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Vacuum flex lines design, production, qualification and tests for the ATLAS IBL CO2 cooling system

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The Insertable B-Layer (IBL) is the innermost layer of the ATLAS pixel detector; it has been installed on a new beam pipe with reduced diameter and successfully inserted in the Inner Detector (ID) volume. The IBL is a fundamental detector to improve the vertex reconstruction and to provide an additional tracking layer in case of failure or radiation damage in the other three layers of the Pixel Detector of ATLAS. To extract the 1.5 kW power dissipated by its on-detector electronics, the IBL is equipped with an evaporative CO2 cooling system based on a 2-PACL (2-Phase Accumulator Controlled Loop) cooling concept. The cooling plant is connected to the IBL thanks to a long vacuum transfer line of about 90 m that reaches the Muon sector 5 of ATLAS where a junction box, provided with a dummy load and a distribution manifold, are installed. From the manifold box the fluid is distributed to the detector thanks to 14 vacuum flex lines. Vacuum is a very effective thermal insulation system and in cryogenic installation vacuum is quite commonly used to reduce the heat transfer by convection. In our case this choice was fundamental in order to transfer the coolant through a volume in which the dew point is just a few degrees below the ambient temperature and the humidity level could become a serious problem. The 11 meter long stainless steel flex lines are constituted of 3 concentric pipes: starting from the smaller we find the inlet liquid capillary (ø 1.6x0.3 mm), the outlet gas pipe (ø 4x0.5mm) and the vacuum hose (ø 17.2mm). They are made of commercial and customized components. The flex lines concept was mechanically and thermally tested in the laboratory by bending the lines to check if and how this may affect the mechanical stability and thermal insulation. The design criteria were mainly driven by the results of these tests and on the assembly sequence of the parts. The construction of the flex lines was done according to a precise sequence of operations and quality checks; it took about 12 weeks starting from the orbital welding parameters optimization to the final flow tests. The quality criteria were very carefully defined to guarantee the reliability of the lines given that each one cools 7 % of the IBL. This paper is about the concept design, production and qualification of the 14 vacuum concentric flex lines that were successfully installed and are now fully operational. We will present the details of the mechanical assembly process, the solutions we adopted, the tooling preparation and the qualification tests that were carried out in order to guarantee the best performance and long term stability.

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