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Feasibility Study for an Unpiggable Subsea Pipeline

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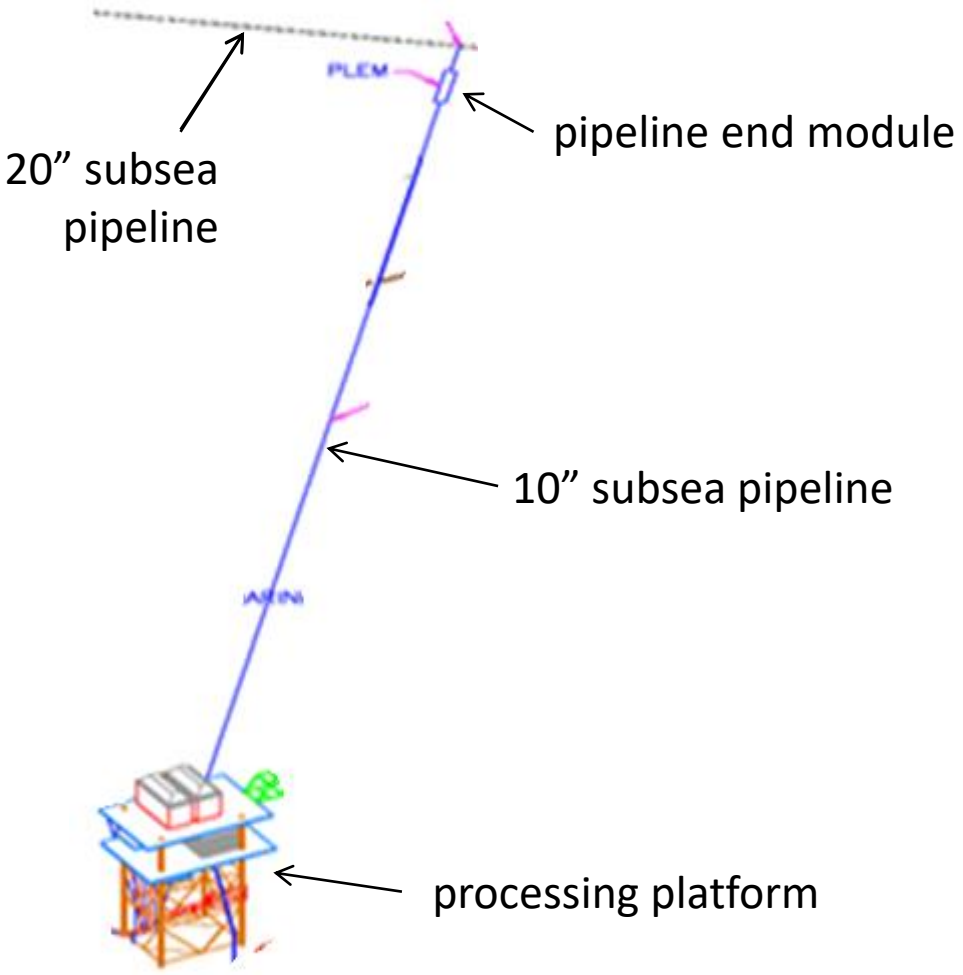
Introduction

The long-term integrity of many export and transportation pipelines is dependent on being able to inspect the whole length of the pipeline using In-Line Inspection (ILI) technologies; however, not every pipeline can be inspected using ILI technologies due to its construction and/or location specifics.

Therefore for these pipelines, the short term integrity becomes more of a priority. The results will form a key input to developing a longer term integrity management plan for these pipelines.

The solution presented here has come from a complete desktop feasibility study of the available information relating to the product and the pipeline in order to determine the likely type of corrosion present and the most likely locations for the corrosion to occur.

Introduction…



Introduction…

The desktop feasibility study has investigated the use of external ultrasonic scanning (auto-UT) to manage the short term integrity of the pipeline, and was comprised of the following tasks:

- Product Composition – Review of product composition and assessment of corrosion threats
- Pipeline Configuration – Identifying the locations most susceptible to internal corrosion.
- Inspection Method – Preparation of Inspection including review of Cathodic Protection.

Product Composition

Assessment of the product composition was carried out in order to determine which types of corrosion were possible within the 10” pipeline.

- Pitting and general corrosion
- Sour cracking (Hydrogen Induced Cracking HIC and Sulphide Stress Cracking SSC)
- Microbial corrosion
- Mesa corrosion
- Erosion – corrosion

Product Composition

Pitting and General Corrosion

- Low flow rates recorded ~ typically 0.28 m/s
- Protective film of FeS scale precipitation is expected on the internal surface of the pipeline, due to sour service.
- Corrosion growth rates reported are less than 0.025 mm/year .
- However damage to FeS film would allow pitting corrosion to be major threat to pipeline.

Sour Cracking Corrosion

- Hydrogen Induced Cracking (HIC) and Sulphide Stress Cracking (SSC)
- The 10" pipeline is manufactured in accordance with the requirements of sour service.
- Sour cracking is not considered to be a conceivable threat to the pipeline integrity.

Product Composition

MESA Corrosion

- Mesa corrosion attack is unlikely, because the Corrosion mechanism is dominated by H_2S as the ratio of $CO_2 / H_2S < 20$.

Microbial Corrosion

- Low risk of microbial corrosion, as low microbial contamination has been recorded on the processing stages and biocide treatment is applied.

Erosion – Corrosion

- Erosion - Corrosion is unlikely due to the low flow velocity (~0.28 m/s).

Product Composition

To Summarise

- In general under the current operating conditions the pipeline is stable.
- The most likely form of internal corrosion is in the form of pitting corrosion.
- However, as long as H_20, H_2S and CO_2 content is low and the durability of protective FeS film is maintained the risk from this form of corrosion is low.
- Threats associated other forms of corrosion are considered to be negligible.

Pipeline Configuration

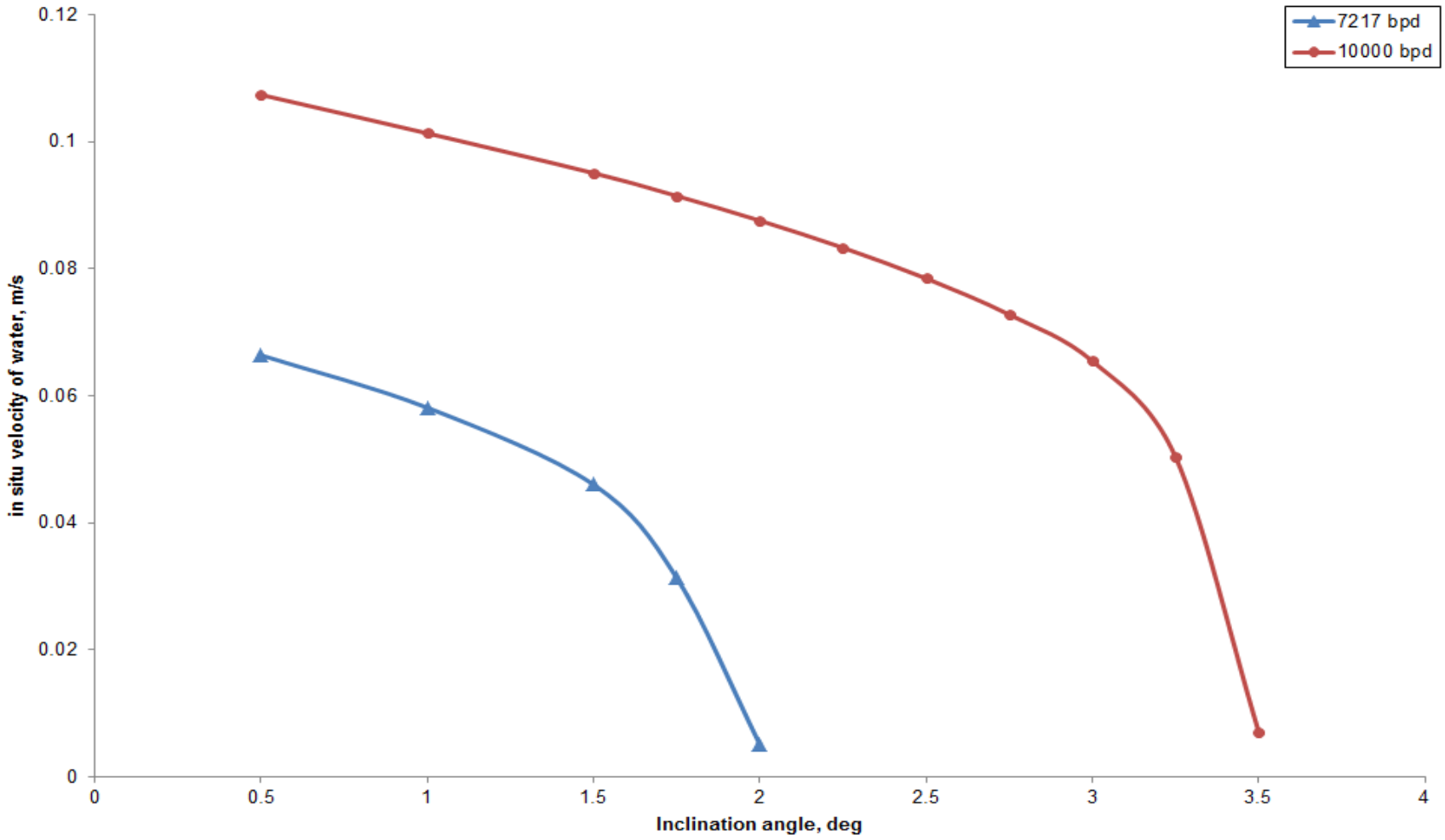
Outside diameter	10.75” / 273.05 mm
Length of pipeline	40.5 km
Nominal wall thickness	0.5” / 12.7 mm
Pipe Manufacturing Process	Seamless
Pipe Steel Grade	API 5l Grade X52
Specified Minimum Yield Strength	359 MPa
Design Pressure	50.0 bar
Maximum Allowable Operating Pressure	30.0 bar
Hydrotest Pressure	62.5 bar
Product type	Crude Oil
Product Flow (typical)	0.28 m/s

Pipeline Configuration

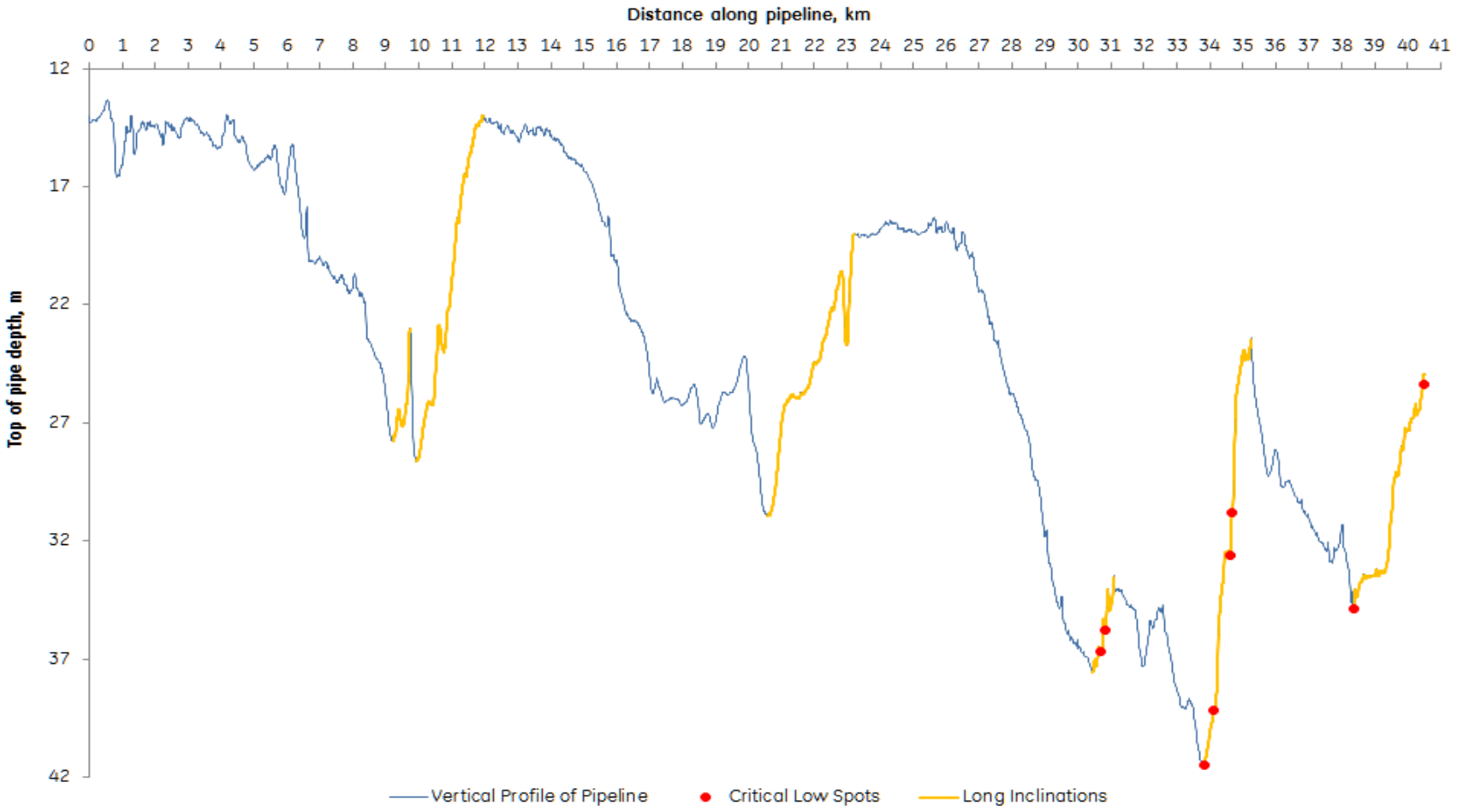
Possible locations of water drop out are:

- Low spots
- Long uphill sections (causing water in oil emulsion separation).
- Sections directly upstream of segments with inclination angle exceeding critical angle for water drop out. [NACE SP 0208, Appendix A, page 25]

Pipeline Configuration



Pipeline Configuration



Pipeline Configuration

KP Start, km	TOP Depth start, m	KP End, km	TOP Depth end, m	Length, km	Δ elevation, m	Max Angle	Comment
9.213	27.7	9.742	23.2	0.529	4.5	3.6	Long Incline.
9.642	26.2	9.742	23.2	0.100	3.0	3.6	Low spot
9.905	28.6	11.973	14.0	2.068	14.6	1.8	Long Incline
20.580	30.9	22.842	20.6	2.262	10.3	1.0	Long Incline
22.980	**23.7**	**23.202**	**19.0**	**0.222**	**4.7**	**2.1**	**Low spot**
30.444	37.6	31.105	33.7	0.661	3.9	2.7	Long Incline.
30.688	36.7	30.782	35.5	0.094	1.2	2.7	Low spot
30.808	35.8	30.904	34.2	0.096	1.6	2.2	Low spot
33.809	41.5	35.265	23.5	1.456	18.0	4.1	Long Incline
34.124	39.2	34.449	32.5	0.325	6.7	4.1	Low spot
34.609	32.6	34.670	30.8	0.061	1.8	3.4	Low spot
34.683	**30.8**	**35.036**	**24.0**	**0.353**	**6.8**	**3.6**	**Low spot**
38.360	34.9	40.510	24.9	2.150	10.0	5.7	Long Incline
40.473	25.4	40.486	24.9	0.013	0.5	5.7	Low spot

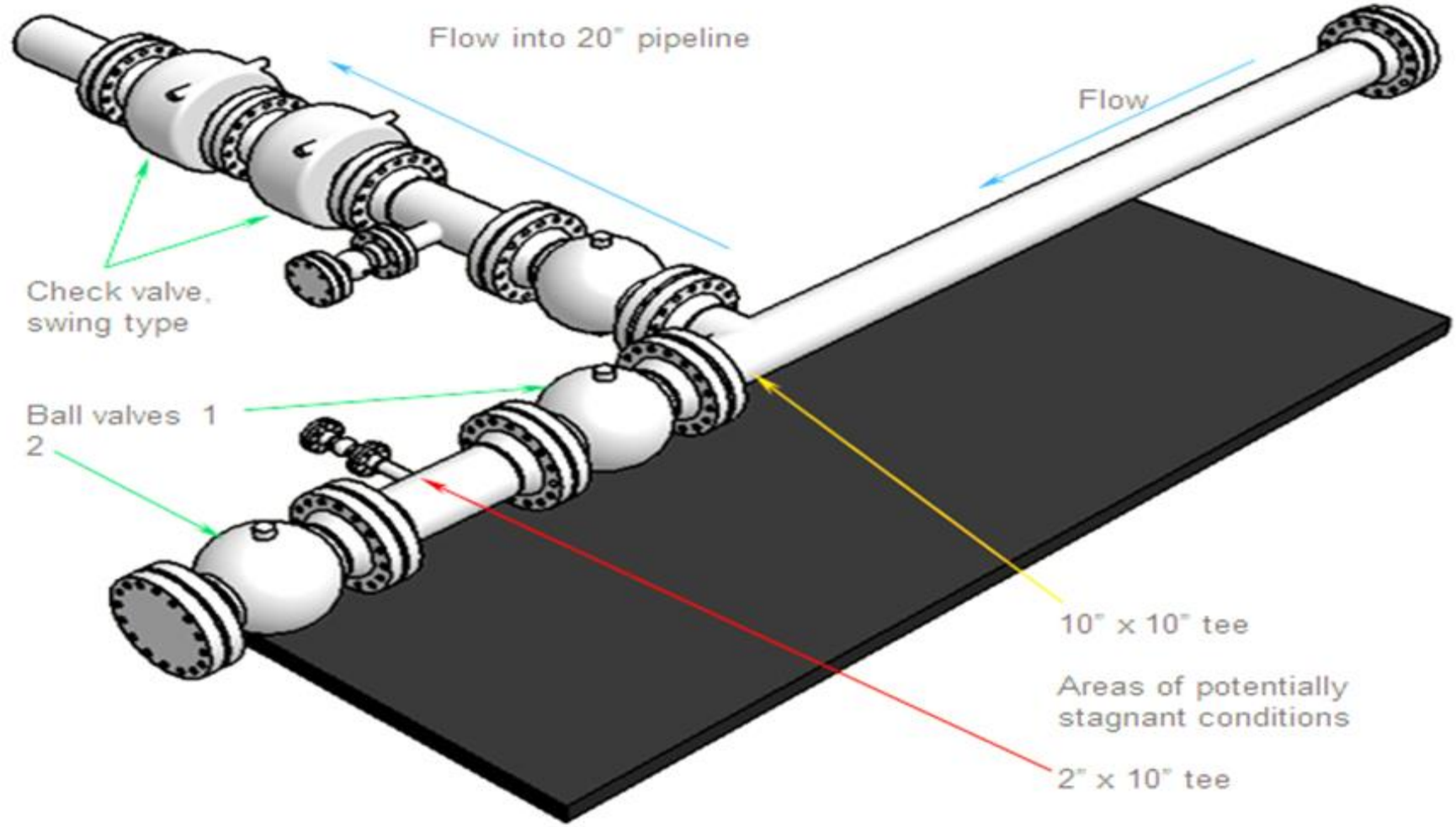
Pipeline Configuration

Locations that are predicted to have the highest susceptibility to solids accumulation include (but are not limited to):

- For solids drop out
  - Overbends
  - Isolation valves, fittings
  - Pipeline diameter increases
  - New product inlets
  - Long uphill sections

- For water, solids and microbial accumulation
  - Stagnant areas, facility components or fittings that rarely or never experience flow (dead legs, tees)

Pipeline Configuration



Pipeline Configuration

To summarise

Four locations prioritised in terms of success for an Auto-UT inspection in finding internal corrosion

2 low spots @ 22.980 km and 34.683 km along the pipeline

2 locations within the PLEM, bottom of 2” and 10” tees.

Inspection Method

The aim of the task was to provide guidance on the preparation necessary for the auto-UT inspection and to consider inherent risks to the pipeline before, during and after the auto-UT inspection.

First need to determine the appropriateness of conducting an Auto-UT inspection on the 10” pipeline and establish the confidence of the Auto-UT inspection.

Then discuss the requirements and risks in performing an Auto-UT inspection on a subsea pipeline.

Inspection Method

According to the NACE SP0208 LP-ICDA standard there are certain situations where an auto-UT inspection approach would not be able to provide reasonable confidence regarding the pipeline condition, these are considered to be:

- The susceptibility to internal corrosion cannot be evaluated based on the data available.
- The pipeline is expected to have a continuous water phase during normal operation (i.e. susceptibility to corrosion will be high along full pipeline).
- The pipeline has a continuous internal coating for the entire length of the line.
- The pipeline cannot be made accessible for detailed examination (auto-UT inspection).

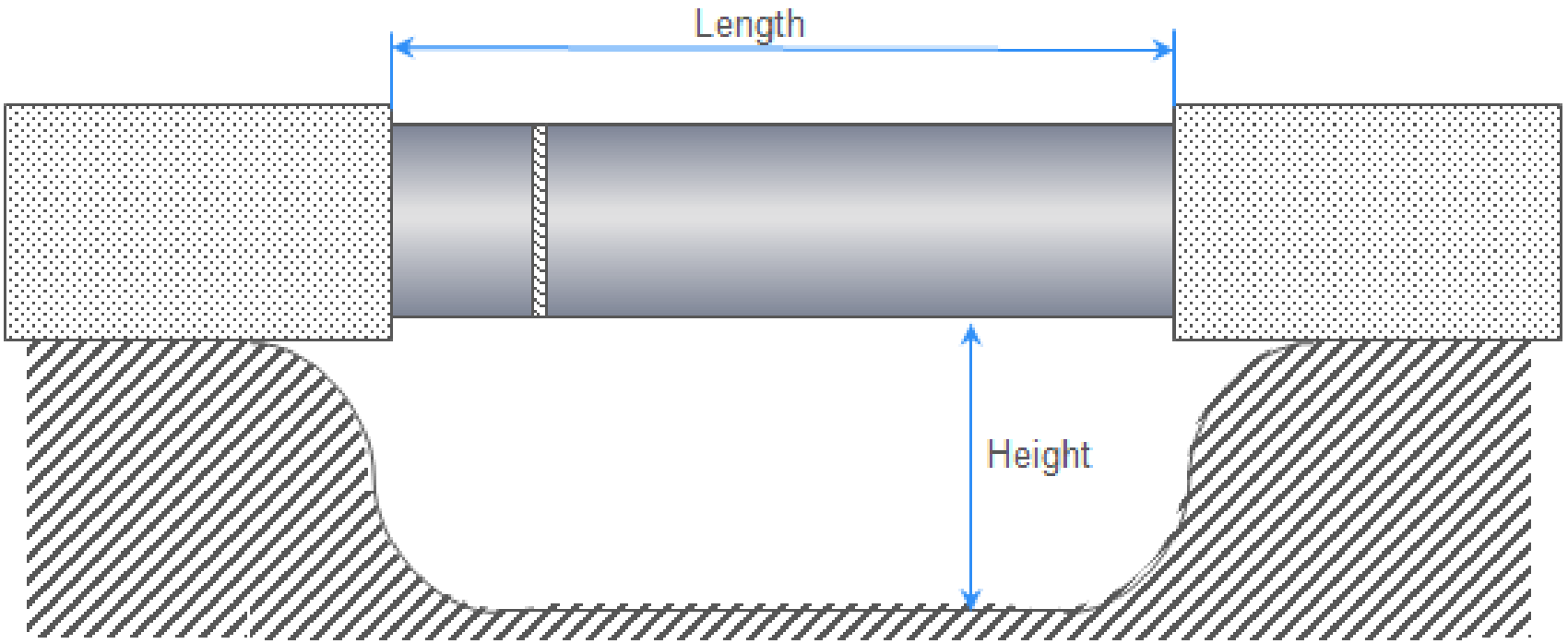
Inspection Method

As we have established that a Auto-UT inspection is appropriate for this line, what considerations need to be taken into account in order to perform the inspection.

NACE SP 0208 does not provide general guidance on the required length of each Auto-UT site. However the standard practice contains some recommendations for pipelines susceptible to solid deposition and flow disturbance by pipeline fittings.

- Valves (downstream joint or 5 m minimum)
- Diameter increases (downstream joint or 5 m minimum)
- Overbends (5 m downstream, beginning at overbend)
- Injection points (5 m downstream, beginning at injection point)

Inspection Method



Inspection Method

A review of the current Cathodic Protection (CP) was performed to ensure that there is adequate protection to the pipeline from external corrosion at the Auto-UT sites.

If Auto-UT site to be used once and pipeline immediately re-coated, the current CP system provides enough protection against external corrosion

However, if the Auto-UT site is to be left for repeat inspections, there no redundancy within the CP system for to allow for protection of any additional exposed pipeline at a UT site for any significant period of time.

Consequently additional CP protection would need to be added to the current CP system.

Conclusion

Review of product composition suggests that the pipeline maybe susceptible to internal pitting and general corrosion.

Other types of corrosion are considered to be negligible.

Review of the pipeline configuration identified 2 sites along the pipeline and 2 sites with the PLEM suitable for Auto-UT inspection.

A positive conclusion could be made for the appropriateness of the UT inspection of the pipeline.

Current cathodic protection adequate, provided external coating re-instated after inspection. Additional anodes required if inspection site to remain exposed for future investigations

Closing Remarks

Examination of the four sites selected for Auto-UT examination indicated internal corrosion pits at one of the locations, with depths between 14% wt. and 22% wt.

Evaluation of these internal corrosion pits did not indicate a significant threat to the immediate integrity of the pipeline.

Annual monitoring at the locations recommended to establish corrosion growth rates, until the pipeline made piggable.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