III.A.4 Evaluation of Natural Gas Pipeline Materials and Infrastructure for Hydrogen/Hythane Service

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Projected End Date: 2010

Objectives

- The objective of this project is to evaluate the feasibility of using the existing natural gas transmission and distribution piping network for hydrogen/mixed hydrogen-natural gas delivery.
- Develop and perform the requisite hydrogen/mixed hydrogen-natural gas testing methods and data regression to provide the technical basis for qualification of existing natural gas pipelines for hydrogen/mixed hydrogen-natural gas service.
- Develop and apply advanced fracture and failure methodologies to allow for data transference from laboratory testing to real-world systems and components.
- Identify key technical challenges and risks to successfully using the existing natural gas pipeline network for hydrogen/mixed hydrogen-natural gas distribution and develop mitigating strategies for these risks.

Technical Barriers

This project addresses the following technical barriers from the Hydrogen Delivery section (3.2.4.2) of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

(D) High Capital Cost and Hydrogen Embrittlement of Pipelines

Technical Targets

This project is conducting comprehensive characterization of steel materials, with and without prior natural gas service, to evaluate their behavior in hydrogen/mixed hydrogen-natural gas operating environments. Insights gained will support qualifications of these materials for hydrogen service including the DOE 2010 delivery targets:

- Pipeline Transmission and Distribution Cost: $1M/mile
- Pipeline Transmission and Distribution Reliability: Understood
- Hydrogen Leakage: <2%

Approach

In the past, hydrogen-induced losses in mechanical properties have been attributed to three primary factors:

a. The development of a critical, absorbed, localized hydrogen concentration.
b. The existence of a critical stress intensity (crack length and applied or residual stress).
c. The existence of a susceptible path for hydrogen damage.

Full characterization of the mechanical behavior of natural gas pipeline alloys, which have experienced extensive field service, when exposed to gaseous hydrogen, comprises the central focus of the proposed research. The investigation of the ability of existing distribution pipeline steels to transport either nominally pure gaseous hydrogen (GH_2) or mixed hydrogen–natural gas (i.e., hythane–20% H_2-80% natural gas) will consist of four tasks: Task I will investigate the mechanical properties of typical pipeline steels exposed to the expected hydrogen/mixed hydrogen-natural gas environments and will evaluate the overall susceptibility of these materials to hydrogen embrittlement using advanced fracture mechanics measurement techniques and analysis; Task II will focus on the development of environment controlled/modified failure assessment diagrams used to predict flaw tolerance and stability in pipeline systems; Task III will evaluate fatigue behavior of pipes in distribution service environments; and Task IV will consist of finite element modeling using properties developed in the previous phases to predict burst failure.

Accomplishments

Due to budget constraints in FY06 project funding was suspended and the scope deferred to the following fiscal years.