Design of a multipurpose test facility (MTF) for HTS cables

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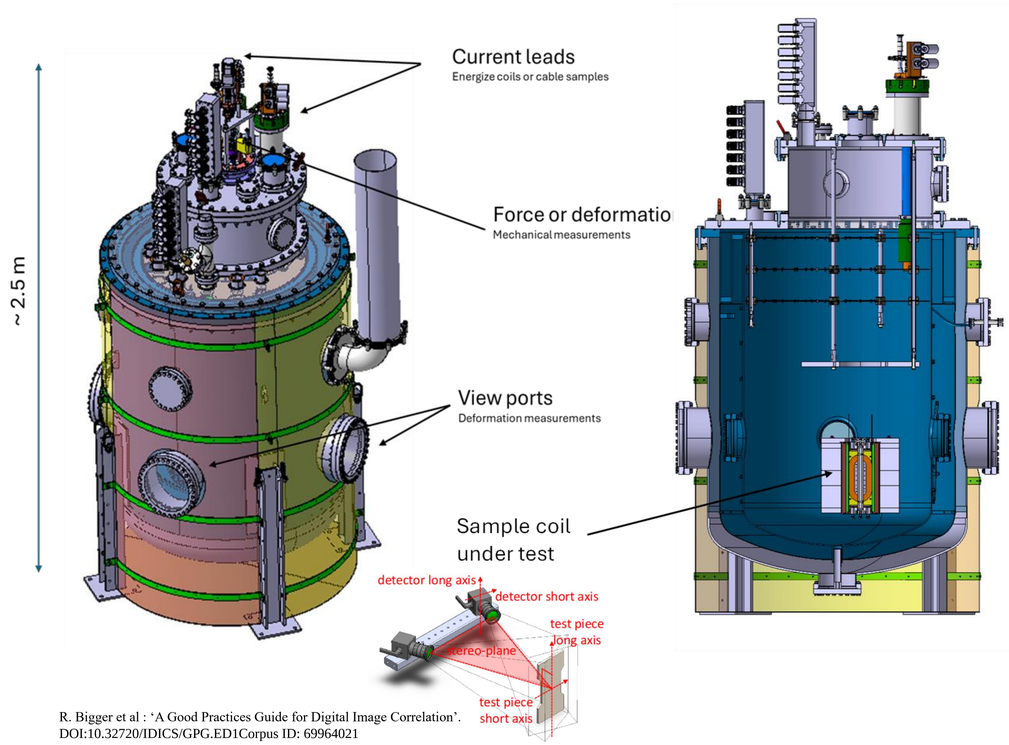
CONTEXT

The High Field Magnet (HFM) program foresees, among others, the systematic measurement and assessment of mechanical, thermal, and electrical properties of high temperature superconductors (HTS) cables. These measurements are key parameters to size coils and magnets, characterize the conductor, verify its performances and control the production quality.
Cable and coil properties must be measured at room temperature, in liquid nitrogen, in helium gas at 20 K – 30 K and in liquid helium at about 5 K. The mechanical and electrical loads can be applied simultaneously or in different combinations. The output data span over a large range of signals: strain measured by strain gages, optical fibres or digital image correlation techniques, critical currents, displacements, and structural deformations.
The proposed multipurpose test facility is a testing station capable of simultaneous measurements to facilitate the development of correlation laws: for example, by powering a small HTS coil at 20 K while measuring its deformation via digital image correlation; or by measuring the critical current in a sample under a given mechanical pressure or after a certain amount of load cycles.

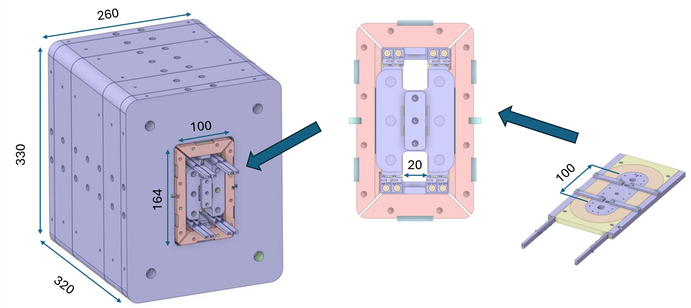
THE TEST FACILITY



R. Bigger et al : 'A Good Practices Guide for Digital Image Correlation'. DOI:10.32720/IDICS/GPG.ED1Corpus ID: 69964021

- **Components**: current leads, access points to apply external loads or displacements, and optical ports to observe the tests using the digital image correlation technique.
- **Structure**: an external vacuum tank, an actively cooled intermediate thermal screen, and an internal pressure vessel.
- **Cooling Options**:
  1. liquid helium bath at about 5 K ,
  2. closed circuit with liquid or gaseous helium. A second independent circuit is available for conduction-cooling of the sample.
- **Size**: can accommodate samples up to 600 mm x 600 mm x 600 mm
- **Temperature Range**: allows tests in vacuum or in a coolant bath with temperatures ranging from 5 K to several tens of Kelvins.
- **Experiment Setup**: the sample and necessary services (cooling pipes, signal wires, current leads, mechanical actuators) are supported by a top removable plate, enabling complete preparation outside the cryostat.
- **Safety and Maintenance**: safety valves, coolant pipes, and level control elements have dedicated ports on the cryostat, independent from the top plate. This simplify quick changes of test samples.

SCALABLE SUPPORT STRUCTURE



On the right a racetrack coil. In the centre, four coils are placed inside the intermediate support plates to form a common coil configuration. Then the system is inserted in the iron cavity and the cold mass is completed (on the left). In this configuration, the field in the centre of the two cavities is about 5 T.

POSSIBLE MEASUREMENTS AT DIFFERENT TEMPERATURES

	Force / Deformat.	View ports	Current leads
Cable / coil Young's modulus	x	x	
Cable elastic limit	x	x	
Cable / coil thermal expansion coefficient		x	
Cable critical current after bending / shearing forces / compression (static load or fatigue)	x	x	x
Coil deformation during cool down and powering		x	x

CONCLUSIONS

In this phase of the HTS coil and magnet development, it is important to have a flexible and short turnaround time installation to measure many different cable samples and coils. In this way it will be possible to assess from the beginning key parameters to design, develop and test multiple options. A multipurpose measuring facility able to deliver the needed possibilities has been designed and is under construction in this moment. Scalable support structures, easy to be installed in the test device, have been designed. They can accommodate systems of coils and reach fields up to 15 - 20 T.