2-Page Summary of Research: Future Proofing Plastic Pipes (RP3.1-03)

Summary of Key Findings and Results

Plastic pipes:

- The study examined a wide range of plastic materials used in Australia's gas network, including modern and vintage polyethylene (PE) types (PE100, PE80, PE63), Polyamide 11 (PA11), and unplasticised PVC (uPVC).
- Bulk pipe materials (without defects) showed no significant degradation when exposed to hydrogen at 80 bar and room temperature.
- However, PE pipes with stress concentrators, such as butt welds, exhibited changes in mechanical properties after hydrogen exposure. Tensile testing showed a noticeable increase in strain at break, more evident in butt welded PE100 pipes.
- Hydrogen exposure influenced slow crack growth (SCG) behaviour in PE63, potentially altering its failure kinetics and service life.
- Analysis of the molecular structure suggests that hydrogen may cause re-orientation of polymer crystals, especially in PE materials, which could affect crack propagation.

Elastomers:

- Four elastomers were tested: two nitrile-butadiene rubbers (NBR70-S1 and NBR70-S2), hydrogenated NBR (HNBR), and fluoroelastomer (VITON).
- All elastomers showed less swelling but increased stiffness and deformation when exposed to 100% hydrogen compared to methane or hydrogen/methane blends.
- These changes were non-permanent and materials gradually returned to their original state after removal from the hydrogen environment.
- Molecular structure analysis (via FTIR) revealed two types of gas-material interactions:
  - Hydrocarbon-based elastomers (NBRs and HNBR) showed interactions with additives.
  - VITON, a fluoroelastomer, showed interactions with its polymer backbone, suggesting a different mechanism of hydrogen influence.

Industry Implications and Recommendations

Network compatibility:

- The existing plastic pipe infrastructure, particularly bulk PE materials, appears largely compatible with hydrogen, supporting the feasibility of repurposing current networks.
- However, welded joints and vintage materials (such as PE63) may be more vulnerable to hydrogen, possibly requiring targeted inspection and monitoring.
- Modern PE types (e.g., PE100) appear reasonably compatible with hydrogen and could be considered for future installations, though further investigation into potential effects on strain at break, crystal re-orientation, and IR peaks is recommended.
- For specific considerations for elastomers, refer to FFCRC project RP3.1-14.

Operational & design considerations:

- Hydrogen exposure may temporarily alter mechanical properties of elastomers, potentially affecting seal performance. These changes should be considered for both the design of new systems and the operation of existing infrastructure with hydrogen.
- Elastomers of the same type may not necessarily have the same behaviour or performance in hydrogen—refer to RP3.1-14 for further details.
- Standardised testing protocols developed in this study can be used to develop service life models and understand the relative performance against the "baseline" condition of natural gas service.

Standards and regulation:

- The findings of this research are referenced in the APGA "Hydrogen Pipeline Systems Code of Practice" (Rev1.0).
- Findings support updating industry standards to reflect hydrogen compatibility, although further work may be necessary to provide specific guidance (e.g. considerations for joint integrity and elastomer performance).

Next Steps and Future Work

Extended testing:

- Long-term exposure studies under real-world conditions are needed to further understand any permanent material changes due to hydrogen (refer RP3.1-07).
- This long-term testing will also enable improved translation of laboratory results to in-field performance (i.e. service life models).
- Allows investigation of real-world operational scenarios, including network maintenance activities, permeation rates, leak detection, and seal degradation over time.

Elastomer compatibility:

- The preliminary work on elastomers in this project suggests a different response to hydrogen for elastomers of the same "type" but from different suppliers/manufacturers.
- A follow-on project (RP3.1-14) has been commissioned to extend the work on elastomers and understand the impact on the performance and integrity of network components.

Field performance and service life predictions:

- This work suggests that hydrogen can lead to changes in material behaviour—but translating this to in-field performance is key.
- With real-world hydrogen injection trials underway, this may provide an opportunity to complement the lab-based testing and validate the findings.

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