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GFK-Cryostat for a Cryogenic Current Comparator

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A large volume glass-fibre liquid helium cryostat with beam tube was developed for a Cryogenic Current Comparator (CCC). Cryogenic Current Comparators are used for beam diagnostics in accelerators and storage rings.

Measurement problem
Cryogenic Current Comparators (CCC) have been developed for electrical metrology to compare ratios of two electrical currents with the highest precision [1]. This is needed, for example, for high precision measurements of resistances, non-contact measuring of tiny currents or the amplification of small currents.
Intensities of beam currents in particle accelerators or storage rings need to be measurable. A major problem arises if the following requirements must be met:
• the beam has to be (energetically) unaffected
• very small beam currents have to be measured
• reduction of measurements to national standards must be achieved.
In accelerator research, the monitoring and non-destructive measurement of very small beam intensities is a major challenge. The beam currents to be measured are generated by charged particles such as ions, protons or antiprotons. The production of anti-particles is particularly complex and the yield is low.
A solution to this problem is the detection of the magnetic field generated by the moving charged particles using a non-destructive beam monitoring system based on the CCC-principle.
The CCC consists of a superconducting low-temperature SQUID (Superconducting Quantum Interference Device), a superconducting ring-shaped pickup coil and a highly effective meandering superconducting shield. This device enables the measurement of continuous (DC) and pulsed beam currents.
A current resolution of 6 - 65 pA Hz-1/2 depending on the frequency range should be achieved, allowing measurement of ion beams with intensities down to 107 particles per second with high accuracy.
To measure such tiny currents, the CCCs are using dc-SQUID recording techniques, which require cooling with liquid helium (4.2K), i.e. cryostats.
Up to now these cryostats for CCC were made from metallic material. To prevent disturbing currents due to electromagnetical noise they used an essential circuit breaker located in the 4.2K area. Supracon AG innovative design transfers the circuit breaker to an ambient temperature area of the cryostat. An obvious solution is a cryostat made from glass-fibre enforced epoxy. A new approach allows Supracon AG to manufacture the first cryostat for a CCC from epoxy enforced materials such as glass-fibre.

Solution: glass-fibre liquid helium cryostat with beam tube
Our cryostat contains two containers with a high vacuum in-between to insulate the inner container, which is filled with liquid Helium (4.2K). Vapor-cooled radiation shields and super insulation reduce the boil-off rate substantially. The super isolation is placed between the inner and the outer container as well as between the radiation shields.
A beam tube (cold one) is mounted in the inner dewar on the "cold"side. Furthermore, a smaller beam tube (warm side) is mounted inside the first one and is vacuum-tight connected with the outer container. Between the cold and warm beam tube super isolation and radiation shields are located. A special design of the thermal insulation prevents electromagnetic induced currents along the beam tube.
The super isolation and radiation shields are mounted on the inner container. The radiation shields are fixed at the neck. Between each radiation shield, several layers of isolation are wrapped using super isolation foil, aluminium tape, tulle and Kevlar.

Results
Our cryostat covers the following specifications:
Height: 900mm
Diameter: 488mm
Overall diameter: 540mm
Neck diameter: 120mm
Beam tube diameter: 50mm
Helium reservoir: 70l

Repetitive thermal tests confirmed the following thermal performance data of the cryostat (including coil, SQUIDs and cables):
Boil-off rate: about 5 l/d
Holding time: up to 14 d

Outlook
The GSI Helmholtz Centre for Heavy Ion Research in Darmstadt is now subjecting the CCC built in Jena to a series of tests to prepare the device for a future continuous running.

References
[1] I. K. Harvey, "A precise low temperature dc ratio transformer", Rev. Sci. Instrum. Vol. 43, 1972.

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