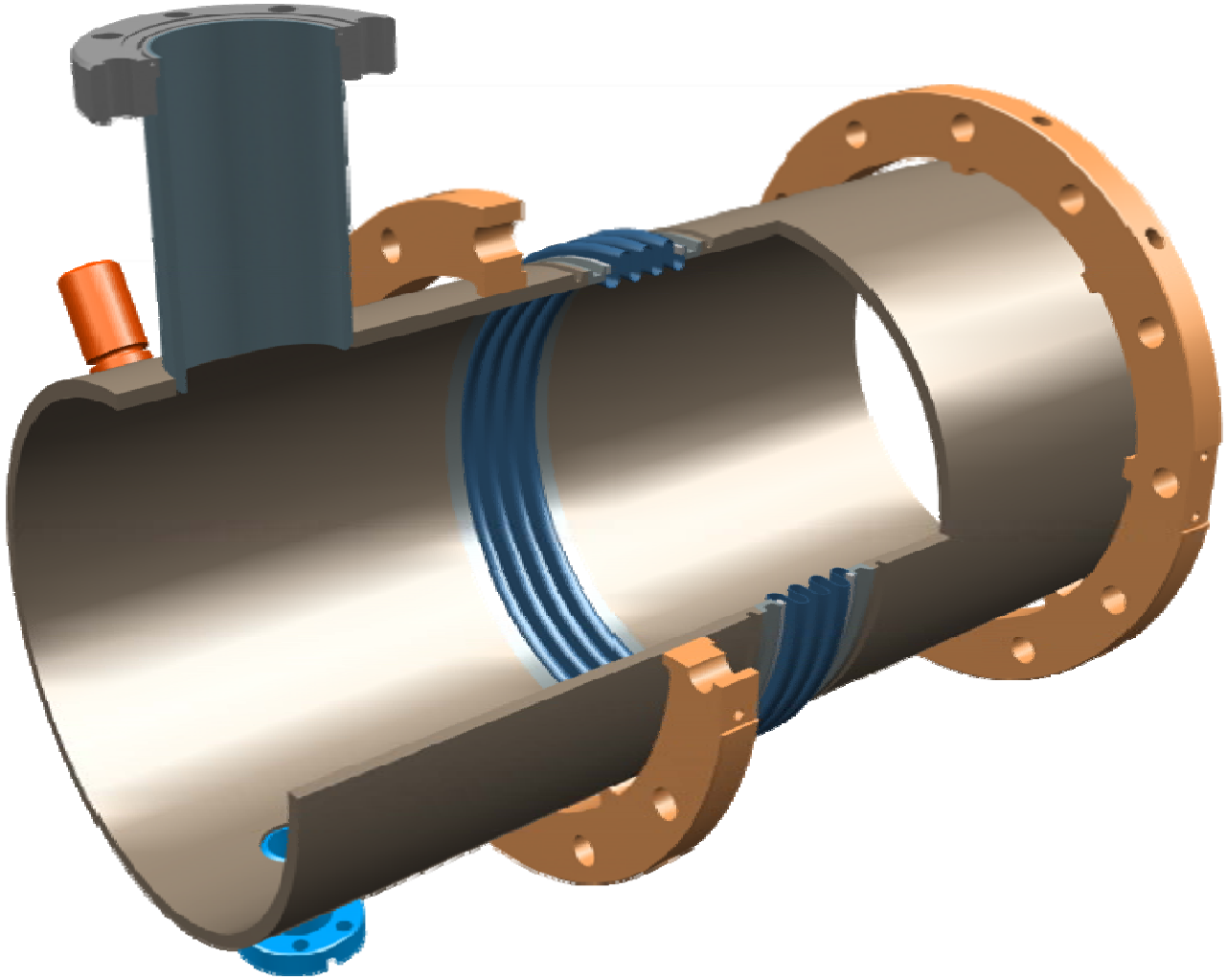
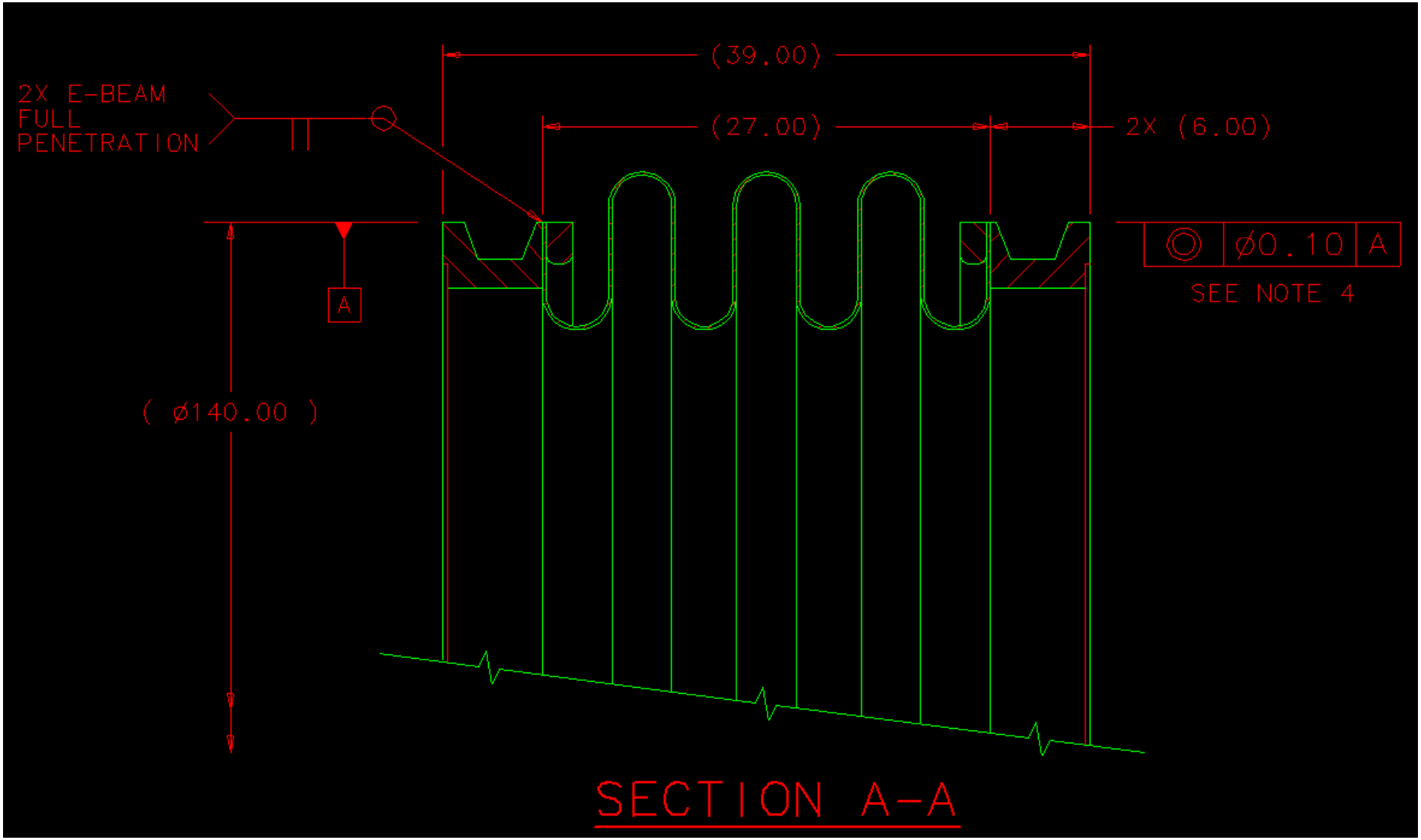
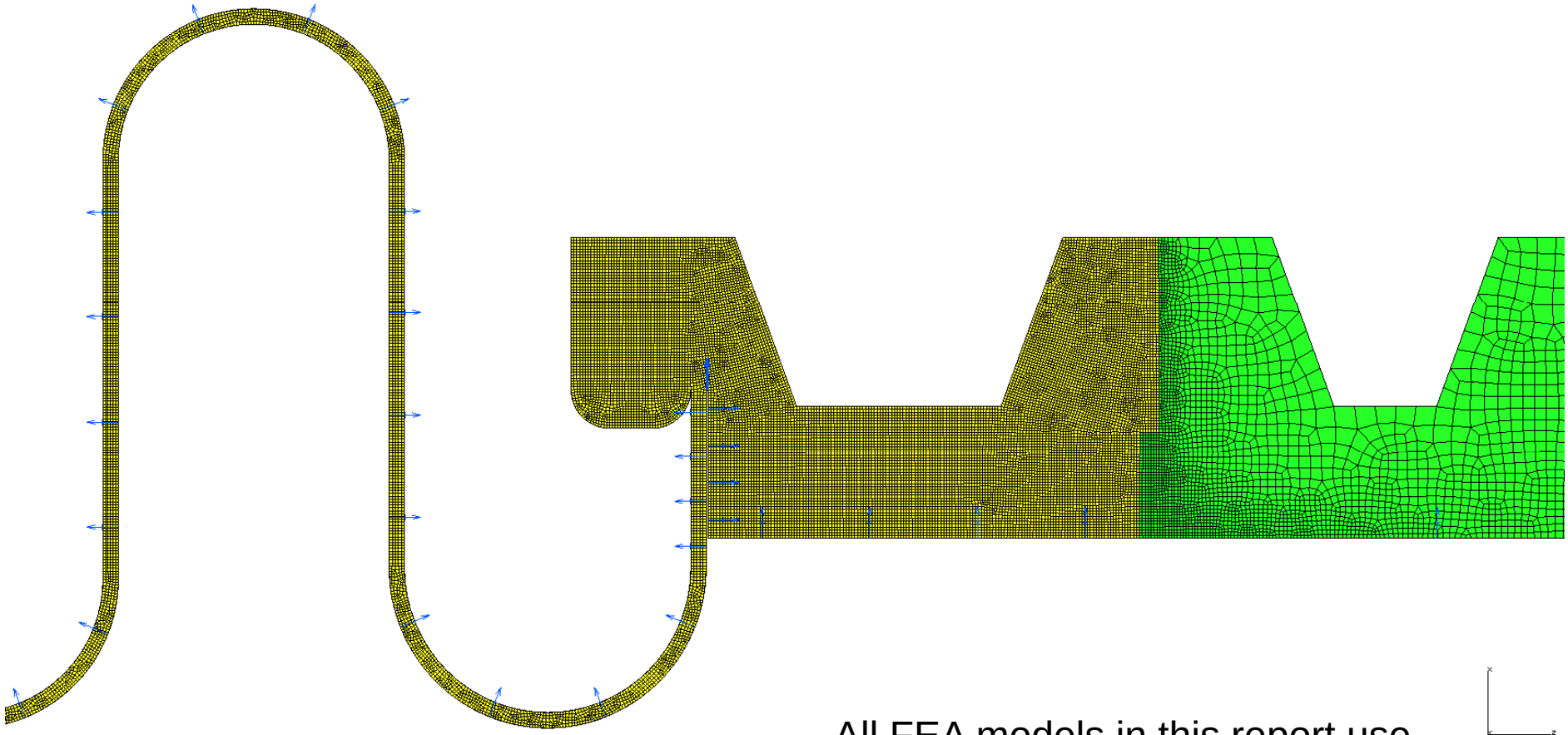
Titanium Bellows Comparison for the 3.9 GHz Helium Vessel



Current 3.9 GHz Bellows Design

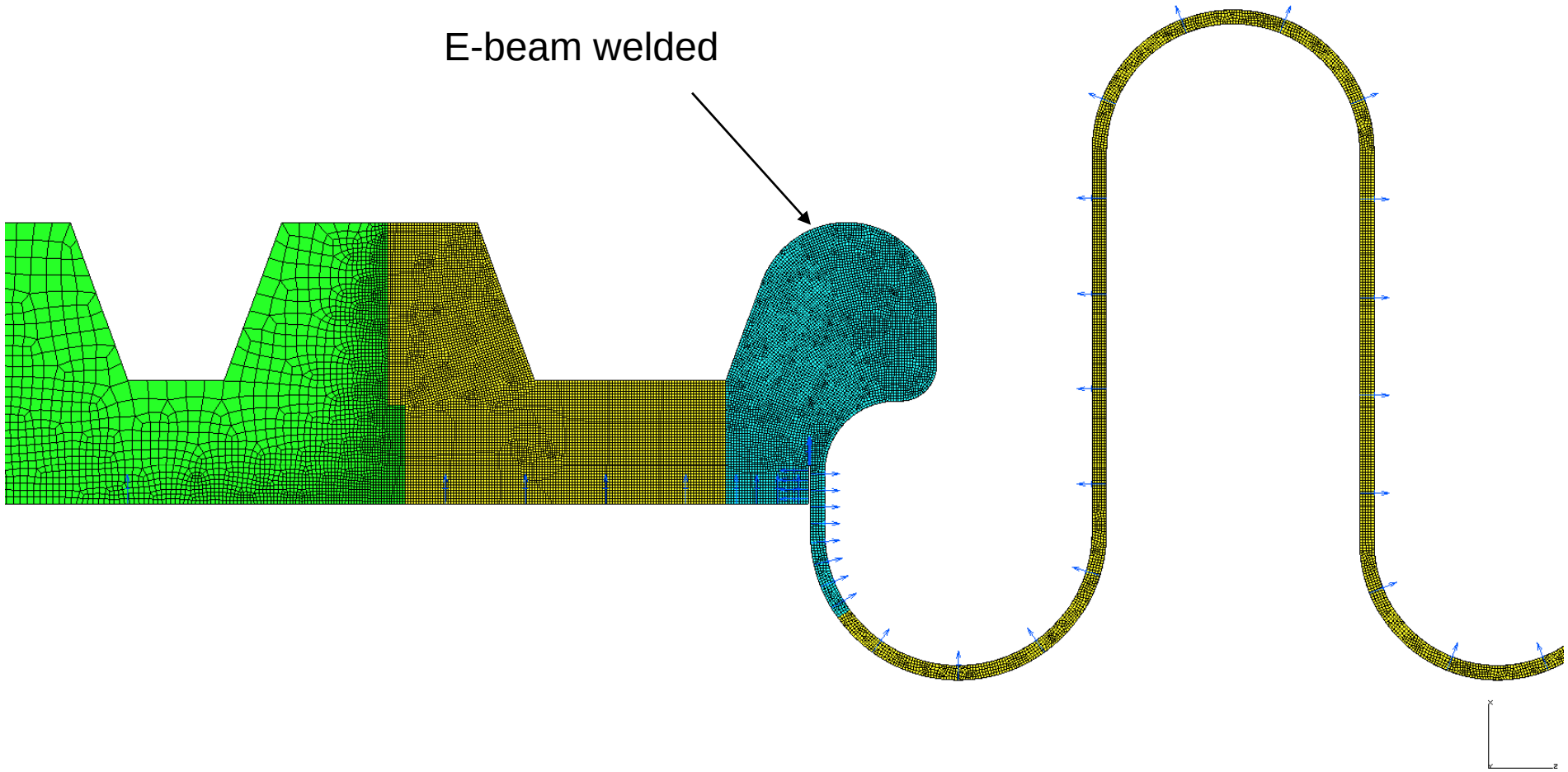


FEA Model of the 3.9 GHz Bellows

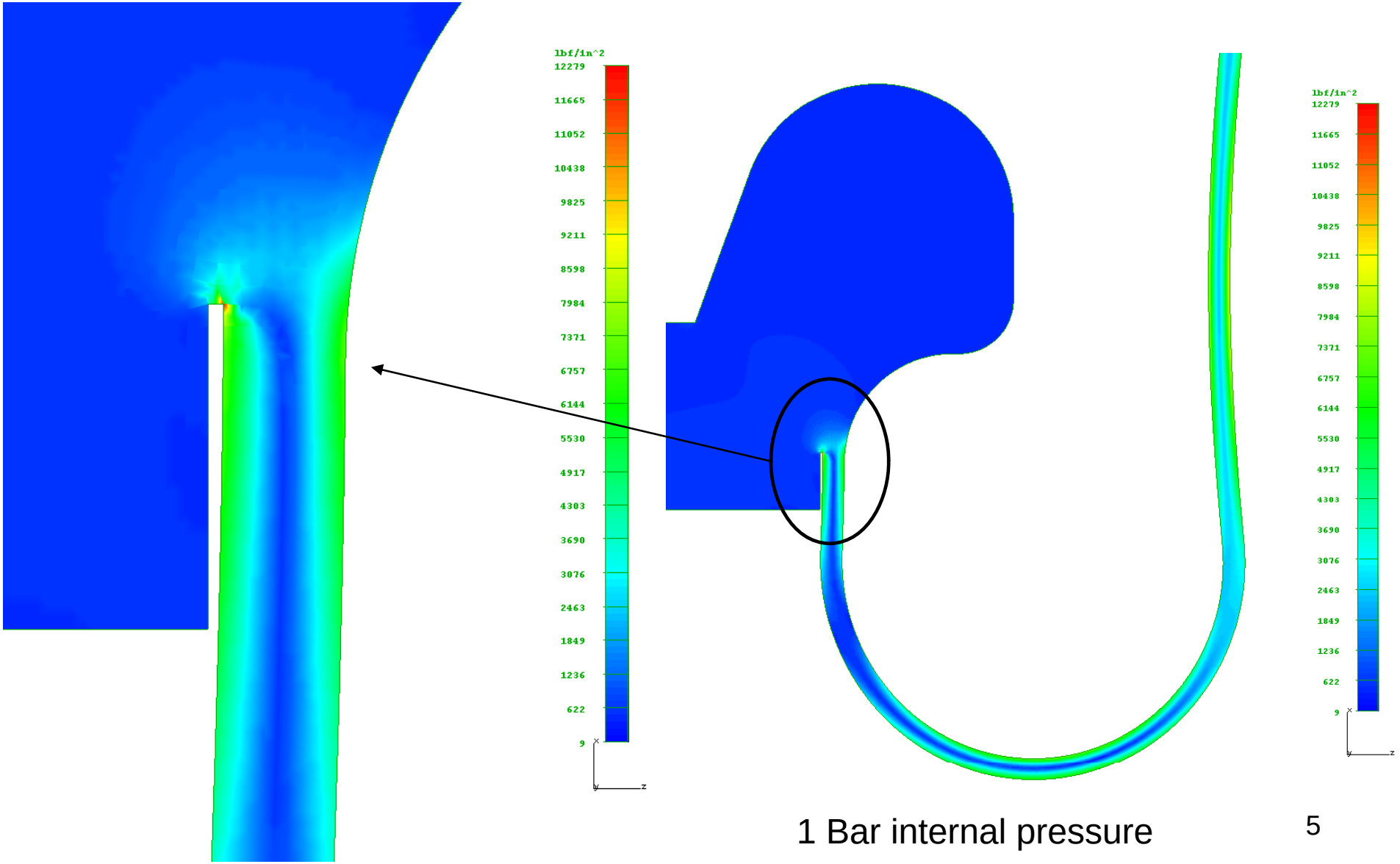


All FEA models in this report use the axisymmetric element type

FEA Model of the 3.9 GHz Bellows

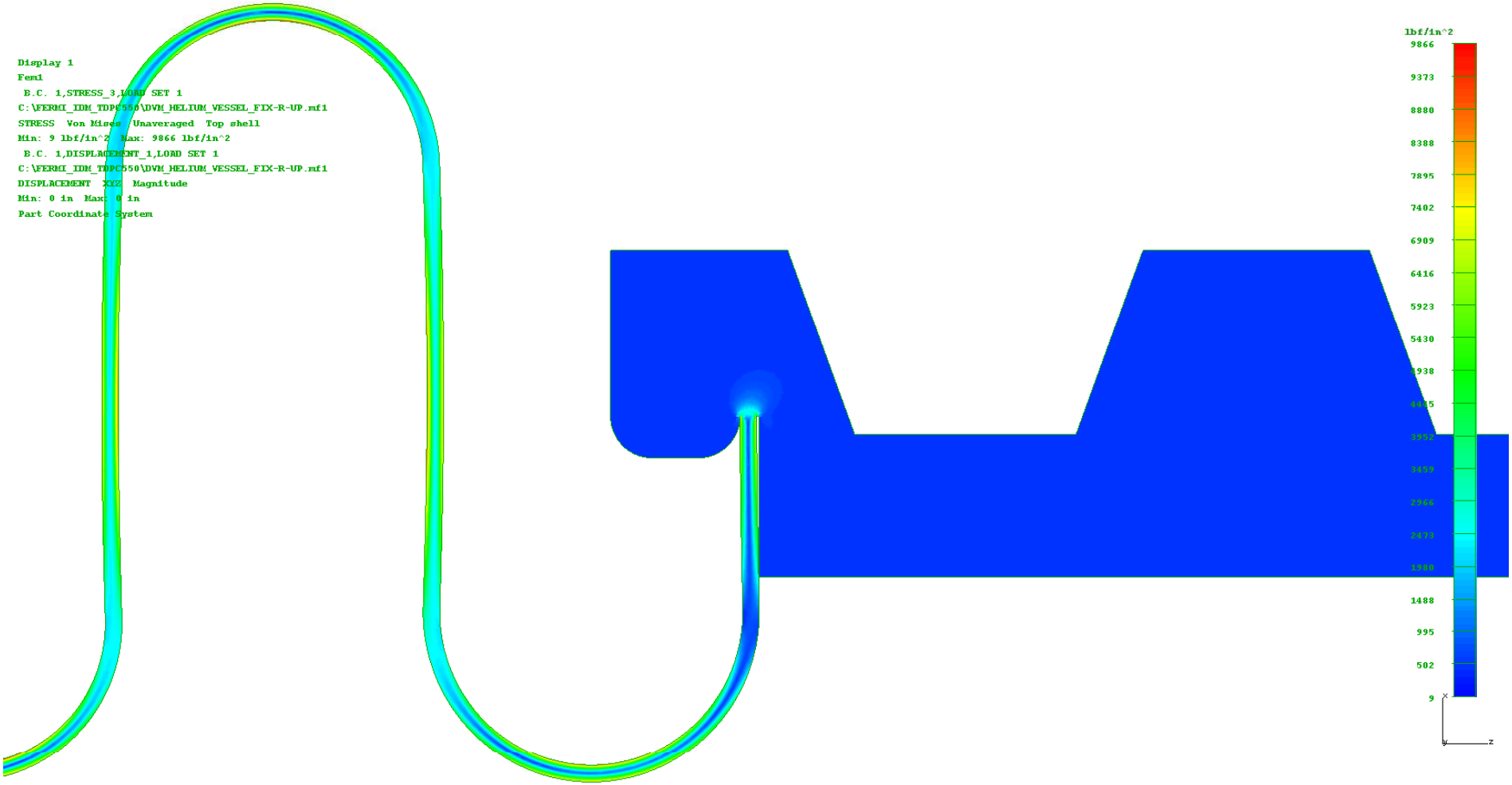


FEA Results of the 3.9 GHz Bellows



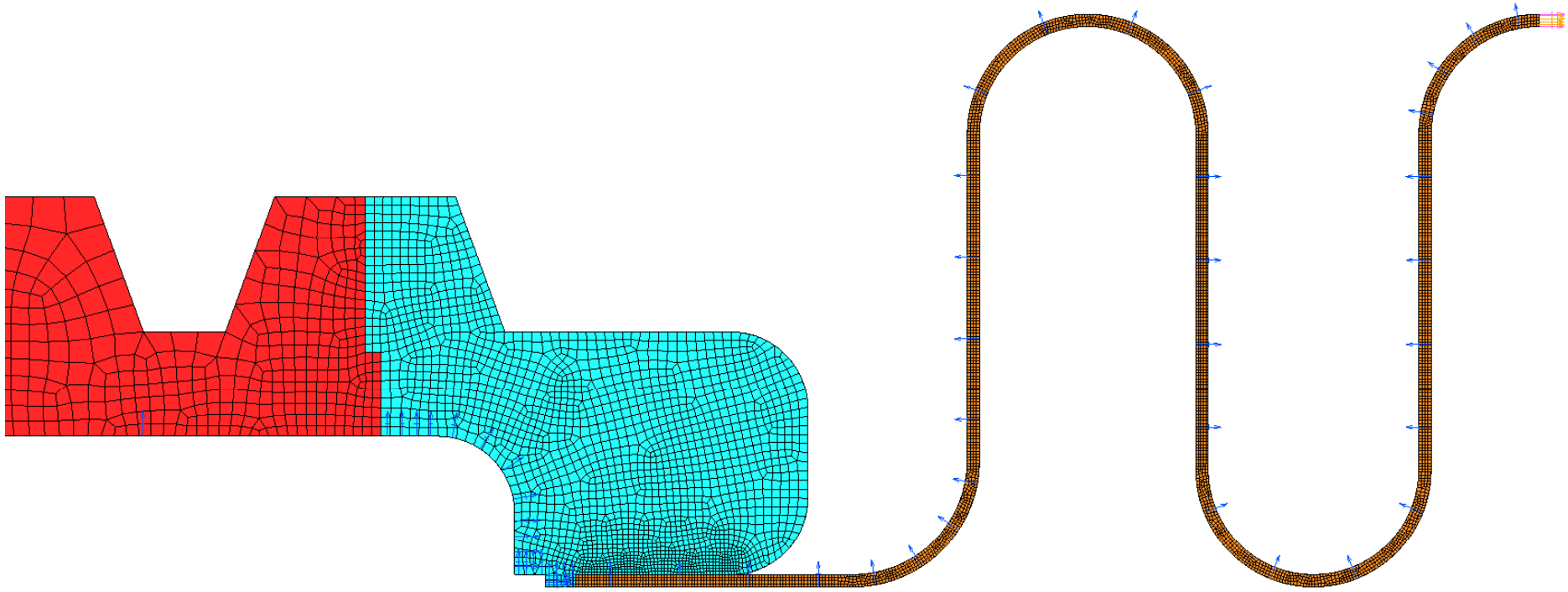
1 Bar internal pressure

FEA Results of the 3.9 GHz Bellows

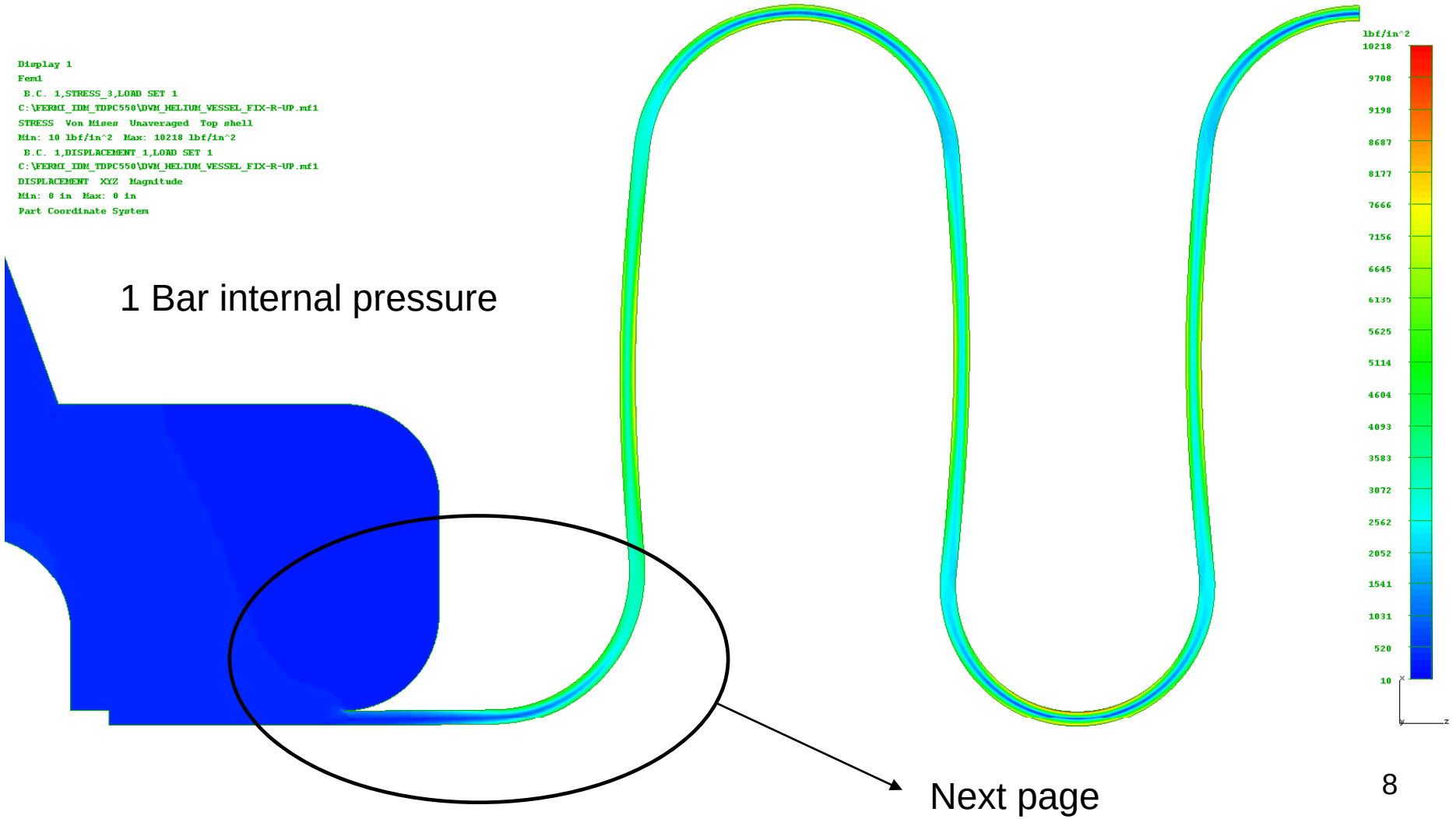


1 Bar internal pressure

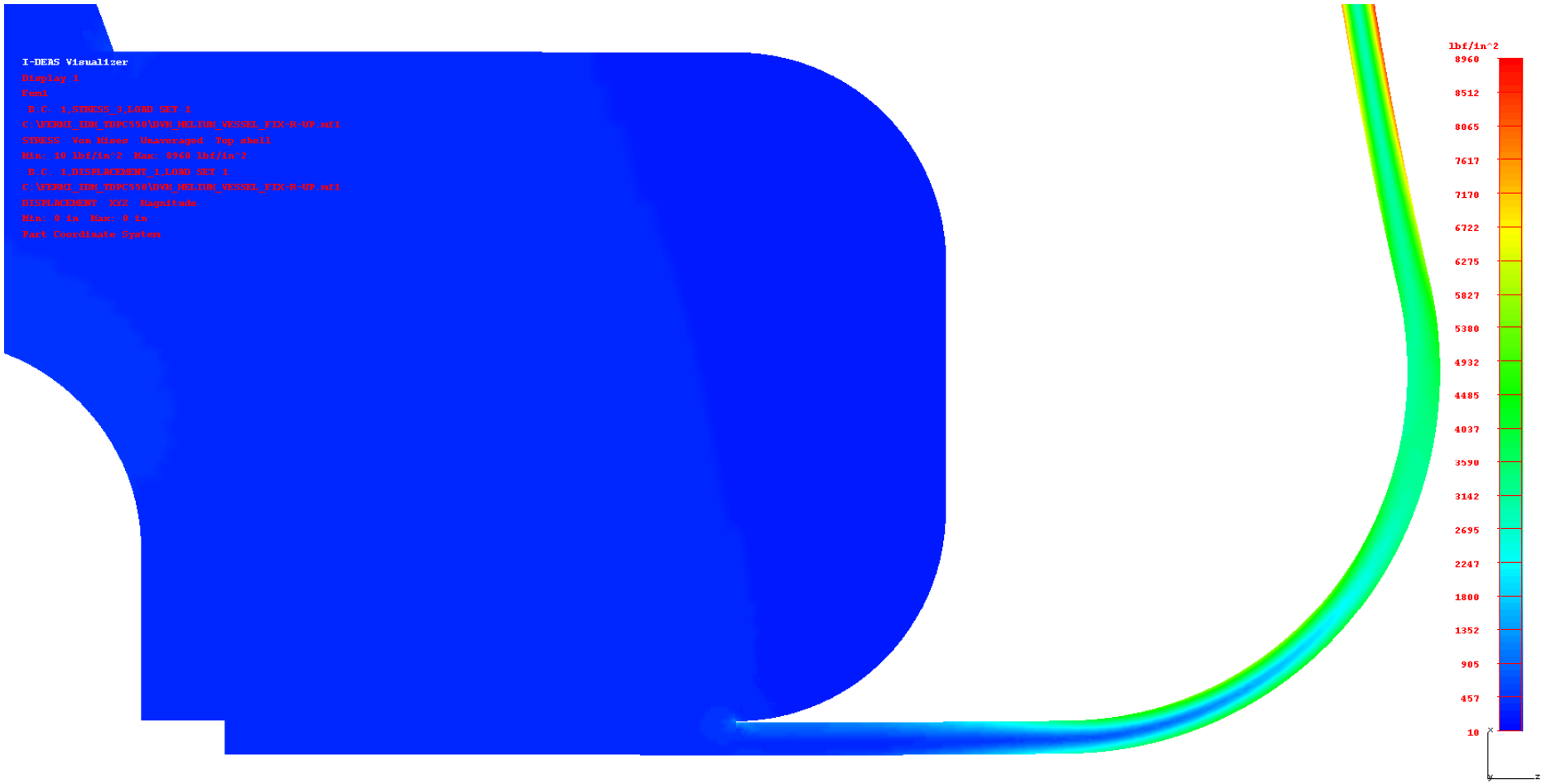
FEA Model of the 3.9 GHz Proposed Bellows



FEA Results of the 3.9 GHz Proposed Bellows



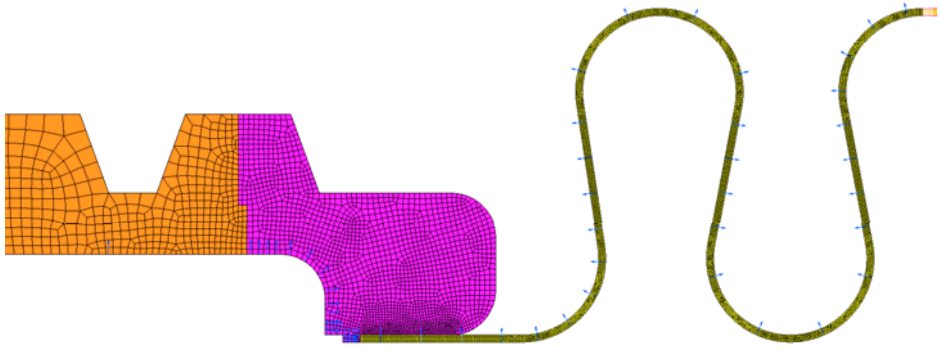
FEA Results of the 3.9 GHz Proposed Bellows



1 Bar internal pressure

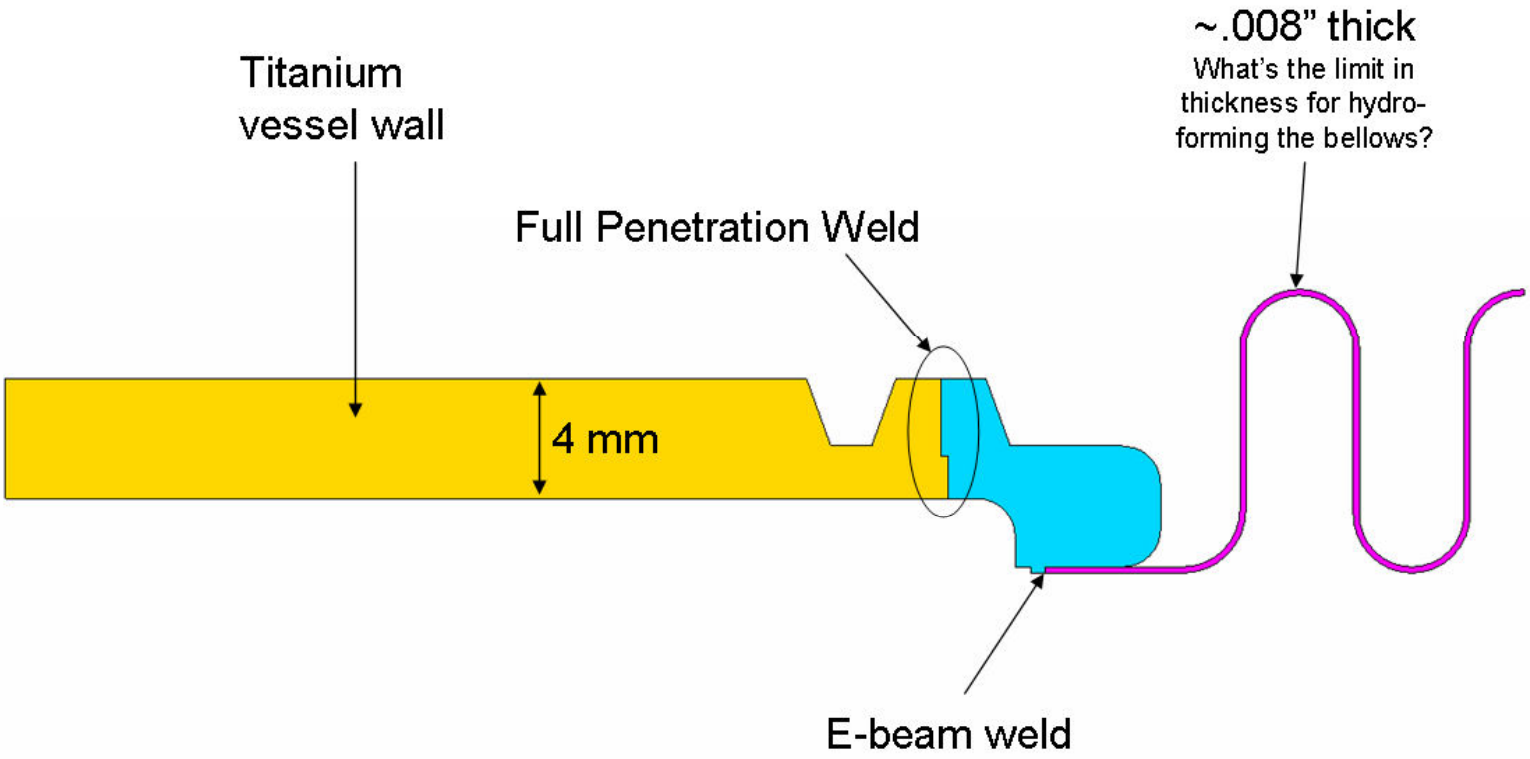
Proposed Bellows Changes

- Thicker Bellows (perhaps .012” thick)
- Weld Rings that look more like a bellows cuff to reduce:
  - Flexing
  - Stress concentrations
  - Fabrication complexity and cost
  - Difficult welding



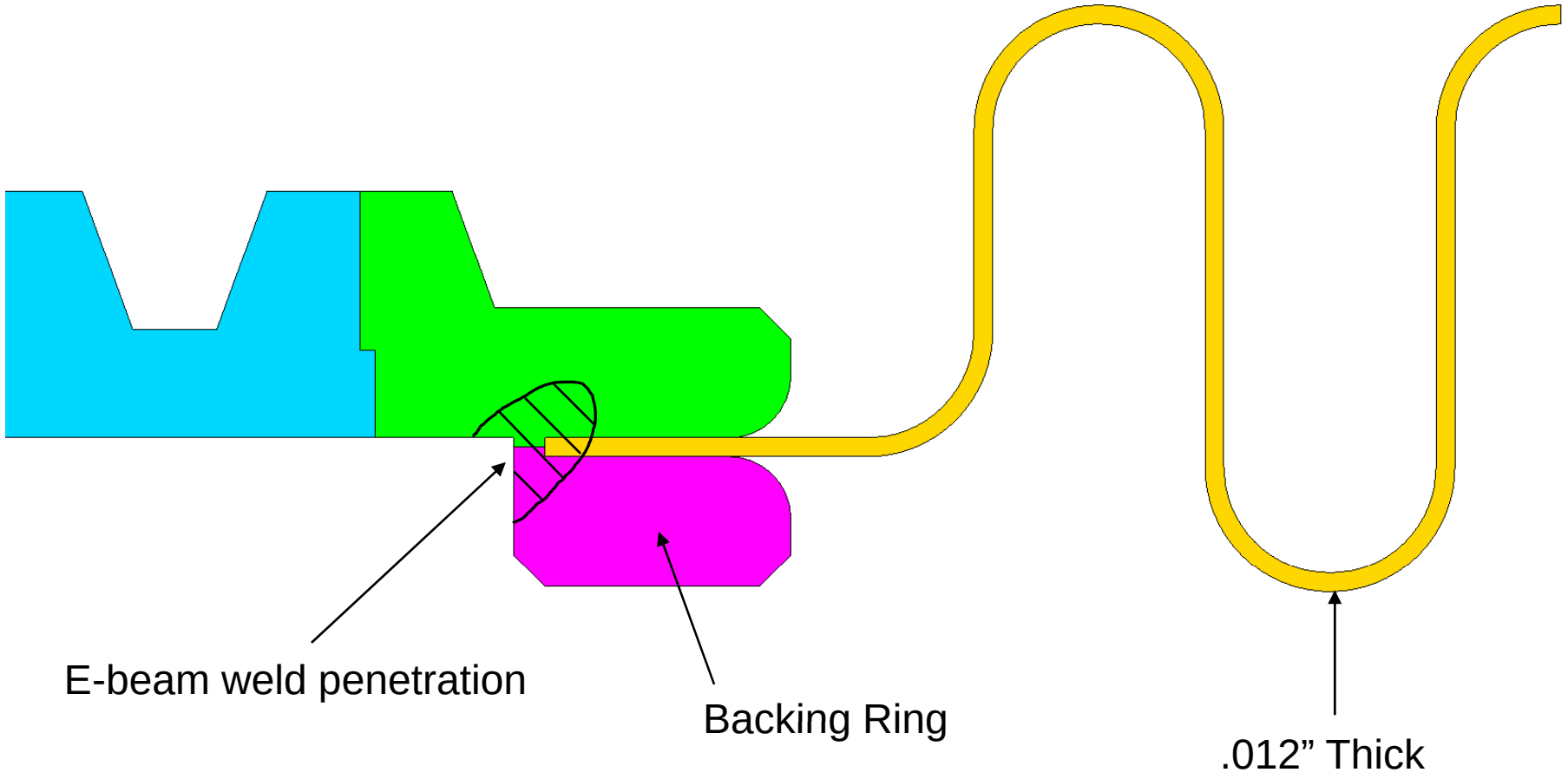
Sent to Vendor for Comments

Titanium Helium Vessel and Titanium Bellows



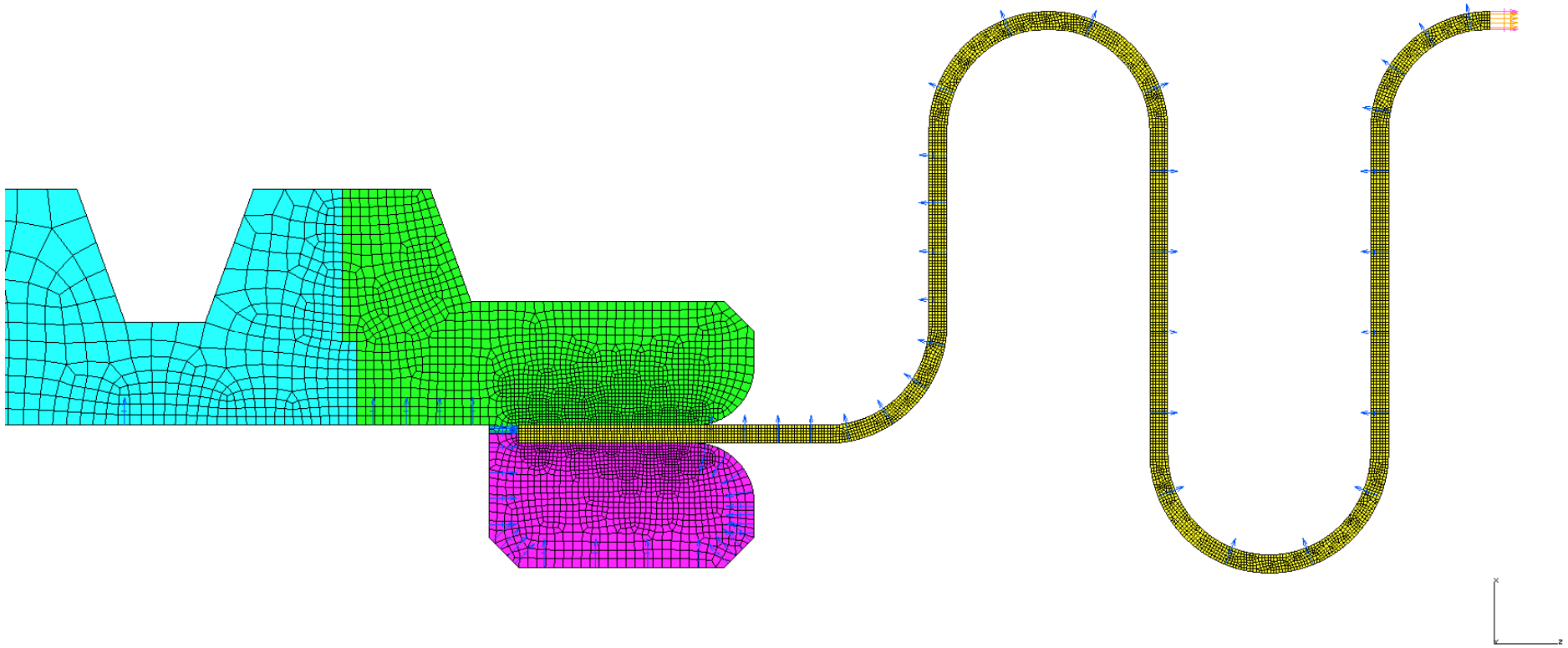
Proposed Design Change (WIP)
(internal pressure of 4 bar, warm)

Design Proposal after 1st Meeting

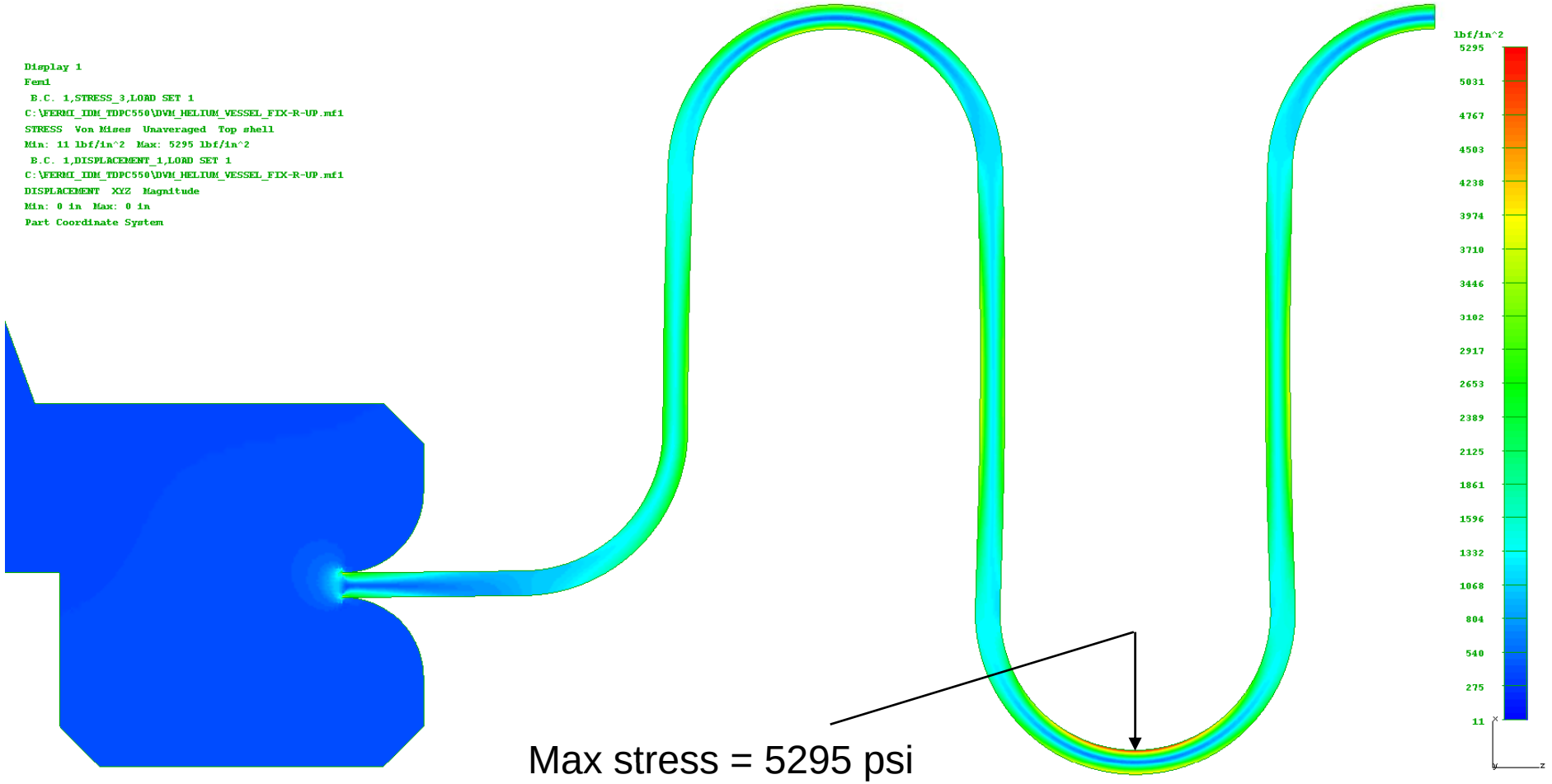


Design Proposal FEA Model 1

1 Bar internal pressure only



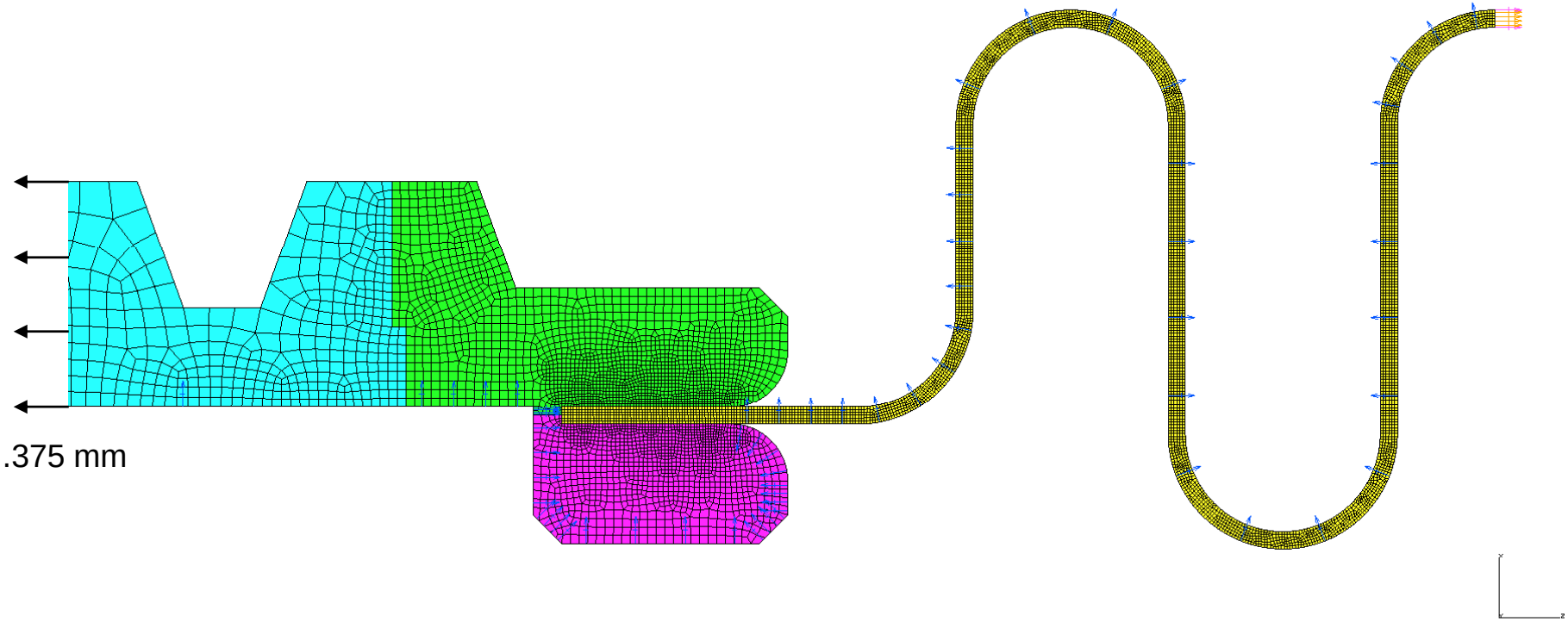
Design Proposal FEA Results 1



1 Bar internal pressure

Design Proposal FEA Model 2

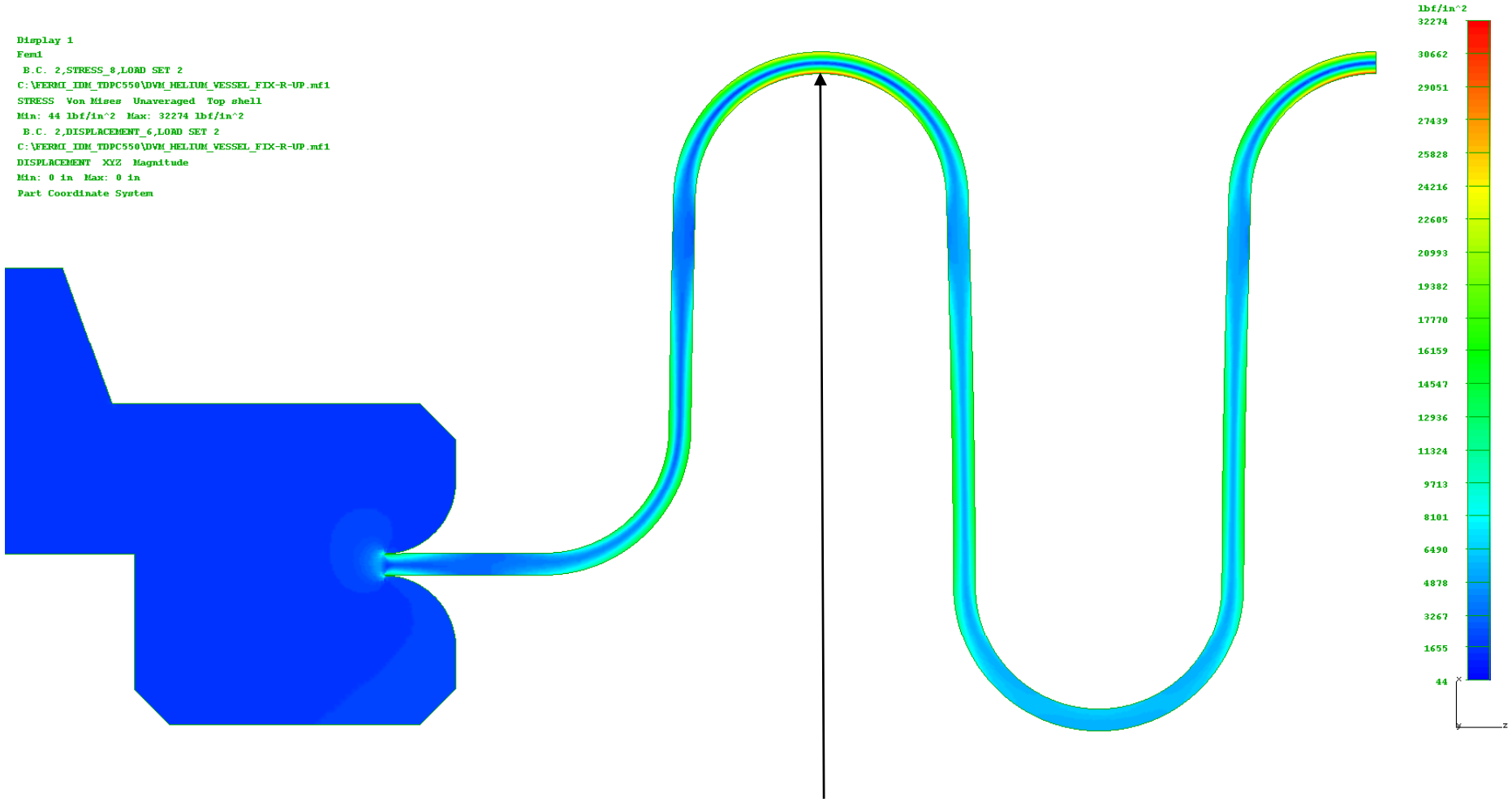
4 Bar internal pressure w/ .375 mm bellows stretch



Symmetric loading condition:
actual stretch = .75mm

Design Proposal FEA Results 2

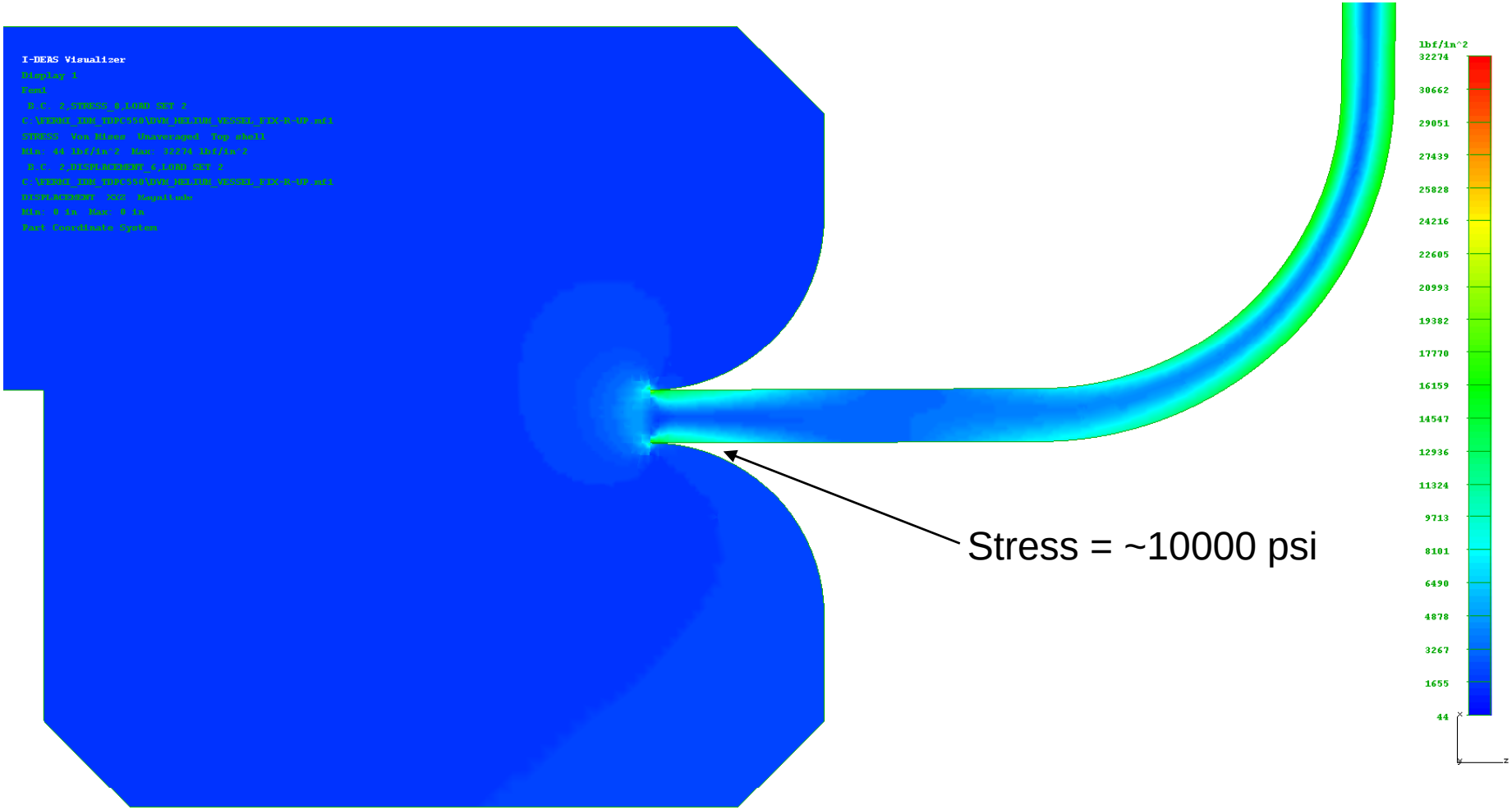
4 Bar internal pressure w/ .375 mm bellows stretch



Max stress = 32274 psi

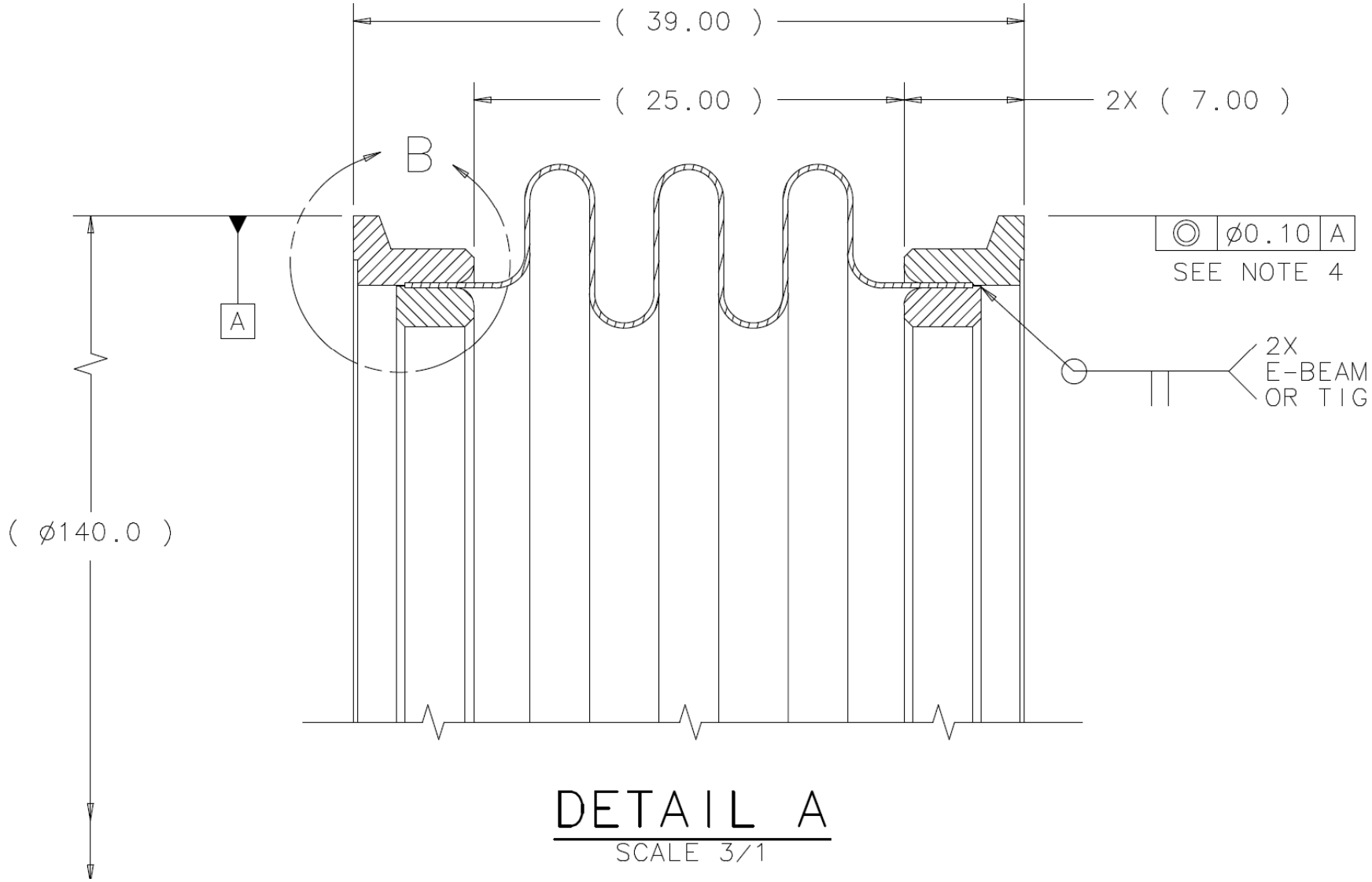
Design Proposal FEA Results 2

4 Bar internal pressure w/ .375 mm bellows stretch



Design Sent to Vendor

(3rd Harmonic)



Conclusions

- Bellows redesign looks adequate for 4 Bar, warm.
- Backing ring helps with e-beam welding and reduces stresses in the weld when leak testing the vessel.
- Thicker bellows (.012”) greatly reduces stress and allows the bellows to meet the 4 Bar criteria.
- Waiting for vendor feed-back on fabrication variations.
- 3-D model and drawings completed.