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Effects of Substituting all Kapton covered wedges for the Kapton-Glass Epoxy Tape covering normally used on SSC 50mm Short Inner Coils

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Introduction

The present procedure for molding SSC 50mm Coils at FNAL calls for first winding the cable and wedges with a 50% overlapped layer of .001" Type-H Kapton film . Then this .002" of Kapton is overwrapped with a single layer of .0045" nominal thickness woven glass tape impregnated with 15 to 20% uncured epoxy. Upon stripping the cured coil out of the steel mold it was observed that the outside radius of the wedge bars either stuck to the mold liners or parted from the liner but retained a metalic stain. This suggests that the very high local pressures of the outside radius of the wedge bars was causing the glass fiber overwrap to *"dig in"* to the steel mold. The inside of the steel liner displayed a matching cloth pattern imprinted by the glass fiber abrasion along the areas of the wedge bars.

By adjusting the recipe of the mold release and adding a *"mold conditioning"* step consisting of oven baking a first coat of mold release, the gross sticking of the glass tape to the liner was greatly reduced. However the staining of the glass fiber by the steel liner was still evident. The local pressure points created by the fibers in the glass were exceeding the film strength of the mold release coating.

There is also evidence in the sizing data of these coils that suggests that there are considerable frictional forces between the coil and the curing mold retainer keeping the coil from being smoothly and evenly centered and compressed into the mold during the curing process.

As an experiment to try to eliminate the abrasive effects of the wedges on the mold walls and reduce friction so that the coil being molded would better center itself in the mold, three SSC 50mm Model Inner Coils were molded with a 50% overwrapped layer of .001" thick Kapton tape substituted for the standard single layer of glass epoxy tape on all the wedges.

Measurements of wedges on coil cross sections ("cookies") showed that the two layers of glass tape between the cable and wedge averaged .0035" or .00175" for each compressed and cured layer of glass epoxy tape. The two layers of .001" standard Kapton tape, for a total thickness of .002", at face value, should have produced a total coil size error of (6 layers X (.00025") = .0015" over size.

The results of the experiment are shown in Table 1. The three experimental coils, 122, 123, and 124 have been compared to earlier coils 113 thru 117 which were chosen because they were all run from the same reel of cable and were cured using identical parameters. However, coils 122, 123 and 124 did have a 5 mil Stop Bar shim added as part of a correction called for from a larger collaring force balance study. The 5 mil shim has been producing about 2.5 mils of coil growth. To compare the shimed coils with the unshimed coils the "W/O Shim" row subtracts the 2.5 mils. The size range dropped from .0059" to .0024" or -59.3%. the standard deviation dropped from .0015" to .0005" or -66%. The modulus of elasticity dropped from 2.36 E+06 to 2.07 E+06 or -12.3%. The whole coil average size dropped a suprising 2.8 mils (after correcting for the shim).

All of these changes point to a significant reduction in coefficient of friction between the coil and the retainer. Because the wedges were now able to slide more easily against the retainer the sizing bars were better able to pack the individual turns of the left and right coils sides against the pole key.

Figure 1 shows the *"Horizontal error"* of the coils used for this study. This horizontal error is defined as coil quadrant I/III minus coil quadrant II/IV the quantity divided by two. This is a measure of the symmetry of the two sides of the coil. The reader will notice the non-systematic nature of coils 113 thru 117 and, while still not systematic, coils 122, 123 and 124 are lower in amplitude. The writer submits that the non-systematic nature of the horizontal error is a measure of the friction between the coil and mold.

Figure 2 shows the *"Vertical error"* of the study coils. Vertical error is the sum of the absolute value dimensions of the two coil quadrants divided by two. This gives a measure of how the dimensions of each segment of both sides of the coil vary from the whole coil average. Although the segment by segment variations of these curves are related to the dimensional errors (tolerance) of the mold parts of the scatter of each point is probably related to the friction of the coil to the mold. The reader will notice that vertical errors of the first three Kapton wedge coils, 122, 123 and 124 are very low and very close to each other. Obviously more coils need to be molded to confirm this trend.

The lower average modulus of elasticity could also be explained by the apparent lower coil friction to the mold. First, during curing in the mold the force of the sizing bars were more evenly transferred down the curve of the coil instead of losing part of this force at each wedge to friction to the retainer wall. Now the top third of the coil is less dense because the first wedge was able to slide down. The same follows for the middle and bottom thirds of the coil. Second, when the all Kapton wedge coil is measured the same lower wedge-to-measuring fixture friction allows the coil to compress more evenly and yield a lower M.O.E. reading.

Future Works

1. More inner and outer 50mm Short Coils will be molded with all Kapton wedges to build the data base.

2. Several practice coils will be molded with different stop bar shims to obtain data on shim corrections with the all Kapton wedges

References

1. Terry Skweres, 50mm Short Coil Azimuthal Sizing Report

2. Jim Cahill, Computer Graphics for Figures 1 and 2 of this paper.

Comparison of Short 50mm Inner Coil With Glass-epoxy tape or Kapton as Outer Wrap of Wedges

INNER COIL #	QUAD I/II AVG. W.R.T.M. (INCHES)	QUAD II/IV AVG. W.R.T.M. (INCHES)	WHOLE COIL AVG. W.R.T.M. (INCHES)	SIZE RANGE (INCHES)	WHOLE COIL STD.DEV. (INCHES)	MODULUS OF ELASTICITY COIL AVG. (X E+06)	CABLE REEL S/N
113	0.0055	0.0059	0.0057	0.0047	0.0013	2.34	3500021
114	0.007	0.0068	0.0069	0.0046	0.0012	2.3	3500021
115	0.007	0.0054	0.0062	0.0071	0.0017	2.42	3500021
116	0.0069	0.0068	0.0069	0.0072	0.0019	2.35	3500021
117	0.0057	0.0064	0.0061	0.0058	0.0014	2.38	3500021
AVG. OF 5	0.0064	0.0063	0.0064	0.0059	0.0015	2.36	
122	0.0058	0.0054	0.0056	0.0025	0.0007	2.05	PRACT."F"
123	0.0058	0.0047	0.0053	0.0027	0.0004	2.09	3500026
124	0.0054	0.0047	0.005	0.0021	0.0005	2.06	3500026
AVG. OF 2	0.0057	0.0049	0.0053	0.0024	0.0005	2.07	
W/O SHIM	(-.0025) .0032	(-.0025) .0024	(-.0025) .0028				
%CNG.	-50%	-62%	-56%	-59.3%	-66.6%	-12.3%	

W.R.T.M. = With Respect To The Master

TABLE 1

SHORT INNER COIL (113-117 & 122-124)
HORIZONTAL ERROR (IN) VS POSITION NUMBER

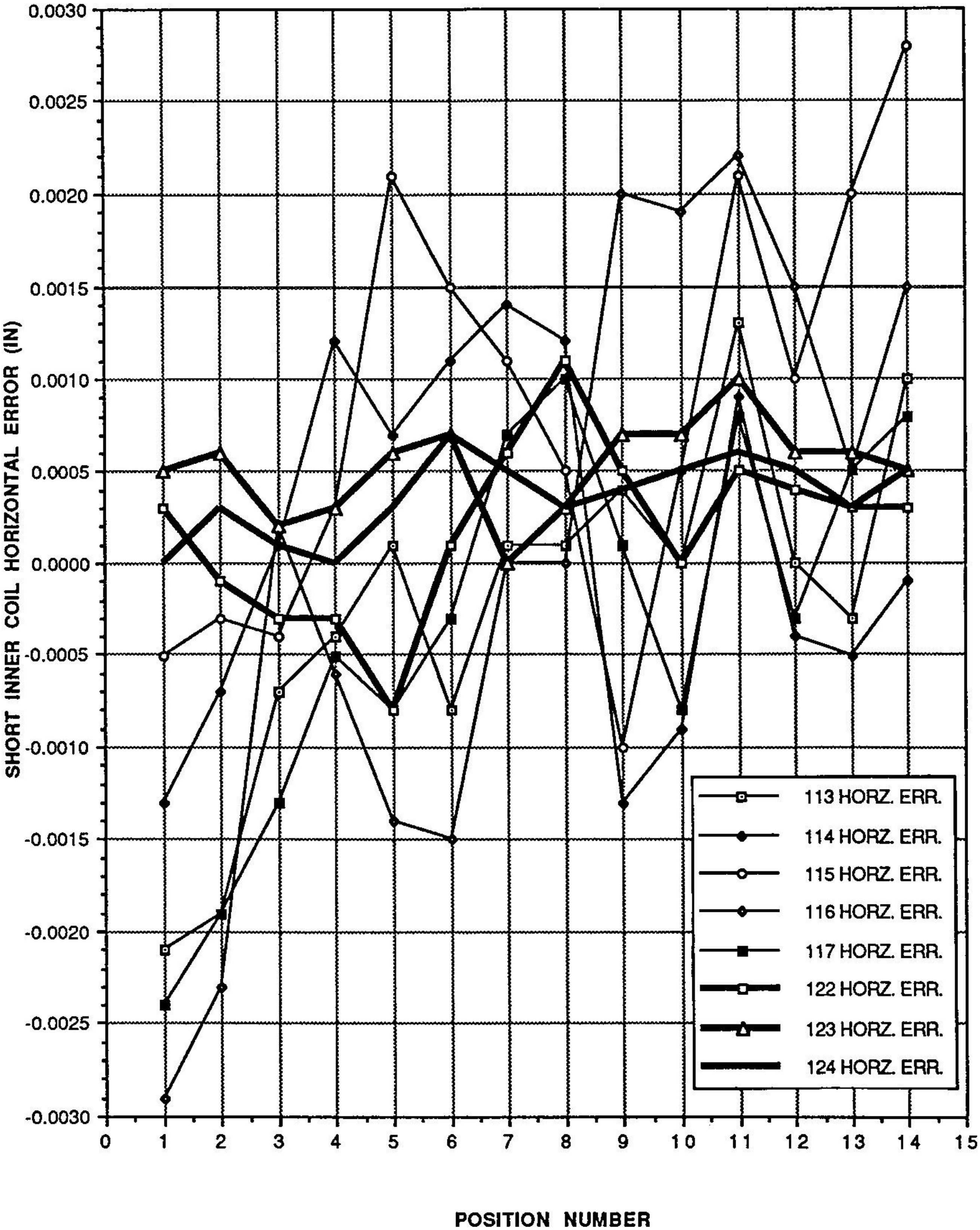

FIGURE 1

SHORT INNER COIL (113-117 & 122-124)
VERTICAL ERROR (IN) VS POSITION NUMBER

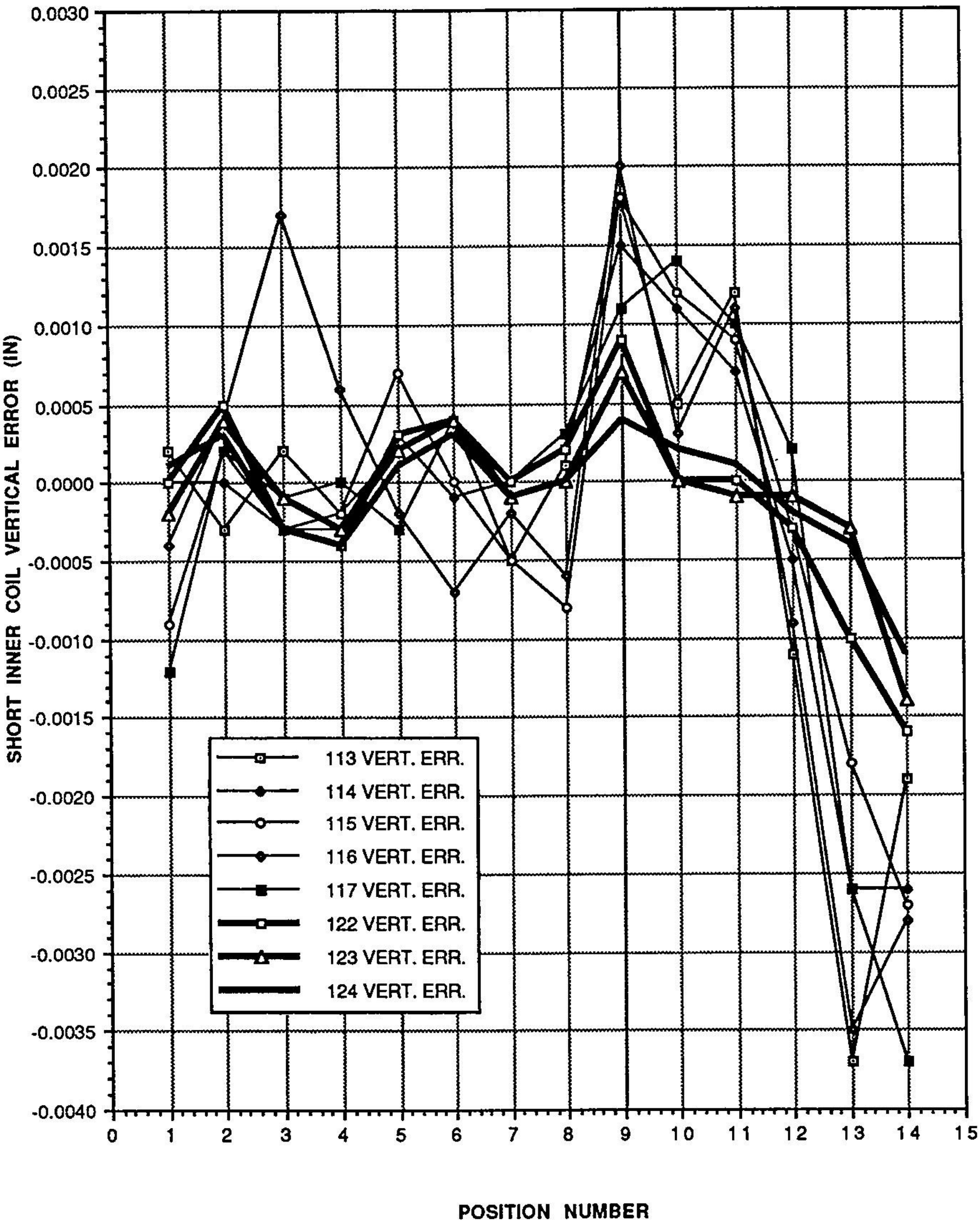

FIGURE 2