Feedthrough e-field, concentric cylinders, simple calculation D. Shuman 6/7/11

from Alston L.L. <u>High Voltage Engineering</u>, table 1.1 performing parallel calculations using "vectors" in MathCAD

given a range of outer radii: and optimum values for inner radii (minimizing enhancement factor)

$$V_c := 95\text{kV} \quad R_o := \begin{pmatrix} 4 \\ 5 \\ 6 \end{pmatrix}\text{cm} \qquad r_i := e^{-1}R_o \qquad r_i = \begin{pmatrix} 1.472 \\ 1.839 \\ 2.207 \end{pmatrix}\text{cm}$$

maximum field enhancement factor

$$E_M := \overrightarrow{\frac{V_c}{r_i \cdot \ln\left(\frac{R_o}{r_i}\right)}} \qquad E_M = \begin{pmatrix} 64.559 \\ 51.647 \\ 43.039 \end{pmatrix}\frac{\text{kV}}{\text{cm}} \qquad f_e := \overrightarrow{\frac{R_o - r_i}{r_i \cdot \ln\left(\frac{R_o}{r_i}\right)}} \qquad f_e = \begin{pmatrix} 1.718 \\ 1.718 \\ 1.718 \end{pmatrix}$$

enhancement over that of annulus nominal e-field annulus E/p

$$f_{ea} := \frac{E_M}{E_{an}} \qquad f_{ea} = \begin{pmatrix} 2.152 \\ 1.722 \\ 1.435 \end{pmatrix} \qquad E_{an} = 30\frac{\text{kV}}{\text{cm}} \qquad EoverP_{noEL\_side} = 2\frac{\text{kV}}{\text{cm}\cdot\text{bar}}$$

There will be an additional enhancement at the corner formed by the union of nozzle and vessel; this looks very much like a cylinder through torus, for which we have only a graph:

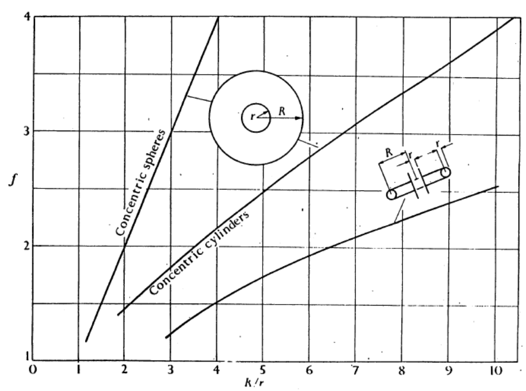

Fig. 1.2. Dependence of the ratio $f = \frac{\text{maximum stress}}{\text{mean stress}}$ on electrode geometry for concentric cylinders and spheres (calculated from Table 1.1), and for cylinder surrounded by a torus (from Cater and Loh[4]).

Unfortunately this graph assumes weld radius equal to center conductor radius which rules out TIG welding (5mm radius maximum possibly achievable). Assume we machine nozzle to conductor radius then: $f_c := 1.2$

We can consider this an upper limit as there is no "shielding" from the annulus field in the graph geometry, so total enhancement would be:

$$f_t := f_{ea} \cdot f_c \qquad f_t = \begin{pmatrix} 2.582 \\ 2.066 \\ 1.722 \end{pmatrix}$$

to keep total enhancement below 2 (which puts us into E/p=4 territory), we need a 6 cm conductor radius and a corner radius of 2cm. We should check FEA though to see if a sharper corner will be OK.