Mesh tension required:

$\varepsilon_0 := 8.85 \cdot 10^{-12} \frac{F}{m}$

Mesh modulus: assume no wire crossing

wire dia	wire spacing	wire elastic modulus	Voltage	gap
$d_{mw} := .001in$	$s_{mw} := 1mm$	$E_{ss} := 28 \cdot 10^6 psi$	$V_{el} := 9kV$	$d_{el} := 3mm$

$E_{el} := \frac{V_{el}}{d_{el}}$ $\quad E_{el} = 30 \frac{kV}{cm}$

mesh modulus will be material modulus * cross section areal fill ratio

$N_a := \frac{\frac{\pi}{4} d_{mw}^2}{s_{mw} \cdot d_{mw}}$ $\quad N_a = 0.02$

$E_{mesh} := E_{ss} N_a$ $\quad E_{mesh} = 3.851 \times 10^9 Pa$

Pressure, from electric field

$P_{el} := \varepsilon_0 \frac{V_{el}^2}{2 d_{el}^2}$ $\quad P_{el} = 39.825 Pa$

We desire a 1% uniformity of EL gradient:

$\delta_{max} := .01 d_{el}$ $\quad \delta_{max} = 0.03 mm$

frame radius, (circular approximation)

$R_{mp} := 7cm$

For thin membrane, with no plate stiffness, deflection is a function of initial stress only (up to three thicknesses of deflection)

$\delta_{mem} := \frac{P_{el} \cdot R_{mp}^2}{4 \sigma_i \cdot d_{mw}}$ $\quad \sigma_i := \frac{P_{el} \cdot R_{mp}^2}{4 \delta_{max} \cdot d_{mw}}$ $\quad \sigma_i = 9286 psi$ Uh oh!

actual wire stress:

$S_{y\_ss} := 75000psi$

$\sigma_{mw} := \sigma_i \cdot \frac{s_{mw} \cdot d_{mw}}{\frac{\pi}{4} d_{mw}^2}$ $\quad \sigma_{mw} = 4.655 \times 10^5 psi$ way too high to achieve 1% EL gradient uniformity (10% just possible at yield)

Large Deflection Formula for Circular Membrane with initial stress under pressure loading Eaton, et. al.

let: $\sigma_{ps} := 0.75 S_{y\_ss} \cdot N_a$ $\quad \sigma_{ps} = 1.122 \times 10^3 psi$

$h := d_{mw}$ $\quad a := R_{mp}$ $\quad \varepsilon_i := \frac{\sigma_{ps}}{E_{mesh}}$ $\quad \varepsilon_i = 2.009 \times 10^{-3}$ $\quad E := E_{mesh}$ $\quad \nu := .3$

$P := P_{el}$ $\quad \eta := 1$

$D := \frac{\eta \cdot E \cdot h^3}{12(1 - \nu^2)}$

$$\alpha := 14 \cdot \frac{(2 \cdot h)^2 + 3a^2 \cdot \varepsilon_i \cdot (1 + \nu)}{(1 + \nu) \cdot (23 - 9\nu)}$$

$$\beta := -7P \cdot a^4 \frac{h^2}{8D \cdot (1 + \nu) \cdot (23 - 9\nu)}$$

$$\gamma := \sqrt{\frac{\alpha^3}{27} + \frac{\beta^2}{4}}$$

$$f := \sqrt[3]{\frac{-\beta}{2} + \gamma} + \sqrt[3]{\frac{-\beta}{2} - \gamma} \qquad f = 0.174\,\mathrm{mm} \qquad \frac{f}{d_{el}} = 5.784\,\%$$