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C1Or4C-03: On the Thermodynamic Boundaries of Cryogenic Liquid Storage in Closed Containers

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The self-pressurization behaviour of a cryogenic liquid due to the inevitable heat inleak into a closed cryogenic storage system is of great importance for the design of such a storage vessel. In recent years, the resurgence of cryogenic liquid hydrogen as a fuel in future sustainable transportation and logistics sparked new interest in this field of research. The cryogenic fuel tank represents the core of these liquid hydrogen applications. It is the goal to store as much total hydrogen mass for as long as possible and, most importantly, loss-free. Key design parameters of such a tank are therefore the so called dormancy time and the pressure increase rate. It is already known that the geometry and the heat inleak distribution play an important role in the self-pressurization behaviour of a closed cryogenic system. We want to expand on this idea and study the underlying thermodynamic changes of state resulting in two theoretical boundary cases: One process that gives a maximum dormancy time (minimum pressure increase rate) and another process that gives minimum dormancy time (maximum pressure increase rate). With this, we want to capture the notion of non-uniformly distributed heat being the most significant influencing factor on the self-pressurization behaviour of closed cryogenic liquid storage systems. These theoretical boundary cases give the opportunity to quantify the quality of actual cryogenic storage vessels and to consider the maldistribution of heat on a more abstract level. This theoretical analysis could support future design choices of cryogenic liquid storage systems.

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