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STEP's Plan for Understanding REBCO Coated Conductors in the Fusion Environment

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***Abstract*—The UKAEA's Spherical Tokamak for Energy Production (STEP) programme aims to demonstrate the ability of a low aspect ratio tokamak to generate net electricity from deuterium-tritium (DT) fusion. Specifically, it aims to deliver a prototype fusion power plant, targeting 2040, and a path to the commercial viability of fusion, by engaging with and invigorating relevant industry and the supply chain.**

STEP will utilise REBCO coated conductors (CC) as the current carrier for its toroidal and poloidal field magnets. Based on the current literature (e.g., [1],[2]), it has been recognised that neutron irradiation leads to the degradation of REBCO's superconducting properties, and that this degradation will limit STEP's operating life. However, this literature does not, at present, cover all the conditions that REBCO CC will be subjected to whilst operating in STEP's magnets, i.e., the simultaneous irradiation with neutrons and gammas whilst the REBCO CC is at its cryogenic operating temperature, carrying current and subject to magnetic field and strain. Recent preliminary works (e.g., [3],[4]) have shown that these additional conditions could exacerbate the degradation in REBCO's superconducting properties, and therefore they each require further investigation.

STEP's Confinement System Materials group has developed a plan to characterize the superconducting properties of REBCO CC under as-close-as-reasonably-possible operating conditions within STEP prior to its construction. The campaign will thoroughly inform and validate the choice of REBCO CC used in the construction of STEP's magnets and the magnets for other compact fusion reactor designs. In this presentation, the knowledge gaps are defined (as outlined in Iliffe et al. [5]), an overview of the plan is presented, and a progress report will be given along with results where they exist.

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[1] Fischer et al., "The effect of fast neutron irradiation on the superconducting properties of REBCO coated conductors with and without artificial pinning centers" SUST 31 044006 2018
[2] Iliffe et al., "In-situ measurements of the effect of radiation damage on the superconducting properties of coated conductors" SUST 34 09LT01 2021
[3] Iliffe et al., "The effect of in situ irradiation on the superconducting performance of $REBa_2Cu_3O_{7-\delta}$ coated conductors" MRS Bulletin Impact Article 48, p. 1, 2023.
[4] Fischer et al., ASC Presentation: "Effects of cryogenic proton irradiation on Ic and Tc in REBCO tapes" 2022
[5] Iliffe et al., "STEP's plan for understanding REBCO coated conductors in the Fusion Environment" IEEE. Trans. Plasma. Sci. (submitted)

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