# EFFECT OF A LINEAR TAPER OF CONDUCTOR THICKNESS ON MAGNETIC FIELD QUALITY: SSC RING DIPOLE MAGNETS

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A systematic variation in conductor thickness (azimuthal dimension of in-place conductor) has a potential for producing large field errors. If the conductor near the pole is thinner than that near the midplane, then the centers of all the conductors are pushed toward the pole. In this report we consider, simply, a linear taper in conductor thickness. Higher-order tapers could be considered, but the linear taper will serve to define the magnitude of the problem. By no means, however, is the linear taper the worst case.

I am told that such a taper can indeed exist. It can be caused by thermal expansion of the turkshead as it warms up during a run of cable. While steps can be taken to eliminate it, it seems unlikely that it can be reduced to zero. At present there is no specification on taper; there is only a specification on thickness variation. In the absense of such a specification, one must assume that such a taper can exist.

The results of this study are shown in Table 1, showing sensitivity to unit error in conductor thickness, plus and minus from nominal. The first pair of columns of sensitivities are for a taper, from maximum at the pole to minimum at the midplane, for the conductor in both layers of the top half of the coil. The last two pairs of columns of sensitivities are for a taper also in the bottom half of the coil, either in the same sense or in the opposite sense to that in the top half. Some multipoles add, others cancel.

The mathematics of the calculations will be described fully in a separate report, but is described here briefly. The coil is approximated by one in which the sides of the blocks of conductor are radial ("fully keystoned" conductor). The positions of the block edges at the pole and the midplane are considered fixed. (Variation of those positions is considered elsewhere.) The wedges separating blocks are assumed to be infinitely rigid; the conductor is assumed to be uniformly elastic. An error in the thickness of any one conductor causes azimuthal displacements of all conductors. The field error multipole coefficients, and their derivatives with respect to azimuthal displacements, are calculated as if the conductor has zero azimuthal thickness. The yoke is assumed to have infinite permeability.

TABLE 1
Sensitivity of Magnetic Field Quality to
End-to-End Conductor Thickness Taper.

"Units"* for a taper from nominal+0.001 in. to nominal-0.001 in.

| Multipole order | Tapered conductor in ... | | | | | |
|---|---|---|---|---|---|---|
| | Top half only | | Top and bottom halves, same senses | | Top and bottom halves, opposite senses | |
| | Real, skew A | Imag., normal B | Real, skew A | Imag., normal B | Real, skew A | Imag., normal B |
| Dipole | 0 | +7.37 | 0 | +14.7 | 0 | +14.7 |
| Quad. | -3.97 | 0 | 0 | 0 | -7.93 | 0 |
| Sext. | 0 | +3.44 | 0 | +6.88 | 0 | +6.88 |
| Oct. | +0.702 | 0 | 0 | 0 | +1.41 | 0 |
| Dec. | 0 | +0.182 | 0 | +0.364 | 0 | +0.364 |
| 12-pole | +0.104 | 0 | 0 | 0 | +0.208 | 0 |
| 14-pole | 0 | +0.0016 | 0 | +0.0033 | 0 | +0.0033 |
| 16-pole | +0.0087 | 0 | 0 | 0 | +0.0175 | 0 |
| 18-pole | 0 | +0.0003 | 0 | +0.0007 | 0 | +0.0007 |
| 20-pole | +0.0010 | 0 | 0 | 0 | +0.0019 | 0 |
| 22-pole | 0 | +0.0001 | 0 | +0.0002 | 0 | +0.0002 |
| 24-pole | +0.0002 | 0 | 0 | 0 | +0.0004 | 0 |

* A "unit" is 1/10,000 of the dipole field. Reference radius is 10 mm.