





# In-line Inspection Design

## Assessment of Hydrogen Pipelines

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Tod Barker, Senior Product Manager  
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## **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

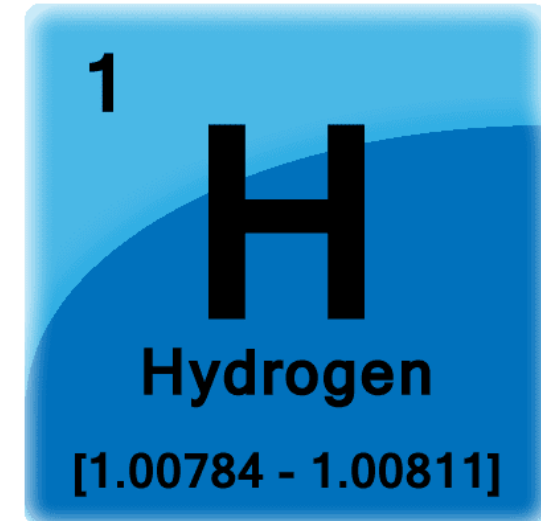
# HYDROGEN DEMAND

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EUROPEAN AND GLOBAL MARKETS

## Hydrogen properties

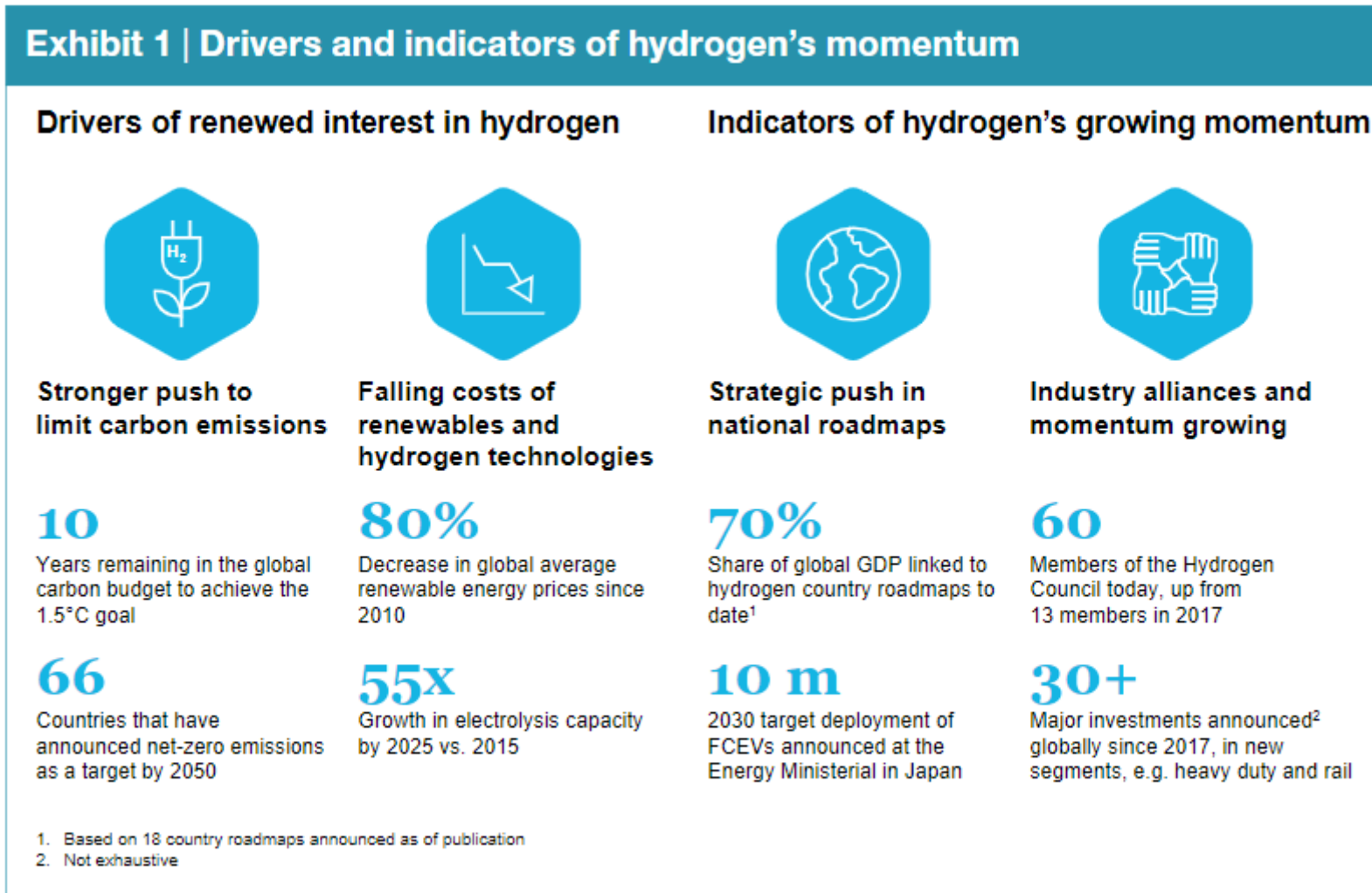
- Smallest, lightest and most abundant element
- Predominately used for refining diesel and gasoline
- Extremely flammable



# Hydrogen Demand



## Europe Green Deal



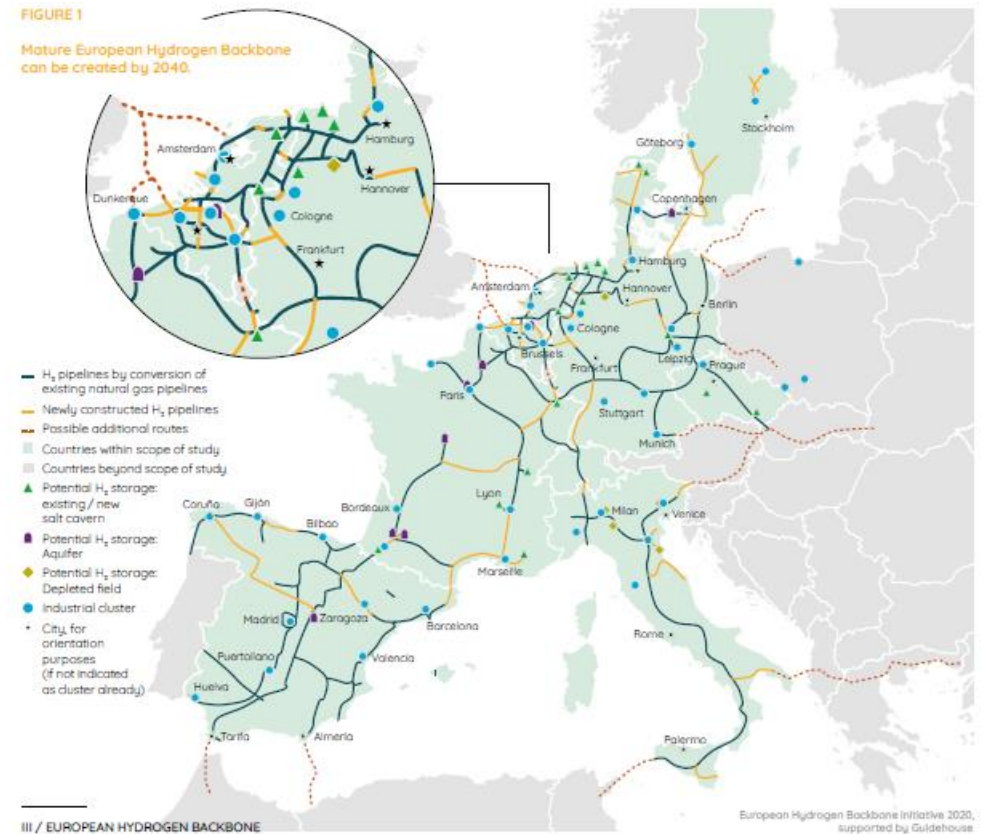
Source: Path to hydrogen competitiveness – A cost perspective, 20 January 2020

# Hydrogen Demand



## Reduced methane

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



Source: European hydrogen backbone

# Hydrogen Demand



## U.S. demand for hydrogen

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



<https://www.chron.com/life/health/article/Air-Products-dedicates-world-s-largest-hydrogen-9453155.php#photo-11151456>



# ILI OF HYDROGEN PIPELINE

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# In-line Inspection (ILI) of Hydrogen Pipeline



## Background

Hydrogen is flammable gas

- DOT 192 regulations
- Pipeline must remain in continuous operation



# In-line Inspection (ILI) of Hydrogen Pipeline



ILI vendor partnership

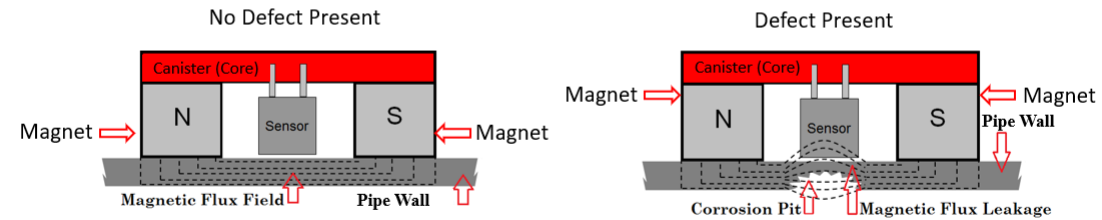
R&D capabilities

Technology selection

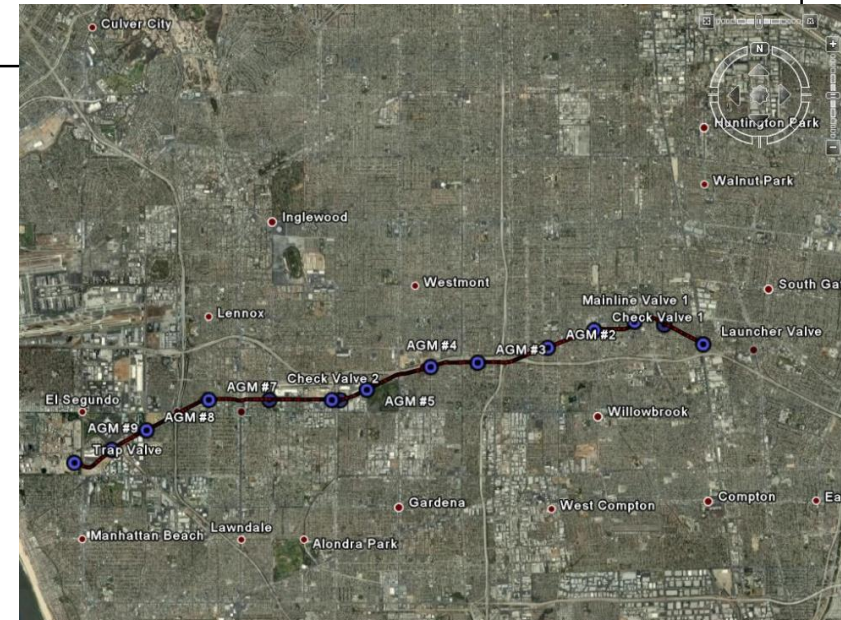
Tool capability evaluation

## MFL technology

- Magnets contact the steel pipe wall saturating the steel with magnetic flux
- Sensors in between the poles measure magnetic field strength
- Magnetic flux leakage increases where metal loss is present

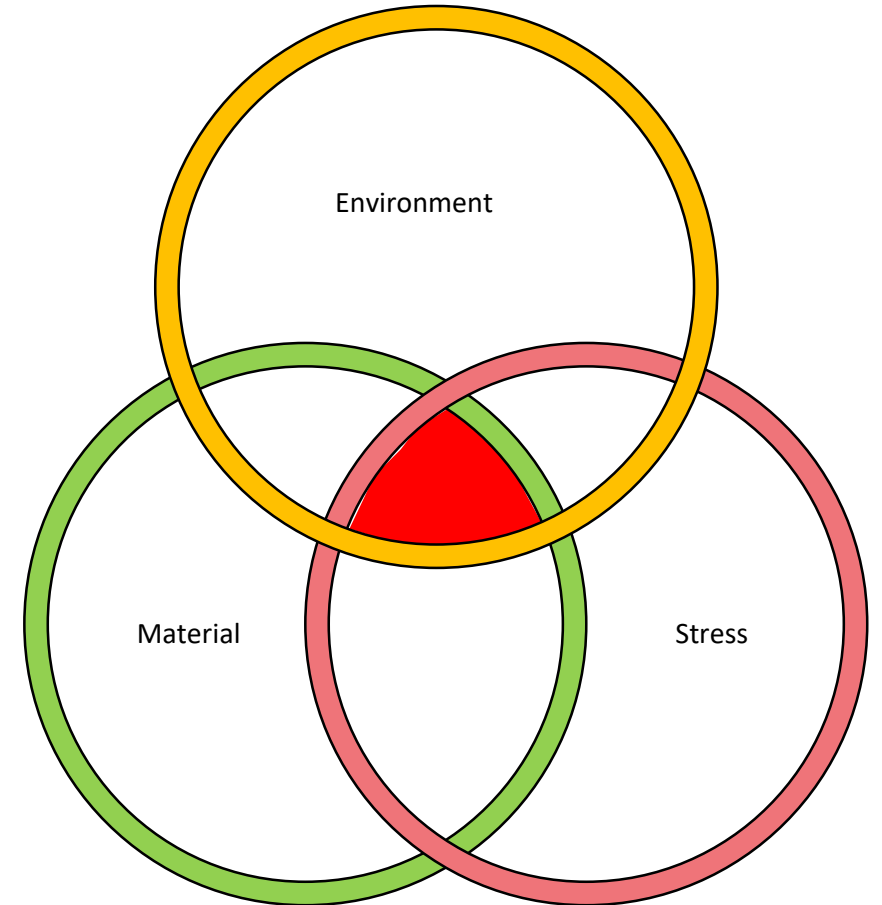


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## Hydrogen embrittlement failure

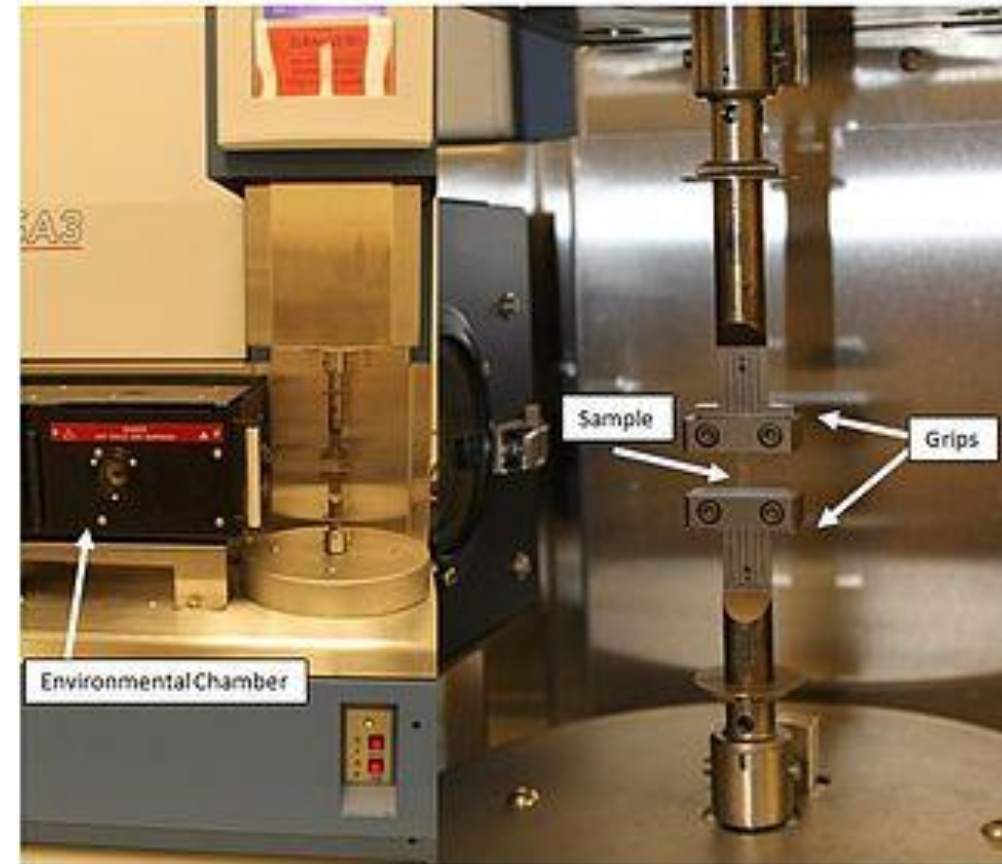
- Environment:
  - Hydrogen, temperature, impurities
- Stress:
  - Geometry, load cycle frequency
- Material:
  - Composition, microstructure



# In-line Inspection (ILI) of Hydrogen Pipeline



## Hydrogen compatibility testing



# In-line Inspection (ILI) of Hydrogen Pipeline



## Initial material test results

**Before**



**After**

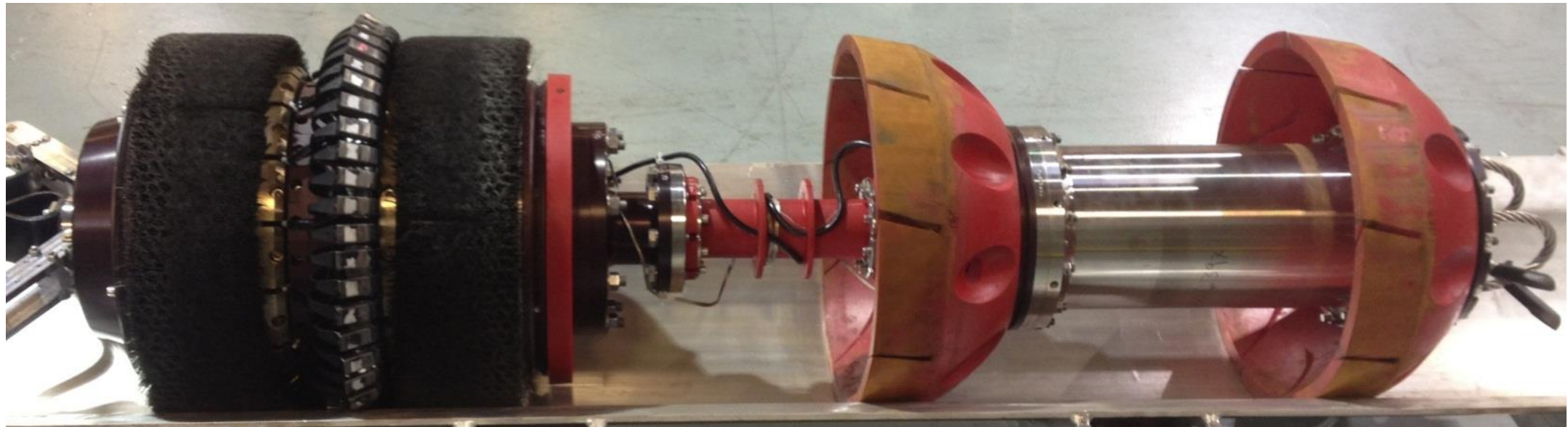




# In-line Inspection (ILI) of Hydrogen Pipeline



New hydrogen compatible ILI tool



# In-line Inspection (ILI) of Hydrogen Pipeline



## Tool recovery





# EVALUATION AND TESTING

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## Root cause evaluation

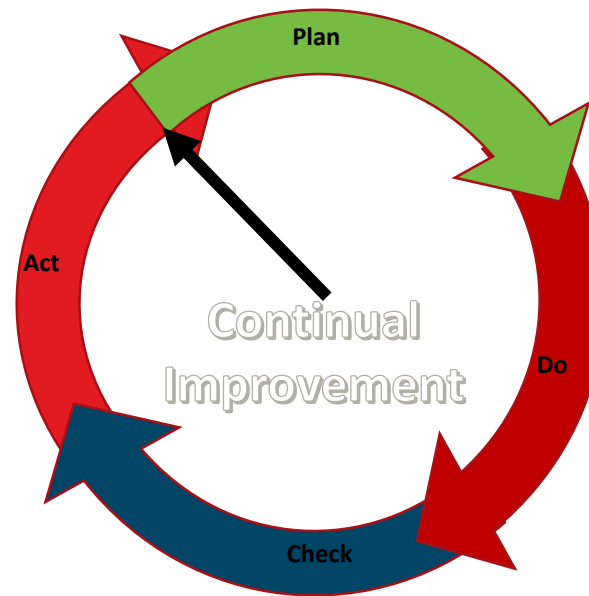
### Materials:

- High strength steels
- Magnets
- Brushes
- Seals

### Systems:

- Coupling

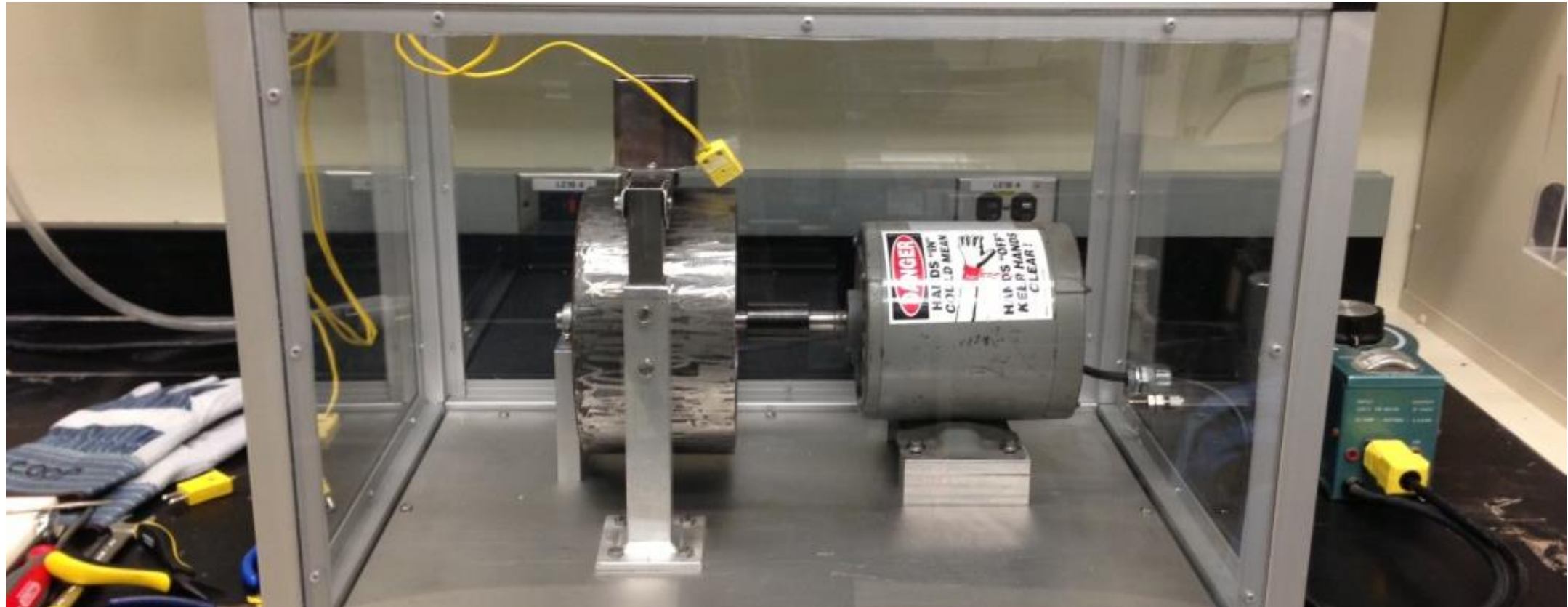
## PDCA



# Evaluation and Testing



## Mechanical wear testing



# PIPELINE OPERATION

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# Pipeline Operation



## Second ILI run

Updated tool based on RCA

Different pipeline segment chosen



# Pipeline Operation

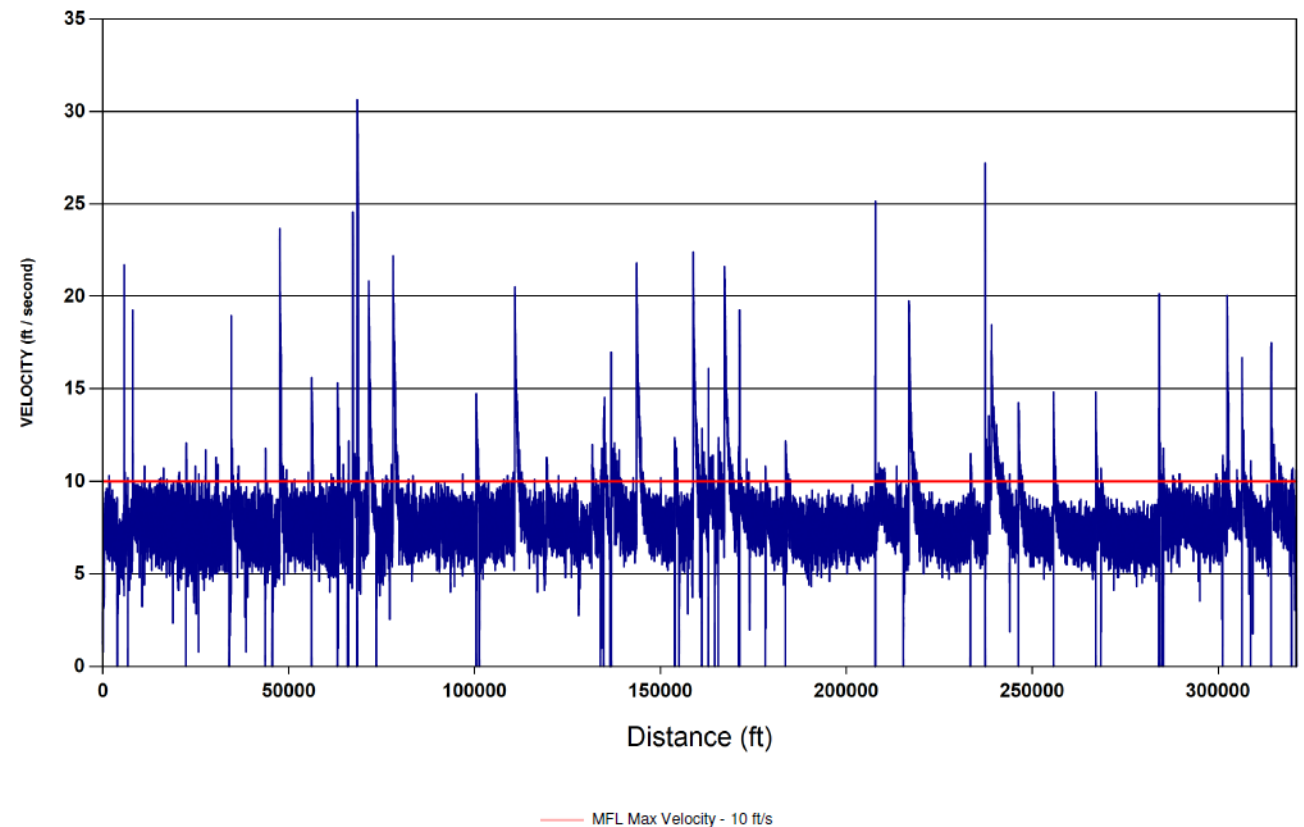


## Successful inspection

Tool launched and received without issue

- No mechanical damage
- Some overspeed

*Tool Velocity Graph*





# Pipeline Operation



## ILI run report data

- 61 miles in 100% H2
- 100% sensor data collected



# LESSONS LEARNED & CONCLUSION

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# 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

