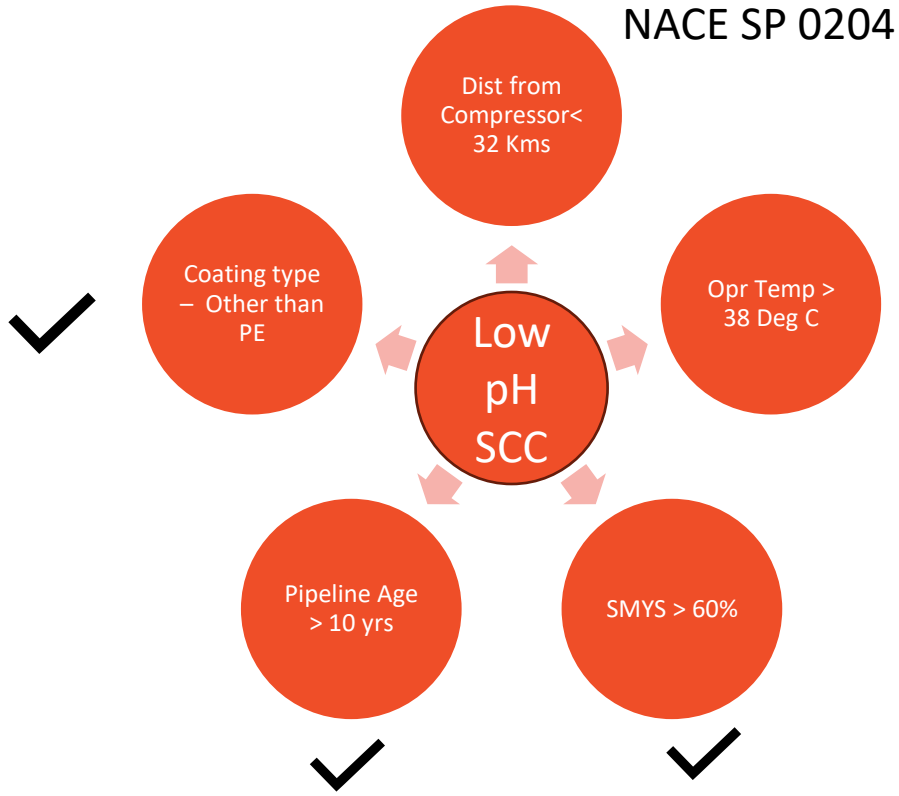


Pre-Assessment (PrA)

ECDA:
NACE SP 0502
Data collection & review related to
(a) Pipeline operating parameters
(b) Soil Data
(c) Identification of HCAs
(d) Assessment of ECDA feasibility
(e) All construction data , pipeline commissioning reports, historical CP trends, etc

ICDA:
NACE – WG ICDA standard
Parameters reviewed:
(a) Product temperature
(b) Product Pressure
(c) Gas composition
(d) Flow rate
(e) Gas Density
(f) Elevation profiles

SCCDA:
NACE SP 0204 and ASME B 31.8S



Apart from above, PrA for SCCDA shall also consider history of failures due to SCC, specific pipe manufacturers type, presence of disbonded coating, corrosion deposits on pipeline etc

In-direct Inspection

For ECDA / SCCDA

As a minimum requirement, 2 tools are selected. Vendor performed 6 surveys in tandem:

(a) DCVG
(b) ACVG
(c) CAT
(d) CIPL
(e) Soil / Terrain Survey
(f) Soil resistivity Survey

For ICDA

Corrosion modelling and flow modelling done considering different scenarios of flow rate, moisture composition

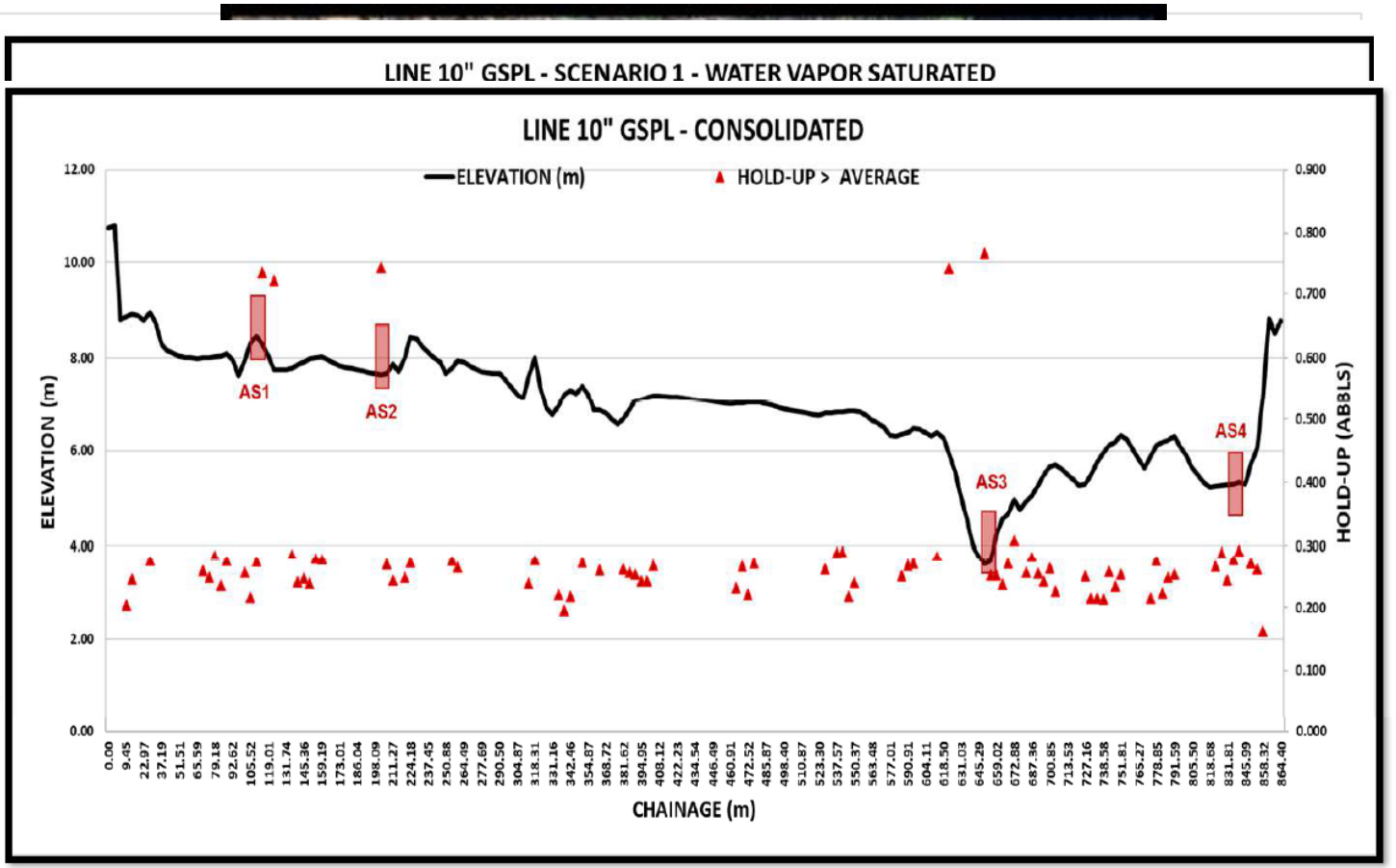


Figure 50: Calculated cumulative % wall loss along with probable DEx assessment sites

Detailed Examination (DEx)

DEx locations are identified based upon the results of ECDA , SCCDA and ICDA IDi.

Tests performed:

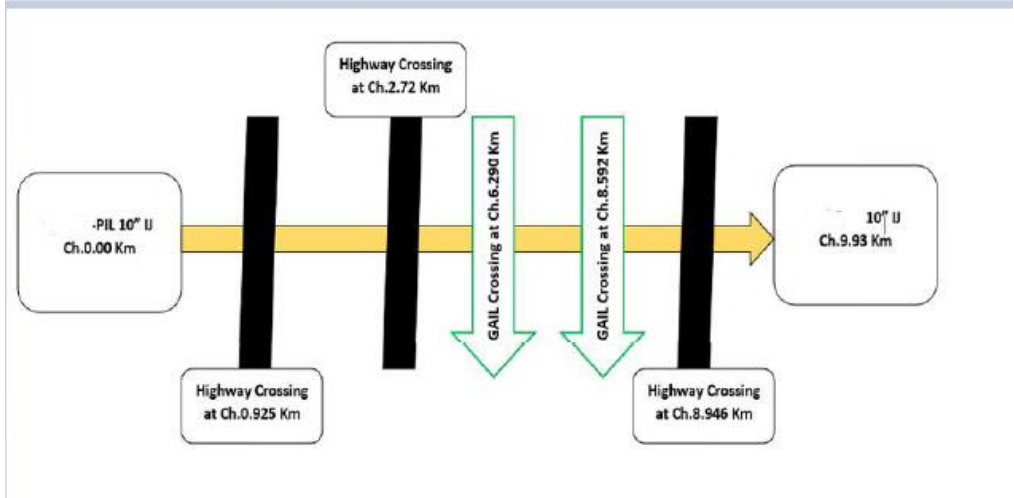
(a) Ultrasonic testing for internal corrosion mapping
(b) Magnetic Particle Inspection (MPI)
(c) Peel Test
(d) Surface roughness test
(e) Patch coatings are tested
(f) Soil measurements – pH

Post DEx cold wrap tape is applied & holiday test is done before backfilling.

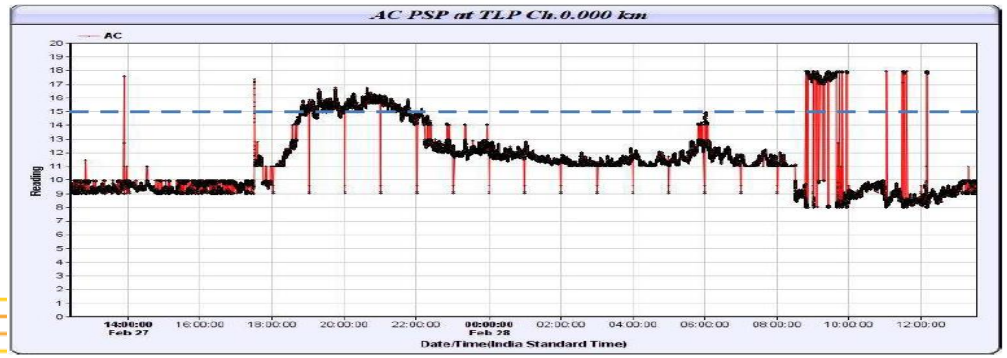
Repair

Case Study 1: Spurline in Andhra Pradesh

Basic Features: 10.75” OD, 10 Kms length, commissioned in 2009



24 h data logging was carried out and AC PSP was seen to be reaching a maximum of 18 V during night time



IDi FINDINGS - ECDA

Anomalies were flagged off and summarized post the IDi as below:

Item	Number	Comments / Conditions
Geotechnical anomalous areas	1	DOC < 1 m
Quantitative coating indications (DCVG & ACVG)	0	No flagged indications
Qualitative coating indications (ACCA)	62	Severe. ACCA used for severity prioritization of all IDi surveys conducted together
CP criteria (UP)	92	Instant off PSP < -0.85
CP criteria (OP)	199	Instant off PSP > -1.2 V

AC current density was also calculated & found be in the range of 1296 A/m2

Case Study 1 : Spurline in Andhra Pradesh

Pipeline Infrastructure Limited

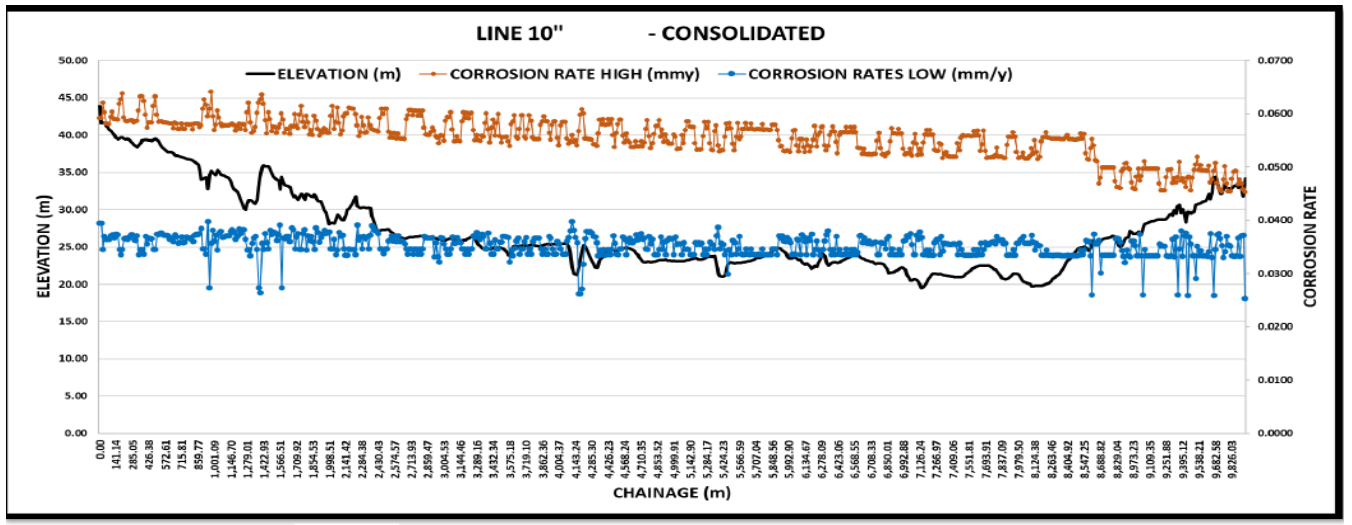
IDi FINDINGS - SCCDA

Soil augers + Carbonate testing done

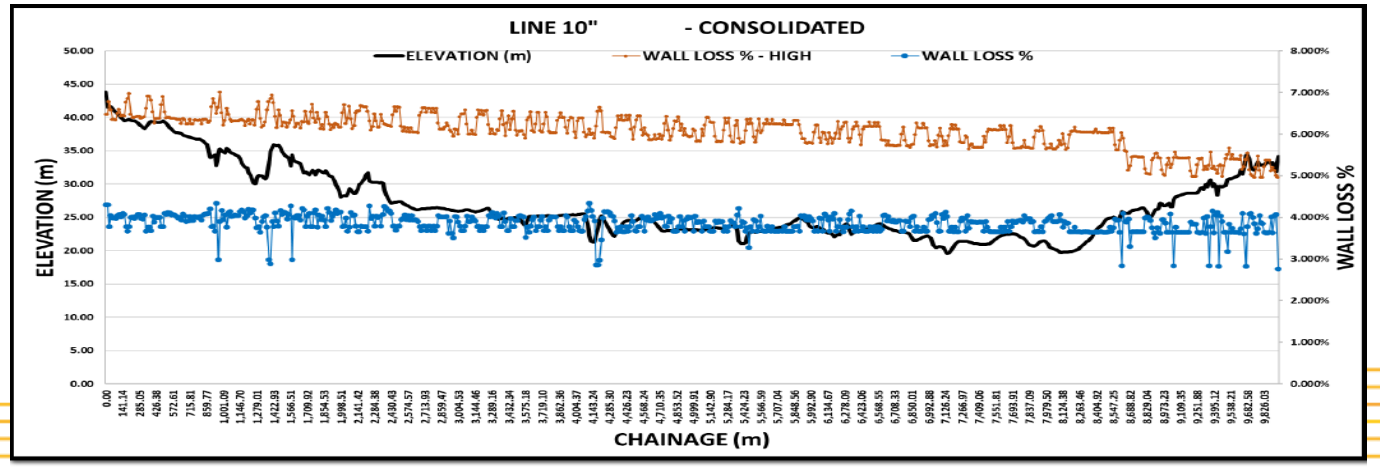
Soil sampling – pH, TDS, sulphide , Soil temp, chlorides, sulphates , %moisture, carbonates

Also due to the absence of flow, low susceptibility seen for SCC

IDi FINDINGS - ICDA



Calculated consolidated corrosion rates for the subject Line



Calculated consolidated % wall loss for the subject Line

Case Study 1: Spurline in Andhra Pradesh

Detailed Examination Findings:

Historical coating patch

No corrosion deposits below the patch

Peel test success on HSS

Peel test fail on 3LPE

Probable Causes of Coating Disbondment:

(a) Epoxy thickness was seen to be 179 µm. ISO 2808e specifies 200 µm
(b) Instant OFF PSP >-1.2 V at certain points
(c) High AC PSP seen at some points which can lead to coating becoming electrically charged and break down leading to formation of bubbles causing disbondment
(d) Soil has alternate drying & wetting properties which can accelerate disbondment

Results & Conclusions

(a) No metal loss anomalies recorded.
(b) No stress corrosion cracks found
(c) Psafe calculations done using assumed IC threat simulations (WCS max depth of 0.64mm).
(d) This Psafe> PIL Design pressure
(e) Can continue operations in "as is" conditions
(f) Remaining life – 16 years (Design – 30 years)
(g) Re-assessment interval – 8-10 years

Case Study 2: Spurline in Maharashtra

Basic Features: 30.75” OD, 0.757 Kms length, commissioned in 2009

IDi FINDINGS - ECDA

Anomalies were flagged off and summarized post the IDi as below:

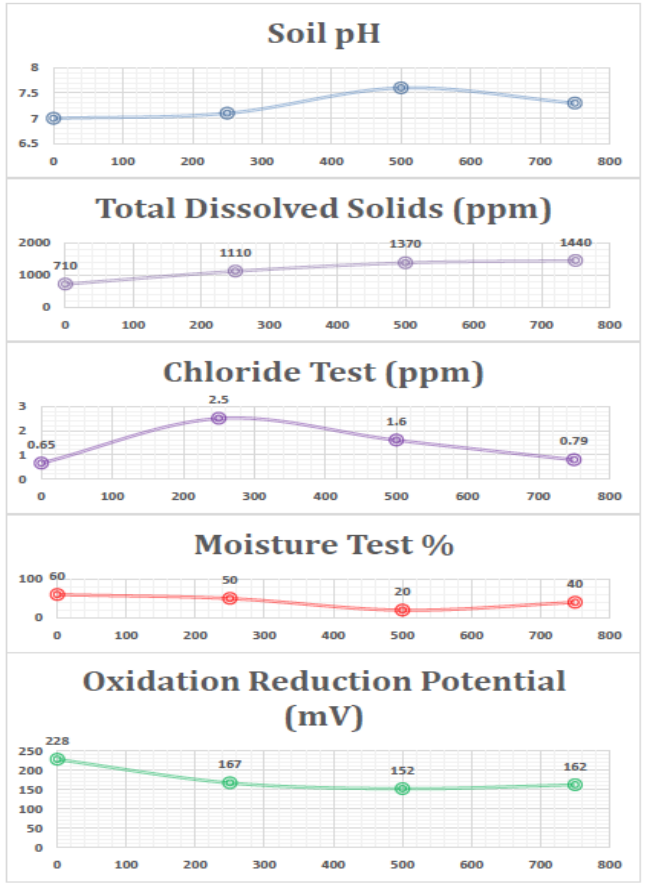
Item	Number	Comments / Conditions
Geotechnical anomalous areas	2	DOC < 1 m
Quantitative coating indications (DCVG & ACVG)	0	No flagged indications
Qualitative coating indications (ACCA)	4	Severe. ACCA used for severity prioritization of all IDi surveys conducted together
CP criteria (UP)	0	Instant off PSP < -0.85
CP criteria (OP)	0	Instant off PSP > -1.2 V

- AC PSP within limit. Max. current density 35 A/m2 (Corrosion unpredictable)
- No foreign pipeline interference seen
- Coating documented was 3LPE and on excavation was seen to be HSS

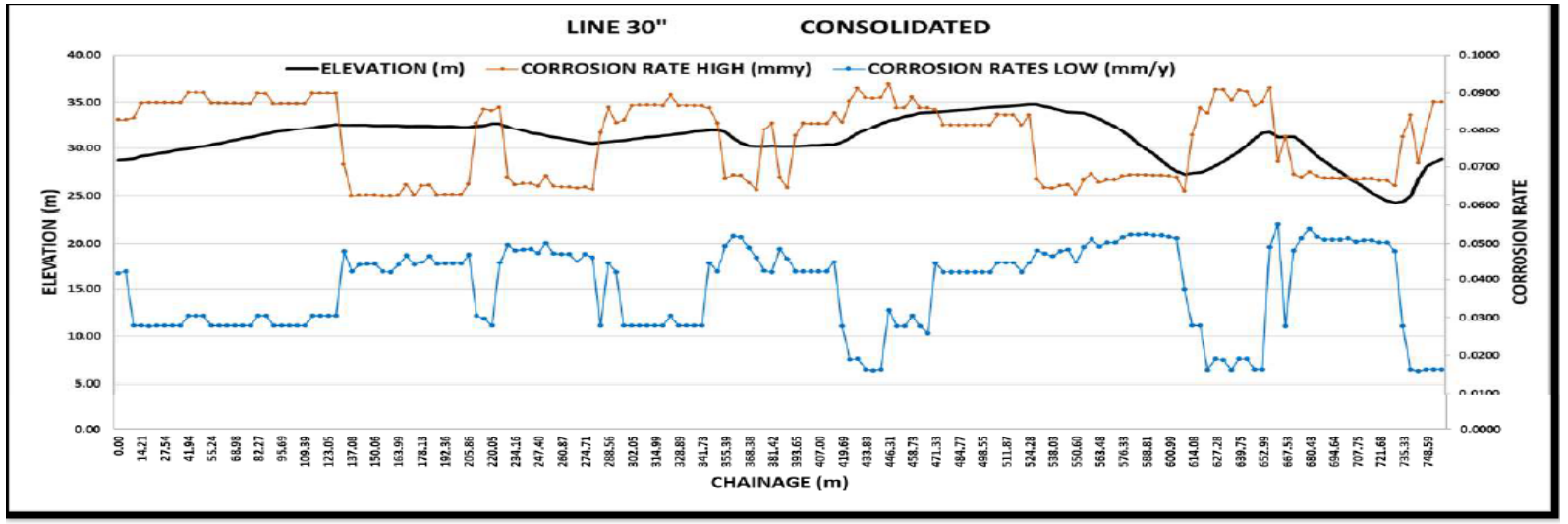
Case Study 2: Spurline in Maharashtra

Pipeline Infrastructure Limited

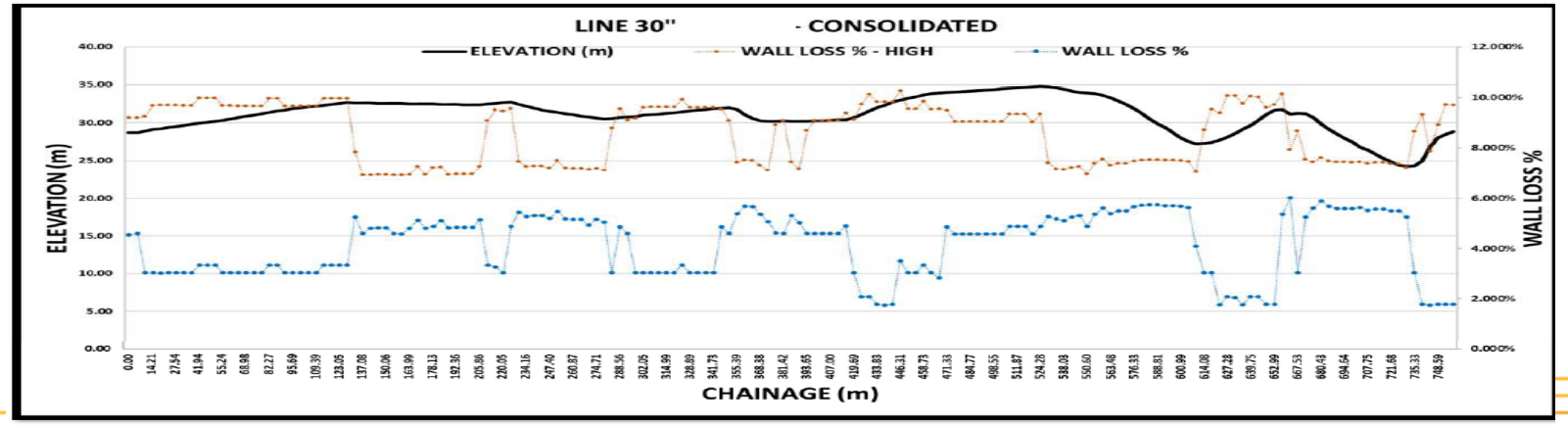
IDi FINDINGS - SCCDA



IDi FINDINGS - ICDA



Calculated consolidated corrosion rates for the subject Line



Calculated consolidated % wall loss for the subject Line

Case Study 2: Spurline in Maharashtra

Peel test – disbondment

MPI – No signs of SCC

Deposits of FeO/OH and CaCO3

Major findings - DEx

(a) Coating system applied- HSS (100% disbondment)
(b) External corrosion metal loss featured at both sites – 1 isolated pit at one site, 3 external corrosion anomalies.
(c) Active AC corrosion phenomena

Probable Causes for Disbondment

(a) Instant Off >-1.0 V with thin or no epoxy layer for 14 years

Results & Conclusions

(a) Pressure burst calculations done as per ASME B 31G, ASME B 31G modified
(b) For all scenarios, Psafe > PIL Design pressure
(c) Max External Pit depth – 1mm
(d) Simulated max. IC PD – 1.58 mm
(e) For calculation of remaining life, max non-leaking flaw dimensions to be considered.
(f) RL – 9.61 years
(g) Re-assessment interval 4.8 years

Results & Discussions

The four main causes of coating disbondment are:

i) Insufficient surface anchor profile/surface roughness, prior to epoxy application. The epoxy thickness could not be measured at most of the locations as it was not adhered to the pipe. Epoxy thickness in the milling process could be a factor related to coating disbondment.

(ii) Cathodic disbondment due to overprotection voltages from the CP system. NACE SP0169 specifies the limits of overprotection as Instant Off PSP > -1.2 V. Higher voltages can increase susceptibility of Coating Disbondment. The documented CP instant off also exceeds the NACE overprotection criterion at some locations for few of the spurlines during the Indirect Inspection (IDi) step and coating disbondment also documented in Direct Inspection DEx (DEx) step.

(iii) High induced AC voltages on the pipeline can also cause the coating to become electrically charged and break down, leading to formation of bubbles or voids which can eventually cause disbondment.

(iv) Based on the drainage properties of the soils at all the excavated locations, the soils are subject to alternate wetting and drying conditions, which can enhance coating disbondment over time.

Conclusions

- The integrity assessment conducted for all ten (10) pipelines were deemed validated for all three (3) time-dependent threats of internal corrosion, external corrosion and stress corrosion cracking
- Phenomenon of AC interference was found to be active in **5** pipelines
- Phenomenon of coating disbondment off the pipe substrate was found to be active in all the **10** inspected pipelines
- External corrosion-based metal loss with maximum of **10% (Pit depth of 1 mm)** has been documented in **1** out of the **10** pipelines
- Internal corrosion threat for the entire system is deemed to be low – considering the natural gas quality and operating parameters remain the same (in addition to having internal coating)
- The soil, terrain and environment for all ten (10) pipelines was documented to be susceptible to environmentally assisted stress corrosion cracking (ea-SCC). But no SCC was detected at all locations inspected.

Action Points for PIL – Way Forward

- DEx has been completed at almost all pending locations in 2024.
- XLI shall be done at critical locations going forward
- Foreign Pipeline Interference survey at identified locations
- AC interference mitigation being completed on priority at identified locations of active AC phenomena
- Software modelling to be done at AC prone areas
- Maintain instant OFF PSP in the range of -1.1 V DC for spurline in AP and -1.0 V for spurline in Maharashtra considering minimum PSP requirements also.


Thank you!