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Cylindrical Boiloff Calorimeters for Testing of Thermal Insulation Systems

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Several cryostat instruments for the testing of thermal insulation systems in a cylindrical configuration have been developed and standardized for laboratory operation. The measurement principal is boiloff calorimetry for the determination of the effective thermal conductivity (k_e) and heat flux (q) of a test specimen at a fixed environmental condition (boundary temperatures, cold vacuum pressure, and residual gas composition). Liquid nitrogen is the energy meter through heat of vaporization properties, but the design is adaptable for different cryogens. The main instrument, Cryostat-100, is guarded on top and bottom and provides directly measured absolute thermal performance data. A cold mass assembly, including the upper and lower guard chambers and a middle test vessel, is suspended from a lid of the vacuum canister. Each of the three chambers is filled and vented through a single feedthrough for minimum overall heat leak and simplified operation. The cold mass design provides thermal isolation by precluding direct solid conduction heat transfer from one liquid volume to another. Such isolation is critical for the very low heat measurement capability to be achieved as small variations in liquid temperatures between chambers can easily lead to dramatic errors in the results. All fluid and instrumentation feedthroughs are mounted and suspended from a top-domed lid to allow easy removal of the cold mass. A lift mechanism allows manipulation of the cold mass assembly and insulation test specimen. The cryostat system design details and laboratory standard test methods are discussed. Results for select thermal insulation materials including multilayer insulation, powders, foams, and aerogel blankets are presented. Additional cylindrical boiloff calorimeters including the comparative apparatus, Cryostat-200, and progress toward a liquid hydrogen apparatus are also discussed.

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