

SIXTH FRAMEWORK PROGRAMME



Project n° SES6-CT-2004-502615

SUPER3C
Super Coated Conductor Cable

Specific Targeted Project
Priority 6.1: Sustainable Energy Systems

FINAL ACTIVITY REPORT

Period covered: from June 1, 2004 to November 30, 2008

Date of preparation: March 2010

Start date of project: June 1, 2004

Duration: 4.5 years

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Project coordinator organisation name: Nexans France

Publishable final activity report

The feasibility of the High Temperature Superconducting (HTS) cable technology was proven through several projects using $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10-x}$ multifilamentary HTS tapes as current carrying elements. Lengths up to 600 meters, voltages up to 138 kV, currents up to 3 kA were demonstrated. This technology is now moving towards the pre-commercial stage through kilometric cable projects. However, expensive multifilamentary HTS tapes are expected to be replaced in the near future by the second generation of HTS wires, the $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ (YBCO) Coated Conductor (CC) tapes, which, through a lower production cost, will allow for a wider use of HTS cables. These CC tapes exhibit a multilayer structure which consists of a metallic substrate covered by a few buffer layers, the YBCO HTS layer and a thin metallic cap layer.

The Super3C project aimed at establishing the feasibility of a HTS power cable using CC tapes. It comprised the development, manufacturing and testing of a functional model consisting of a one-phase, 30-meter long cable system targeting a 1 kA current at 10 kV for a transmitted power of 17 MVA.

The project involved thirteen partners from six countries and was coordinated by Nexans France (NXF). The Tampere University of Technology (Finland) led the cable modeling task with supports from the Bratislava Institute of Electrical Engineering (Slovakia), from Nexans Germany and from the Göttingen Center for Functional Materials (ZFW, Germany). Bruker HTS (Germany) led the CC tape development task with supports from Nexans SuperConductors (Germany) and from the Barcelona Institute of Materials Sciences (ICMAB, Spain). Bruker HTS fabricated the CC tapes for the functional cable model. Nexans Germany led the functional cable model manufacturing. Nexans Norway fabricated the cable core which was inserted in a flexible cryogenic envelope supplied by Nexans Germany. Nexans France provided the cable terminations. Labein (Spain) led the network integration study and cable tests with supports from E.ON Engineering (Germany) for network integration and from Air Liquide (France) which supplied the liquid nitrogen cooling system allowing the CC tape to reach its superconducting state around -200°C . E.ON Energie (Germany) led the technical, economical and social assessments.

After an extensive modelling program, cable and terminations designs were validated through the test of prototypes. In parallel, a HTS-copper hybrid CC tape was developed using Alternating Beam Assisted Deposition (ABAD) and High-Rate Pulse Laser Deposition (HRPLD). The main deliverable, the 30-meter one-phase functional cable model, including terminations and liquid nitrogen cooling system, was manufactured and successfully tested through an extensive program including short-circuit tests up to 40 kA during 1s. The 17 MVA target was met through a voltage of 20 kV and a current of 0,5 kA.

The work carried out within the framework of this project also provided a much clearer vision of how superconducting cables could be integrated in power grids and how they compare with conventional technologies on an economical standpoint.

The Super3C functional model has been one of the first HTS coated conductor cable in the world and has positioned Europe in the leading group for that technology.



Final plan for using and disseminating the knowledge

Actual dates	Type	Type of audience	Partners responsible
September 05	EUCAS 2005 conference [1]	Research and industry in the field of superconductors	IEE
January 2006	Press article (in Power Engineering International)	Industry in the field of power engineering	NXF
March 2006	Publication [2]	Research in the field of superconductors	TUT
April 2006	EC meeting		NXF
August 2006	ASC 2006 conference [3]	Research and industry in the field of superconductors	IEE and TUT
August 2008	ASC 2008 conference [4]	Research and industry in the field of superconductors	NSC

[1] *AC loss of YBCO coated tape prepared by laser ablation*

[2] *Design of the 30 m long 1 kA 10 kV YBCO cable in Superconductor Science and Technology* (Supercond. Sci. Technol. 19 (2006) 418-422)

[3] Two papers were presented at the 2006 Applied Superconductivity Conference in Seattle and published:

. *AC loss measurement of the YBCO cable model* by J. Šouc, F. Gömöry, B. Klinčok, L. Frolek, M. Vojenčiak, A. Usoskin, and A. Rutt in IEEE Trans. Applied Supercond. 17 (2007) 1718-1721

. *AC loss and current sharing in an YBCO cable* by L. J. Rostila, J. R. Lehtonen, M. J. Masti, R. Mikkonen, F. Gömöry, T. Melišek, E. Seiler, J. Šouc and A. Usoskin in IEEE Trans. Applied Supercond. 17 (2007) 1688-1691

[4] *Simplified procedure for estimating epitaxy of La₂Zr₂O₇-buffered NiW RABITS using XRD* by M. O. Rikel, D. Isfort, M. Klein, J. Ehrenberg, J. Bock, M. Sun-Wagener, O. Weber, D. Sporn, S. Engel, O. de Haas, M. Schubert, and B. Holzapfel