

Liquid Hydrogen Propellant Tank Sub-Surface Pressurization with Gaseous Helium

J. R. Stephens¹ and W. Cartagena²

¹*Propulsion Systems Dep. / ER24, NASA Marshall Space Flight Center, Huntsville, AL 35812 U.S.A.*

²*Propulsion Systems Dep. / ER22, NASA Marshall Space Flight Center, Huntsville, AL 35812 U.S.A.*

A series of tests were conducted to evaluate the performance of a propellant tank pressurization system with the pressurant diffuser intentionally submerged beneath the surface of the liquid. Propellant tanks and pressurization systems are typically designed with the diffuser positioned to apply pressurant gas directly into the tank ullage space when the liquid propellant is settled. Space vehicles, and potentially propellant depots, may need to conduct tank pressurization operations in micro-gravity environments where the exact location of the liquid relative to the diffuser is not well understood. If the diffuser is positioned to supply pressurant gas directly to the tank ullage space when the propellant is settled, then it may become partially or completely submerged when the liquid becomes unsettled in a micro-gravity environment. In such case, the pressurization system performance will be adversely affected requiring additional pressurant mass and longer pressurization times. This series of tests compares and evaluates pressurization system performance using the conventional method of supplying pressurant gas directly to the propellant tank ullage, and then supplying pressurant gas beneath the liquid surface.

The pressurization tests were conducted on the Engineering Development Unit (EDU) located at Test Stand 300 at NASA Marshall Space Flight Center (MSFC). EDU is a ground based Cryogenic Fluid Management (CFM) test article supported by Glenn Research Center (GRC) and MSFC. A 150 ft³ propellant tank was filled with liquid hydrogen (LH₂). The pressurization system used regulated ambient helium (GHe) as a pressurant, a variable position valve to maintain flow rate, and two identical independent pressurant diffusers. The ullage diffuser was located in the forward end of the tank and was completely exposed to the tank ullage. The submerged diffuser was located in the aft end of the tank and was completely submerged when the tank liquid level was 10% or greater. The ullage diffuser tests were conducted as a baseline to evaluate the performance of the pressurization system, and the submerged diffuser tests showed how the performance of the pressurization system was compromised when the diffuser was submerged in LH₂. The test results are evaluated and compared, and included in this report for various propellant tank fill levels.