

# Structural tests of selected prototype dipole magnet vacuum chambers

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STRUCTURAL TESTS OF SELECTED  
PROTOTYPE DIPOLE MAGNET VACUUM CHAMBERS

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# STRUCTURAL TESTS OF SELECTED PROTOTYPE DIPOLE MAGNET VACUUM CHAMBERS

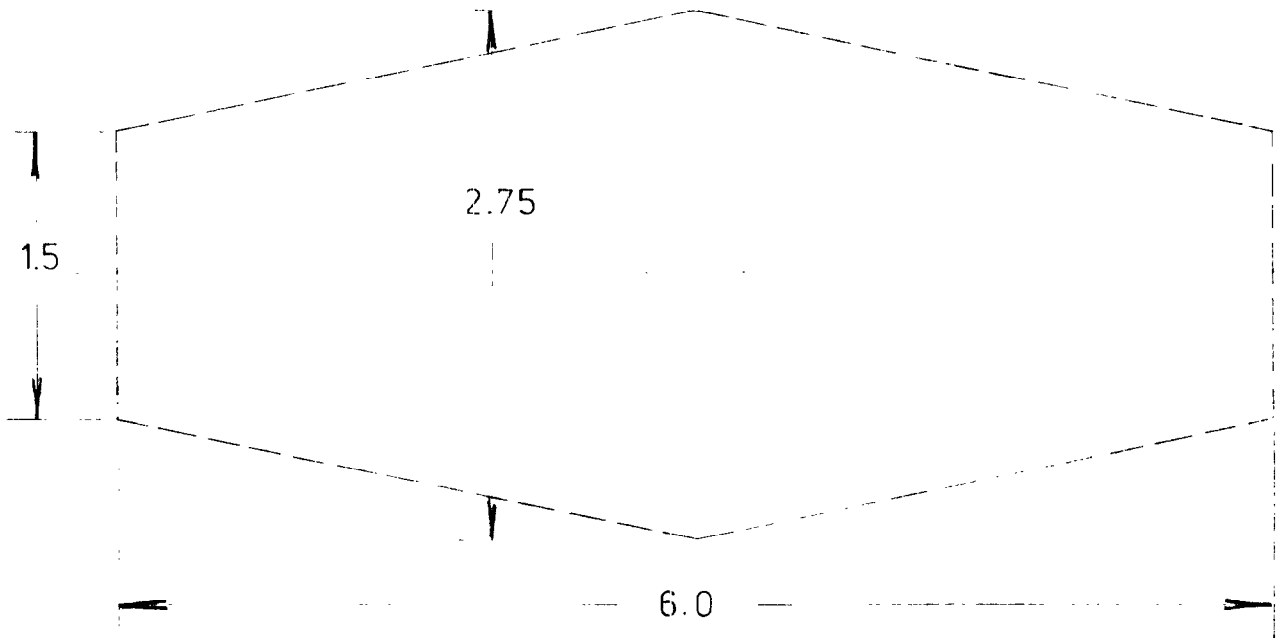
B. McDOWELL

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## INTRODUCTION:

Three vacuum chambers each 24" long were produced by Central Shops to measure elastic and permanent dimensional changes under vacuum conditions.

The chamber cross-sections were designed to have the unobstructed internal area shown below, as per Y. Y. Lee.



Sample 1 is a scaled down AGS type chamber manufactured in Central Shops to the nominal dimensions of (figure 1). The sample was produced on a brake press

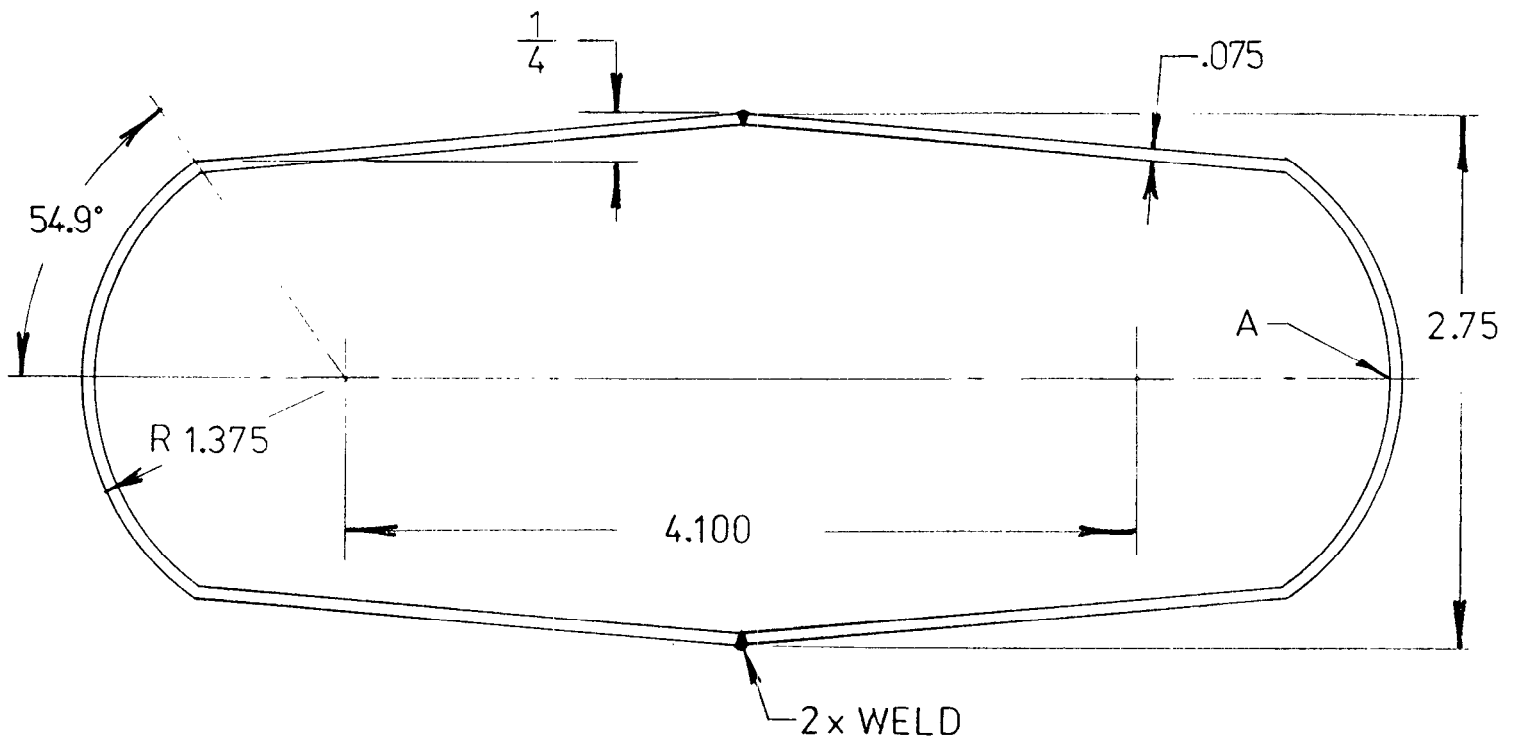


figure 1  
AGS TYPE CHAMBER

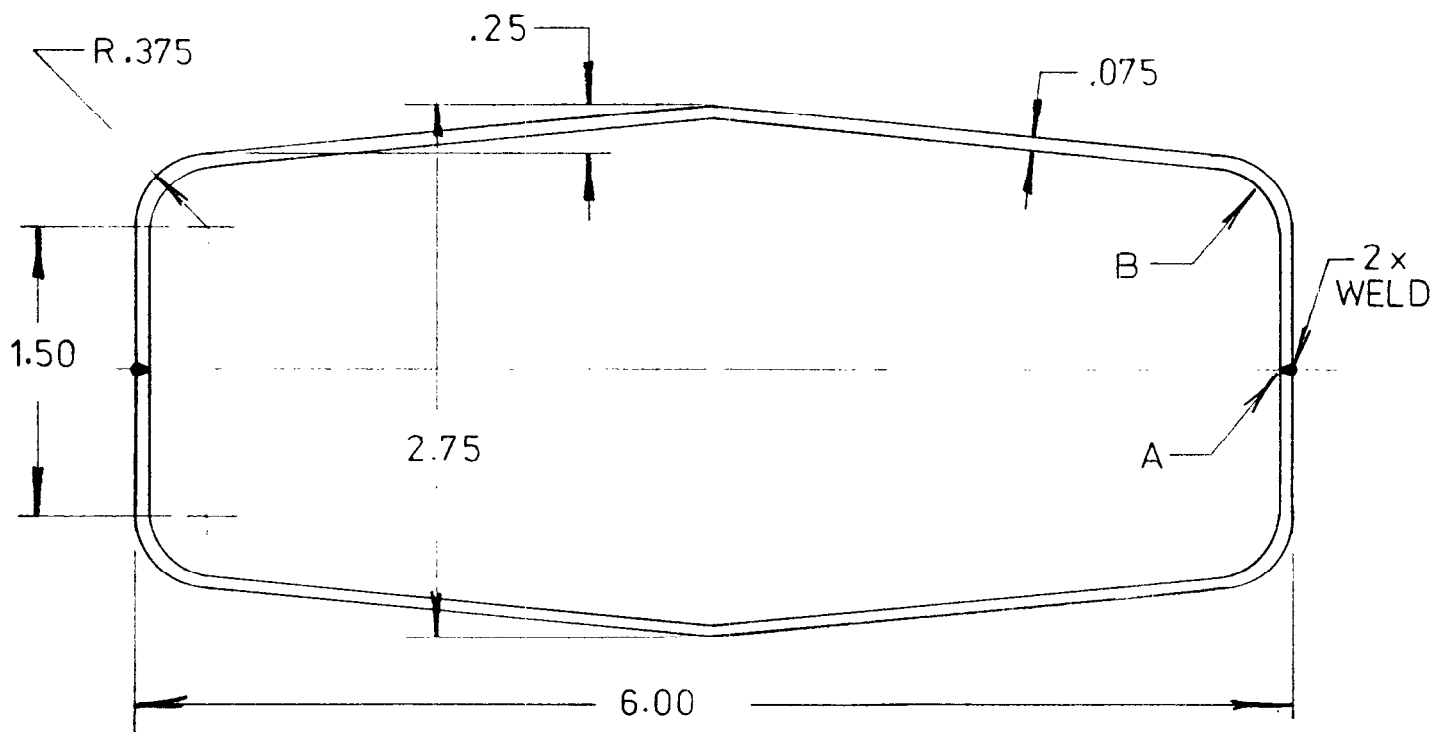


figure 2

in two halves from 14GA (.075") Gr 316L stainless steel. The two halves were then heliarc welded to form a tube as shown in figure 1.

Sample 2 was manufactured in similar fashion from 14GA (.075") GR 316L stainless to the nominal dimensions of figure 2.

Sample 3 was manufactured from 16GA (.060") GR 304 stainless steel to the dimensions of figure 2. The reader should keep in mind the only significant mechanical difference between 316L and 304 is the yield point stress of 30,000 psi and 35,000 psi respectively.

The height and width of the three samples were measured, at three locations prior to, during, and after application of a 175 micron vacuum.

#### RESULTS:

The results are self explanatory and presented in tabular form.

Dimensions expressed are the average of three measurements.

	<u>Sample 1</u>	<u>Sample 2</u>	<u>Sample 3</u>
Maximum stress (psi)	44,000(a)	32,500(a)	49,500(a)
Point of maximum stress (see figures 1 & 2)	A	B	B
Original height (in)	2.885	2.746	2.666
Original width (in)	6.779	6.011	6.053
Height reduction under vacuum (in)	.242	.180	.401
Width increase under vacuum (in)	.071	.043	.113
Permanent height reduction after 1 vacuum cycle (in)	.038	.024	.120
Permanent width increase after 1 vacuum cycle (in)	.008	.010	.048

(a) calculated using ANSYS finite element analysis program.

#### DISCUSSION OF CHAMBER GEOMETRY:

The cross-section depicted in figure 2 has incorporated many improvements over the elliptical and near elliptical cross-sections thus far suggested.

By adopting the flattened sides shown in figure 2 the maximum stress is improved from 44,000 psi to 32,500 psi.

This is accomplished by reducing the overall span needed to attain the requisite internal dimensions. Stresses are further reduced by distributing them between two small radii rather than one large one.

The location of maximum stress is advantageously moved from point A to point B in the figure 2 option (see figure 2). Because of this, a seam weld can be placed at A without mechanical disadvantage. Magnetic effects induced by welding would cause the minimum field distortions at location A.

Finally, an improvement in elastic deformation from .242" to .180" makes the figure 2 option the most attractive non-reinforced option thus far investigated.

#### DISCUSSION OF CHAMBER WALL THICKNESS:

The strength of various cross-sections and the geometric parameters that govern that strength have been thoroughly investigated.<sup>1,2</sup> The figure 2 option is probably approaching the optimum in a non-reinforced chamber of uniform thickness.

Stresses and deformations of non-reinforced .060" wall chambers over a 6" span are excessive. If possible, a wall thickness of .075" should be adopted for the dipole (b) vacuum chamber.

(b) .060" would be acceptable for the round cross-section of the quadrupole vacuum tube.

References:

- 1) J. G. Cottingham, Booster Vacuum Chamber Considerations, BST/TN 30, (1986).
- 2) B. McDowell, Proposed Beam Tube for Eddy Current Test, BNL memorandum, ADD, (4/23/86).