Cryogenics for the Large Hadron Collider (LHC): from Construction to Operation and Future Upgrades

Ph. Lebrun

DG Unit, CERN, CH-1211 Geneva 23, Switzerland

Abstract - The Large Hadron Collider (LHC) at CERN, the European Organization for Nuclear Research near Geneva, is the most advanced research instrument in elementary particle physics: it accelerates and brings into collision intense beams of protons and ions at high energy, to probe the structure of matter and study the forces of nature at the unprecedented scale of TeV per elementary constituent. Exploration of this *terra incognita* has already led to the discovery of the long-sought Higgs boson in 2012. To guide and focus its rigid beams along the 26.7 km circumference of the accelerator tunnel, the LHC uses more than 1600 high-field superconducting magnets operating in 80 t superfluid helium at 1.9 K, cooled by the largest helium cryogenic system in the world. Eight large 18 kW @ 4.5 K helium cryoplants, complemented by 2.4 kW @ 1.8 K stages, produce refrigeration for the eight 3.3 km long sectors of the machine, deep underground. The superconducting magnets, which expose some 50’000 m2 of surface area at 1.9 K, are housed in efficient cryostats of industrial construction to contain heat loads. Cooldown of the 37’500 t cold mass is achieved by vaporization of some 12’000 m3 liquid nitrogen. 21’300 cryogenic sensors monitor the machine, while 4700 analog control loops ensure its cryogenic operation. We recall the technical stakes and main features of the LHC cryogenic system, present the outcome of the first operation phase with emphasis on reliability and energy efficiency, and discuss different stages of future upgrade, planned or under study to maximize scientific return from this unique facility.

IEEE/CSC & ESAS SUPERCONDUCTIVITY NEWS FORUM (global edition), July 2013
Received July 17, 2013; Accepted July 17, 2013. Reference No. CRP34; Category 5,6,11.
Plenary ICMC presentation at the CEC/ICMC 2013