SSC DETECTOR SOLENOID DESIGN NOTE #2

TITLE: Shell Thicknesses per ASME Code

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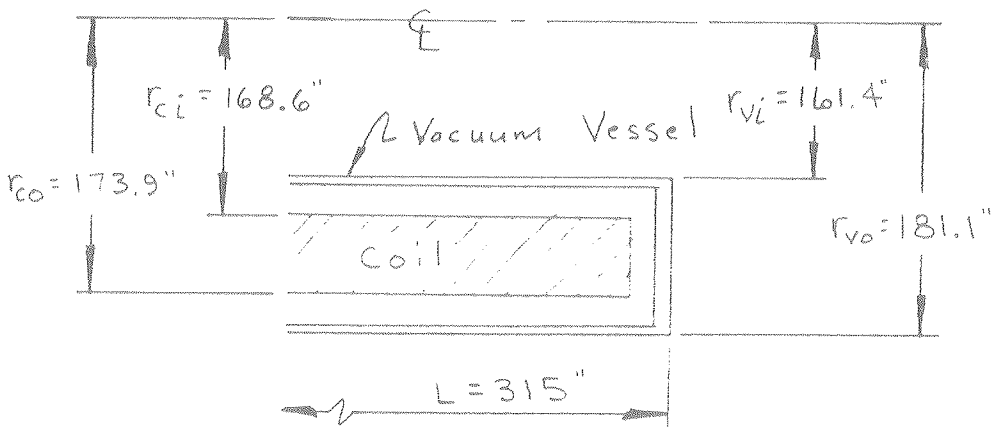
Problem : To determine the minimum material thickness of the inner and outer cylindrical shells of the LHe Vessel and Vacuum Vessel.

Assumptions: The material is 304 Stainless steel. Longitudinal and circumferential joints are double welded 15° V-grooves. No radiographic examination of the welds is assumed.



Coil Cross Section

Solution : The shell thicknesses are approximated using the procedures outlined in Parts UG-27 & UG-28 (P.23-5) in Section VIII - Div. 1 of the ASME Boiler and Pressure Vessel Code. Therefore, minimum shell thicknesses due to internal pressure

loading may be represented by:

$$t = \frac{PR}{SE - 0.6P} \quad \text{AND} \quad t = \frac{PR}{2SE - 0.4P}$$

(Circum. Stress) (Long. Stress)

Where:

t = minimum required thickness (in)

P = design pressure (psi)

R = inside radius of shell (in)

S = maximum allowable stress (psi)

E = joint efficiency

The maximum allowable external pressure for a given shell thickness is represented by:

$$P_a = \frac{4B}{3(D_o/t)}$$

Where:

D_o = outside diameter of shell (in)

t = given shell thickness (in)

The value of B is extracted from Fig. 5-UHA-28.1 (P. 548) in Appendix 5 of the Pressure Vessel Code. The value of A in the same figure is determined by interpolating the necessary values listed in Table 5-UGO-28.0 (P. 553-4) of Appendix 5.

Outer Vacuum Shell

Internal loading 15 PSI

$$t_{cir.} = \frac{PR}{SE - 0.6P}$$

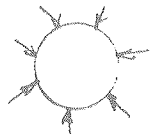
$$= \frac{(15)(181.1)}{(18.8 \times 10^3)(.7) - 0.6(15)}$$

$$\boxed{= .207 \text{ in}}$$

$$t_{long.} = \frac{PR}{2SE - 0.4P}$$

$$= \frac{(15)(181.1)}{2(18.8 \times 10^3)(.7) - 0.4(15)}$$

$$\boxed{= .103 \text{ in}}$$

External loading  15 PSI

$$\boxed{t = 1.25 \text{ in}}$$

$$L/D_o = 315 \text{ in} / 362.2 \text{ in}$$

$$= 0.87$$

$$D_o/t_{1.25} = 290$$

$$A = .281 \times 10^{-3}$$

$$B = 4{,}000$$

$$P_a = \frac{4B}{3(D_o/t)}$$

$$= \frac{4(4{,}000)}{3(290)}$$

$$\boxed{= 18.4 \text{ PSI}}$$

Inner Vacuum Shell

Internal loading 15 PSI

$$t_{cir.} = \frac{PR}{SE - 0.6P}$$

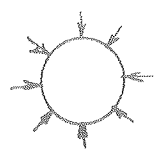
$$= \frac{(15)(161.4)}{(18.8 \times 10^3)(.7) - 0.6(15)}$$

$$\boxed{= .184 \text{ in}}$$

$$t_{long.} = \frac{PR}{2SE - 0.4P}$$

$$= \frac{(15)(161.4)}{2(18.8 \times 10^3)(.7) - 0.4(15)}$$

$$\boxed{= .092 \text{ in}}$$

External loading  15 PSI

$$\boxed{t = 1.125 \text{ in}}$$

$$L / D_o = 315 \text{ in} / 322.8 \text{ in}$$

$$= 0.98$$

$$D_o / t_{1.125} = 287$$

$$A = .283 \times 10^{-3}$$

$$B = 4,000$$

$$P_a = \frac{4B}{3(D_o/t)}$$

$$= \frac{4(4,000)}{3(287)}$$

$$\boxed{= 18.6 \text{ PSI}}$$

Outer LHe Vessel Shell

Internal loading 100 PSI

$$t_{cir.} = \frac{PR}{SE - 0.6P}$$

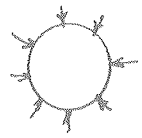
$$= \frac{(100)(173.9)}{(18.8 \times 10^3)(.7) - 0.6(100)}$$

$$\boxed{= 1.328 \text{ in}}$$

$$t_{long.} = \frac{PR}{2SE - 0.4P}$$

$$= \frac{(100)(173.9)}{2(18.8 \times 10^3)(.7) - 0.4(100)}$$

$$\boxed{= .662 \text{ in}}$$

External loading  15 PSI

$$\boxed{t = 1.125}$$

$$L / D_o = 315 \text{ in} / 347.8 \text{ in}$$

$$= 0.91$$

$$D_o / t_{1.125} = 309$$

$$A = .275 \times 10^{-3}$$

$$B = 3{,}750$$

$$P_a = \frac{4B}{3(D_o/t)}$$

$$= \frac{4(3{,}750)}{3(309)}$$

$$\boxed{= 16.2 \text{ PSI}}$$

Inner LHe Vessel Shell

Internal loading 15 PSI

$$t_{cir.} = \frac{PR}{SE - 0.6P}$$

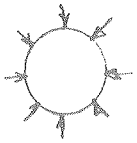
$$= \frac{(15)(168.6)}{(18.8 \times 10^3)(.7) - 0.6(15)}$$

$$\boxed{= .192 \text{ in}}$$

$$t_{long.} = \frac{PR}{2SE - 0.4P}$$

$$= \frac{(15)(168.6)}{2(18.8 \times 10^3)(.7) - 0.4(15)}$$

$$\boxed{= .096 \text{ in}}$$

External loading  100 PSI

$$\boxed{t = 2.75 \text{ in}}$$

$$L / D_o = 315 \text{ in} / 337.2 \text{ in}$$

$$= 0.93$$

$$D_o / t_{2.75} = 123$$

$$A = 1.078 \times 10^{-3}$$

$$B = 9{,}200$$

$$P_a = \frac{4B}{3(D_o/t)}$$

$$= \frac{4(9{,}200)}{3(123)}$$

$$\boxed{= 99.7 \text{ PSI}}$$

Inner LHe Vessel Shell

Internal loading 15 PSI

$$t_{cir.} = \frac{PR}{SE - 0.6P}$$

$$= \frac{(15)(168.6)}{(18.8\times10^3)(.7) - 0.6(15)}$$

$$\boxed{= .192 \text{ in}}$$

$$t_{long.} = \frac{PR}{2SE - 0.4P}$$

$$= \frac{(15)(168.6)}{2(18.8\times10^3)(.7) - 0.4(15)}$$

Cast by DN#2

$$\boxed{= .096 \text{ in}}$$

External loading 100 PSI

$$\boxed{t = 2.00 \text{ in}}$$

$L = 2m$

$$L/D_o = 78.74 \text{ in} / 337.2 \text{ in}$$

$$= 0.23$$

$$D_o/t_2 = 169$$

$$A = 3.38\times10^{-3}$$

$$B = 12{,}500$$

$$P_a = \frac{4B}{3(D_o/t)}$$

$$= \frac{4(12{,}500)}{3(169)}$$

$$\boxed{= 98.6 \text{ PSI}}$$