DESIGN, CONSTRUCTION AND PERFORMANCE OF A POST TYPE CRYOGENIC SUPPORT

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ABSTRACT

A support member for superconducting magnets and other cryogenic devices has been designed, fabricated and structurally and thermally evaluated. The member is a cylindrical post constructed with fiber reinforced plastic (FRP) tubing and having metallic heat intercepts and end connections. All FRP to metal connections are made by mechanical shrink fitting and do not employ adhesives or fasteners. The post can operate in tension, compression and flexure or in combinations of these loads. The details of the design and construction are enumerated. Structural performance has been measured in tension and compression at 80 and 300 K and in flexure at 300 K. Creep effects on the shrink fit joint reliability are being evaluated. Thermal performance has been measured for a post with ends at 4.5 and 300 K and with heat intercepts at 10 and 80 K. The measured performance has been compared with the analytical predictions. Full scale, working, prototype posts have been successfully utilized in several model cryostats for the Superconducting Super Collider dipole magnet development program.

INTRODUCTION

As a part of the conceptual design of superconducting magnet cryostats for the Superconducting Super Collider (SSC), a post type cryogenic support has been developed, built and tested.

As a result of their function in the SSC accelerator rings, the magnets have a small cross-section, a ~5 cm bore, and are relatively long. The magnet coil assembly must be suspended by a system that provides position stability, low refrigeration loads, high reliability, installation and adjustment ease, and low cost construction. The suspension system must provide support during magnet assembly, shipping and installation, cooldown and warmup phases, steady state operation and upset conditions.

An iron-less cosφ magnet configuration for the SSC dipole imposes a unique design requirement for the suspension system since magnetic forces can exist between the coil assembly and the steel vacuum vessel...
required for magnetic shielding. The forces are caused by an offset of the axes of the coil and vacuum vessel assemblies due to component manufacturing and assembly tolerances. Since the offset can be random, the force can occur in any direction in a plane normal to the magnet axis. The magnitude of the forces can be high, about 3 times the assembly static weight. The effective spring constant of the suspension system must be greater than the displacement spring constant of the coil-iron coupling in order to prevent a runaway condition where the coil is displaced until it touches the iron.

After consideration of several types of suspension systems, a cylindrical post type support was selected for the iron-less cosθ SSC dipole. The main features of the post are as follow:

- **Load Carrying Versatility** - A cylindrical section results in a support that can carry tension, compression, bending and torsional loads.
- **Low Heat Leak** - The use of FRP materials with effective heat intercepts results in predictably low heat leaks.
- **Installation and Adjustment Ease** - The post, involving only a single support member at a suspension point, simplifies installation and adjustment.

**GEOMETRY**

The basic elements of the post support are the tubular sections that comprise its major structure. A tubular section allows for the development of flexure and torsional stiffness while maintaining a small cross-sectional area. Depending on the geometrical and/or structural requirements, the support can consist of a single tube, stepped tubes or reentrant tubes. Possible geometries for a 300 to 4.5 K support are as shown by Fig. 1.

The dimensions of the tubular elements are determined by simultaneous consideration of stress, deflection, heat leak, creep and the installation geometry. For the iron-less cosθ magnet, short and long term position stability; i.e., creep, were the controlling design conditions which resulted in a lightly stressed design.

In order to accommodate the axial thermal contraction from ambient (300 K) to operating (4.5 K) conditions of the coil assembly relative to the vacuum vessel the support is hinged at its ends or incorporates a slide at one end.

![Fig. 1. Post support geometries](image-url)