III.4 Fiber Reinforced Composite Pipeline

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Project Objectives

- Successfully adapt spoolable fiber reinforced polymer (FRP) composite pipeline currently used in the oil and natural gas industry for use in high-pressure hydrogen delivery systems and develop the data needed for codification of fiber reinforced composite piping into the American Society of Mechanical Engineers (ASME) B31.12 Hydrogen Piping Code

Fiscal Year (FY) 2015 Objectives

- Provide proposal for codification for FRP into the ASME B31.12 Hydrogen Piping Code
- Perform initial leak and burst testing on samples of dry wrap thermoplastic piping

Technical Barriers

This project addresses the following technical barriers from the Hydrogen Delivery section of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan:

(D) High As-Installed Cost of Pipelines

(J) Hydrogen Leakage and Sensors

(K) Safety, Codes and Standards, Permitting

Technical Targets

This project is focused on the evaluation of FRP for hydrogen service applications. Assessment of the structural integrity of the FRP piping and the individual manufacturing components in hydrogen will be performed. Insights gained will support qualifications of these materials for hydrogen service including:

- Distribution pipeline lifetime: 50 years
- Distribution pipeline pressure: 100 bar
- Distribution pipeline leakage: 0.02%

FY 2015 Accomplishments

In FY 2015, the main activities at SRNL were to complete codification of FRP into the ASME B31.12 Hydrogen Piping Code and to provide initial burst and leak test data for dry wrap thermoplastic piping.

- The code case for inclusion of fiber reinforced plastic piping has been drafted and reviewed by FRP manufacturers.
- The code case has been approved by the B31.12 Hydrogen Piping Committee.
- Two burst tests were completed on dry-wrapped thermoplastic piping. The results of the burst tests showed acceptable design margins.
- Two leakage tests were completed on a crimped connector design used on thermoplastic piping. The results indicated that the connectors met the acceptance criteria. There were indications for high permeation rates from the leak testing.

INTRODUCTION

The goal of the overall project is to successfully adapt spoolable FRP currently used in the oil industry for use in high-pressure hydrogen pipelines. The use of FRP materials for hydrogen service will rely on the demonstrated compatibility of these materials for pipeline service environments and operating conditions. The ability of the polymer piping to withstand degradation while in service and development of the tools and data required for life management are imperative for successful implementation of these materials for hydrogen pipelines.

APPROACH

To achieve the objective, an FRP life management plan was developed. The plan was a joint document developed by SRNL and the ASME to guide generation of a technical basis for safe use of FRP in delivery applications. The plan addresses the needed material evaluations and also focuses on the needed information for codification of FRP into the ASME B31 Code of Pressure Piping. The testing performed by SRNL has:

- Critically evaluated the current application of available FRP product standards through independent testing.
- Defined changes to the current FRP product standards to meet the ASME Code Methodology.
- Provided a body of data to support inclusion of FRP in the ASME B31.12 Hydrogen Piping Code.

The methodology being followed to address qualification of FRP for hydrogen is based on application of currently accepted industry standards for the FRP products. Independent testing has been performed to address any gaps in the existing qualification of FRP.

RESULTS

FRP Codification into ASME B31.12

During FY 2015 a code case providing the requirements for use of FRP in hydrogen service was completed. The code case was approved by the ASME B31.12 Hydrogen Piping Committee and Balloted to the ASME B31 standards committee. Additional comments have been received from the standards committee review. These comments have been incorporated in the code case, and it is moving through the approval process.

Thermoplastic Pipe Testing

Leak and burst testing was performed on two samples of dry wrap thermoplastic piping. The dry wrap thermoplastic piping is a relatively new concept for fiber reinforced pipe that is site manufactured in lengths up to two to three miles. The structural layer typically consists of an even number of helically wound tapes. There is no thermosetting resin within or between the various layers. The dry wrap allows for forming the piping into a compact shape that can easily be pulled through existing abandoned pipelines to ease installation in urban areas. The dry wrap thermoplastic piping will be included in the FRP codification proposal.

Two leak tests were performed in the dry wrapped thermoplastic pipe samples. The samples were formed into a compact C shape and re-rounded prior to testing. This forming process and shape are shown in Figure 1. The shape is formed into the piping to reduce the cross section to aide in pulling the pipe through existing piping. The test samples were C-formed and rerounded to ensure they would undergo the same loads as field installed piping.

Both tests were below the acceptable leak rate for a 25 minute test indicating no connector leakage. There were, however, indications of permeation following the connector leak test.

Following the leak tests, the samples were burst tested to evaluate their pressure design margins. The pressure design basis follows the American Society for Testing and Materials (ASTM) D2992 standard used for the thermosetting resin FRP. Two burst tests were performed in the dry-wrapped thermoplastic pipe samples. The burst test data are shown in Table 1. The rated pressure value includes a 0.67 hazardous gas service factor at 140°F service temperature. Burst pressures were above the manufacturer's acceptance limit of 3,538 psig, though burst testing used lower pressurization rates than specified by ASTM D1599.

TABLE 1. Burst Test Data for Dry Wrapped Thermoplastic Pipe

Test ID	Rated 50 Year Pressure (psig)	Burst Pressure (psig)
1	580	3,670
2	580	3,870

CONCLUSIONS AND FUTURE DIRECTIONS

Conclusions

- The code case for inclusion of fiber reinforced plastic piping has been drafted and reviewed by FRP manufacturers.

FIGURE 1. Forming process for C shape

- The code case has been approved by the B31.12 Hydrogen Piping Committee.
- The code case has been balloted to the B31 standards committee and additional comments have been incorporated.
- Two burst tests were completed on dry wrapped thermoplastic piping. The results of the burst tests showed acceptable design margins.
- Two leakage tests were completed on a crimped connector design used on thermoplastic piping. The results indicated that the connectors met the acceptance criteria. There were indications for high permeation rates from the leak testing.

Future Work

- Complete the FRP Codification into ASME B31.12.

FY 2015 PUBLICATIONS/PRESENTATIONS

1. Hydrogen Delivery Technology Team, Washington, DC, June 2014.

2. B31.12 Hydrogen Piping Committee Meeting, San Diego CA, September 2014.

3. B31.12 Hydrogen Piping Committee Meeting, Atlanta, GA, March 2015.