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Process design and control strategies of the two large 1.9K Helium refrigeration plants at CERN

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In 2022, Linde received the order to deliver two large helium refrigeration systems operating at 4.5 K and 1.9 K for the European Organization for Nuclear Research (CERN) in Geneva, Switzerland. The two identical plants will be installed at opposing points along the circumference of the Large Hadron Collider (LHC). They will facilitate the peak luminosity by a factor of five beyond the LHC's design value.
Due to the operation of the superconducting magnets at 1.9 K, parts of the cryoplant operate at a very low pressure, down to 15 mbar a. While operating in a steady state, each of the cryoplants delivers up to 14 kW of equivalent power at 4.5 K, including 3.25 kW at 1.9 K (isothermal and non-isothermal),13.5 kW at 60 K to 90 K as well as various loads having 4.5 K supply.
The very low pressure at which the liquid helium is evaporated inside the LHC's magnets to achieve 1.9 K leads to a high-volume flow of gaseous helium returning from the LHC experiment to the cryoplant. Cold compressors lower the volume flow, which pre-compresses the helium returning from the experiment before it is conveyed to the refrigeration cold box. Due to smaller volume flow, heat exchangers can be designed to be more compact, and the warm screw compressor requires lower capacity.
Since the LHC is located underground, each cryoplant is split into two separate cold boxes. The larger main cold box (refrigerator) is located at the surface, and a second, smaller cold box, which contains mainly the cold compressors, is in the underground cavern close to the experiment.
The combination of floating pressure in all four pressure stages with an integrated 3,500 L LHe phase separator enables rapid adaptation to load changes without using a variable frequency drive for the main compressors. A floating pressure cycle maintains high efficiency even during turndown operation.
The paper covers the process design according to CERN's specification and the control strategies for load adaption.

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