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Detailed study of the cryogenic jumper connections between the cryogenic distribution line and the superconducting magnets of the High Luminosity LHC upgrade at CERN

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The High Luminosity upgrade of the Large Hadron Collider (HL-LHC) project will require a new cryogenic system to cooldown the new superconducting components in the final focusing regions for the ATLAS and the CMS experiments. The existing magnets will be replaced with newly developed superconducting magnets that will operate in pressurized HeII at 1.9 K with a generated heat load of several hundred Watts per magnet. The liquid and gaseous helium needed to cool the magnets will be supplied by means of a new cryogenic distribution line (QXL). The connection to the QXL is performed at specific service modules through cryogenic jumpers that must provide all the required cryogenic and mechanical functions while considering the very limited space available in the LHC tunnel. The jumpers must provide the flexibility required for installation and allow, while in cryogenic conditions, the displacements due to thermal contraction and to the remote alignment system of the magnets.
This article presents the functional requirements and the design constraints of the connections. It describes the development of the QXL cryogenic jumpers from the conceptual stage to the design after a combination of preliminary design studies and tests. This includes the definition and validation of the mechanical compensation scheme adopted for the vacuum vessel and the cryogenic lines, the thermal shield, and the vacuum barrier between the QXL and the magnet insulation vacuum. Finally, the article reports on the testing campaign carried out to provide an improved characterization of the flexural and axial stiffness of metallic flexible hoses used in the design of the cryogenic lines.

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