BESPOKE RESEARCH AND CONSULTANCY FROM HSE

H21 Phase 1A

An investigation into the change in leakage when switching from natural gas to hydrogen in the UK

Bespoke research and consultancy - using our scientific expertise and regulatory insight to address health and safety risks

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Key Messages

- Main questions to be answered through the project:
  - What is the ratio of hydrogen to natural gas leak rates?
    - Between 1.2 and 2.9.
  - Do any assets leak hydrogen but not natural gas?
    - No.
  - What trends are shown in the results?
    - Leakage ratio increases with pressure.

INTRODUCTION

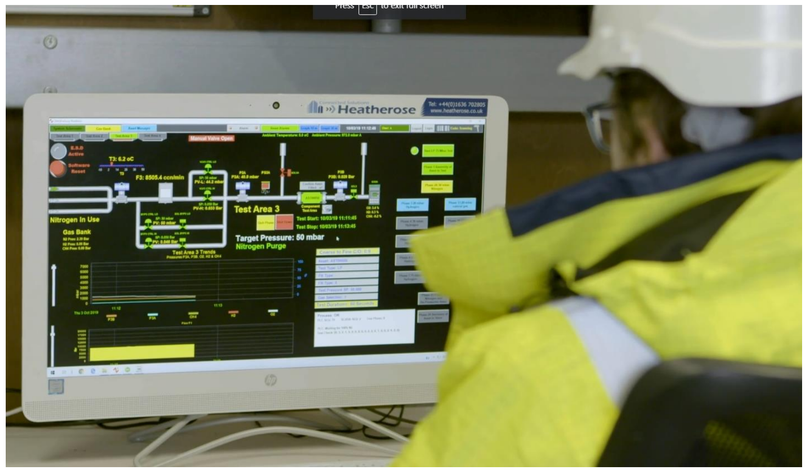
Asset Selection and Retrieval

- Extract from the Master Testing Selection

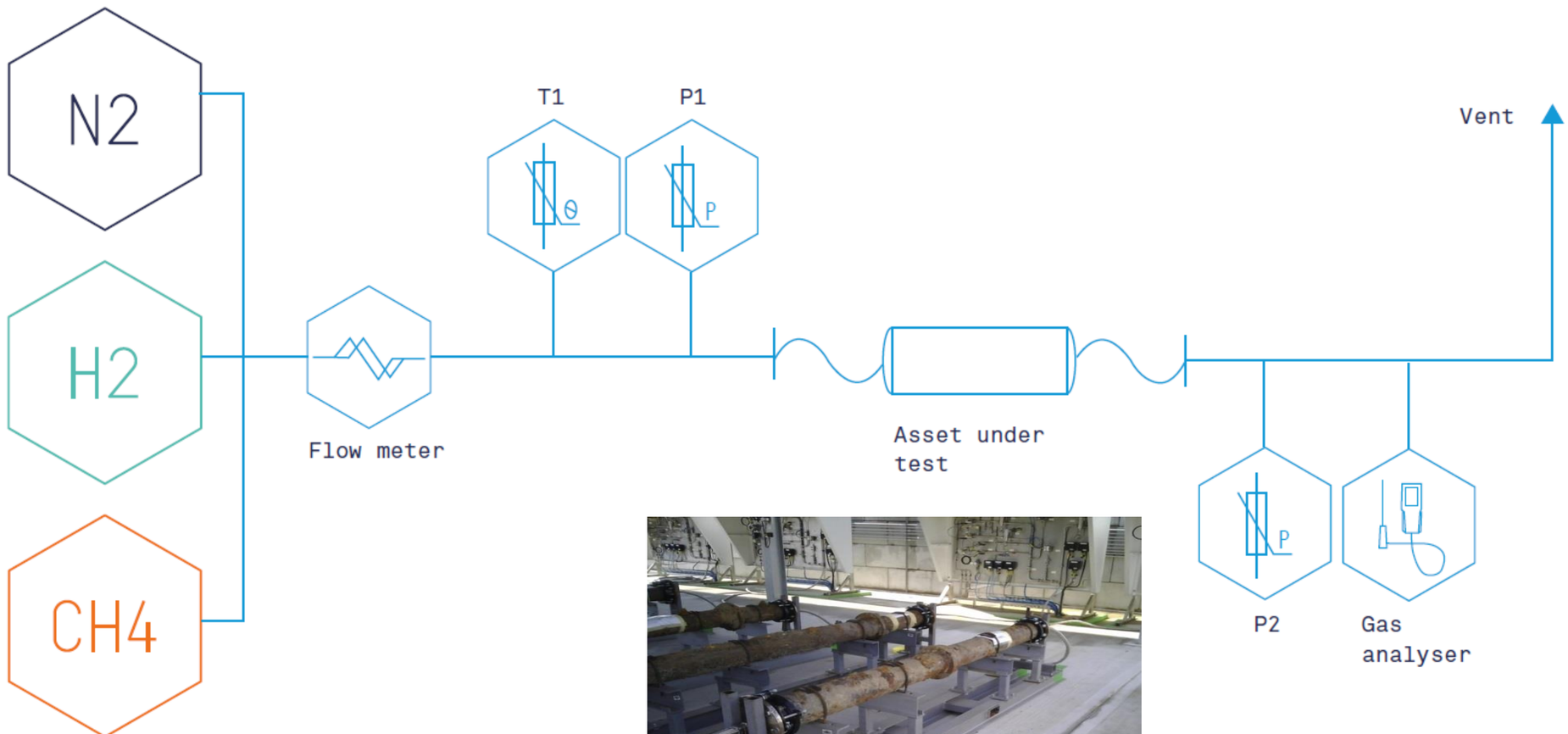
Material	Diameter	Joint Type	Number of samples to test
Steel	4 IN	Screwed	2
	4 IN	Welded	2
	4 IN	Flanged	2
	4 IN	Mechanical Coupling	2
	6 IN	Screwed	2
	6 IN	Welded	2
	6 IN	Flanged	2
	6 IN	Mechanical Coupling	2

- Assets retrieved from network through mains replacement program, so increased likelihood of leaking.

Buxton Test Facility



Simple Test Facility Layout



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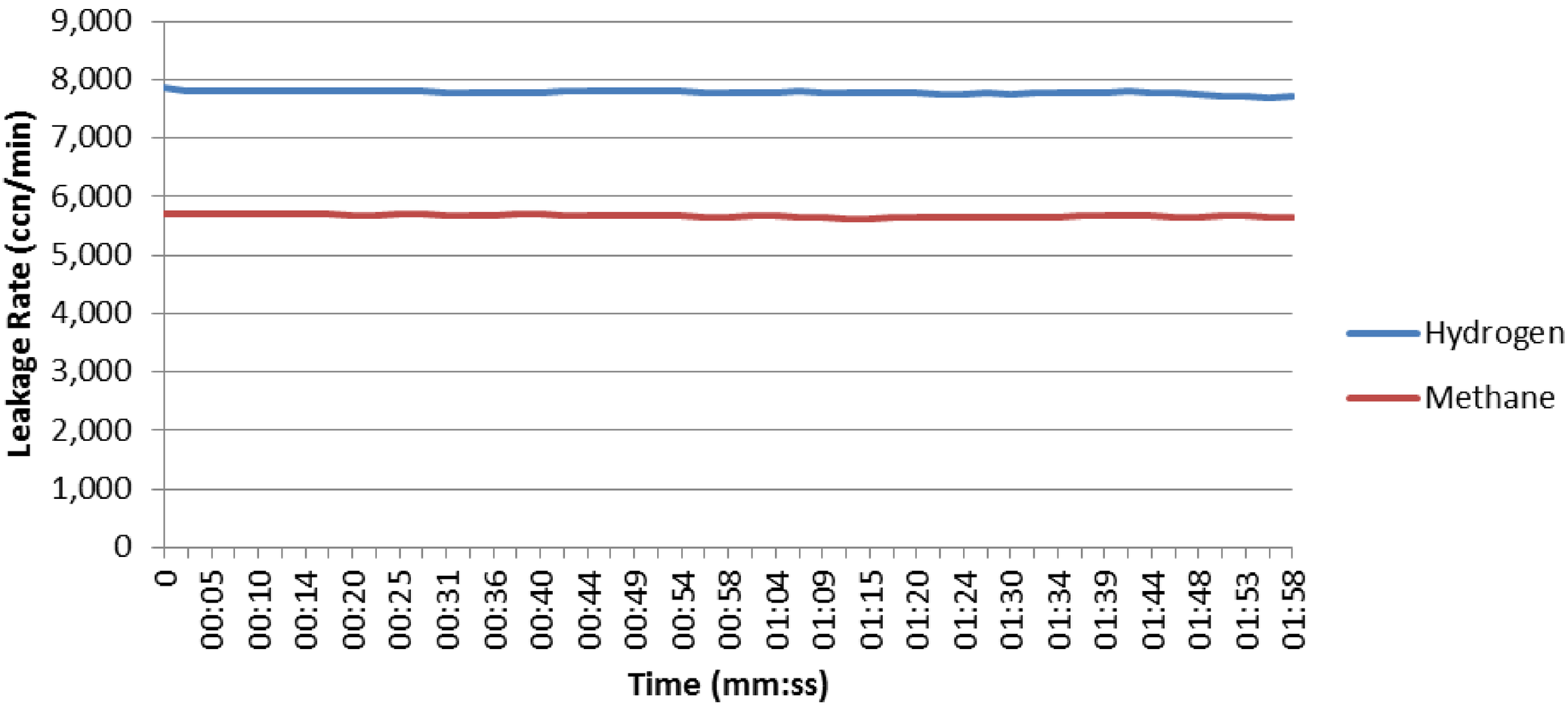
METHODS

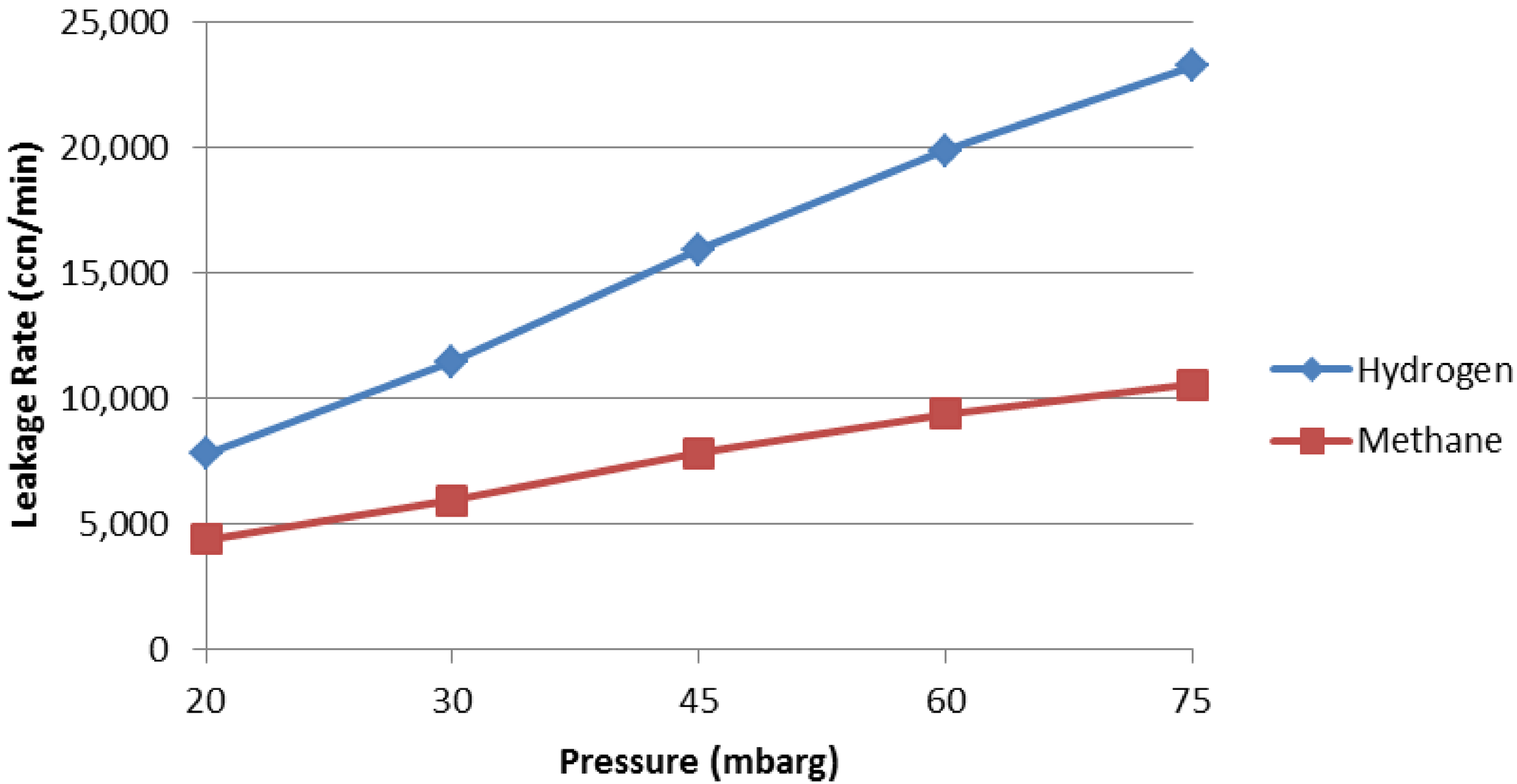
Testing Methodology

- The three pressure ranges of the assets which were tested in Phase 1A are:
  - Low Pressure (LP): 19 mbar – 75 mbar
  - Medium Pressure (MP): 75 mbar – 2 bar
  - Intermediate Pressure (IP): 2 bar – 7 bar
- Leak considered anything >100 ccn/min based on flow meter lower limit and UP1.

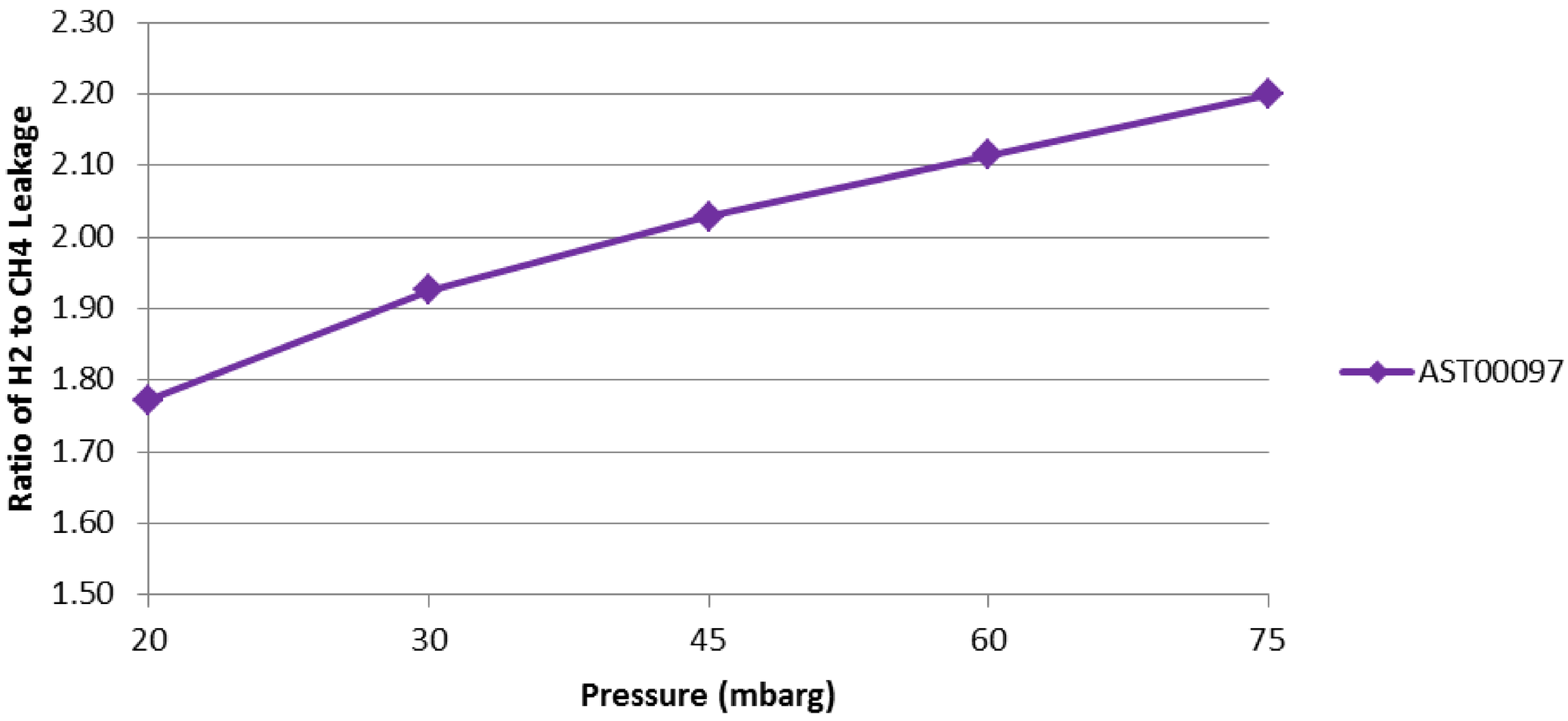
Step 1 Leak Measurement



Step 2 Leaks collated for pressure range



Step 3 Calculated Ratio of H2 to CH4



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Predictions

Ratio of volumetric flow rates

- Leaks of gas can occur in several different flow regimes:
  - Choked/ Sonic flow (compressible) 2.9
    - >0.85 barg for methane, >0.91 barg for hydrogen
  - Subsonic flow (compressible) 2.9
  - Turbulent flow (incompressible) 2.8
  - Laminar flow (incompressible) 1.2

- Therefore, it is predicted that the ratio of volumetric flow of hydrogen to methane will lie between 1.2 and 2.9.

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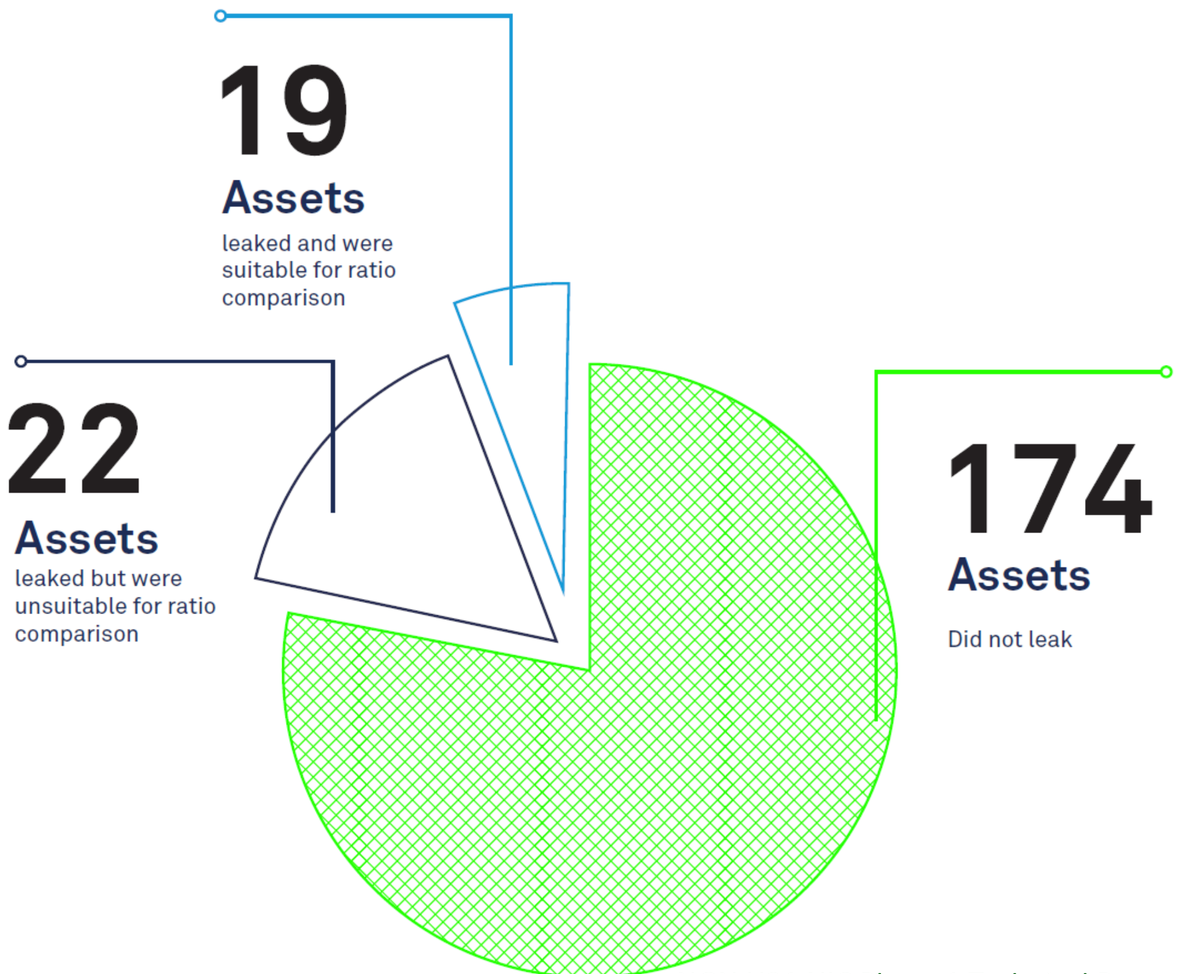
RESULTS

Key Outcomes



- 215 Assets tested.
- Assets which leaked on hydrogen also leak on methane.

Testing Pictures

Installed 1870 and didn't leak

Sample of Leaking Assets

- Information provided by NGN

Asset No.	Test Type	Additional Fittings Present	Date Installed / Laid	Diameter (inch)	Material (see key)	Pressure Regime	Joint Type
AST00009	Main	n/a	Unknown	12	Spun Iron	Low Pressure	Bolted
AST00013	Main	n/a	1968	4	Spun Iron	Low Pressure	Bolted
AST00014	Fitting	2 Part UPT	Unknown	12	Spun Iron	Low Pressure	Bolted
AST00026	Main	2 x 2" Emid plug	1947	12	Ductile Iron	Low Pressure	Bolted
AST00035	Main	Valve	1973	6	Ductile Iron	Low Pressure	Bolted

Sample of Leaking Assets

- Information obtained through experiment

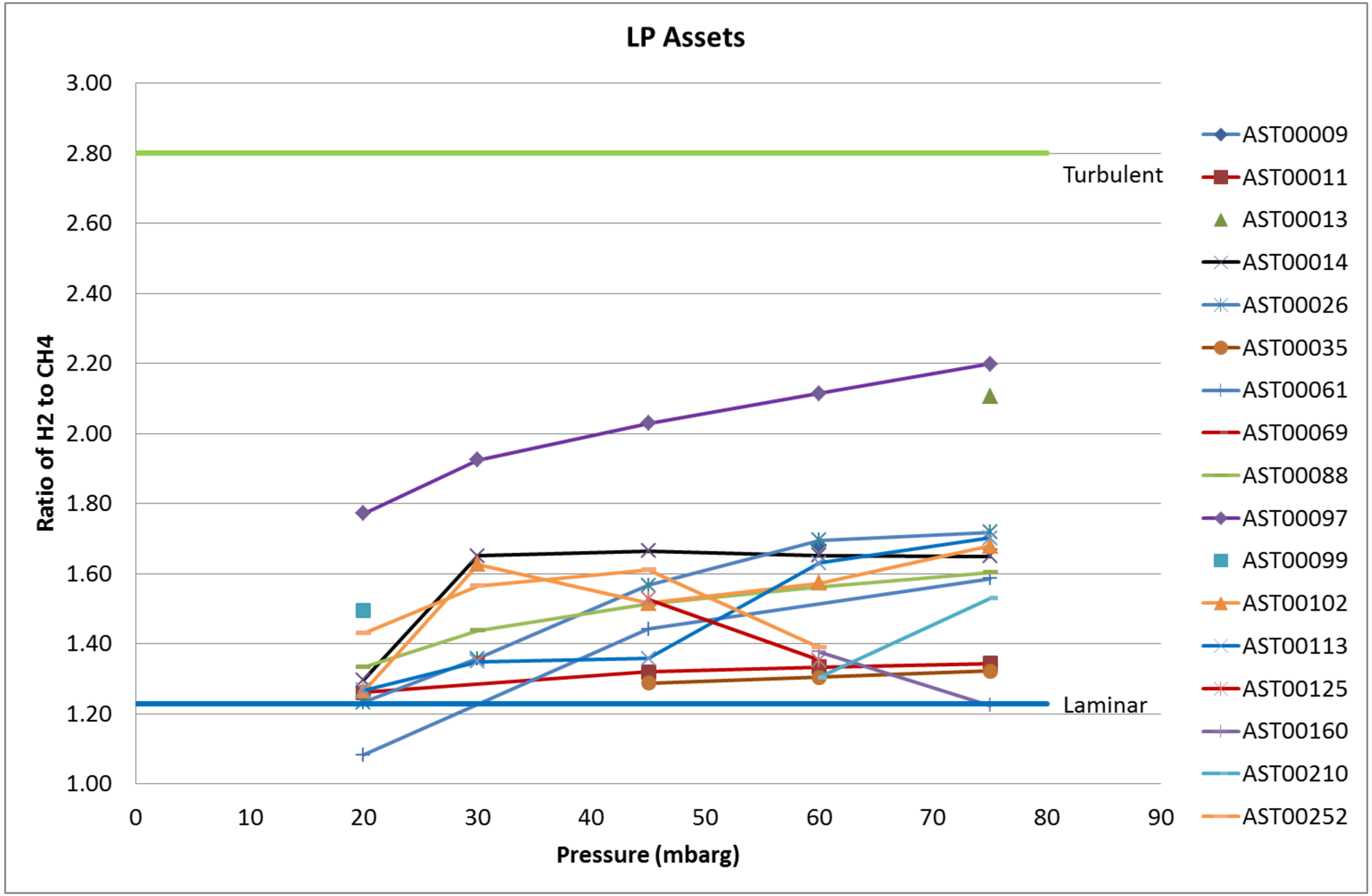
Test Date	Suitable for testing	Leak Y/N	Recordable leak on both H2 and CH4	Type of leak
17.03.20	Yes	Yes	Y	Lead Yarn

- Through Wall

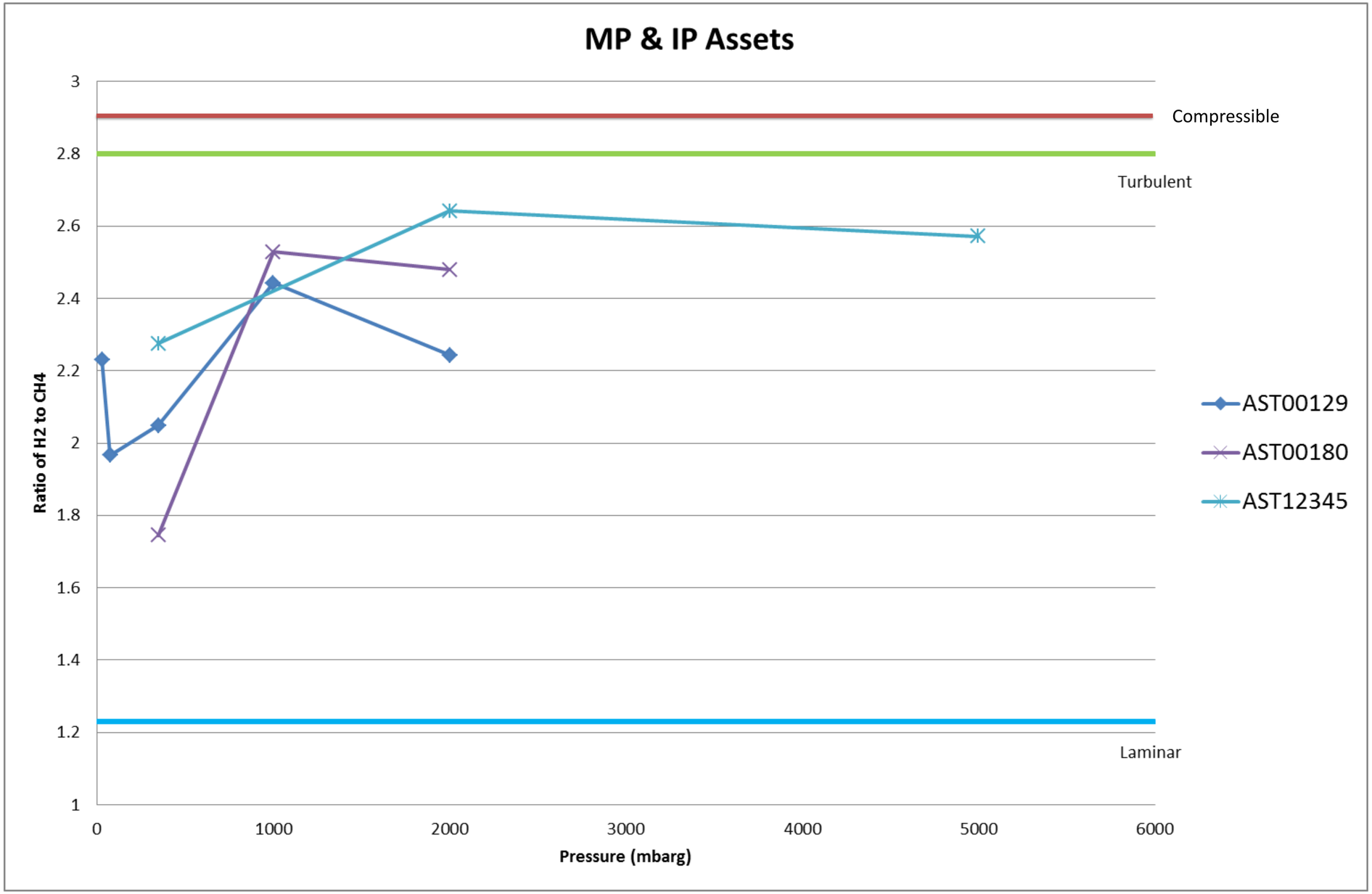
- Hook Bolt

- Lead Yarn in Steel

- Lead Yarn in Cast Iron



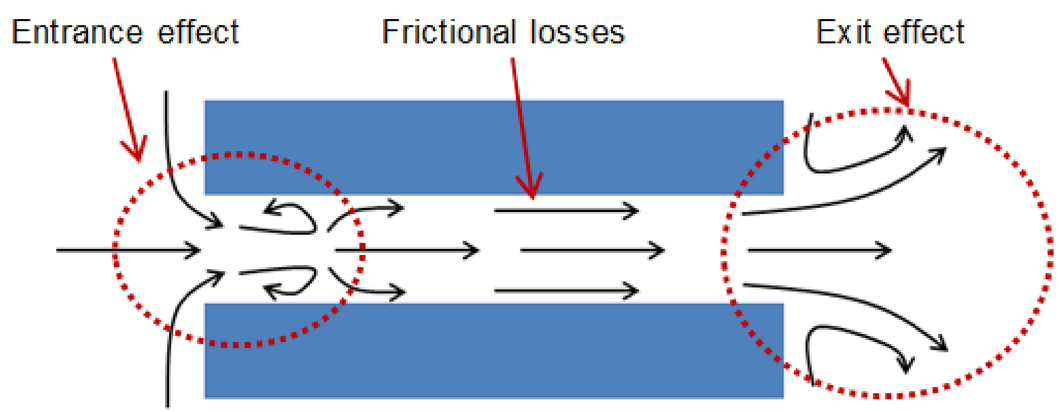
- The ratio is bounded by the upper limit of turbulent flow, 2.8.



DISCUSSION

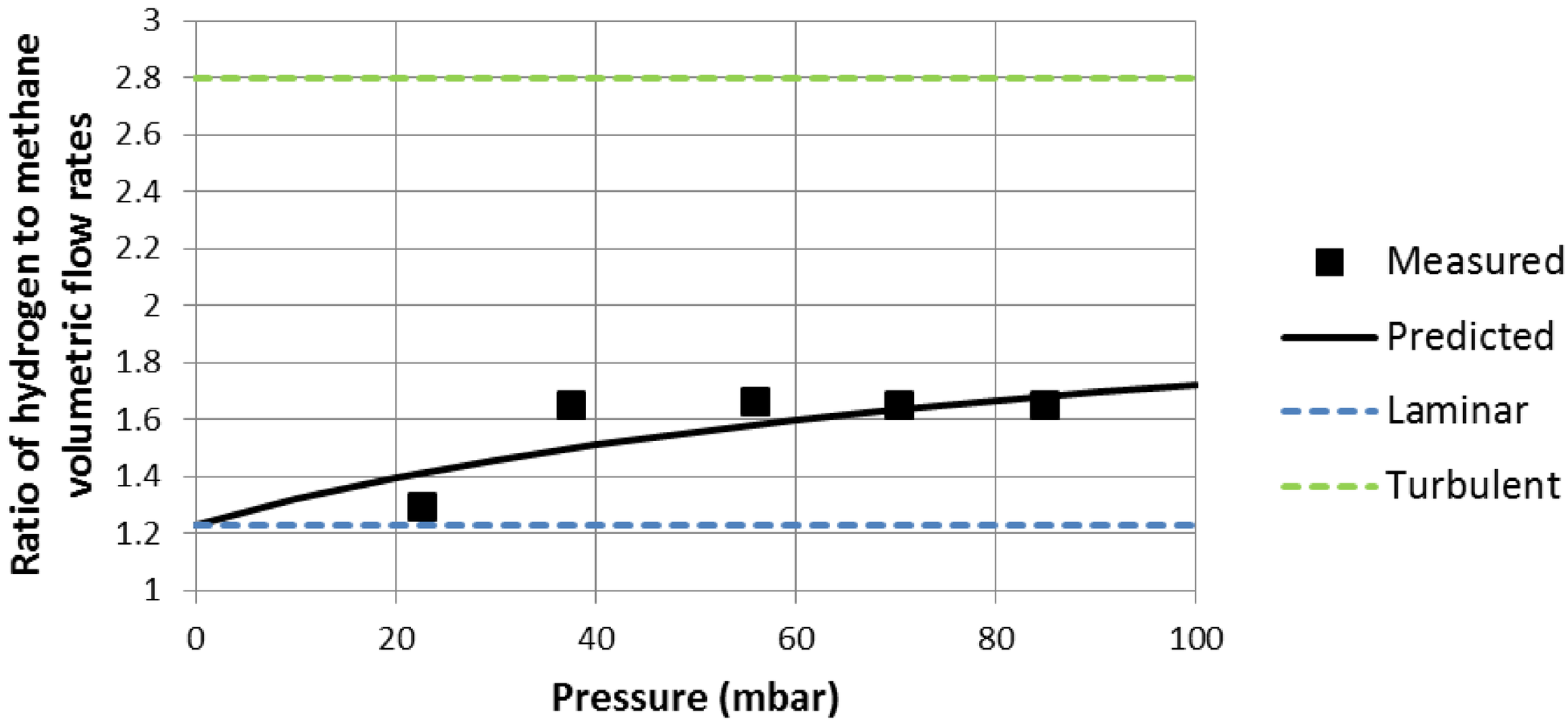
Why does the ratio increase with pressure?

- Ann Halford (DNV GL) consider the flow rate to be made up of two components:
  - Entrance and Exit Effects (Turbulent flow) proportional to $\sqrt{P}$
  - Frictional Losses (Laminar flow) proportional to P



  - By calculating each component, based on Methane measurements, the ratio can be predicted.

Model prediction of the ratio of flow rates



Asset Parameters

- In addition to the flow measurements, the asset parameters were statistically analysed for trends:
  - Asset Diameter
  - Pipe Material
  - Date of installation
  - Joints
  - Valves
  - Fittings
  - Services
  - Regulators
  - Repairs
  - Soap Tests
- No significant parameter trends which will impact on the conversion.
- Trends based on 41 leaking assets and influenced by majority of retrievals being through the mains replacement program.

CONCLUSIONS

Key Outcomes

- The ratio of volumetric leak rate of hydrogen to natural gas is bounded by the upper limit of compressible turbulent flow, 2.9.
- Assets which leak on H2 leak on CH4
- This information will feed into the justifications in the safety case for the conversion.

- Full reports available at **H21.green**

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