



Guidelines for Testing Thermoplastic Materials' Compatibility for High Pressure Hydrogen Service



**JOINT INDUSTRY
PROJECT OUTLINE**

PROP310365

Summary

The application of gaseous hydrogen as a mainstream energy carrier is dependent on the development of a reliable hydrogen infrastructure. Hydrogen infrastructure consists of production, delivery, storage, conversion and end-use application elements that employ materials ranging from metals to polymers. The effects of hydrogen on failure modes in metal has been an active area of research for many years. However, the effect of hydrogen on failure of polymeric components has been less widely studied. At present, there are no standards or well established testing procedures to determine the suitability of a polymer for hydrogen service. This proposal is for studies that build on the findings of TWI's Core Research Project 34250 and will develop best practice for quantifying the effect of hydrogen on polymeric pipeline, sealing and vessel materials, over a range of service temperature, pressure, humidity and weathering conditions. This will allow industry to choose and qualify materials suitable for the intended operation. At the end of the project specific guidelines and methods for testing polymers in high pressure hydrogen applications (>70bar) will be recommended.

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Project Concept

Having agreed industry best practice for thermoplastics exposed to gaseous hydrogen will allow standardisation of testing for improved quality and safety. Therefore, this Joint Industry Project is aimed at the development of consensus regarding the most robust testing procedures to determine polymer compatibility with high pressure hydrogen. The results will be presented in the form of guidance on testing for polymer selection and qualification for hydrogen service. The output will be intended for companies involved in every stage of the hydrogen infrastructure supply chain, including resin manufacturers and end-users in industries such as energy, aerospace and automotive.

Objectives

- Establish the current industrial state of the art with respect to polymer selection and qualification for hydrogen service and identify gaps.
- Compare and contrast existing test methods, and where appropriate propose new or improved methods, including laboratory trials on the most promising methods, to benchmark their suitability.
- Produce an agreed industry best practice guidance document, which may be shared at the Sponsor's discretion with standardisation bodies (e.g. ISO technical committee on plastics - ISO/TC61).

Benefits

- This project will reduce the need for organisations to make their own subjective judgements regarding test methods for selecting and qualifying polymeric materials for high pressure hydrogen service.
- Developing guidance with other companies facing similar challenges will improve the reliability of the recommendations.
- Developed guidance may form the basis of internationally-accepted standards, which will allow the Sponsors the opportunity to shape future practice, should they so wish.

Approach

Proposed project will consist of two phases and four work packages (Figure 1).

■ Phase 1: Material and testing data survey

- The technical literature review on thermoplastic materials used in high-pressure hydrogen service applications that was produced in TWI's [Core Research Programme \(CRP\) Project 34250](#) will be updated and expanded.
- An industrial survey will be conducted by reaching out to a range of companies to seek information they are willing to share on current practice, including in-house methods, projects and standardisation working groups. The industrial survey will involve:
 - What non-metallic materials are utilised (or planned) in hydrogen infrastructure.
 - How material properties are quantified in a hydrogen environment, over a range of operating conditions and conducted studies.
 - Desk based comparison of testing methods currently used in industry.
 - Proposed improvements to available tests to make them more realistic and representative of the service conditions that polymers are exposed to during high pressure hydrogen applications and/or propose new testing procedures for specific applications.
- Based on the collected information from the industrial survey, and input from the Sponsors, a number of materials and test methods will be selected for Phase 2 of the JIP.
- A comparative testing programme will be developed for specific target applications based on the outcome of collected information, as defined above, and with input from Sponsors.

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□ A design of dedicated testing facility (to be agreed with JIP sponsors) will be prepared.

■ Phase 2: Development of guidelines for testing polymeric materials compatibility for high pressure hydrogen service

- Dedicated testing facility will be built to undertake a comparison of the test methods selected in Phase 1. The JIP sponsors will get access to the facility and will be able to utilise it for future testing programmes.
- Using this facility, TWI will compare the testing procedures in terms of the quality of data generated and reproducibility for the polymer types chosen in Phase 1.
- TWI will prepare testing best practice guidelines with input from Sponsors, which will be included in the final JIP report.
- Subject to agreement from the JIP Sponsors, TWI will submit the testing procedures to one or more standardisation organisations.

Work Packages

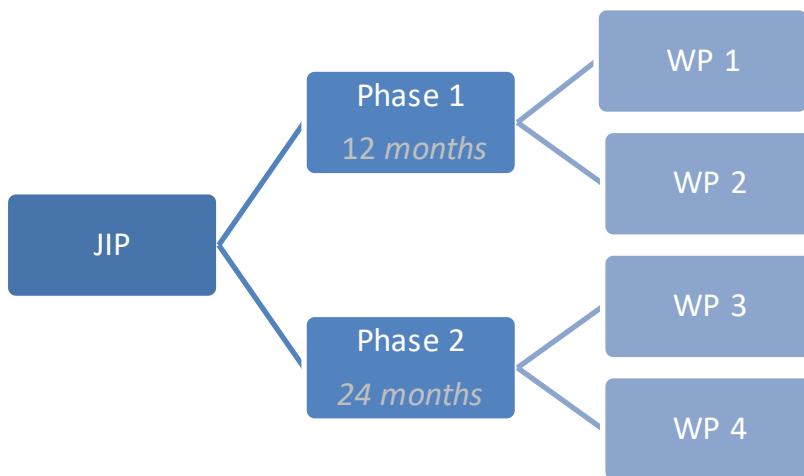


Figure 1 Project Phases

The project will consist of the following work packages (WP):

WP1: Thermoplastic material and testing/service condition survey

- Task 1.1: Industry survey on materials for hydrogen infrastructure, service conditions and qualification testing procedures
- Task 1.2: Selection of materials and applications of interest

WP2: Development of testing methodology and design of testing facility

- Task 2.1: Development of testing procedures
- Task 2.2: Design of a dedicated testing facility

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WP3: Testing selected materials

- Task 3.1: Sourcing materials and manufacturing of test specimens
- Task 3.2: Assembly of a dedicated testing facility
- Task 3.3: Exposure of selected materials to ageing processes
- Task 3.4: Material characterisation post exposure
- Task 3.5: Data analysis

WP4: Guidelines for testing of thermoplastic materials employed in hydrogen infrastructure

- Task 4.1: Evaluation and improvement/modification of test methodologies
- Task 4.2: Development of guidelines
- Task 4.3: Submitting developed guidelines to selected standardisation organisation

Deliverables

Phase 1

- Industry survey on polymeric materials utilised in hydrogen infrastructure, operating conditions and tests currently used.
- List of materials and applications to be used in Phase 2.
- Application specific testing programme to be used in Phase 2.
- Design of a dedicated testing facility to be built in Phase 2.

Phase 2

- Dedicated testing facility.
- Final report summarising the experimental results and proposed testing methodologies.
- Guidelines for testing polymeric materials for high pressure hydrogen service.

Price and Duration

Phase 1 of the project will cost £230,000 (excluding VAT). Duration of Phase 1 will be 12 months. The project may be started with a reduced budget and a reduced scope if agreed by the Sponsors.

Further Information

For further information on how a Joint Industry Project (JIP) runs please visit:

<https://www.twi-global.com/what-we-do/research-and-technology/current-research-programmes/joint-industry-projects#/>

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