

Thermal–hydraulic test and analysis of the ENEA TF conductor sample for the EU DEMO fusion reactor



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INTRODUCTION

Short sample of the conductor proposed by ENEA for TF coils [1]

Assess friction factor correlations accuracy against experiment Calibrate hole-to-bundle heat transfer in 4C code [2], used in the TF coils design phase [3]



- Fast T homogenization, $< \frac{3}{4}$ of last cabling stage twist pitch (~0.69 m)
- \rightarrow large heat (and mass) transfer across the spiral
- [1] L. Muzzi et al., "Design, Manufacture, and Test of an 80 kA-Class Nb₃Sn Cable-In-Conduit Conductor With Rectangular Geometry and Distributed Pressure Relief Channels," IEEE Trans. Appl. Supercond., vol. 27, no. 4, Jun. 2017, Art. no. 4800206. [2] L.Savoldi et al., "The 4C code for the cryogenic circuit conductor and coil modeling in ITER," Cryogenics, vol. 50, no. 3, Mar. 2010, pp. 167-176.
- [3] R. Zanino et al., "Development of a Thermal-Hydraulic Model for the European DEMO TF Coil," IEEE Trans. Appl. Supercond., vol. 26, no. 3, Apr. 2016, Art. no. 4201606.
- [4] M. Bagnasco, L. Bottura, and M. Lewandowska, "Friction factor correlation for CICC's based on a porous media analogy," Cryogenics, vol. 50, 2010, pp. 711-719.

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CONCLUSIONS

- **TEST**: well-instrumented, short sample of the ENEA conductor proposal for the DEMO TF coils underwent successful TH characterization in SULTAN • ANALYSIS:
 - Friction: CFD-based correlation for hole + Darcy-Forchheimer for bundle successfully reproduce exp. data
 - Heat transfer:

Time (s)

- Characteristic length of temperature homogenization on the conductor cross section $< \frac{3}{4}$ of the last cabling stage twist pitch
- B/H heat transfer computed from standard thermal resistance model, suitably enhanced to account for local turbulence