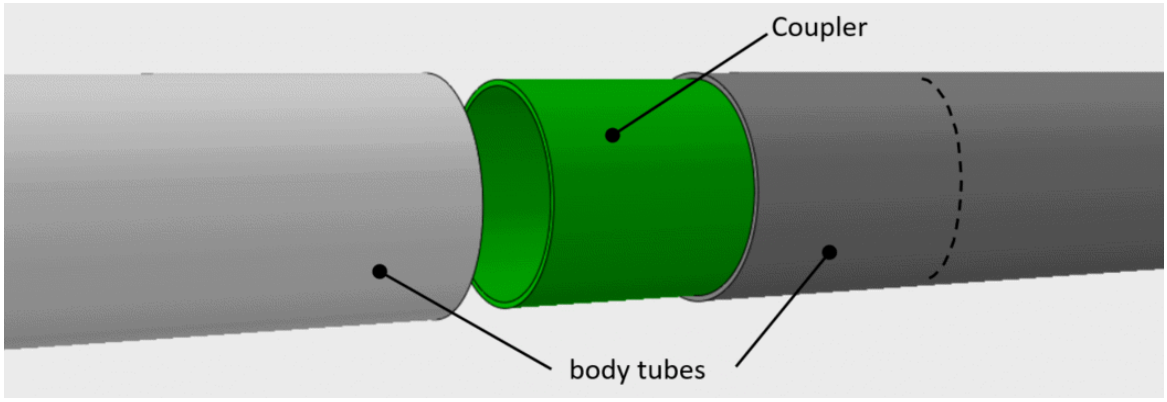
(Information might be already known, but this is just the important details on Body Joints in regards to wall thickness and screws forces to take bending moments through the body)**

Body Joints – Coupler



- A joint must possess sufficient ***strength*** to take bending loads (in flight and handling/transport) and must be ***rigid*** such that it does not allow the rocket to flex at the joint.
- Assuming a coupler tube has the same outer diameter as the inner diameter of the body tube, and the body tube is considered to be a thin-walled structure, the ***coupler wall thickness*** (t) is given by:

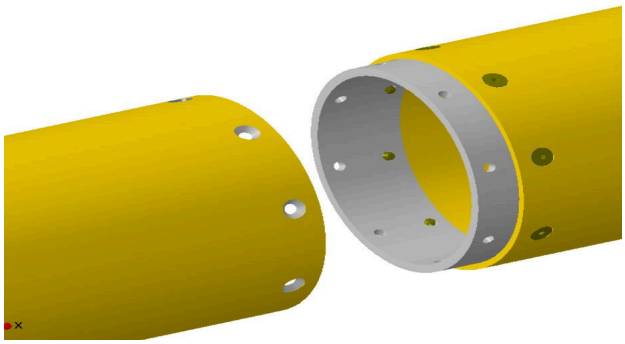
$$t = \frac{1}{2}\, d - \left(\frac{d^4}{8} - \frac{D^4}{16}\right)^{1/4}$$

  - *D* = outer diameter
  - *d* = inner diameter

- It may be necessary to make the wall with additional thickness to provide enough thread length such that the threads are not inadvertently stripped due to repeated installation and removal of joint screws.

- **Separable joint** is required to separate a rocket for release of a parachute. In such a case, nylon screws are used to hold the joint together. Nylon screws have a low shear strength that allows the joint to separate when the separation charge is fired.

- **Possible drawbacks to this joint**: it occupies length and can be rather heavy, especially for larger EX rockets. For a non-separable joint, a better option is a ***Ring Coupler***.



- **<u>Advantages of ring coupler</u>**: With a ring coupler joint, any bending loads (or *bending moment*) that the rocket is subjected to is carried by the coupler attachment screws in shear. The ring coupler is short in length and can be very lightweight.

Maximum Shear Force

- The maximum shear force that any of the attachments screws is subjected to is dependent upon the total number of fasteners in the ring coupler joint

$$F_{max} = f \frac{M}{D}$$

  - F_{max} = maximum force (lbf or N.) tending to shear the fastener
  - *f* = load fraction dependent upon number of fasteners in joint
    - F = ⅔ for six fasteners
    - F = ½ for six fasteners
    - F = ⅖ for six fasteners
    - F = ⅓ for six fasteners
  - M = applied bending moment (lbf-inch or N-m)
  - D = outer diameter of coupler (inches or mm)
- The edge distance (e) of the fasteners should be no less than 2x the diameter of the hole (D) in the part of the prevent shear tear-out failure (e = 2D, minimum). (D) should be taken as the average hole diameter.

Fasteners

- Recommended fasteners:
  - Alloy Steel Flat Head Cap Screws (130,000 psi)
    https://www.mcmaster.com/91253A194/

    
  - Alloy Steel Button Head Cap Screws (120,000 psi)
    https://www.mcmaster.com/91255A194/

- **<u>Advantages</u>**:
  - Guaranteed Strength
  - Alloy Steel screws have excellent strength, has tensile and shear strength

- Ring Coupler joints may also fail if fastener bearing stress is too high.
- Bearing stress is defined as the fastener shear load acting over the contact area, it is the contact pressure that results when a joint is subjected to a bending moment.

$$f_{br} = \frac{F_s}{D_m\, t}$$

  - F_s = shear force acting on the fastener (lbf or N.)
  - D_m = fastener major diameter (inches or mm)
  - t = wall thickness of the body tube at the join (inches or mm)

- If bearing stress is too high, the joint will fail by ***shear-tear out or ovalization*** of the hole in the body tube. Must be lower than the bearing strength of the body tube material, with the desired safety factor applied.