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C1Or4A-02: Development of a test apparatus for thermal conductivity measurements of insulation materials with adsorbed nitrogen between 20 and 77 K

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With the growing interest in utilizing liquid hydrogen to decarbonize the aviation and transportation industries, understanding the effective thermal conductivity of insulations utilized in vacuum-jacketed liquid hydrogen vessels is critical to predicting heat leak and boil-off characteristics. Moreover, the ability to predict the transient heat flux during a loss of vacuum event is a critical metric that will impact the design of safety systems and hold time of these tanks. While these metrics have been characterized thoroughly with liquid nitrogen cold boundary temperatures (77 K and above), there is a lack of measurements at liquid hydrogen boundary temperatures. Boil-off calorimetry has been a typical method for measuring thermal conductivities but proves challenging for liquid hydrogen temperatures (20 K). In this study, a cryogenic refrigerator enables thermal conductivity measurements of three common insulations (glass microbubbles, aerogel, and multi-layer insulation) with an accuracy better than ± 1 mW/m-K at liquid hydrogen boundary temperatures. Additionally, the experiment is capable of uniformly introducing gas in the insulation space, simulating a catastrophic fail of vacuum. Transient heat fluxes can be determined from these experiments and utilized to design safety systems. Measurements are compared to a theoretical model for validation purposes, enabling the use of this data for development of liquid hydrogen storage vessels.

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