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SUPERCONDUCTING CABLES – STATUS AND APPLICATIONS

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ABSTRACT

Superconducting cables provide a new way to solve power transmission issues by enhancing the transmitted power through a very high ampacity whereas the classic technology usually relies on a voltage increase. This paper provides an overview of this emerging technology, describing the various types of superconducting cables, reviewing the main projects in the world and highlighting the specific benefits provided by superconducting cable systems.

KEYWORDS

Superconductor, HTS, superconducting wire, superconducting cable

INTRODUCTION

Power utilities are facing increasing challenges to adapt to steadily growing needs, additions of new generators, enhanced reliability requirements and rising constraints to install new equipments, especially at extra-high voltage. There is consequently a rising interest for new technologies which can help to increase electrical grid capacity and flexibility, and superconducting cables constitute a very promising one. Among other benefits, they indeed provide a new way to solve power transmission issues by enhancing the transmitted power through a very high ampacity whereas the classic technology usually relies on a voltage increase when the current exceeds 1,500 A.

OVERVIEW OF SUPERCONDUCTORS

Superconductors are materials which do not exhibit any electrical resistance below a certain temperature called the *critical temperature* (T_c). This phenomenon has been known since 1911 and observed in what are called now the Low Temperature Superconducting (LTS) materials because they are typically cooled with liquid helium at 4 K. LTS compounds are for instance used in Magnetic Resonance Imaging for medical applications, Nuclear Magnetic Resonance for analyses and in fusion reactors such as ITER.

In the late 1980's, a new family of superconductors, the High Temperature Superconducting (HTS) materials, was discovered (figure 1). These compounds differ from the previous ones though a much higher critical temperature allowing them to reach their superconducting properties at 77 K in liquid nitrogen, a cheap, abundant and environmentally benign cooling fluid. All HTS materials are copper oxide-based ceramics.

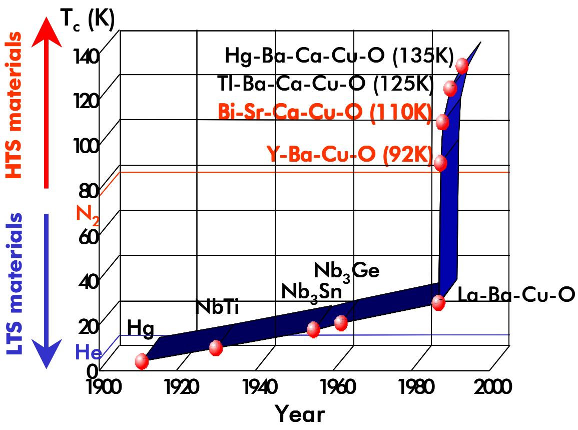

Figure 1: Gradual increase of critical temperature T_c

HTS CABLE SPECIFIC COMPONENTS

HTS WIRES

HTS wires constitute the current carrying elements of superconducting cables in normal operation. Two HTS materials are being used for power cable applications: $Bi_2Sr_2Ca_2Cu_3O_{10}$ (Bi-2223) and $YBa_2Cu_3O_7$ (Y-123).

The first generation of HTS wires has a multifilament structure. Bi-2223 filaments are embedded in a silver matrix (figure 2).

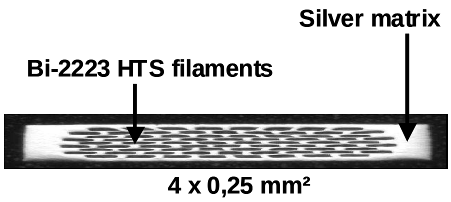

Figure 2: First generation of HTS wire (cross section)

First generation wires are available in kilometric lengths with critical currents exceeding 180 A.

Coated conductors constitute the second generation of HTS wires. They consist of a metallic tape coated with ceramic layers, the top one being made of Y-123 (figure 3).