Fermilab

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MEMO TO: R. Bossert, J. Carson, S. Delchamps, N. Hassan, J Kerby, W. Koska, D. Sims, M. Wake, M. Winters

FROM: Jim Strait

SUBJECT: End Clamp Design: Choice of Materials

Up to now our discussions about the end clamp have concentrated mostly on the return end because it is "simpler." The added "complication" of the splice at the lead end, however, may change our conclusions about what materials are most desirable. At the return end it is clear that 4 K prestress is maximized by using material with the largest thermal contraction for the outer cylinder and with the smallest thermal contraction for the four piece "insulator." Only the radial contraction matters; because of the 30 mil gaps between the pieces, the azimuthal contraction is irrelevant.

At the lead end, because of the green putty used to hold the splices, it is possible that all four gaps are closed after assembly. If the "insulators have a small thermal contraction in the azimuthal direction, then with cooldown the clamping pressure on the splices will increase, but little of the increase in the azimuthal stress of the outer cylinder will be transferred to the coil as radial pressure. In the extreme case the four insulators might act as a solid cylinder of low thermal contraction material, which would result in a very large coil prestress loss. As far as the coil is concerned, a material with small radial and large azimuthal thermal contraction would be ideal. In this case, however, the clamping pressure on the splice, which is minimal at room temperature, would decrease.

If the outer cylinder and the "insulators" both had the same thermal contraction as the coil, then there would be no change in prestress with cooldown either on the coil or the splice. This would be the case if aluminum were used for all the end clamp parts. Stycast has a thermal contraction somewhat larger than aluminum, but presumably could be loaded with low contraction material to give a composite that matches aluminum.

There are two draw backs to an all-aluminum design: 1) there would be a discontinuity at the collar-end clamp boundary in that the coil prestress would change with thermal cycling on one side and not the other, (it is, of course, not obvious that this is a real problem) and 2) the splice is clamped with essentially zero pressure at operating temperature. If both the outer cylinder and the "insulators" were made of stainless steel then the behavior of the end with cooldown would more closely match that of the body. Because the coil shrinks faster than the end clamp, the clamping force on the splice should increase modestly. If the outer cylinder were aluminum and the "insulators" were stainless steel, then the splice clamping force would increase more. At the return end (and at the lead end to the extent that the "insulator-insulator" gaps are open at room temperature) the coil prestress would increase with cooldown.

The following table summarizes my expectation for the prestress change with cooldown at the return end, lead end and in the splice.

		Cylinder	
		Aluminum	Stainless
"Insulators"	Aluminum	0, 0, 0	--, --, -
	Stainless	+, *, ++	-, -, +

*Depends on the extent to which the insulator gaps are open.

I suggest that Jim run his ANSYS model for an aluminum cylinder (twice the current thickness) with stainless and aluminum "insulators" and for the all-stainless case. If possible he should run these both with the the "insulator" gaps open (return end) and with the gaps closed after preload (lead end).

My conclusion is that if a discontinuity in prestress loss at the magnet end is deemed not to be a problem, then the stainless "insulator," aluminum cylinder design is clearly favored. Otherwise the all-stainless design appears best. I solicit your comments on this.