D. Shuman, 1/19/11

Pressure Vessel Scaling, first order:

given the invariants:

Gas (ideal) mass: $M_{gas.}$ material strength: S length/radius ratio: C vessel mtl. density: ρ

and, given initial conditions and dimensions:

pressure: P_1 radius: R_1 length: $L_1 := C \cdot R_1$

assume spherical or elliptical ends requiring similar thickness to cylindrical section

then: thickness: $t_1 := \dfrac{P_1 \cdot R_1}{S}$

vessel volume: $V_1 := 2\pi R_1{}^2 (C \cdot R)$

and, mass of vessel $M_1 := \rho\left(2\pi R_1{}^2 t_1 + 2\pi R_1 \cdot L_1 \cdot t\right)$ $M_1 := (1 + C)\rho \cdot 2\pi R_1{}^2 t_1$

or, simply·

$V \equiv R^3$ $t \equiv P \cdot R$ $M \equiv t \cdot R^2$

now, double the radius

$R_2 := 2R_1$

then $V2 := (2R_1)^3$ $V_2 := 8V_1$

and $P_2 := \dfrac{1}{8}P_1$

then $t_2 := \dfrac{1}{8}P_1 \cdot 2R_1$ $t_2 := \dfrac{1}{4}t_1$

but $M_2 := \dfrac{1}{4}t_1 \cdot (2R_1)^2$ $M_2 := M_1$

Vessel mass is proportional to gas mass, and invariant to dimensional changes