Bending Walls and Stretching Wires

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Stretching a wire

- How much should a wire stretch when put under tension?
  - BeCu has a Young's modulus of 110 GPa (giga pascals)
  - 75 μm wire diameter ⇒ 4.4 10^{-9} m^2
  - Tension ⇒ 1.20 Newtons (122 grams-force)
  - Stress on the wire ⇒ 1.2 / 4.4 10^{-9} ⇒ 0.27 Gpa
  - Relative strain on the wire ⇒ 0.27 / 110 ⇒ 0.25% change in length

- 75 cm long BeCu wires (75 μm diameter) will stretch 1.8 mm when under a tension of 122 grams-force

- A wire at the top of our sector (after installation) has been stretched 1.5 mm if it came off of a 75 cm wide transfer frame

- A wire at the bottom our sector (after installation) has been stretched 0.7 mm if it came off a 75 cm wide transfer frame

Bending a Wall

- A wall will bend if forces are applied
- Forces applied at the top of a wall is similar to an end loaded beam deflecting under the force of gravity (see Wikipedia)

  δ(deflection) = Force * (Height of Wall)^3 / (3 * Young's Modulus * I)

  I = moment of Inertia of the wall $\Rightarrow$ Width of wall * Thickness^3 / 12

  so

  δ = (Force/Width) * (4/Y) * (Height/Thickness)^3

  $\Rightarrow$ (Force per unit width) * (4/Y) * (Height/Thickness)^3
- G10 has a Young's Modulus of 18 GPa

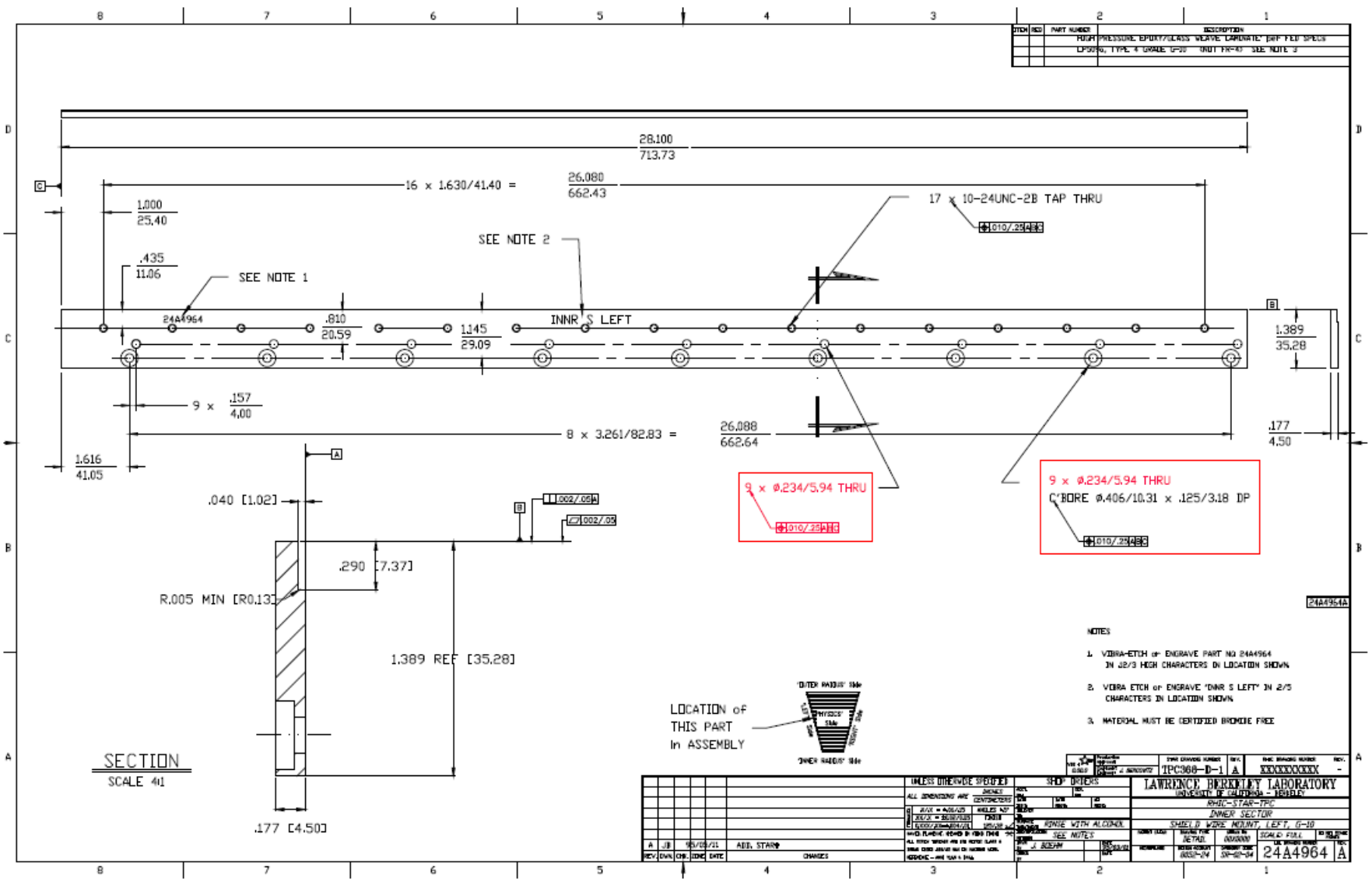
  The Shield grid wires are spaced 1 mm apart, so

  δ = (1.2 Newtons/mm) * 0.22 GPa^{-1} * (Height/Thickness) ^{3}

  $\Rightarrow$ 0.26 μm * (Height/Thickness) ^{3}
- The Height of the wiremount is the distance of unsupported G10 above the strongback, or the point of last rigid support
  - Height of the Shield wiremount ~7.5 mm
  - Thickness of the Shield wiremounts is ~3.5 mm

  $\delta \approx$ 2.5 μm
- Homework: Aluminum has a Young's Modulus of 69 GPa ☺

Critical Dimensions for a Shield Wiremount



Issues and Concerns

- **The Shield wiremounts bend by ≈ 2.5 μm under the tension of the wires**

- **The wires will release some of their tension in response to the bending of the walls**
  - **Top of the sector: 2.5 μm / 1.5 mm ≈ 0.17% loss of tension**
  - **Bottom of sector: 2.5 μm / 0.7 mm ≈ 0.35% loss of tension**

- **If the Shield grid wiremount is not supported firmly by the layers underneath it (i.e. the anode wiremount board), then a bump near the screw holes is the next point of support. Thus, the Height of the wall grows and could be as much as 29 mm tall.**
  - **Cubic growth in the deflection of the wall .vs. height**
  - **Top of the sector: 145 μm / 1.5 mm ≈ 10%**
  - **Bottom of sector: 145 μm / 0.7 mm ≈ 20%**

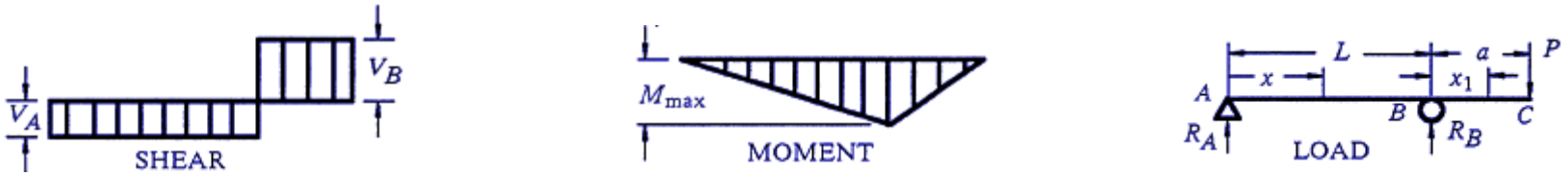
Recommendations

- **If we are seeing ≈10% loss of tension on the shield wires, then the shield grid wiremount is probably not supported by the strongback and padplane. Rather, the support appears to be coming further away from the wires. Perhaps near the screws … with a gap between the anode and shield grid wiremounts from the screws to the top of the wall.**

- **Recommendation:**
  - **Check that all wiremounts are clean and flat. Very flat. Remove any bumps and dust (< 25 μm). Counter bore screw holes and through-holes.**
  - **When epoxying the shield grid wires to the wiremount, all screws should be inserted and tightened into the Shield Grid wiremount. (18 not just 9)**
  - **Better yet, a "dummy" gated grid wiremount (i.e. no angle on top) should be installed while epoxying the shield grid wires into place. The "dummy" allows the extra 9 screws to be installed, naturally, and also stiffens the stack of wiremount boards so the shield wall cannot bend so much. The "dummy" should be made of Aluminum because it has a higher Young's Modulus than G10 (perhaps with a rib down the center to stiffen the wall)**
  - **The dummy can/should be removed after the epoxy has cured and after the wires have been cut free from the Shield Grid transfer frame.**

Backup Slides

Alternate Idea: Overhanging end loaded beam



- **Force applied at top of a wall, but supported at a point part way up the wall**
  - **δ(deflection) = Force * (Height of Wall)^2 * (L+a) / (3 * Young's Modulus * I)**
  - **I = moment of Inertia of the wall $\Rightarrow$ Width of wall * Thickness^3 / 12**
  - **so (if we define a $\equiv$ Height of wall)**
  - **δ = (Force/Width) * (4/Y) * [(Height/Thickness)^3 + (L*Height^2)/Thickness^3]**
  - **$\Rightarrow$ (Force per unit width) * (4/Y) * [(Height/Thickness)^3 + (L*Height^2)/Thickness^3]**
- **G10 has a Young's Modulus of 18 GPa**
  - **The Shield grid wires are spaced 1 mm apart, so**
  - **δ = 0.26 μm * [(Height/Thickness)^3 + (L*Height^2)/Thickness^3]**
- **The Height of the wiremount is the distance of unsupported G10 above the strongback, L is the distance from the screws to the top of the strongback**
  - **Height of the Shield wiremount ~7.5 mm, L is ~21.5 mm**
  - **Thickness of the Shield wiremounts is ~3.5 mm (actually thicker, lower down)**

$\delta \approx$ 10 μm or about 1% loss of Tension on the wires … but not 10%