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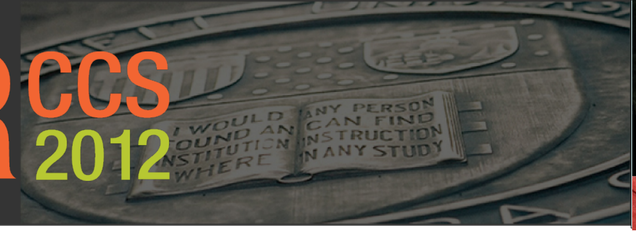
SRCCS 2012



Summer Research for Community College Students – 2012

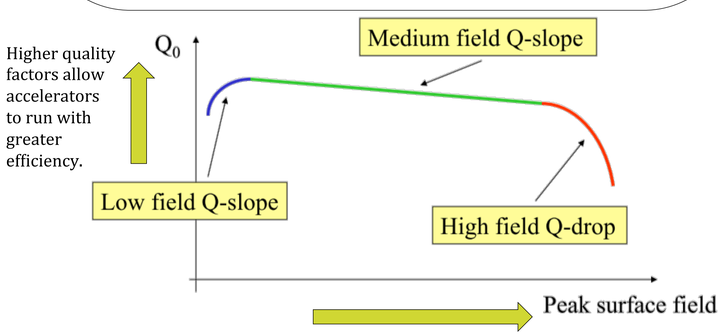
120˚C Bakeout System for Single-cell SRF Cavities

Motivation

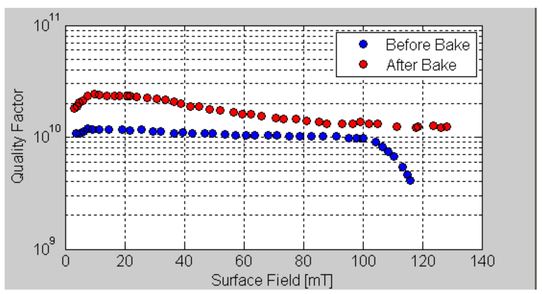
One crucial measurement of Superconducting radio frequency cavities is their quality factor, Q_0. This is the amount of energy stored in the cavity times resonant frequency over power dissipated, or $Q↓0 = \omega U / P↓d$.

SRF cavities are commonly evaluated by measuring quality factor versus accelerating field in the cavity, as seen immediately below.

Researchers have discovered that baking cells at a low temperature (120˚C) for 48 hours with an ultra-high vacuum inside the cavity can dramatically improve performance. Q_0 may be increased by up to a factor of two. This is understood to be caused by the introduction of oxygen impurities into the RF layer of the niobium. This decreases the mean free path of electrons, reducing the BCS contribution to the AC resistance of the superconductor.



Higher field capabilities allow accelerators to be designed with fewer SRF cavities, with each cavity running at a higher accelerating gradient.

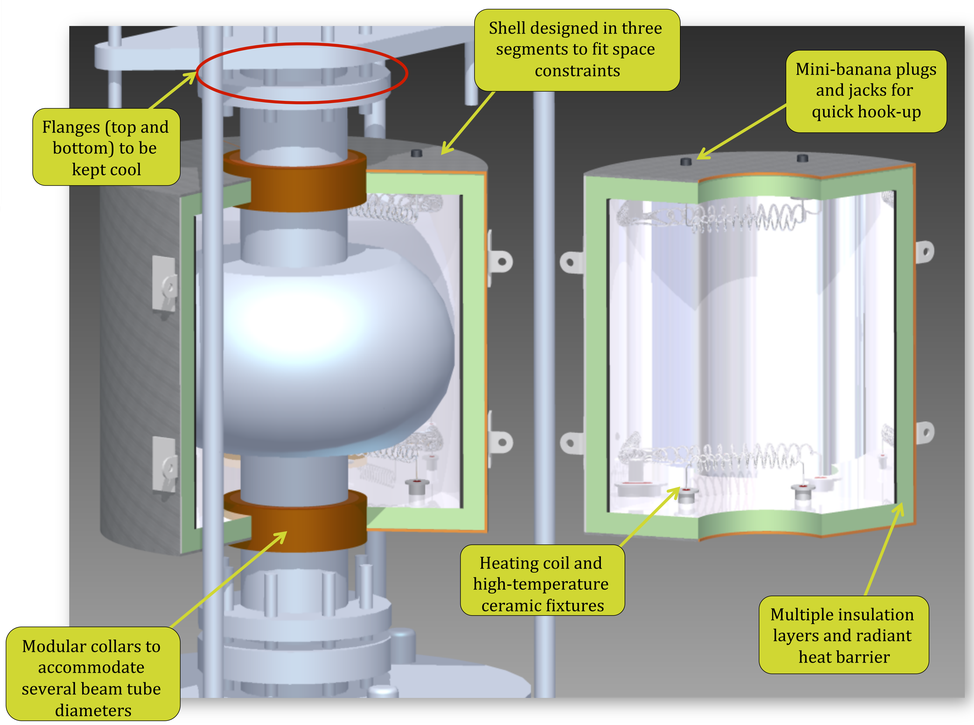


Post-bake Q_0 vs. E plots typically display other important changes, such as the absence of a high field Q-drop.

Images and Data from G. Ciovati, 2004

Design Considerations

The primary goal of this bakeout system is to create an even heating field in order to maximize Q_0 improvement. A second requirement is that the baking system fits within the confines of single-cell cavity test stands, so that an ultra-high vacuum may be maintained during the bake. This also requires that the flanges are kept free from heating, as several cavities utilize indium gaskets with melting temperatures of 153˚C.



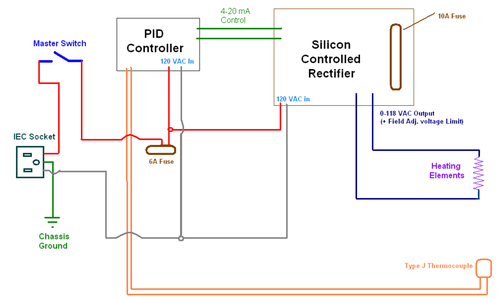
Construction

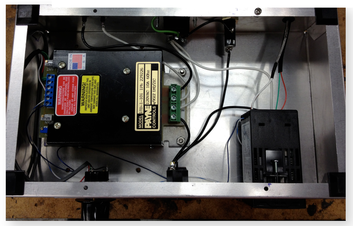
Shell skeletons and clasps:	1/16” 6061 aluminum
Bulk insulation:	½” open-cell melamine
Extra panel insulation:	0.079” super-insulating aerogel
Collars, gasket:	Extreme-temperature silicone rubber
Radiant barrier:	Ultra-high vacuum aluminum foil
Heater coils:	22 AWG nickel-chrome wire

Heater Control System

The heating system was designed from the ground up to offer fine control over the heating elements:

- PID temperature controller reads cavity temperature via thermocouple, adjusts the control signal sent to silicon controlled rectifier (SCR).
- The SCR outputs proportional current to heater coils.
- Secondary fuse protects control electronics, limits maximum heating. Accepts standard AGC fuses.
- System fused for 540W. Maximum power: 1180 W.





Completed chassis

Heater coil test

Testing and Validation

The control system has been completed and tested. The shell segments will be completed by the end of the SRCCS program.

Initial testing of the new bakeout system is scheduled to begin in August 2012. The performance gains of cavities baked with the new system can then be measured against the gains achieved with the old baking system. Fine adjustments can be made to the temperature programming and heater coil geometry.

In the event that a uniform heating field cannot be obtained with the heating coils, a design and set of drawings have been prepared for a forced air variant of this bakeout shell.

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