ADVANCED MATERIALS RESEARCH & INNOVATION

BLUEPRINT

UK HYDROGEN: TESTING

GAP ANALYSIS AND NEXT STEPS

MAY 2022

ROYCE

Introduction

The ability to test materials for hydrogen production, storage, distribution and end use is critical to widescale hydrogen deployment in a 2050 timescale as outlined in the Henry Royce Institute (Royce) Materials for End-to-End Hydrogen report published in 2021.

Over the past 3 months Royce has been working with a cross industry/academic Working Group to develop a blueprint of the UK's hydrogen materials testing requirements. The blueprint development has involved consultation with businesses, research technology organisations (RTOs), test houses and universities to build a comprehensive picture of current UK capabilities and complete the gap analysis to identify areas for future funding.

This blueprint provides, for the first time, a comprehensive view of the UK testing capabilities to inform future spending plans in this area. We expect the blueprint to be refined further as we continue to receive input and the hydrogen sector evolves.

UK Testing Needs

The UK's hydrogen testing needs can be broadly divided into a series of temperature and pressure domains (see Figure 1) aligned to industry and academic needs in each area.

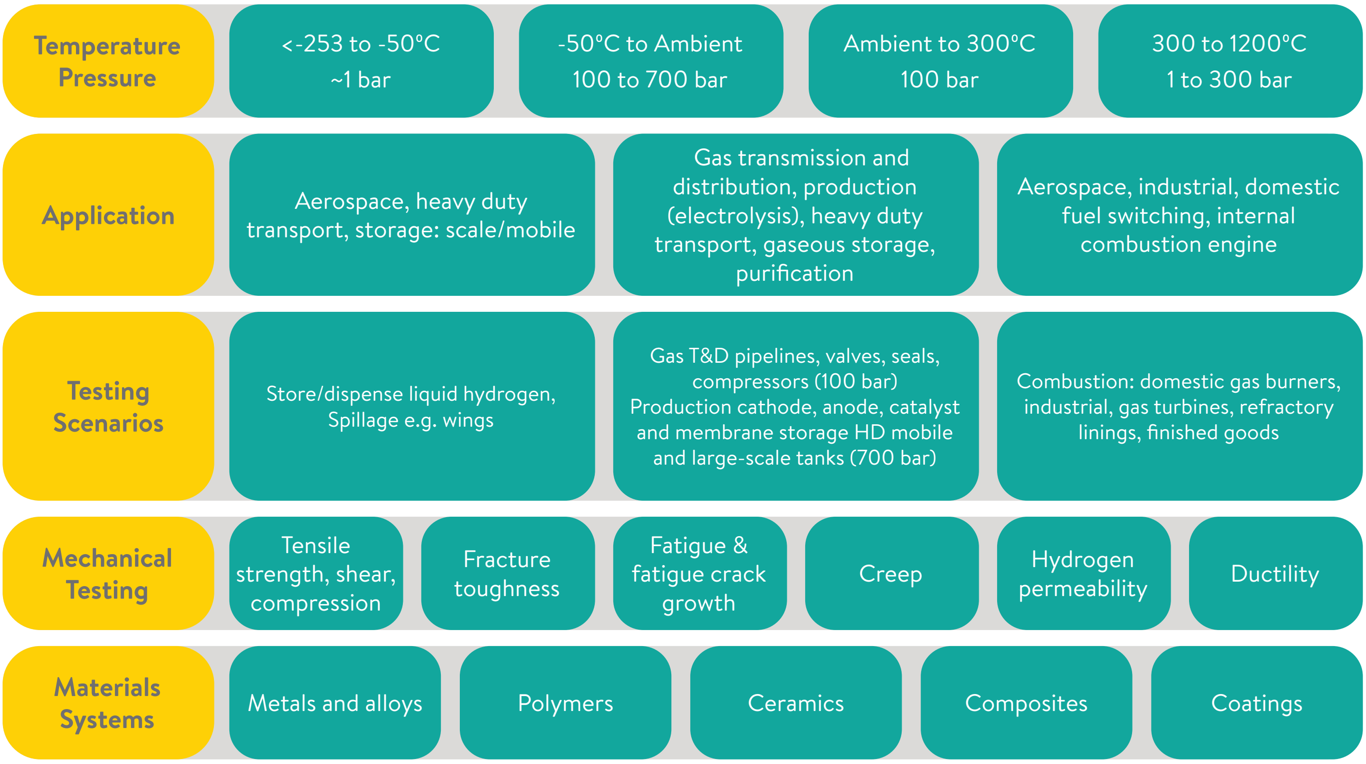

Figure 1 - UK Testing Needs

UK Existing Facilities

The UK has hydrogen testing facilities available which we were able to map across businesses, universities, RTOs, and Test Houses to provide for the first time a consolidated picture of UK capabilities in this space.

Capability Areas	<-253 to –50°C ~1 bar	-50°C to Ambient 100 to 700 bar	Ambient to 300°C 100 bar	300 – 1200°C 1 to 300 bar	Mechanical Testing	In-silico Testing
Universities	Bath Southampton Manchester Birmingham Bristol Oxford	Bath Brunel Bristol Southampton Birmingham	Bath Brunel Bristol Southampton Birmingham Manchester	Birmingham Bath Oxford Manchester	Bath Brunel Bristol Southampton Manchester Imperial Swansea Oxford	
Businesses	Airbus GKN	National Grid NGN Teer Coatings	National Grid NGN Teer Coatings		National Grid Airbus GKN	National Grid Airbus GKN
Testing Houses	Element DNV Composite Test & Evaluation Ltd Rina Tech UK Ltd Rtech Materials TUV Sud	Element DNV Composite Test & Evaluation Ltd Rina Tech UK Ltd Rtech Materials	Element DNV Finden Ltd Pacson Valves TUV Sud LBBC Baskerville	Lucideon Group Ltd	Element DNV Composite Test & Evaluation Ltd Finden Ltd LBBC Baskerville Lucideon Group Ltd Rina Tech RTECH	Element DNV
Research Technology Organisations	STFC UKAEA NCC NPL TWI	HSE TWI NPL UKAEA	HSE TWI NPL NCC UKAEA	STFC UKAEA TWI	TWI NPL NCC STFC	TWI NPL NCC STFC UKAEA

Figure 2 - UK Testing – Existing Facilities

UK Testing Hardware Priorities

From this analysis we were able to determine the hardware priorities to support the testing needs, namely:

- Testing facilities at coupon, component, and system level to assess materials performance over a range of operating pressures and temperatures
- Operando, in-situ, and ex-situ atomic resolution characterisation of materials including chemical and surface interactions of hydrogen (liquid or gas) with material surfaces
- In-silico based testing capability combining physics and data-based models
- Mechanistic studies to understand materials performance and failure modes
- Facilities to understand impact of impurities on coupon, component, and system performance
- Accelerated ageing tests
- Sensor technology development to detect material changes in real time

Hardware Priority Mapping

Based on the input from our cross industry/academic Working Group we were then able to map the existing university capabilities against the hardware priorities.

Capability Areas	Cryogenic testing	High pressure 50 to 300°C testing	High temperature testing	Non-destructive testing & characterisation	Mechanistic studies	Sensors	Accelerated ageing
Bristol	Moderate Match	Partial Match	Partial Match	Moderate Match			
Bath				Partial Match			
Manchester		Partial Match	Partial Match	Partial Match			
Southampton	Strong Match						
Oxford	Partial Match			Partial Match	Partial Match		
Birmingham	Partial Match	Partial Match	Partial Match				
Bangor	Partial Match	Partial Match	Moderate Match	Partial Match			
Swansea		Partial Match		Partial Match			
Cranfield	Partial Match	Partial Match	Partial Match	Partial Match			
Cambridge					Moderate Match	Partial Match	Partial Match
Brunel	Partial Match		Partial Match	Partial Match			
Imperial			Partial Match	Partial Match			

Partial Match Moderate Match Strong Match

Figure 3 - UK Electrolysis – Hardware Priority Mapping

Gap Analysis

The UK has core capabilities in hydrogen testing. The analysis highlighted areas in which we need to invest further to ***strengthen the base*** to provide resilience and develop the future talent pool.

Specifically, this related to following areas:

Universities

- Extend **University of Surrey membranes** expertise to electrochemistry to complement existing activities at other universities for example, **Nottingham**
- Utilise **University of Southampton's** established **cryogenic centre's capabilities** for electrochemistry
- Draw on **Ulster University's** expertise in **hydrogen safety related issues**
- Link **Newcastle University's systems integration expertise and EPSRC Systems Integration** role
- Utilise **H2FC SUPERGEN** hardware and skills base

Businesses, Testing Houses and RTOs

- Extend **cryogenic nuclear testing** capabilities into electrochemistry applications
- Explore further options for **hardware** and **capability sharing** between **RTOs** and **universities**

The study further highlighted some significant gaps that needed to be addressed, specifically this related to the following areas:

Universities

- Lack of **testing facilities** at **lower cryogenic** and **higher temperature** end of spectrum
- Increase resources directed towards **hydrogen sensors, mechanistic studies,** and **accelerated ageing**
- Further development of **in-silico methods** as an alternative to physical testing and simulating degradation pathways (for example accelerated ageing)
- Innovative solutions to **seal development** to enable **high temperature strain testing**

Businesses, Testing Houses and RTOs

- UK **testing capability beyond coupon** (i.e., component and system) level to address businesses increasingly looking overseas to access suitable facilities
- Lack of **UK liquid hydrogen storage and handling** capability

Recommendations and Next Steps

The recommendations and next steps will ensure the UK has the required materials testing resources to support wide scale hydrogen deployment in a 2050 timescale.

Recommendations

An initial £5m investment to address specific areas highlighted in the blueprint, namely;

- Mechanical testing facilities to address industrial end use scenarios
- Accelerated ageing facilities combining physical and in silico approaches to predict material lifetimes
- Integration of blueprint findings into the Department for Business, Energy and Industrial Strategy (Hydrogen Advisory Council and Energy Strategy), EPSRC (Hydrogen Research Co-ordinators) and Innovate UK hydrogen funding plans

Next steps

- Complete development of a publicly accessible hydrogen materials database
- Publish assessment of current UK hydrogen materials testing capabilities
- Define required UK investment to support the remaining priorities in the ***strengthening of the base*** and ***addressing the gaps*** areas referenced in the testing blueprint
- Submit funding bids to address testing blueprint priority areas and leverage further funding from BEIS, EPSRC, Innovate UK and the private sector
- Develop comparable blueprints for end use, distribution and storage
- Complete talent pipeline assessment to support materials blueprint delivery

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