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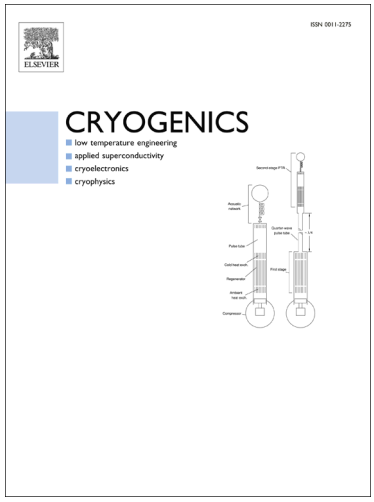

Cooling Unit for the AmpaCity Project – one year successful operation

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Cooling Unit for the AmpaCity Project – one year successful operation

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ABSTRACT

High temperature super conductors (HTS) can efficiently be cooled with liquid nitrogen down to a temperature of 64 K (-209°C). Lower temperatures are not practical, because at 63 K (-210°C) nitrogen becomes solid. To achieve this temperature level the coolant has to be vaporized below atmospheric pressure. Messer has developed a cooling unit with an adequate vacuum subcooler, a liquid nitrogen circulation system, and a storage vessel for cooling an HTS-power cable.

Liquid nitrogen is circulated through the superconducting cable to take out the heat, and afterwards it is pumped through the subcooler to be recooled. In the circulation system liquid nitrogen is used as a dielectric fluid and as a heat transfer medium. It stays always liquid (subcooled) and does not vaporize. On the secondary side of the subcooler liquid nitrogen from the storage vessel is used as refrigerant. It is vaporized under a pressure of 150 mbar to achieve the desired low temperatures.

The cooling unit was delivered in 2013 for the German AmpaCity project of RWE Deutschland AG, Nexans and Karlsruhe Institute of Technology. Within this project RWE and Nexans installed the worldwide longest superconducting power cable in the city of Essen, Germany. The cooling unit cools a 10 kV concentric HTS cable (40 MVA) with a length of 1,000 m.

The cable is in operation since March 10th, 2014. After more than one year of practical operation many important figures from cable and cooling unit are available. These figures are discussed and a total energy balance is shown to compare liquid nitrogen cooling with alternative mechanical cooling systems.

Keywords: subcooler, cryocooler, superconductor, HTS-cooling system, cryogenic cooling, AmpaCity project

1. INTRODUCTION

High temperature super conductors (HTS) are materials which lose their electrical resistance at temperatures close to the boiling point of liquid nitrogen 77 K (-196 °C). In 1987 Georg Bednorz and Alexander Müller received the Nobel Prize for discovering this phenomenon. Today, HTS are used in cables, fault current limiters, electric motors and generators.

A new application for these materials is the almost loss free transportation of electrical energy using power cables, which allows for transportation of very large amounts of energy through