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INTEGRATED PIGGING APPROACH FOR SAFE AND EFFECTIVE PRE-CCS PIPELINE PREPARATION

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Introduction

- Carbon Capture and Storage is crucial for industrial decarbonisation
- Reuse of hydrocarbon pipelines for CO_2 reduces cost and environmental impact
- Dense-phase CO_2 service demands higher cleanliness and integrity standards
- Two gas pipelines underwent pigging and chemical treatment to CCS requirements
- Each line had unique contamination and history that required tailored strategies
  - 34KM 20” subsea pipeline with history of sour gas and inhibitor dosing
  - 27KM 24” onshore sweet gas pipeline with pyrophoric dust and NORM
- Both lines hadn’t been pigged in many years, resulting in thick sludge and debris
  - This presented significant cleaning and safety challenges
  - Cleaning programs were developed specific to each line

Methodology

- The campaign used a progressive pigging sequence:
  - Foam pigs to confirm piggability and remove bulk gas and fluid
  - Gauge pigs to detect internal restrictions
  - Bi-di pigs with magnets and brushes for aggressive mechanical cleaning
  - Chemical slugs to dissolve sludge and flush out contaminants
  - Camera pigs to capture high-resolution imagery and assess cleanliness

Methodology

- Pig trains were custom configured and launched in sequence
- To gradually improve pipeline internal condition and minimise potential for
  - Debris build Up
  - Stuck pigs
  - Less effective cleaning
- Space limitations offshore necessitated reversed pigging direction
- Pigs were launched and propelled from onshore and received offshore
- This allowed optimum location of
  - Nitrogen generation and chemical pumping equipment onshore
  - Waste handling systems offshore
- Simplified logistics and improved operational safety

Methodology

- To mitigate pyrophoric ignition risk, nitrogen purging was used
  - Based on real-time oxygen concentration measurements
  - Ensured that pigging performed under inert conditions
  - Critical due to Black Powder in the 24-inch line
- Lab tests were performed on pipeline residue samples
- Based on lab tests, the most effective cleaning solvent was chosen
- Demineralised water chosen to wash remaining debris and solvent
- In the 24” line, no solvent was required, only demineralised water
- In both lines, a subsequent MEG swab was chosen to remove residual water

20” Offshore Pipeline Pigging Program

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20” Offshore Pipeline Pigging Program

No.	Description	Comments
1.	Degassing pig	Displaced hydrocarbon gas Left line N2 filled also returned a sphere pig Minimal debris as expected: intent was to de-gas only.
2	Single BiDi pigs	Removed residue to prevent saturation of solvent Highly-viscous residue: comparable to previous sample
3.	Solvent pig trains	Removed residue with each run Decreasing viscosity, indicating dissolving and removal
4.	Demin. water pig trains	Continued to remove significant residue
5.	MEG pig train	Need for additional cleaning trains identified
6.	Single Pig	Revised run – single pig instead of a train
7.	Demin. water pig trains	Additional runs added
8.	MEG pig train	
9.	Drying pig train	Foam pigs and Bidi pigs
10.	Camera Pig	

Pigging program was developed based on the expected deposits in the line,

Subsequently amended: addition of pig runs due to large volumes of residue removed.

20” Offshore Pipeline

1st pig: minimal debris, removed hydrocarbon gas, N2 filled.

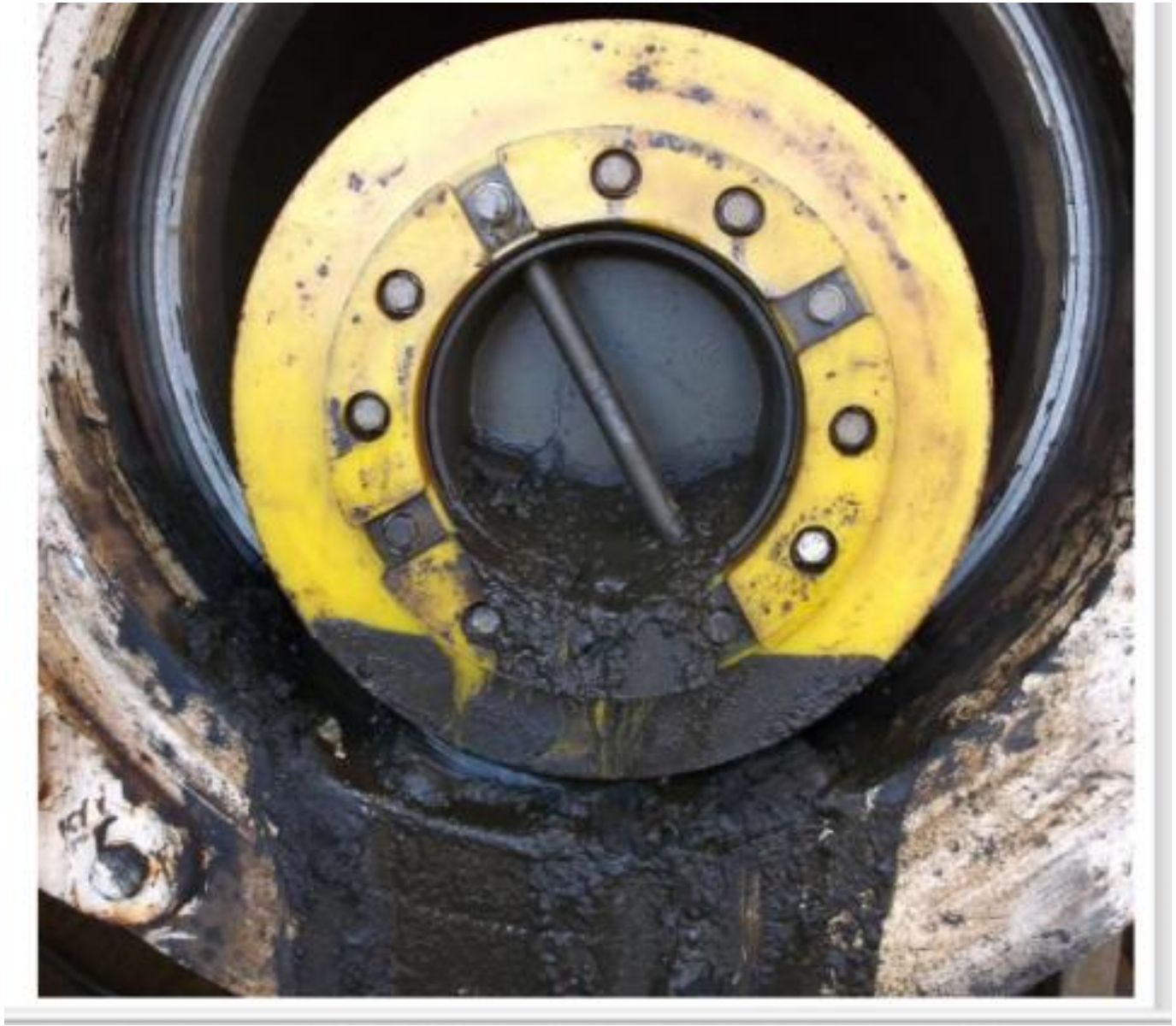
20” Offshore Pipeline

Very heavy and viscous residue recovered by the initial Bi-Di pig runs

20” Offshore Pipeline

Solvent pig trains reduced viscosity, increased residue

20” Offshore Pipeline



Demineralised water trains continued to remove residue

20” Offshore Pipeline

Significant residue still evident after additional pig trains and camera pig run

24” Onshore Pipeline Pigging Program

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24” Onshore Pipeline Pigging Program

No.	Description	Comments
1.	Degassing gauge pig	To displace hydrocarbon gas leaving line N2 filled
2	Pig Train 1	BiDi Gauge, 2 x BiDi Brush with Demineralised water
3.	BiDi Brush Pigs	With Demineralised water
4.	BiDi Brush Pigs	With Demineralised water
5.	BiDi Brush Pigs	With Demineralised water
6.	BiDi Brush Pigs	With Slugs of Nitrogen
7.	BiDi Brush Pigs	With Slugs of MEG
8	BiDi Brush Pigs	With Slugs of Nitrogen
9.	Foam Pigs	With Slugs of Nitrogen
10	BiDi Brush Pigs	With Slugs of Nitrogen
11.	Camera Pig	

It was believed that the 24” line was cleaner than the 20”. Based on this a simpler program was developed

The program proved to be effective, with residue decreasing with each run

24” Onshore Pipeline

Brush pigs in receiver, very little residue evident

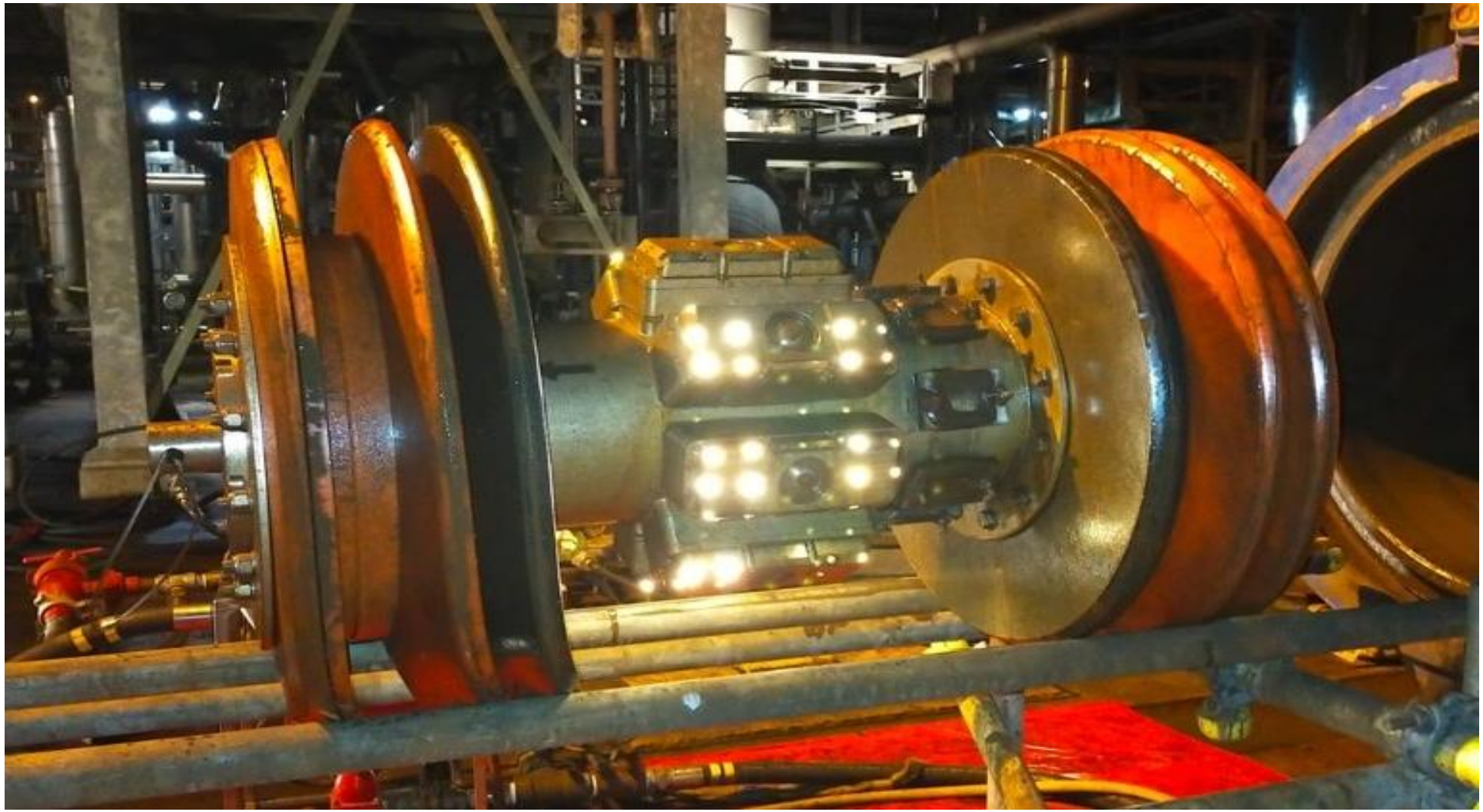
24” Onshore Pipeline

Pigs removed from receiver in good condition

24” Onshore Pipeline

Final pig run, minimal residue and debris

24” Onshore Pipeline



Camera pig confirmed high cleanliness level

Lessons Learned

- Debris, sludge, other residue should be sampled and characterised early to determine most effective cleaning method and chemical treatment
- Reversing pigging direction can improve efficiency where space / access is constrained, especially when large pumping, waste handling facilities required
- Camera pigs are valuable for documenting post-cleaning condition and establishing a visual cleanliness baseline
- Dynamic nitrogen control is critical for pyrophoric risk mitigation particularly in aged sweet gas pipelines.
- Real-time tracking and pressure data recording enabled proactive intervention and reduced pig stall risk during long pigging campaigns

Conclusion

- Preparation of legacy gas lines for CO_2 is a challenge, complex, with stringent requirements.
- Careful design, dynamically adjusted pigging allowed aging lines to be transitioned for CCS
- Integrated pigging with chemicals and visual inspection: allowed real time assessment and enhancement of the pigging operation
- Cleanliness can’t always be measured quantitatively; visual baselines are invaluable.
- Camera pigs gave unprecedented assurance, the visual data is a reference for future phases
- Operational decisions proved crucial in reducing risk, improving safety, avoiding incident.
- The offshore pipeline requires additional cleaning; the onshore pipeline proves concept
- A phased, adaptable cleaning strategy delivered results and supported broader goals
- Integrated approach gave a replicable blueprint for future work
- As we pursue carbon neutrality, reuse of infrastructure is essential.
- Practical insights and learnings help ensure safer, faster, and more reliable CCS transition

THANK YOU

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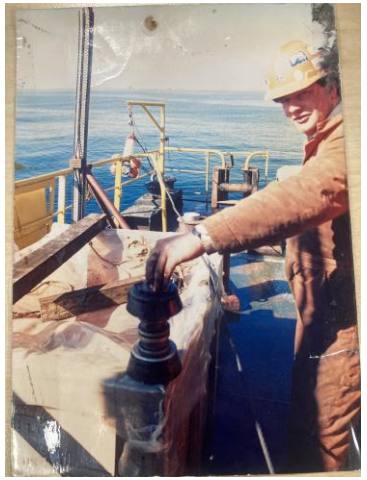

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