

# 3D PRINTED PIPES INCLUDING SENSORS AND HEATERS FOR THERMAL MANAGEMENT SYSTEMS IN SPACE AND ON EARTH

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The AHEAD (Advanced Heat Exchange Devices) project has been launched in the frame of the ATTRACT Phase 2 project, which is one of the main partners of the EP R&D program. Among the AHEAD partners, CERN focuses on the implementation of the AHEAD's technology on the detectors' thermal management systems, relying on carbon dioxide refrigeration. In such systems, sensing of local flow parameters is essential for optimized heat exchange across the thermal circuit. However, in the detector's environment, mass and volume can be limited and therefore the integration of sensors might not be trivial. The use of Additive Manufacturing-produced elements within these hydraulic systems provides the necessary freedom of design to address these constraints, while the inclusion of embedded sensing capabilities allows for the precise monitoring of vital parameters throughout the thermal management system. Furthermore, the integration of Energy Harvesting devices provides standalone and wireless monitoring, which can significantly reduce the amount of cabling required in such systems. In this contribution a part of the AHEAD technology is presented which focuses on the development of pipe segments including temperature sensors, heaters and energy harvesters directly integrated into the pipe thanks to advanced processes of Additive Manufacturing.

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