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C1Po1E-08 [34]: Thermodynamic and cost-effectiveness analyses of chosen cooling loops for local production of saturated superfluid helium in large cryogenic systems

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Large scientific facilities applying HeII technologies usually use the Joule-Thomson expansion for the final production of saturated superfluid helium at their cryomodules or magnet cryostats. Required cooling power is usually delivered by the flow of subcooled liquid helium flow at
4.5 K and 3 to 4 bar(a). Then, the 4.5 K helium is precooled in a heat exchanger and throttled to a sub-atmospheric pressure below 50 mbar(a) to produce superfluid helium. This final throttling goes along an isenthalpic line which leads to the zone of wet vapour at quality of 15.9%. The efficiency of this process can be strongly affected by additional heat loads in the distribution line leading to higher temperatures in the heat exchanger as well as in the inlet to the JT valve, which may result in significantly higher quality of the throttled helium. This imperfection can be partly decreased by using a local subcooler or by splitting the expansion process into two phases with an intermediate point around 1.3 bar(a). However, these solutions require additional components, such as phase separators with some instrumentation and another throttling valve.

The paper presents the comparative thermodynamic analysis of the three cooling loops in respect to the initial, intermediate and final thermodynamic states of helium. Potential savings due to thermodynamic efficiency improvements are verified against the capital costs for different operation times.

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