Target Modifications

The entrance window thickness of the LH2 target and the cryostat isolation vacuum chamber are reduced to 0.06 inch.

4.2.1 Symbols and Formulae

The ASME Code, Section VIII, [9] and Cryogenic Process Engineering [13] provide the design equations, which were used to calculate the minimum shell thickness for the LH_2 vessel and the main vacuum chamber.

List of symbols used in the formulae below:

t = minimum thickness [inch]
p = internal design pressure [psi]
p_c = critical pressure [psi]
R = inside radius [inch]
R_o = outside radius [inch]
D = inside diameter [inch]
D_o = outside diameter [inch]
L = length of cylinder or distance between two stiffening rings, respectively [inch]
S = allowable stress [psi]
Y = modulus of elasticity (Young's modulus)
μ = Poisson's ratio
E = weld joint efficiency factor

(a) Elliptical head under pressure on concave side

$$p = \frac{2SEt}{DK + 0.2t} \tag{2a}$$

where the constant K is given by $K = \frac{1}{6}\left[2 + \left(\frac{D}{2h}\right)^2\right]$ with

$\frac{D}{2h}$ = ratio of the major to the minor axis of elliptical heads.

(b) Elliptical head under pressure on convex side

$$p_c = \left(\frac{t}{R_0^*}\right)^2 \frac{YE}{2[3(1-\mu^2)]^{1/2}} \tag{3a}$$

with $R_0^* = K_1 D$.

K_1 is given in table UG–33.1 of the ASME Code as a function of $\frac{D}{2h}$.

The ASME Code specifies that the critical pressure p_c be four times the maximum allowable (external) working pressure (MAWP) on a vessel.

4.2.2 Values for Material Parameters

The following material constants at room temperature, taken from AMS Handbook, Vol. 2 (Ref. 5) and manufacturer's spec sheets, are used. (The materials have (about 30% – 40%) higher allowable stresses at low temperature. These higher values are not used here.)

(a) Aluminum 6061-T6 (ASME Code approved!)

Ultimate tensile strength: S_u = 49600 psi
$\Rightarrow$ allowable stress S = ¼ S_u = 12400 psi (see ASME Code)

Modulus of elasticity: $Y = 1.0 \times 10^7$ psi

Poisson's ratio: $\mu = 0.33$

4.2.3 Results of Calculations

The design pressure was calculated assuming a thickness t = 0.06 inch using the above formulas.

4.2.3.1 Entrance Window of Target Vessel

The pressure is on the concave side (eq. 2a).

D = 10.5 inch; h = 2.5 inch; $\frac{D}{2h} = 2.1 \quad \Rightarrow \quad K = 1.07$

Internal design pressure:

$$p = \frac{2(12400)(1)(0.06)}{(10.5)(1.07) + (0.2)(0.06)} = 132.3 \text{ psia}$$

4.2.3.2 Entrance Window of Cryostat Isolation Vacuum Chamber

The pressure is on the convex side (eq. 3a).

D_0 = 11.5 inch; h_0 = 2.4 inch; $\frac{D_0}{2h_0} = 2.4 \quad \Rightarrow \quad K_1 = 1.08$

$\Rightarrow \quad R_0^* = 12.4$ inch

$$p_c = \left(\frac{0.06}{12.4}\right)^2 \frac{(1.0 \times 10^7)(1)}{2\left[3\left(1 - 0.33^2\right)\right]^{1/2}} = 71.6$$

Internal design pressure:

$$p = \frac{1}{4} p_c = 17.9 \text{ psia}$$