In-line Inspection Design

Assessment of Hydrogen Pipelines

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Agenda

In-line Inspection Tool Design and Assessment of Hydrogen Pipelines

Subjects to be covered

• Hydrogen demand
• ILI of hydrogen pipelines
• Evaluation and testing
• Pipeline Operation
• Conclusion
HYDROGEN DEMAND

EUROPEAN AND GLOBAL MARKETS
Hydrogen Demand

Hydrogen properties

• Smallest, lightest and most abundant element
• Predominately used for refining diesel and gasoline
• Extremely flammable
Hydrogen Demand

Europe Green Deal

Exhibit 1 | Drivers and indicators of hydrogen's momentum

Drivers of renewed interest in hydrogen
- **Stronger push to limit carbon emissions**
  - 10 Years remaining in the global carbon budget to achieve the 1.5°C goal

- **Falling costs of renewables and hydrogen technologies**
  - 80% Decrease in global average renewable energy prices since 2010

Indicators of hydrogen's growing momentum
- **Strategic push in national roadmaps**
  - 70% Share of global GDP linked to hydrogen country roadmaps to date

- **Industry alliances and momentum growing**
  - 60 Members of the Hydrogen Council today, up from 13 members in 2017

- **55x** Growth in electrolysis capacity by 2025 vs. 2015

- **10 m** 2030 target deployment of FCEVs announced at the Energy Ministerial in Japan

- **30+** Major investments announced globally since 2017, in new segments, e.g. heavy duty and rail

Source: Path to hydrogen competitiveness – A cost perspective, 20 January 2020
Hydrogen Demand

Reduced methane

- Commitment to reduce methane by 2030
- Target of blending 10% hydrogen into methane pipelines by 2030
Hydrogen Demand

U.S. demand for hydrogen

- Hydrogen supplied increased 145%
- New development U.S. pipeline projects planned
- 100 miles of additional hydrogen pipelines

ILI OF HYDROGEN PIPELINE
In-line Inspection (ILI) of Hydrogen Pipeline

Background

Hydrogen is flammable gas

- DOT 192 regulations
- Pipeline must remain in continuous operation

Image from https://pgjonline.com/2016/10/20/inside-iraq-stringent-security-required-for-first-inline-inspection/
In-line Inspection (ILI) of Hydrogen Pipeline

ILI vendor partnership

R&D capabilities

Technology selection

Tool capability evaluation
Hydrogen embrittlement failure

- Environment:
  - Hydrogen, temperature, impurities

- Stress:
  - Geometry, load cycle frequency

- Material:
  - Composition, microstructure
In-line Inspection (ILI) of Hydrogen Pipeline

Hydrogen compatibility testing
In-line Inspection (ILI) of Hydrogen Pipeline

Initial material test results

Before

After
In-line Inspection (ILI) of Hydrogen Pipeline

New hydrogen compatible ILI tool
In-line Inspection (ILI) of Hydrogen Pipeline

Tool recovery
EVALUATION AND TESTING
Root cause evaluation

Materials:
- High strength steels
- Magnets
- Brushes
- Seals

Systems:
- Coupling
Evaluation and Testing

Mechanical wear testing
PIPELINE OPERATION
Pipeline Operation

Second ILI run

Updated tool based on RCA

Different pipeline segment chosen
Pipeline Operation

Successful inspection

Tool launched and received without issue

- No mechanical damage
- Some overspeed

![Tool Velocity Graph](image)
Pipeline Operation

ILI run report data

- 61 miles in 100% H2
- 100% sensor data collected
LESSONS LEARNED & CONCLUSION
Lessons Learned

ILI in hydrogen is possible

- Fine product flow control is important
- Pipeline design has large affect on ILI passage ability
Conclusion

Partnership between operator and ILI vendor was key

H2 requires specific tool design