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Solid-cryogen-stabilized, cable-in-conduit superconductor cables

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This paper considers the use of a solid cryogen as a means to stabilize, both mechanically and thermally, superconducting wires (MgB₂, 2212 or 2G) within a dual channel cable-in-conduit (CIC) cable for use in AC applications, such as a generator stator winding. The cable consists of two separate channels; the outer channel contains the superconducting strands and is filled with a fluid (liquid or gas) that becomes solid at the device operating temperature. Several options for fluid will be presented, such as liquid nitrogen, hydrocarbons and other chlorofluorocarbons (CFCs) that have a range of melting temperatures and volumetric expansions (from solid at operating temperature to fixed volume at room temperature). Implications for the quench protection and conductor stability, enhanced through direct contact with the solid cryogen, which has high heat capacity, will be presented. We present options for filling and cooldown. For example, during cooldown, cold nitrogen gas could be pumped through the outer channel until the cable temperature reaches ~100 K. Liquid nitrogen would then be injected into the cable until the outer channel is filled with liquid, and cold helium gas would be pumped through the inner cooling channel (without the strands) until the cable reaches the target operating temperature, which may be in the range from 20K to 60 K. At this point, the cryogen in the stranded-channel will be solid, essentially locking the wires into the mechanical structure of the cable, preventing degradation due to mechanical deformation and providing enhanced thermal capacity for stability and protection. The relatively high heat capacity of solid cryogenes at these lower temperatures (compared to gaseous helium) enhances the thermal stability of the winding. During operation, coolant flow through the open inner channel will minimize pressure drop.

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