Successful test paves the way for magnet production at CERN

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The magnet, named MQXFB03, is 7.2 meters in length. It is the first of ten that will be needed for the HL-LHC. Credit: CERN

The Large Hadron Collider (LHC) needs specific types of magnets to tightly control the beams of particles at its collision points. Called final-focusing quadrupoles, these magnets are installed in the LHC's interaction regions around the experiments. For the high-luminosity upgrade of the LHC (HL-LHC), the final-focusing magnets at ATLAS and CMS will need replacing. Tests at CERN have now confirmed that the quadrupole magnets newly designed to replace them will work.

Unlike the LHC magnets, which are made from niobium–titanium (Nb–Ti), the new magnets are made from a more challenging material: niobium–tin (Nb3Sn). "Given the brittleness of Nb3Sn and the fact that its coils are very rigid, assembling Nb3Sn magnets requires close attention," explains José Miguel Jiménez, head of the Technology department. "This makes it a much bigger challenge than for Nb–Ti magnets."

The CERN Technology department is developing a series of ten magnets (eight, plus two spare), each 7.2 meters in length. This work builds on the HL-LHC Accelerator Upgrade Project (AUP), based in the U.S., which is currently manufacturing 20 (16, plus four spares) quadrupole magnets, each 4.2 meters long.

Recent tests at Fermilab showed that these magnets operate at target current at both 1.9 kelvin (-271.25°C) and 4.5 kelvin (-268.65°C), thus meeting the project requirements. The CERN team is relying on the same design and similar manufacturing procedures as AUP but scaling them up to 7.2-meter-long magnets.

"The contribution of our U.S. colleagues has been instrumental in developing the design and procedures for these magnets, and the regular cross-checks of manufacturing and test data have helped the teams on both sides of the Atlantic to overcome many challenges," says Ezio Todesco, who is in charge of the HL-LHC interaction region magnets.

The successful test at CERN, which ran from August to October, achieved the target current of 16.53 kA at both 1.9 K and 4.5 K. The target current corresponds to the 7 TeV LHC operation, plus a 300 A margin. Although operation is planned at 1.9 K, the ability to reach target current at 4.5 K confirms design robustness and a comfortable operation margin for the HL-LHC and beyond.

This is the third full-length magnet to be tested as part of a recovery plan decided on after performance limitations were observed on the first two prototypes. The other magnets showed no signs of degradation when tested, but were always limited to below target current when operated at 4.5 K. The team at CERN paused production to investigate this limitation. By improving the design of the outer shell, reducing peak stress on the magnet during coil assembly and changing the parameters of the coil manufacturing process, they eliminated the limitations and the third magnet has outshone its predecessors.

"Thank you to all the contributors for the excellent results and efficient teamwork and for deriving practical and robust engineering solutions to bring niobium–tin technology to the maturity level required for accelerator magnet applications," says Arnaud Devred, the TE-MSC group leader.

"This is a fantastic result for the project," says Oliver Brüning, HL-LHC project leader. "It means that niobium–tin is viable for 7-meter-long accelerator magnets and is an enabling technology for HL-LHC."

Provided by CERN

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