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# Services provided by Linde Kryotechnik for the LHC particle accelerator.

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Linde Kryotechnik AG is the world's leading provider of cryogenic systems. Once again it has proven its competence and the technological superiority of its products: with the European Organization for Nuclear Research, CERN's, new LHC particle accelerator in Geneva.

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On the 10th of September 2008, the world's most powerful particle accelerator, the LHC, will begin its work and deliver proton-proton collisions at the highest energies. It is installed in a ring tunnel of 27 km perimeter, 100 m below the earth's surface. To keep the high energy protons in their paths, extremely strong magnetic fields are necessary. These magnets and the cavities of the particle accelerator are cooled by eight refrigeration systems distributed along the periphery of the ring. Here, four new systems supplement four modified systems from the earlier particle accelerator, the LEP.

The equivalent output of each system is between 15.5 and 18 kW at a temperature of 4.5 K. Each of the eight refrigeration systems has a multi-stage cold compressor system, which reduces the pressure of the vaporising helium to 1.5 kPa absolute, which in turn decreases the temperature of the magnets to 1.8 K. These cold compressor systems are installed in separate "cold boxes".

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Linde Kryotechnik AG performed the following works on the LHC particle accelerator:

- Upgrade of two refrigeration systems from the earlier LEP particle accelerator to meet the new requirements. These systems were fitted with additional compressors and modified turbines to increase the output and meet the special demands of the cold compressors.
- Delivery and installation of liquid nitrogen-powered pre-cooling systems for all four modified LEP refrigeration systems. These pre-cooling systems are equipped with switchable 80 K adsorbers. Each system transfers up to 600 kW of cooling power at temperatures between ambient and 80 K.
- Delivery and installation of two new high performance refrigeration systems, the most powerful on the new particle accelerator. Their measured output is:

- at 4.5 K through isothermal vaporisation	4,400 W
- between 4.5 K and 20 K (for cold compressors)	20,700 W
- between 20 K and 280 K (for power supply lines)	55,400 W
- between 50 K and 75 K (for radiation shield)	33,000 W

CERN recognised the high efficiency of the system with a bonus and a public mention at the ICEC conference in Beijing, China. Noteworthy were also the extremely compact design and the remarkable performance stability.

- Delivery of four-stage cold compressor systems, each with a helium supply capacity of 130 g/s for the four refrigeration systems installed by Linde Kryotechnik in consortium with the Japanese firm IHI. CERN distinguished the ingenious technology of these four systems with the Golden Hadron Award 2003.
  - Provision of a technologically sophisticated new system for Atlas, one of the two gigantic detectors with a total weight of 7,000 t. The outstanding features include firstly a high cooling power (60 kW) from ambient temperature to 40 K, and secondly, the ability to recover a large part of the cold helium flow during quenching of the magnets.
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Linde Kryotechnik AG is not only an important system supplier; in cooperation with Serco and Air Liquide, it also operates and maintains a total of 19 refrigeration systems in the LHC around the clock. This operation contract has been in place for 7 years.

The new LHC particle accelerator is, with respect to both its technology and size, a project of superlatives on a global scale.

## Linde Kryotechnik AG

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