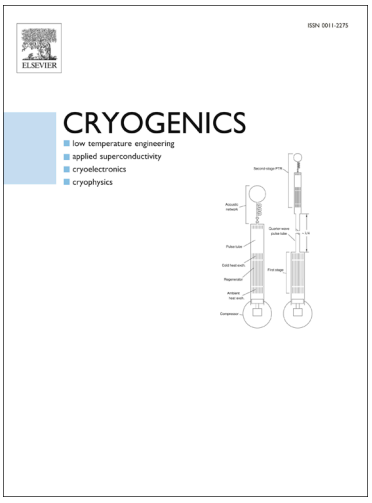

HTS current leads for the NICA accelerator complex

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HTS current leads for the NICA accelerator complex

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Abstract.

The international project "NICA" (Nuclotron-based Ion Collider fAcility) is an accelerator complex which is under construction at the Joint Institute for Nuclear Research (Dubna, Russia). Basing on the NICA project demands NRC "Kurchatov Institute" (Moscow, Russia) designed and manufactured two trial 12 kA 1G current leads (CLs) intended for powering of the JINR superconducting magnets test bench. The main requirements for the CLs were: a reliable and robust design, usage of liquid nitrogen from the NICA cooling circuits as a resistive section coolant, low resistance joints, current ramp rates up to 10 kA/s and the total heat load to the 5 K end not exceeding 0.4 W/kA per one CL. An in-situ cold test of the trial 12 kA CLs held at JINR in 2015 demonstrated the operational reliability of our technological approaches. Following the successful test results the serial production of 20 pairs of 10.5 kA HTS CLs with very few design updates for the accelerator powering started. The first 10 pairs were fabricated, tested and shipped to JINR as a part of the NICA commissioning framework in June 2017. All the CLs fulfilled the acceptance test requirements. The production of the remaining 10 pairs is to be finished in 2018. The paper gives an overview of the 12 kA and 10.5 kA HTS CLs' design, discusses their thermal, magnetic and electrical characteristics and presents the acceptance tests results. We also compare our CLs with earlier works by other groups in the context of HTS stack-and-soldering technique, joints' resistances, relative heat loads into the cryogenic environment etc.

Keywords: HTS current leads, NICA accelerator complex, Bi-2223 tapes, HTS stacks.

Abbreviations: NICA - Nuclotron-based Ion Collider fAcility, CL – current lead, HTS – high temperature superconductor, LTS – low temperature superconductor, 1G – first generation, HEX – heat exchanger, LN2 – liquid nitrogen, GN2 – gaseous nitrogen, GHe – gaseous helium, LHe – liquid helium, LHC – Large Hadron Collider, ITER - International Thermonuclear Experimental Reactor, TF - toroidal field coils, PF - poloidal field coils, CS – central solenoid, CC – correction coil, RT – room temperature, s.f. – self magnetic field, FEM – finite element method, LOFA - loss of coolant flow accident.

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1. Introduction

Today, high temperature superconducting current leads (HTS CLs) are widely used in accelerators, tokamaks, and specialized high field test facilities in order to minimize the heat loads and thereby reduce operating costs. Table 1 is an overview of the extent and timing of the existing HTS CLs projects [1-38]. It can be seen that all of the cited CLs were designed with a circular arrangement of multi-folded 1G HTS stacks. This is the most advantageous solution to reduce the magnetic field component perpendicular to the ab-plane of Bi-2223 tapes. All but one CLs used conduction cooled HTS modules placed in vacuum (an exception – the CLs for the LHC [11-15]). Resistive sections for the majority of the CLs were performed as pure metal heat exchangers cooled with gaseous helium (GHe HEX). The power consumption for LN2 HEX cooling is slightly higher, but it helps to save the cost of the modifying of cryogenic systems providing a helium flow of about 50 K temperature [18, 35-36].