15K thermal buffer using liquid hydrogen

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A problem that typically arises from the use of complex cryogenic chains used in space applications is the existence of heat bursts during the recycling stages of some components, which can compromise the stability of the entire chain. Instead of using large cryogenic liquid reservoirs to cool the system or to compensate for heat bursts, which is a costly and temporary solution (as the liquid will eventually run out), or over dimensioning the cryocoolers, we propose a more practical solution: the introduction of a thermal buffer to absorb these heat bursts without significant temperature change.

Systems composed of mechanical cryocoolers and a thermal buffer or thermal storage unit have been previously demonstrated, either using high heat capacity materials [1], or taking advantage of the latent heat in a phase transition, may it be solid-solid [2], liquid-vapor [3], or solid-liquid-vapor at the triple point [4, 5]; the choice of material depends on the temperature range. This type of system helps reduce the temperature drift that would occur from turning a cryocooler off (for sensitive measurement purpose), and it can act as a temperature stabilizer in a cryogenic chain.

In the framework of an ESA contract we are developing a thermal buffer operating between 15 and 20 K, capable of absorbing a heat burst of 400 J. It takes advantage of the latent heat at the liquid-vapor transition of hydrogen, while being a closed system. This system is composed by a low temperature liquid H_2 reservoir (~15 cm^3) and an expansion volume at room temperature.

As cryogenic chains able to provide cooling down to 50 mK [6] have been investigated as options for XMS on Athena, this kind of device can be used to absorb part of the generated heat bursts. The presented thermal buffer is being designed in order to comply with strict weight, volume and thermal power requirements that allow it to be integrated in the aforementioned cryogenic chain. Challenges that arise from working with hydrogen, such as its storage at low pressure and the ortho-para conversion, as well as working in a microgravity environment, are addressed and solutions are proposed.

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