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C2Or3D-06: Characterization of centrifugal compressors operating in FRIB's sub-atmospheric compression system

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Helium cryogenic systems operating below the normal boiling point (of 4.22 K) are required for many modern high-energy particle accelerators to achieve the necessary performance criteria. Temperatures below the normal boiling point are established by lowering saturation pressure below atmospheric conditions using vacuum equipment. FRIB operates a multi-stage string of cryogenic compressors (or "cold-compressors") to achieve the sub-atmospheric pressures required for the accelerator operating conditions of approximately 2 K (30 mbar). Housed within a vacuum insulated vessel (i.e., the sub-atmospheric cold box), the cold-compressor system re-pressurizes the helium from approximately 30 mbar to above atmospheric conditions before injecting the flow back into the helium refrigerator. Despite the implementation of cold-compressors in several existing large-scale cryogenic systems, openly available research literature is insufficient to provide the information necessary for a general characterization of the performance and stability for these cold compressors. To address this deficiency, this present study provides such a characterization through a modification of a centrifugal compressor performance prediction code previously developed by the authors. This code enables performance prediction by using optimally selected enthalpy loss correlations and basic impeller and diffuser geometrical data. Using this code and extensive test data previously collected for the FRIB cold compressors, the performance of these compressors is characterized, permitting a reliable performance prediction. This is anticipated to allow assessment and prediction of optimal operational envelops that ensure stable and efficient operation.

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