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J1Or2B-02: [Invited] The Benefits and Challenges with On-board Liquid Hydrogen Storage Systems

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The Bipartisan Infrastructure Law has significantly increased the opportunity to use hydrogen as an alternative energy carrier and energy storage medium. However, doing so requires the development of safe and efficient storage vessels, delivery systems, and distribution infrastructure. Cryogenic liquid hydrogen and cryo-compressed gaseous hydrogen are considered high energy density alternatives to ambient temperature gaseous hydrogen but have unique engineering challenges in addition to the typical hydrogen compatibility issues. Cryo-compressed hydrogen requires pressures exceeding 700 bar to achieve higher energy densities, which necessitates extreme material strength requirements. On the other hand, liquid hydrogen systems face extreme environmental demands of including temperature cycles over a 300 K range and to as low as 20 K. It is common to use austenic stainless steels and composite overwrapped metallic vessels for liquid hydrogen and cryocompressed systems, respectively. However, such common materials have rarely been studied at these cryogenic temperatures with hydrogen exposure. In this study, various cooling and pressurization profiles simulating cryocrompressed tank refueling cycles illustrate stress development in metal liner and composite overwrap components. . This study will also illustrate the hydrogen and cryogenic effects on 304L and Nitronic 50 alloys and their welds, and how the effect of composite fiber surface treatments can influence the short-beam shear behavior at temperatures as low as 20K. While lower temperature is known to increase strength properties and reduced elongation at fracture, the presence of internal hydrogen increased both strength and elongation at fracture, but reduced ductility as measured by reduced cross-sectional area. Magnetic evaluation of the uniformly strained region of the test specimens suggests that hydrogen mitigates the strain-induced transformation to α'-martensite. Brittle fracture features and secondary cracking indicative of hydrogen embrittlement were observed on the fracture surfaces of hydrogen-precharged specimens, which is consistent with the loss of ductility

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