Vacuum Chamber For The 3 GeV SPEAR Injector Synchrotron

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Abstract

A 3 GeV booster has been constructed at the Stanford Synchrotron Radiation Laboratory to function as a dedicated, full energy injector into the SPEAR storage ring. [1] Electrons are injected at 120 MeV and accelerated at a cycle rate of 10 Hz to the final energy. The vacuum chamber for this synchrotron has been constructed to avoid eddy current effects due to the rapid changing magnetic field. The chamber consists of stainless steel tubing of 0.3 mm wall thickness, compressed to an elliptical form, with external stiffening ribs. [2] The suitability of such a vacuum chamber for booster synchrotrons has been tested at cycling rates of up to 15 Hz without intolerable heating or detrimental effects on the magnetic field for the beam.

I. INTRODUCTON

The principal vacuum system for the SSRL Injector Booster (32 arc magnet chambers) consists of a thin-walled, ribbed, elliptically shaped (32 x 60 mm) stainless steel chamber. The thin-walled tube was used in order to avoid eddy current effects, and to provide a smooth elliptical beam aperture with a maximum beam space. To form and maintain the chamber shape, and to prevent chamber collapse during pumpdown, stiffening ribs (placed at 25.4 mm intervals), weld flanges, and clamp flanges were brazed to the outside of the chamber.

The vacuum chamber profile was designed to fit into all three magnet apertures (Fig. 1).

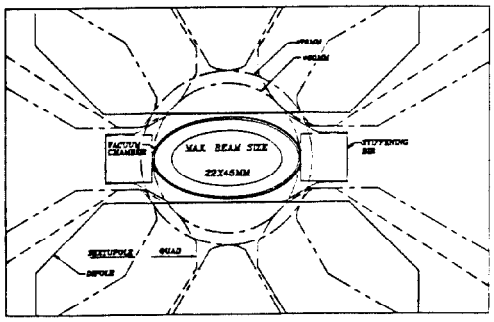

FIG 1 : BEAM SIZE/MAGNET/VACUUM CHAMBER APERTURES

The arc magnet chambers were fabricated from short straight chamber segment lengths of 12 cm to 65 cm. The short chamber segments were welded together to form complete arc magnet chambers of 3.12 M and 3.19 M lengths. The completed assemblies formed chambers which matched the beam curvature and nestled neatly between the dipole 5-block segments, quadrupoles, and sextupoles of the magnet girders. (Fig. 2) [3]

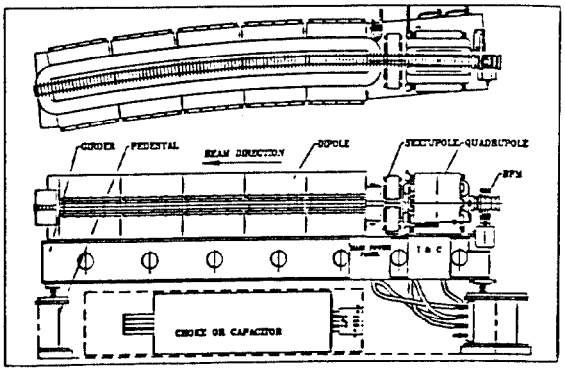

FIG. 2 QF ARC GIRDER

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II. FABRICATION TECHNIQUES [4]

As noted previously, the vacuum chambers were made out of stainless steel. Type 316L was specified for the stiffening ribs (Fig.3) and the round thin-walled seamed tube. Type 304L was specified for the end weld flanges (Fig. 4) and clamp flanges (Fig. 5). The stiffening ribs and weld flanges were stamped out of sheet metal and the clamp flanges were a machined component.

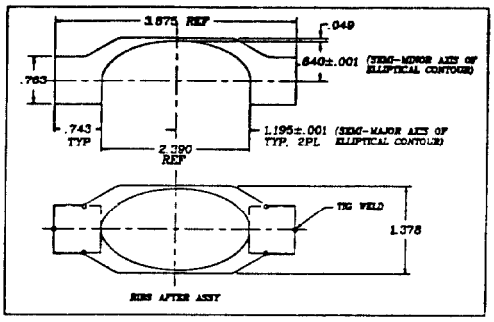

FIG 3 : STIFFENING RIB

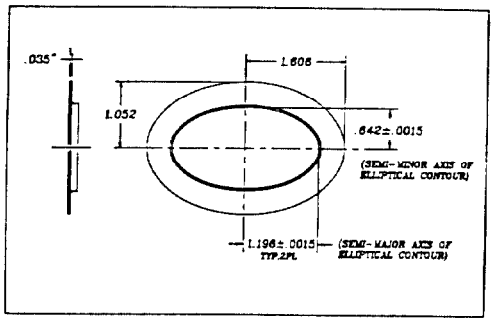

FIG 4 : WELD FLANGE

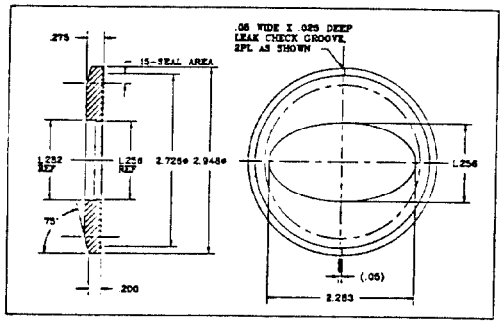

FIG 5 : CLAMP FLANGE

The thin-walled tubing was cut to the appropriate segment length and pre-formed to a 39 x 56 mm elliptical shape by an aluminum pre-forming fixture.

The stiffening ribs essentially form 2 halves of the required 32 x 60 mm elliptical chamber shape. The ribs were placed into a rib loading fixture and compressed onto the pre-formed tube. The ends of the ribs were then tack-welded at 6 places (3 on each end) to maintain the tight fit required for the brazing step. A total of eight chamber segments (4 different types) were required for each arc magnet chamber assembly.

The ribbed tube was placed into its appropriate end flange assembly fixture to correctly align the flanges to the tube. Each flange was then tack-welded to the tube to maintain its position during brazing.

The ribs and end flanges were brazed to the tube in a hydrogen atmosphere furnace at a temperature of 1025°C. Any voids between the ribs or flanges were filled by a slurry of copper powder, nicro-braze cement, and acetone. The braze alloy was 35/65 wire and powder.

The brazed and leak tested chamber segments (Fig. 6) were then placed in position onto the arc magnet chamber assembly fixture (Fig. 7). The weld flanges were clamped together for final TIG-welding.

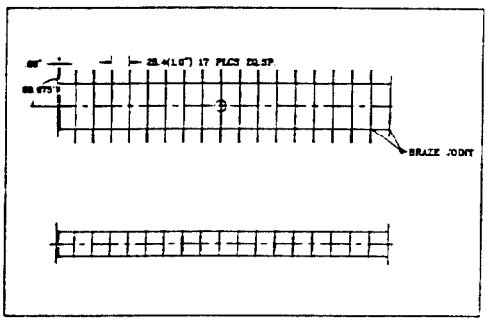

FIG 6 : CHAMBER SEGMENT

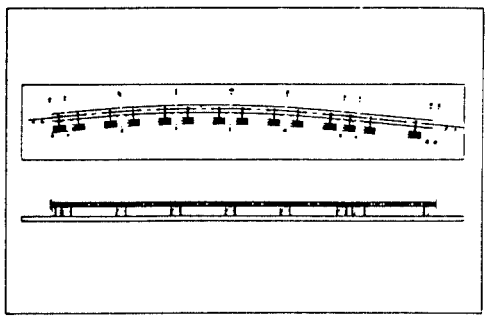

FIG 7 : ARC MAGNET CHAMBER WELD FIXTURE

The completed arc magnet chambers were leak tested and stored for future magnet girder installation. In the injector ring, the vacuum system was interconnected by either quick-release

installation. In the injector ring, the vacuum system was interconnected by either quick-release clamp type smooth face flat flanges or conflat-type knife edge flanges. All-metal seals of aluminum (Helicoflex delta-seal) or copper were used throughout the ring.

A very stringent quality control program and tracking system was adopted for all fabrications and assemblies.

III. RESULTS

Eddy currents generated through the Injector bend magnet vacuum chamber as calculated and plotted by POISSON are not excessive (Fig. 8) [5].

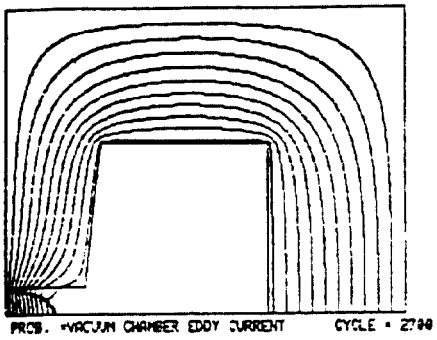

FIG 8 : VACUUM CHAMBER EDDY CURRENT

Several vacuum chamber segments were pressure tested to prove the integrity of the design and assembly. Results showed the chamber design greatly exceeds requirements, deflecting slightly at two atmospheres, and collapsing at >10 atmospheres (Fig. 9) [6].

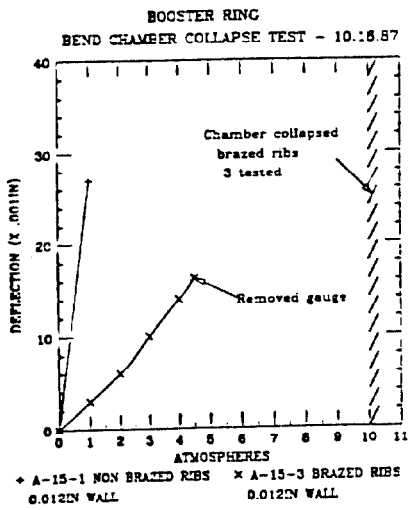

FIG 9 : CHAMBER SEGMENT COLLAPSE TEST

Assembly and installation ran very smoothly, and to date we have had no failures. The ring vacuum system was built on schedule, and within budget.

IV. ACKNOWLEDGEMENTS AND CONTRIBUTORS

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[2] J. Kouptsidis, et al. A Novel Fabrication Technique For Thin Metallic Vacuum Chambers With Low Eddy Current Losses. IEEE., Vol. NS-32, No. 5, Oct. 1985.

[3] M. Baltay, et al. The Ring Magnets For The SSRL SPEAR Injector. IEEE, PAC, May 1991.

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[6] H. Morales, Vacuum Chamber Pressure Deflection Tests, Summary. SSRL Injector Technote #67, March 1988,