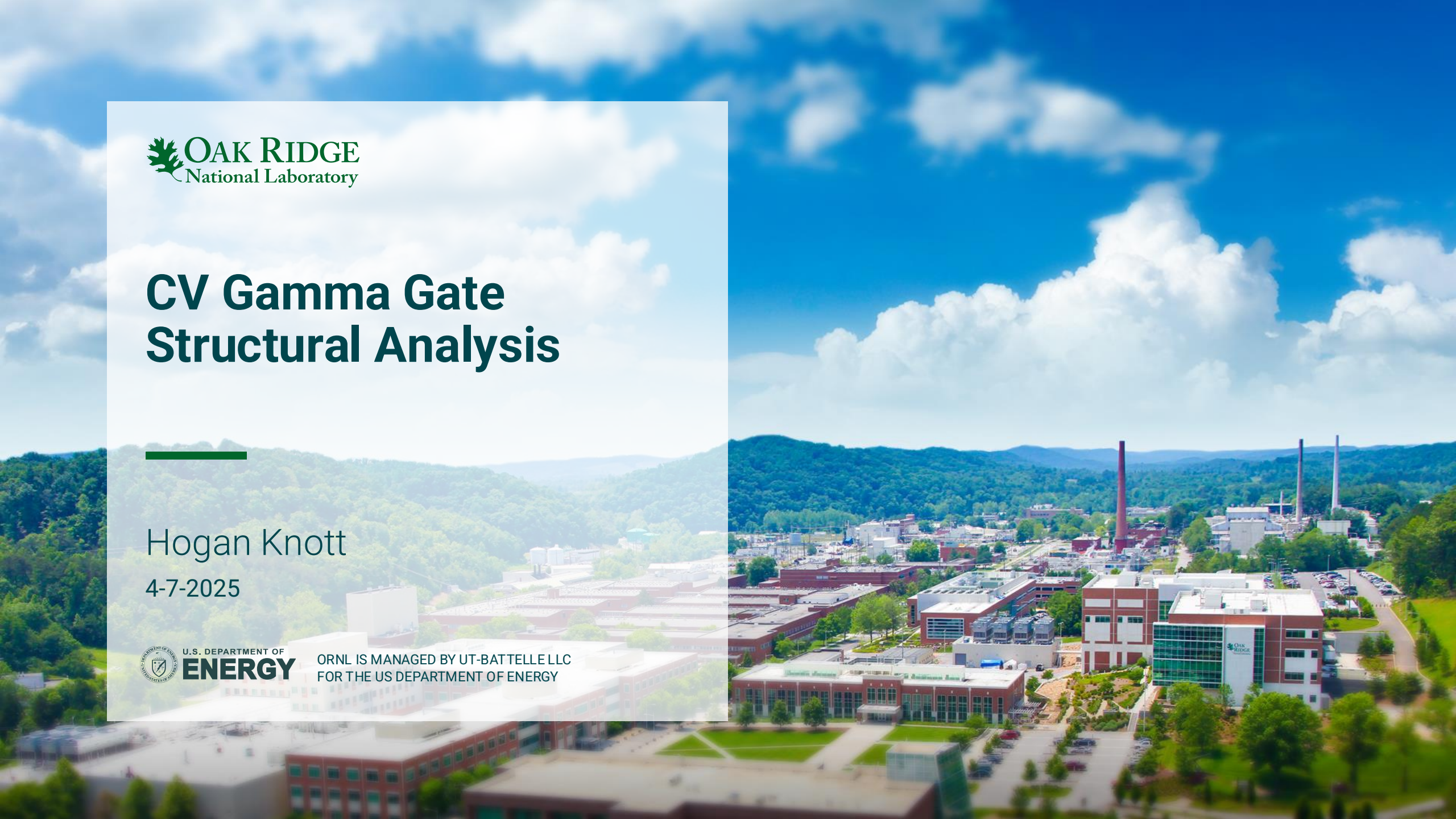

OAK RIDGE National Laboratory

CV Gamma Gate Structural Analysis

Hogan Knott

4-7-2025

U.S. DEPARTMENT OF ENERGY

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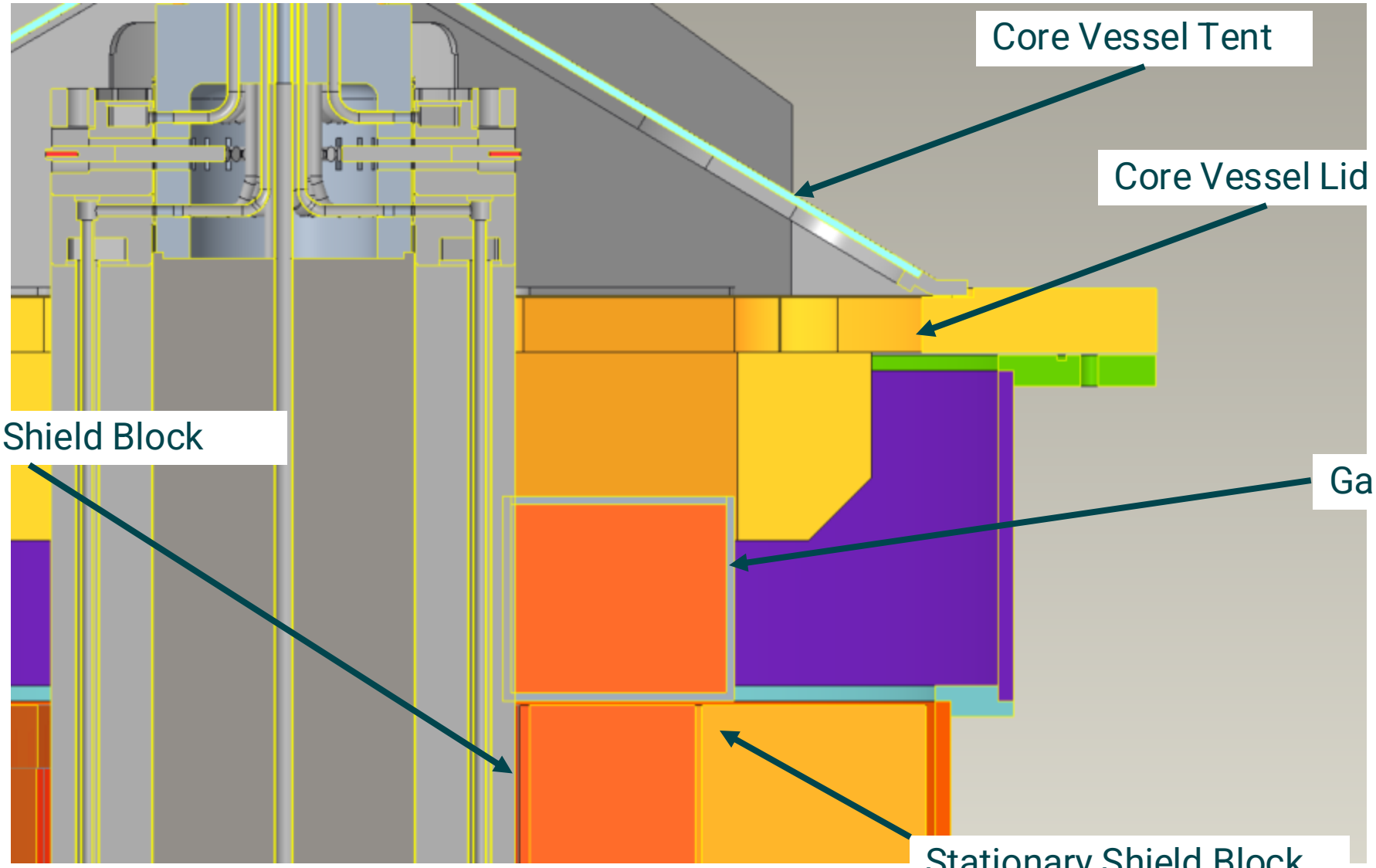
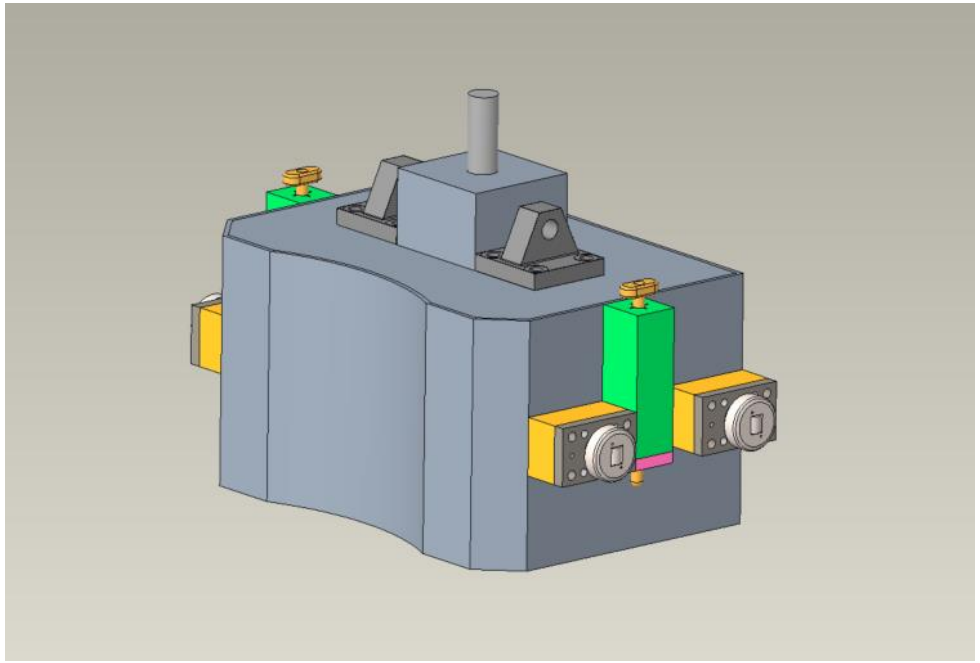
FOR THE US DEPARTMENT OF ENERGY

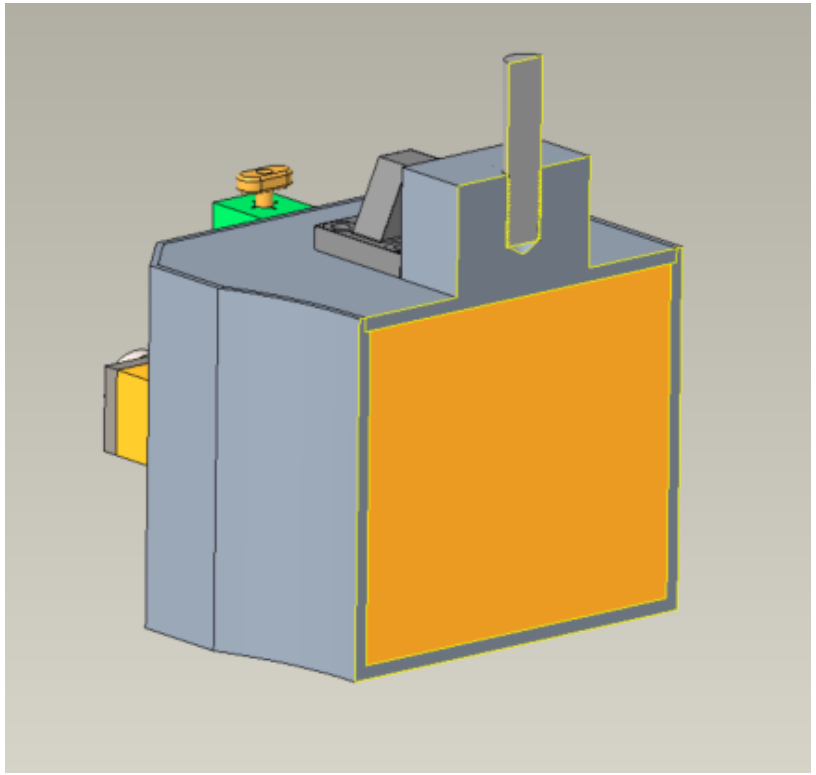
Gamma Gate Area Definition

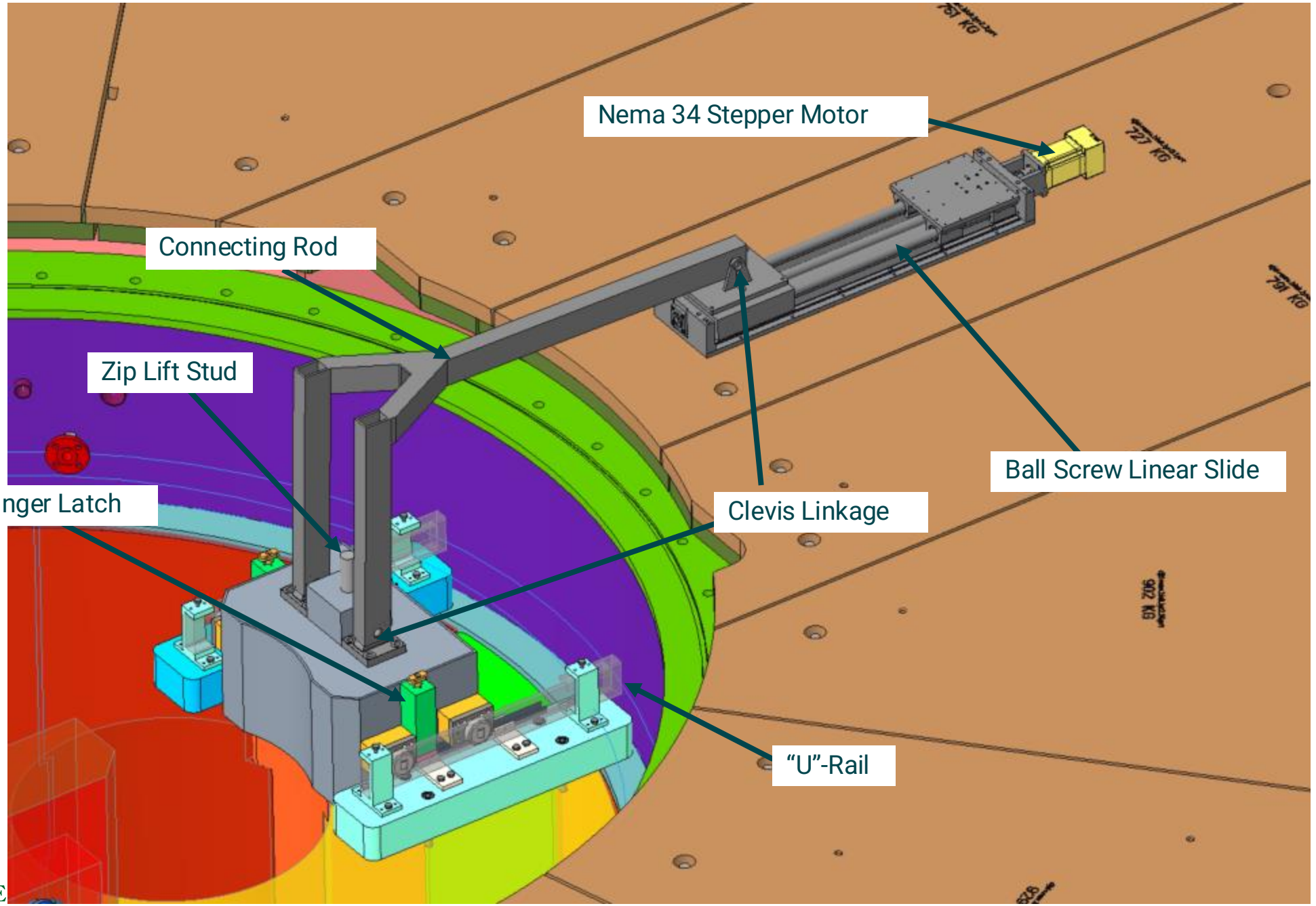


Gamma Gate at a Glance



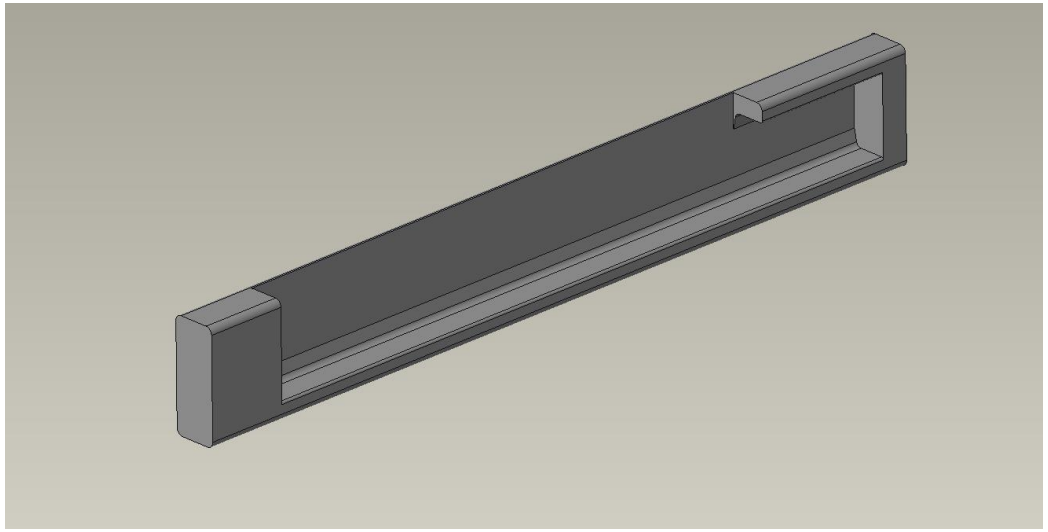
0.5-Inch-Thick Stainless-Steel Vessel
30 cm of lead thickness
~850 kg vessel mass

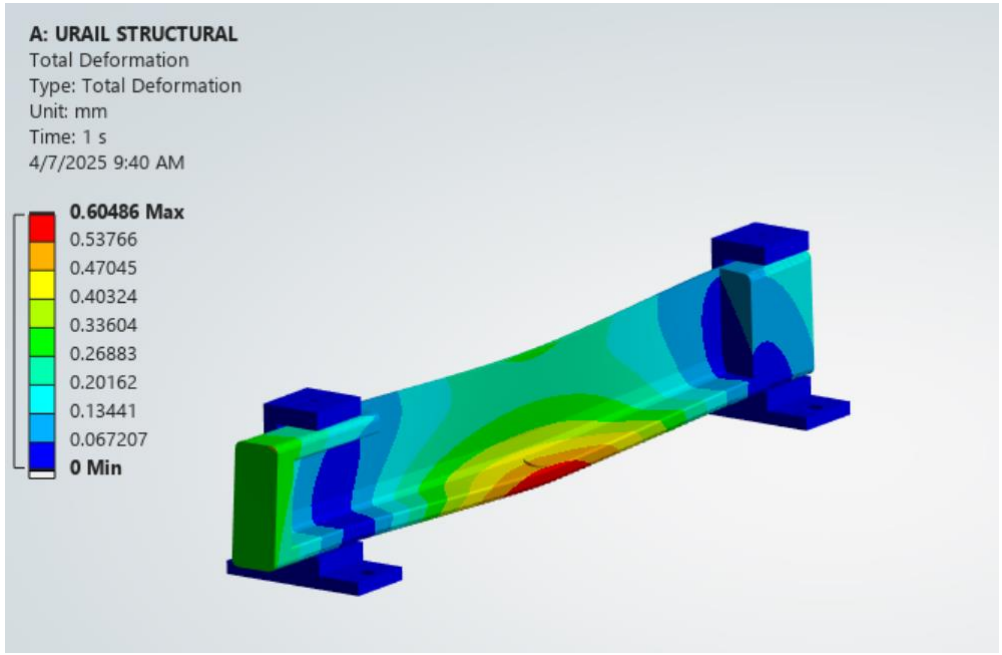


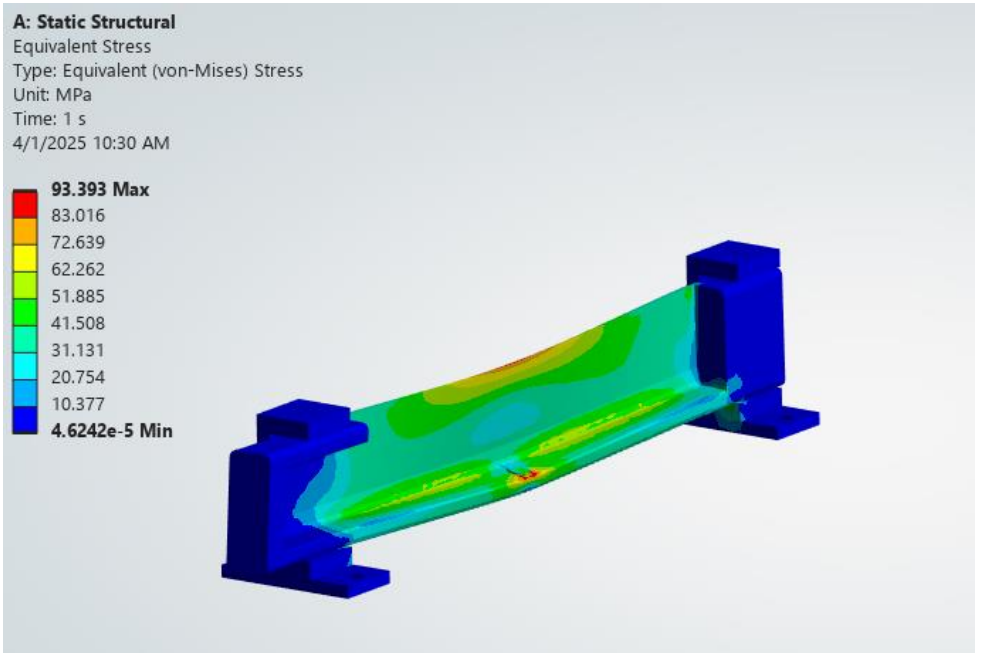

Nema 34 Stepper Motor
Connecting Rod
Zip Lift Stud
Plunger Latch
Clevis Linkage
Ball Screw Linear Slide
“U”-Rail

U-Rail Analysis

Material: Stainless Steel 316L
Load: 10 kN applied at center of the beam







U-Rail Analysis Summary

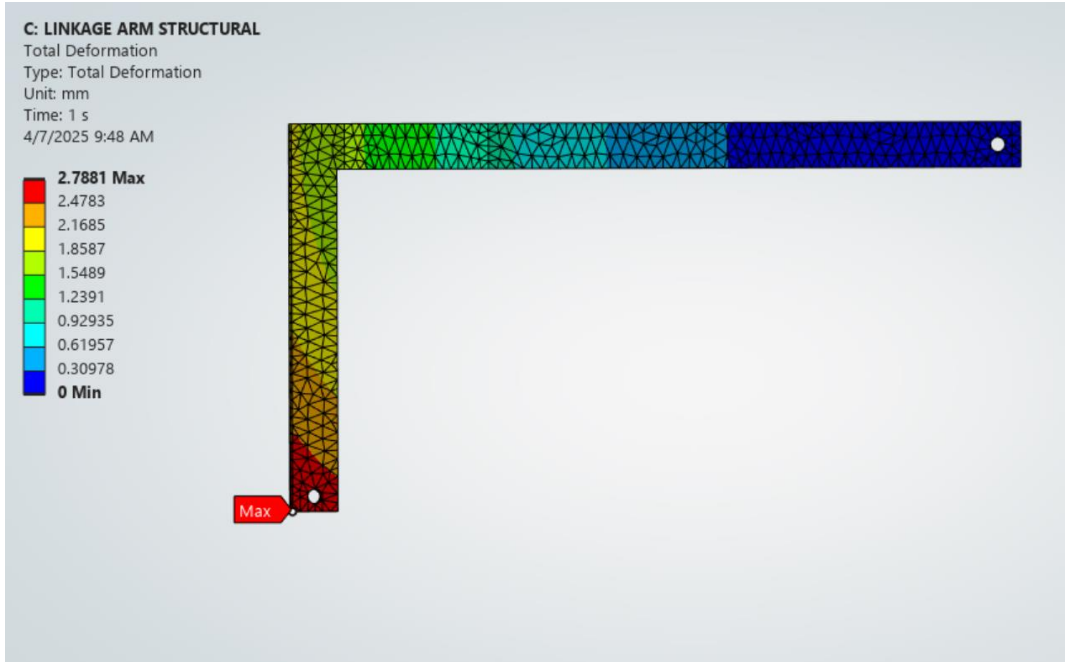
- σ_{max} = 93.4 Mpa
- δ_{max} = 0.6 mm
- U-Rail can support weight of the gamma gate

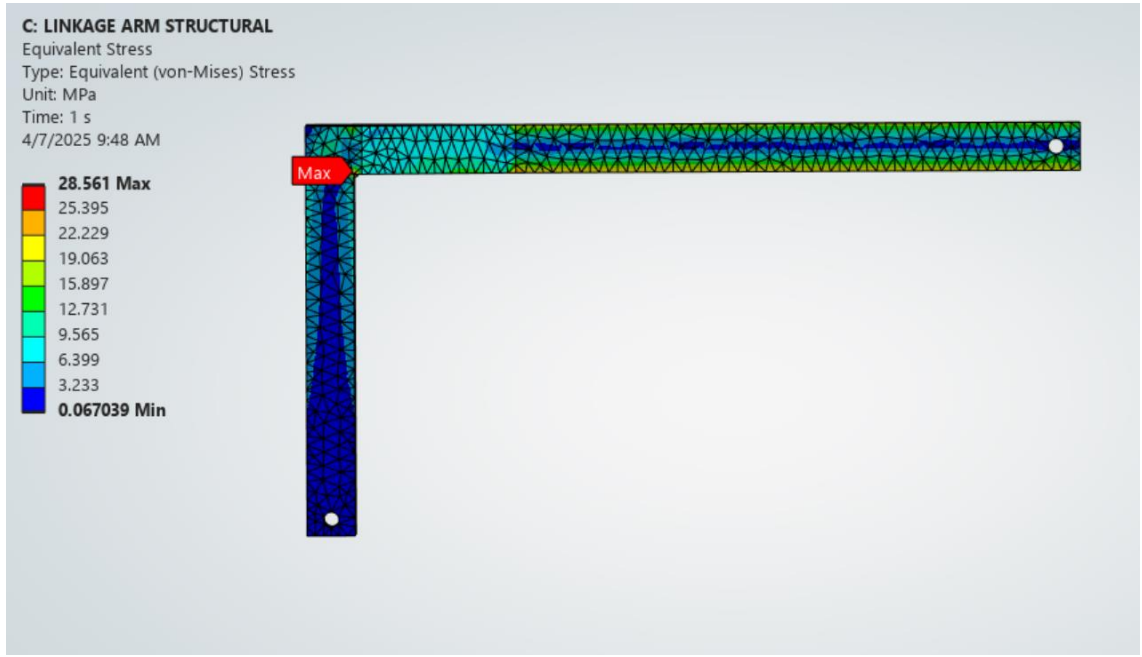
Gamma Gate Friction

- Gamma Gate Mass = 850 kg
- Normal Force on rail = 850 kg * 9.81m/s^2 = 8338.5 N
- Coefficient of static friction = 0.01 [1]
- Design Factor = 12
- Force required to move gamma gate = 0.01 * 8338.5 N * 12 = 1000 N

Linkage Arm Structural

Material: Stainless Steel 316L
Gage: 3”x2”x.25” rectangular tubing
Load: 1000 N





Linkage Arm Analysis Summary

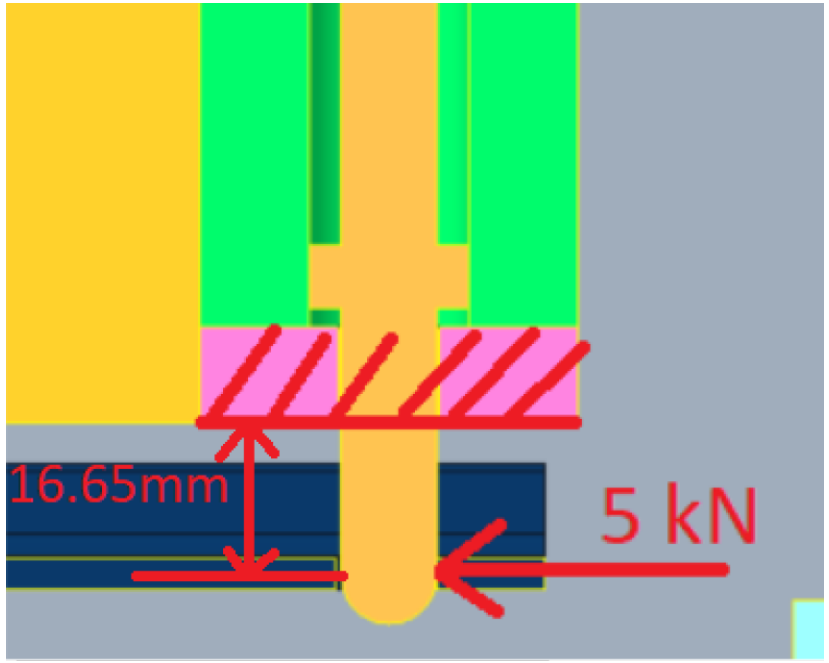
- σ_{max} = 28.6 Mpa
- δ_{max} = 2.8 mm
- Linkage can support load required to actuate the gamma gate

Gamma Gate Under Seismic Loads

- Maximum Horizontal Seismic Force $F_{pmax} = 1.6S_{DS}I_pW_p$: ASCE 7-16 Equation 13.3-2 [2]
- S_{DS}= .485 per USGS at STS coordinates
- I_p= 1.5 : ASCE 7-16 section 13.1.3 [2]
- W_p= 9.81m/s^2 * 850kg = 8338.5 N
- F_{pmax} = 9706 N
- Force per latch pin = 9706 N / 2 = 5000 N

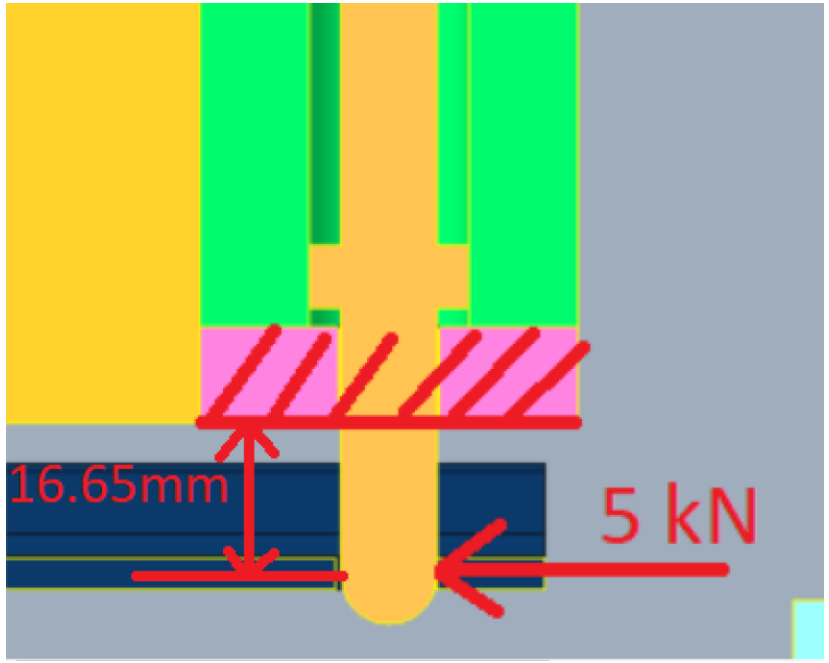
Latch Pin Stress Analysis

- Material: Inconel 718
- 20 mm diameter cylinder cross section
- D = 20 mm
- $\sigma_{max} = (y_{max} * L * F)/(I)$
- $y_{max} = radius = 10\ mm$
- $I = \frac{\pi * D^4}{64} = 7854\ mm^4$
- F = 5 kN
- L = 16.65 mm
- σ_{max} = 106 MPa



Latch Pin Deflection Analysis

- Material: Inconel 718
- 20 mm diameter cylinder cross section
- D = 20 mm
- $\delta_{max} = \frac{P*l^3}{3*E*I}$
- E = 200 Gpa [3]
- $I = \frac{\pi*D^4}{64}$ = 7854 mm^4
- P = 5 kN
- L = 16.65 mm
- δ_{max} = 0.005 mm



Latch Pin Analysis Summary

- σ_{max} = 106 Mpa
- δ_{max} = 0.005 mm
- Latch Pin will prevent motion of the gamma gate during a seismic event

References

1. Product-Catalog-CRT - Hevi-Rail.pdf

2. American Society of Civil Engineers, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE/SEI 7-16)*, ASCE, 2017.

3. American Society of Mechanical Engineers. (2021). *ASME Boiler and Pressure Vessel Code, Section II: Materials*. ASME.

ASCE 7-16 section 13.1.3

13.1.3 Component Importance Factor. All components shall be assigned a component Importance Factor as indicated in this section. The component Importance Factor, I_p, shall be taken as 1.5 if any of the following conditions apply:

1. The component is required to function for life-safety purposes after an earthquake, including fire protection sprinkler systems and egress stairways.
2. The component conveys, supports, or otherwise contains toxic, highly toxic, or explosive substances where the quantity of the material exceeds a threshold quantity established by the Authority Having Jurisdiction and is sufficient to pose a threat to the public if released.
3. The component is in or attached to a Risk Category IV structure, and it is needed for continued operation of the facility or its failure could impair the continued operation of the facility.
4. The component conveys, supports, or otherwise contains hazardous substances and is attached to a structure or portion thereof classified by the Authority Having Jurisdiction as a hazardous occupancy.