**PRESSURE VESSELS**

**Pressure Vessels:** Vessels Contains fluids (G + L) under pressure.

Purpose of design: Identify the size parameters.

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| **Pressure Vessels Types** | | | |
| Thin Pressure Vessels (D/t ≥ 20) **(GATE+ESE)** | | Thick Pressure Vessels (D/t < 20) **(ESE)** | |
| Thin Cylinder | Thin Sphere | Thick Cylinder | Thick Sphere |
| Eg. Boiler PV, Gas Storage Tank | | Eg. Gun Barrel, Normal Water Pipe | |
| Stress Distribution **constant** over thickness | | Stress Distribution is **non uniform** and maximum at inner radius and zero at outer radius | |

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| **Due to Pressure(P) the Stresses in the cylinder is generated** | | |
| **Circumferential/ Tangential / Hoop Stress (σh)** | **Longitudinal Stress (σl)** | **Radial Stress (σr)** |
| Acts Along Circumference and perpendicular to longitudinal section plane | Acts perpendicular to Circumference plane and along longitudinal direction | Acts In radial Direction |
| Bursting force = Resisting force  Pdl = σh (2lt)  **σh = Pd / 2t (for safety σh** ≤ **σallowable**) | Bursting force = Resisting force  P (π/4) d2 = σl (πdt)  **σl = Pd / 4t (for safety σl** ≤ **σallowable**) | Ignored for thin cylinder case  **σr <<< σl , σh** |
| **σh = 2 σl** (Valid only for Constant Pressure) | If ends are open **σl = 0** |  |

**Strain in Thin Cylinder:**

ε1 = δd / d = (Pd / 4tE) (2 - υ) (Because ε1 = (1/E) [σ1 – υ(σ2 + σ3)]

ε2 = δl / l = (Pd / 4tE) (1 - 2υ)

εv = δV / V = ε2 + 2 ε1 = (Pd / 4tE) (5 - 4υ) (here V = L (π/4) d2 )

**Special Case (Hydrostatic Pressure):**

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| **Always possible σh > σl** | |
| Yes, When Pressure distribution is constant | No, When Pressure is varying, we can’t judge |

**Built Up Cylinder-Joint Efficiency:**

**Built Up Cylinder:** Cylinder made of multiple metal sheets Joined by Riveted Joints.

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| **Riveted Joints** | |
| **Longitudinal Riveted Joints** | **Circumferential Riveted Joints** |
| Used in increase Diameter of cylinder | Used to increase Length of cylinder |
| ηl σh = Pd / 2t | ηh σl = Pd / 4t |

Joint Efficiency (η) = Effective Area / Gross Area

**Thin Spherical Pressure Vessels:**

Bursting force = Resisting force

P (π/4) d2 = σh (πdt)

**σh= Pd / 4t (for safety σh** ≤ **σallowable**)

Here ε3 = ε2 = ε1 = δd / d = (Pd / 4tE) (1 - υ) (Because ε1 = (1/E) [σ1 – υ(σ2 + σ3)]

εv = δV / V = ε1 + ε2 + ε3 = (3Pd / 4tE) (1 - υ) (here V =(4/3) π r3 )

**Thin Cylindrical Pressure Vessels with Hemi-Spherical Ends):**

To Avoid Deformation at junction, εhc = [δd / d] Cylinder = [δl / l] Sphere = εhs

(Pd / 4tcE) (2 - υ) = (Pd / 4tsE) (1 - υ)

(ts/tc) = (1 - υ) / (2 - υ)

ts ≤ tc  (Condition to avoid Deformation at junction for same deformation)

To Avoid Deformation at junction, [σmax ] Cylinder = [σmax ] Sphere

(ts/tc) = 0.5 (Condition to avoid Deformation at junction for same maximum stress)

τmax = max { mod[ (σ1 – σ2)/2 ], mod [ (σ2 – σ3)/2 ], mod[ (σ3 – σ1)/2 ]}

τmax = max { 0, Pd/4t, Pd/8t } = Pd/4t (For Sphere)

τmax = max { 0, Pd/8t, Pd/8t } = Pd/8t (For Cylinder)