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C1Or2B-04: Numerical modeling of the cool-down of the helium transfer-lines for FRIB Linac and experimental systems

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The cryogenic distribution system at FRIB is extensive, encompassing three Linac segments, fourteen experimental system superconducting magnets, cross-connect between FRIB and the reconfigured NSCL legacy system, and the A1900 magnets, as well as many other user experimental loads. The cool-down or warm-up of these transfer-lines is an inherently transient process and must be conducted at a gradual enough rate to keep local temperature gradients and corresponding thermal stress on the piping system within acceptable limits. To this end, estimation of this transient process is very helpful in operational planning. Two different models were developed to capture the transient characteristics of the cool-down (or warm-up) process with a real fluid properties, and considering the effects of heat in-leak, momentum, flow resistance, and piping components. The first model employs a Crank-Nicolson implicit method, while the second model uses a MacCormack explicit method. Computational cost of the proposed models were compared, and results were validated against a simple closed-form solution. Each model was then employed to estimate the cool-down of FRIB transfer line sections, and were compared to previously obtained experimental data. This paper discusses the advantages and disadvantages of each numerical method for this model, as well as their accuracy compared to the actual transfer-line.

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