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Fiber Reinforced Composite Pipelines

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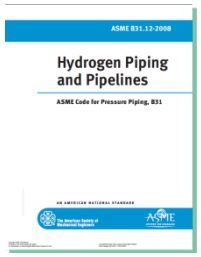



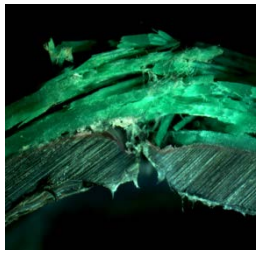

Hydrogen Transmission and Distribution Workshop
February 25, 2014

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Fiber Reinforced Piping for H_2 Delivery

- Impact:
  - Composite pipeline technology has the potential to reduce installation costs and improve reliability for hydrogen pipelines.

- Fiber Reinforced Piping
  - The FRP product form consists of an inner polyethylene liner with an outer fiberglass structural layer.

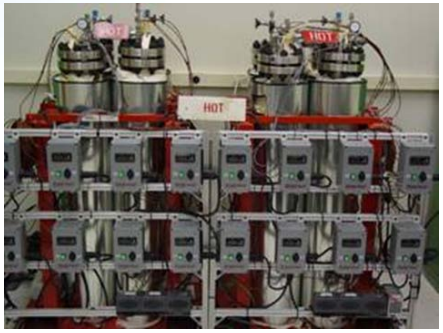
- Existing Technology:
  - FRP is an existing commercial technology currently employed in the oil & gas industry
  - Commercial product up to 6” diameter and 2500 psig pressure rating.
  - Spoolable to ½ mile lengths .

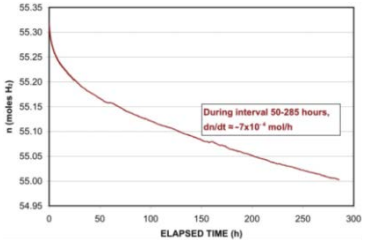
FRP Product

FRP Installation

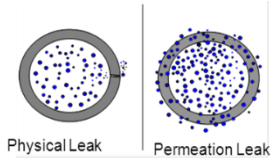
Fiber Reinforced Piping For Hydrogen Delivery

Pipeline H_2 Exposure





ORNL Data



Sample	Leak Rate STD CC H_2/Sec
Fiber 1	9.8×10^{-5}
Fiber 1L	1.4×10^{-4}

Leak Testing

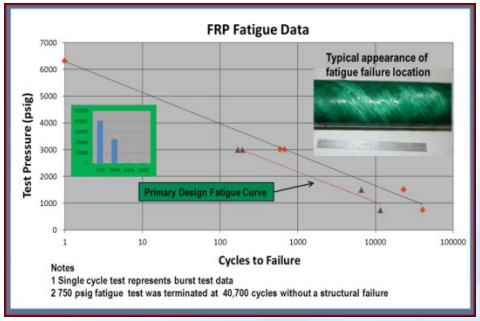
Burst Testing

Flaw tolerance tests show that for flaws up to 40% through-reinforcement and up to 2 " length and 0.25" width a factor of 3X margin is maintained on rated pressure.

Failure mode changes from global to local and then move back towards global as flaw depth increases

Fatigue Testing

Fatigue testing over the range of 750 psig to 3000 psig has been completed. The data provides an initial indication on the fatigue life of FRP. A preliminary design fatigue curve has been proposed based the current test data with a design margin applied based on literature review to estimate the variability



Fatigue Service Degradation of FRP

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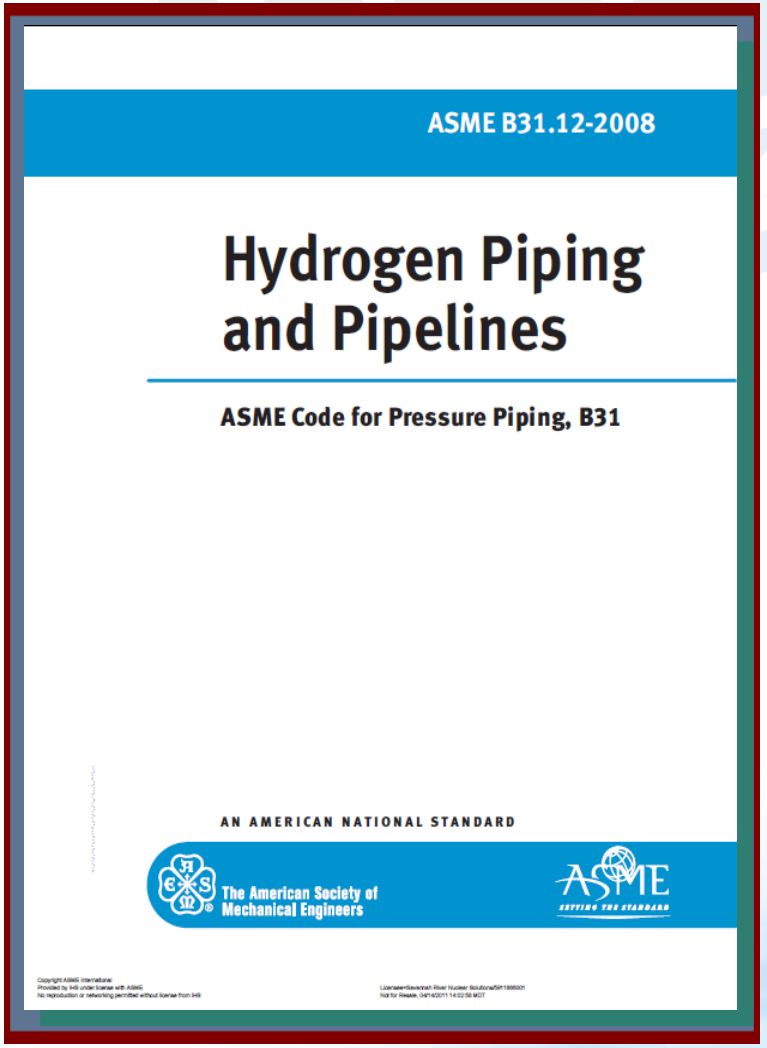
FRP B31.12 Codification Effort

- B31.12 Codification
  - A report summarizing the FRP testing by SRNL and ORNL has been completed. The report will become the basis for ASME Codification of FRP.
  - Review comments from ASME, ORNL and the FRP Manufacturer have been incorporated.
  - The report will be updated to include the 2014 fatigue testing data and the service experience data from the FRP Manufacturer .
  - Data was provided to the B31.12 Code Committee in September 2013
  - Next meeting with B31.12 is planed for March 2014



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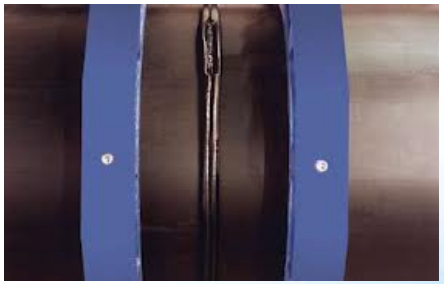
Research Need- FRP Fusion Bonded Joint

- Current Issue
  - The current design relies on O-Ring Seals to ensure a leak tight joint. Current testing has shown that the O-Ring could be a weak link in the design.
  - Pipeline manufacturers have expressed concern about using a mechanical seal that may require maintenance.

- Development Opportunity
  - Develop a FRP fusion bonded joint for the HDPE layer to control leakage. An additional structural layer would be added for pressure integrity.
  - Utilize exiting HDPE bonding techniques for fusion joint.
  - Develop structural layer using current pipe wrap repair technology.
  - Perform burst testing to evaluate structural integrity of joint

Current Mechanical Connector



Fusion Bonded HDPE Joint

Technology Demonstration – FRP Hydrogen Pipeline

- Install a 1000’ FRP pipeline operating in hydrogen service at a design pressure of 1500psi.
- The pipeline would serve as a test, surveillance and demonstration facility for FRP in fielded hydrogen service.

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