Seal Analysis for the Ares-I Upper Stage Fuel Tank Manhole Covers

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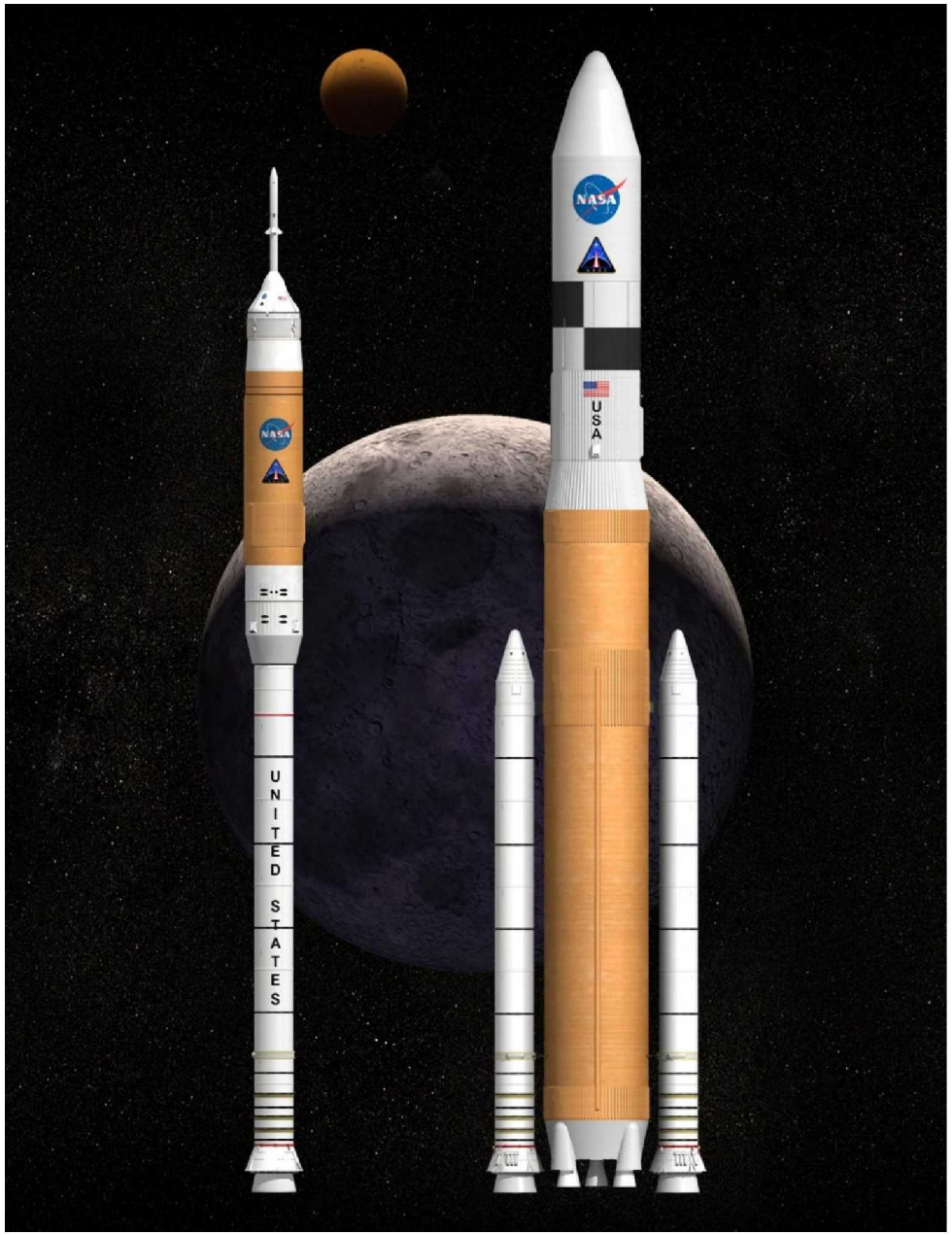
Objective

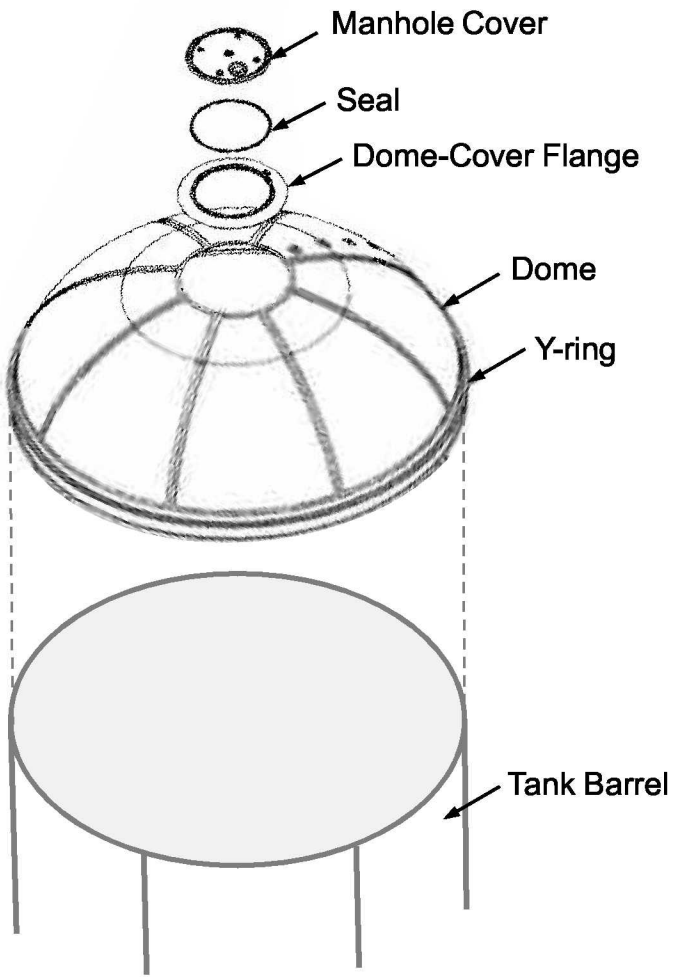
Assess the feasibility that the Naflex seal used with the Space Shuttle External Tank manhole covers can be used for the Ares-I design

Outline

- Problem description
- Background
- Approach for Upper Stage analyses
- Analyses and results
- Summary

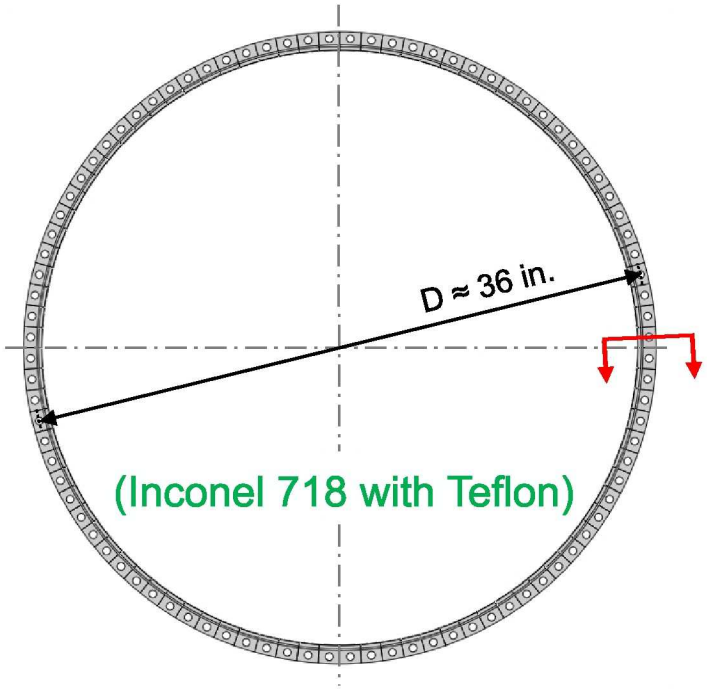
Ares-I Upper Stage LH2 Tank



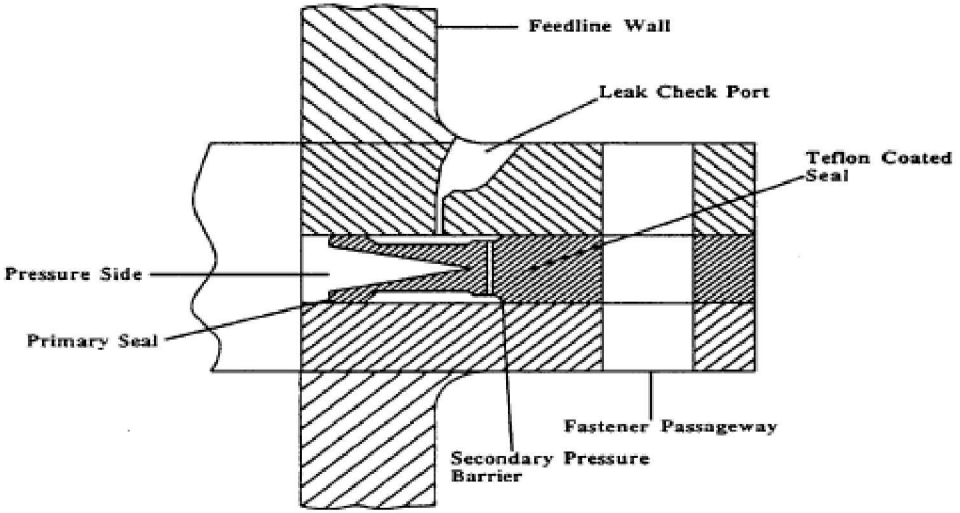


Naflex Pressure-Assisted Seal

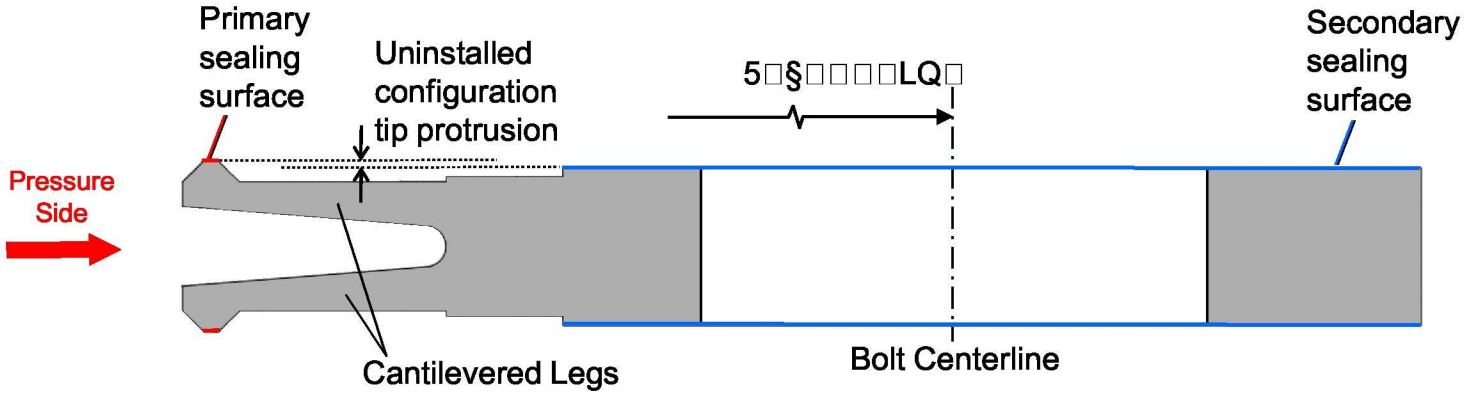
Seal Top View



Typical Joint with a Seal



Seal Section View



Background

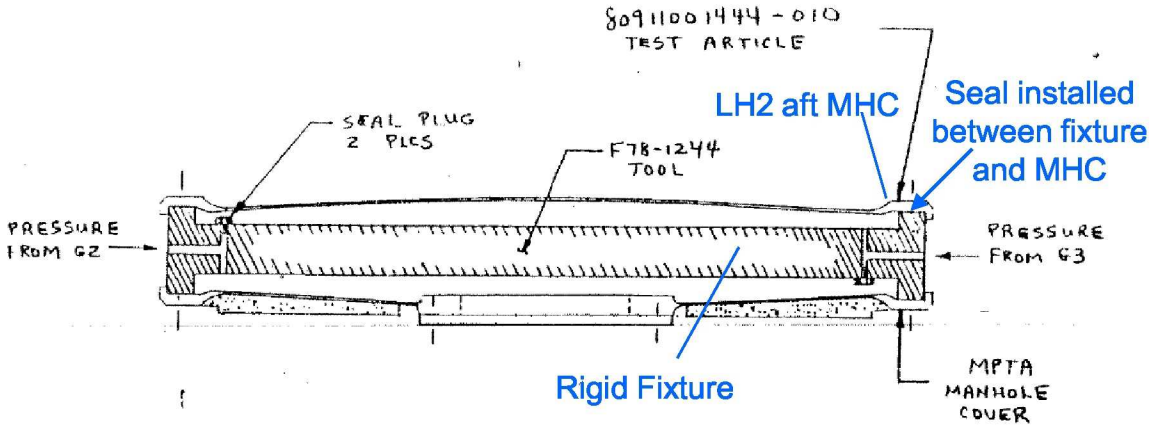
- Naflex seals have long history of use in launch vehicle components, including Saturn stages and Space Shuttle External Tank
- Ares-I Upper Stage tank pressures are higher than ET pressures, requiring performance verification of heritage seal design in new manhole cover configuration

Approach for Upper Stage Analyses

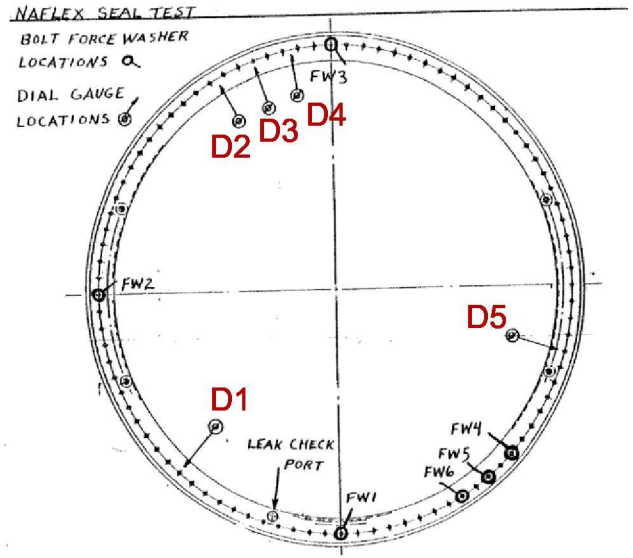
- Heritage ET analyses reviewed for potential application to Upper Stage

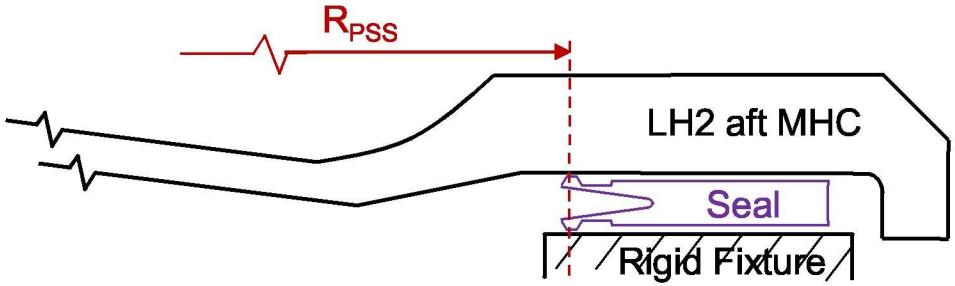
ET Seal Test

Test Set-Up



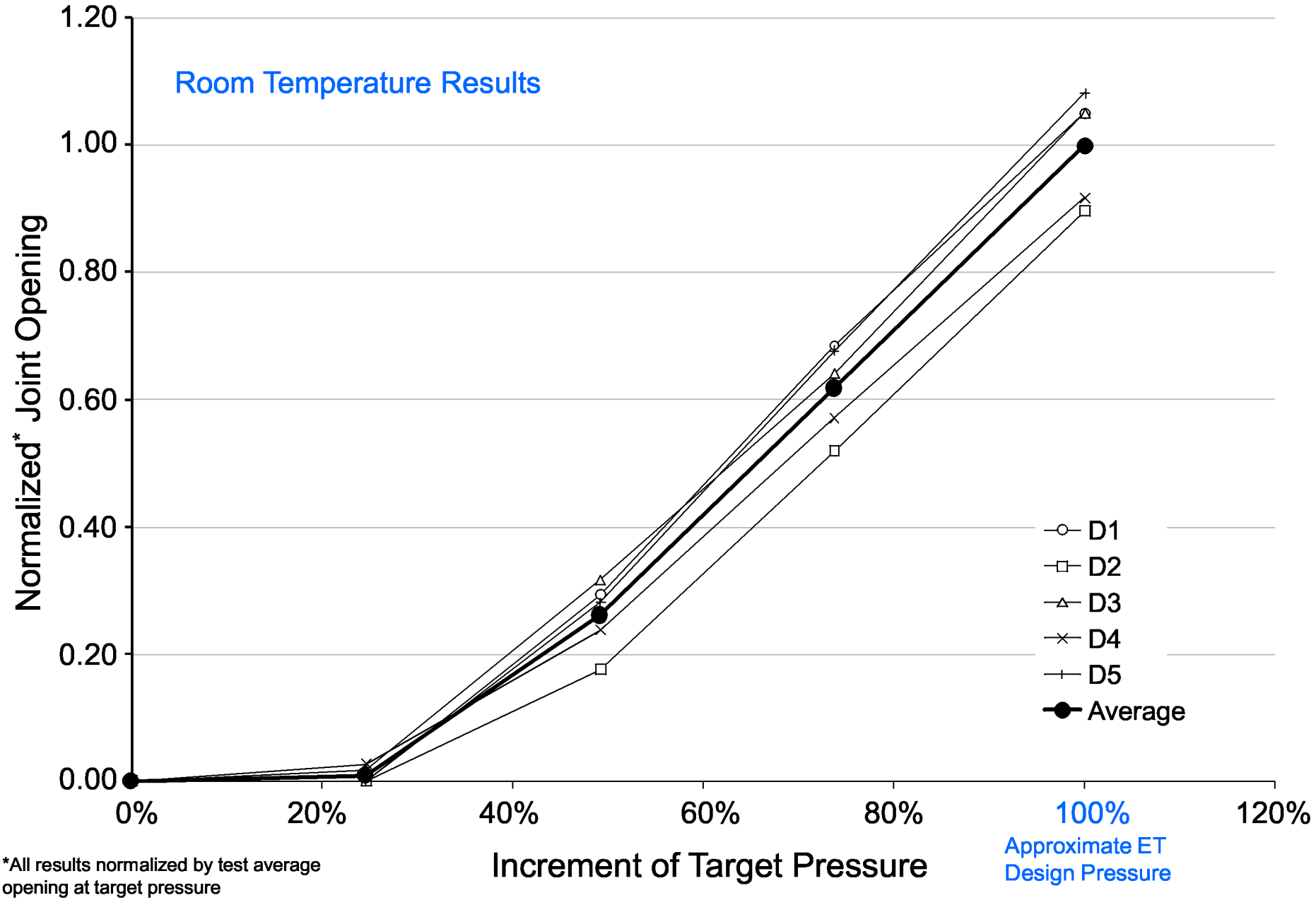
Deflection Gauge Locations





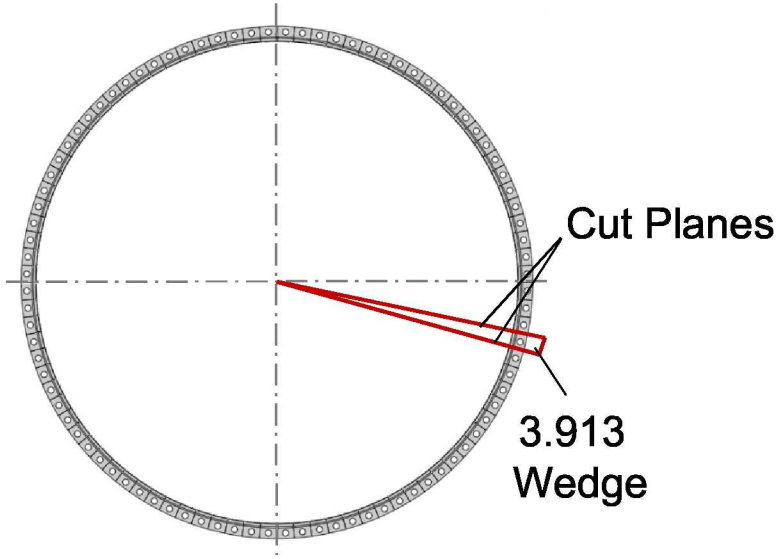
* Drawings from test report

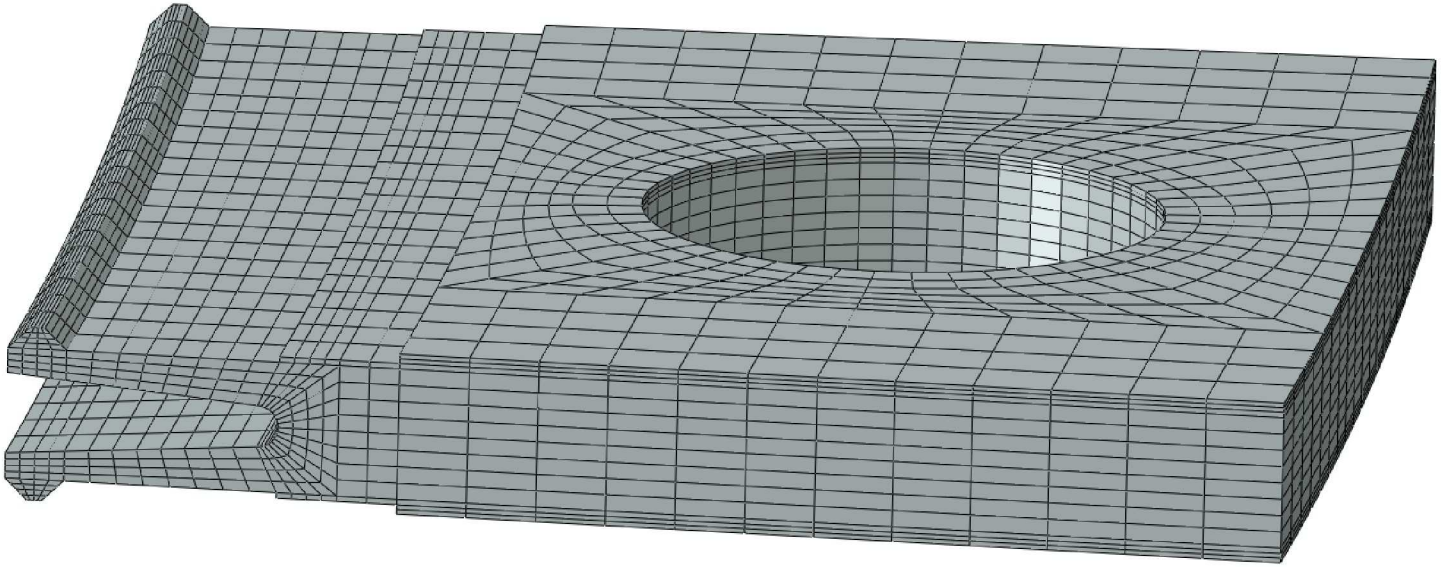
ET Seal Test



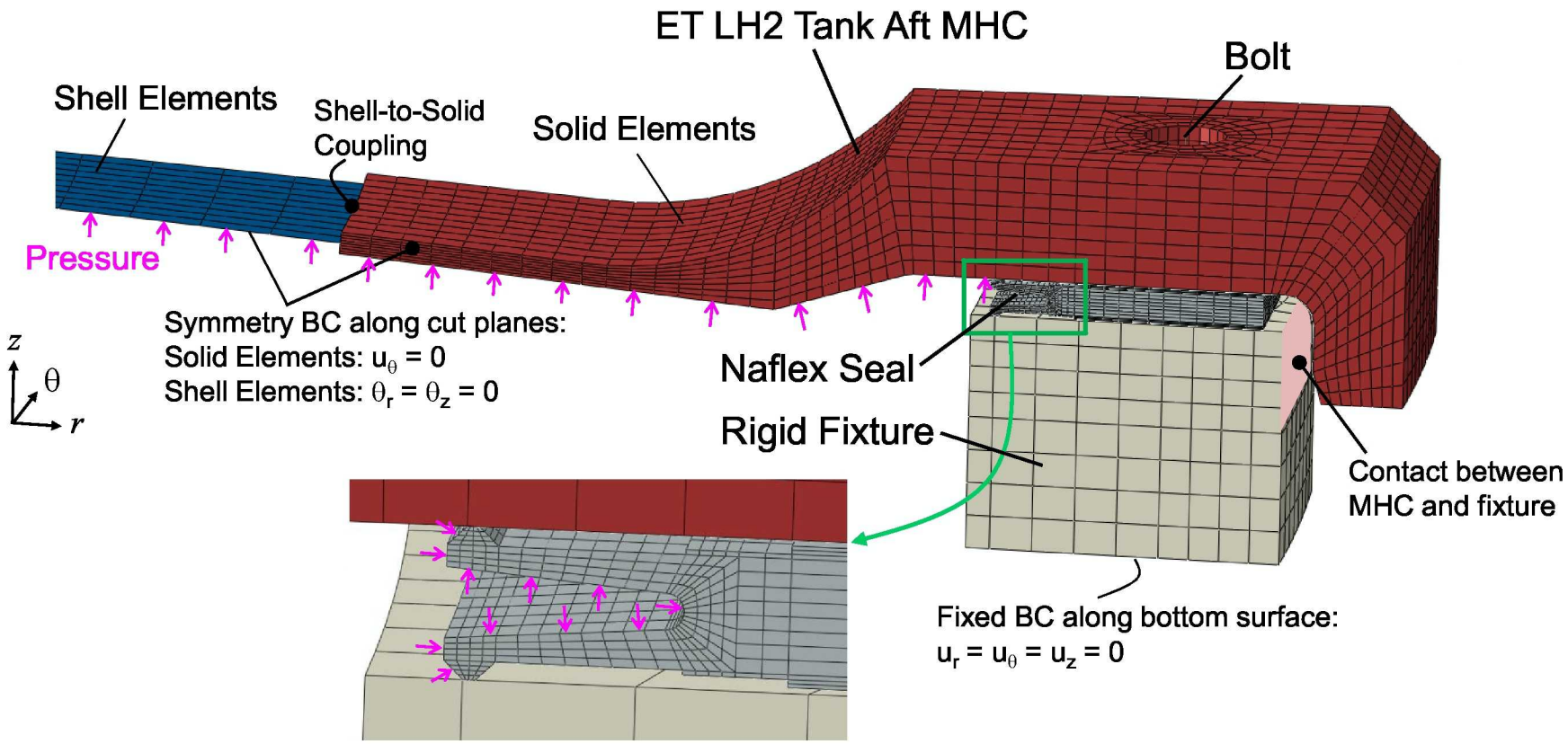
*All results normalized by test average opening at target pressure

3D Symmetric Wedge of Naflex Seal





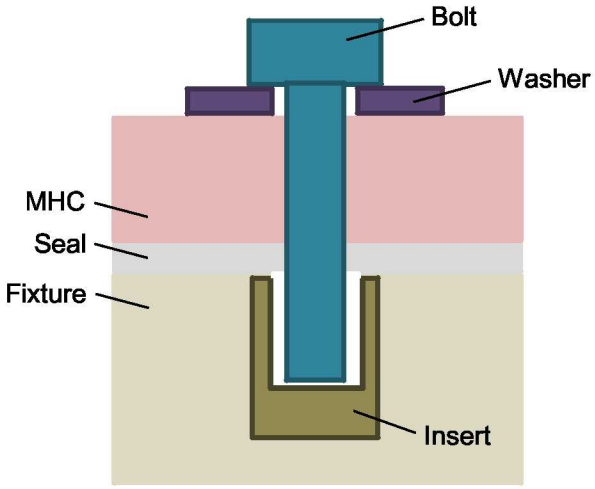
ET Seal Test Finite Element Model



Part	Material
MHC	Aluminum 2219
Seal	Inconel 718
Bolt	A286 Stainless Steel
Fixture	Generic Stiff

ET Seal Test Finite Element Model

Bolted Joint in ET MHC



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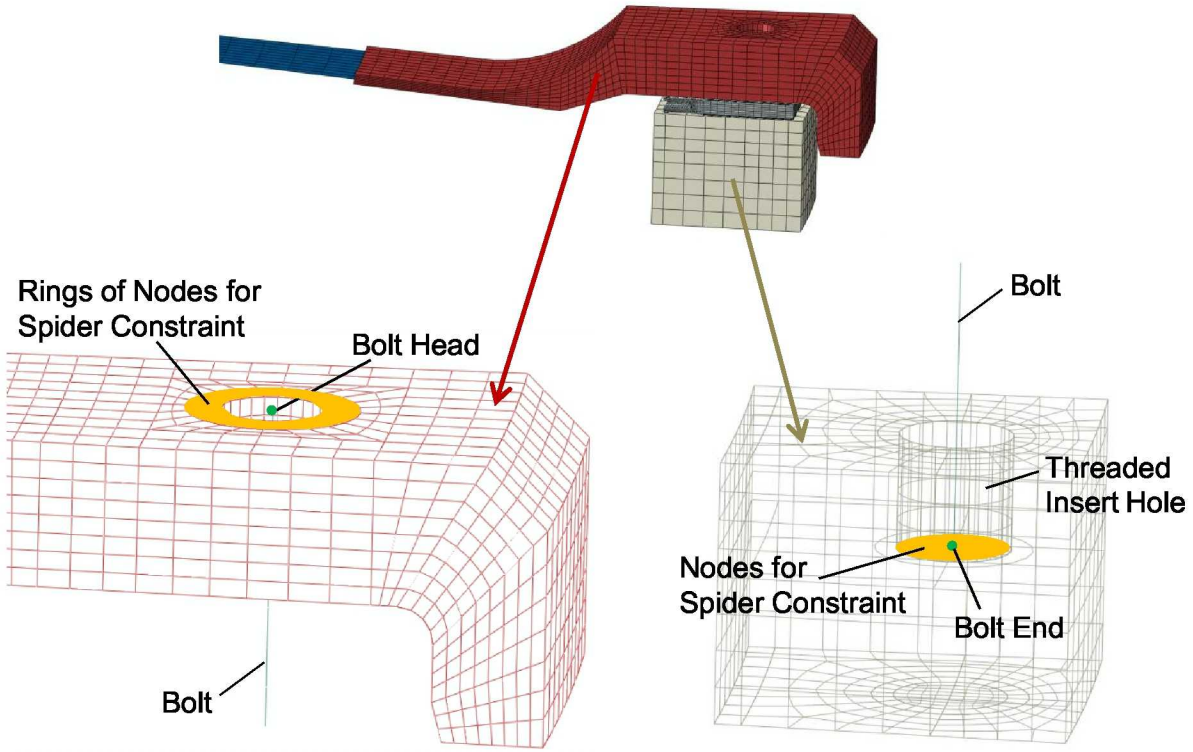
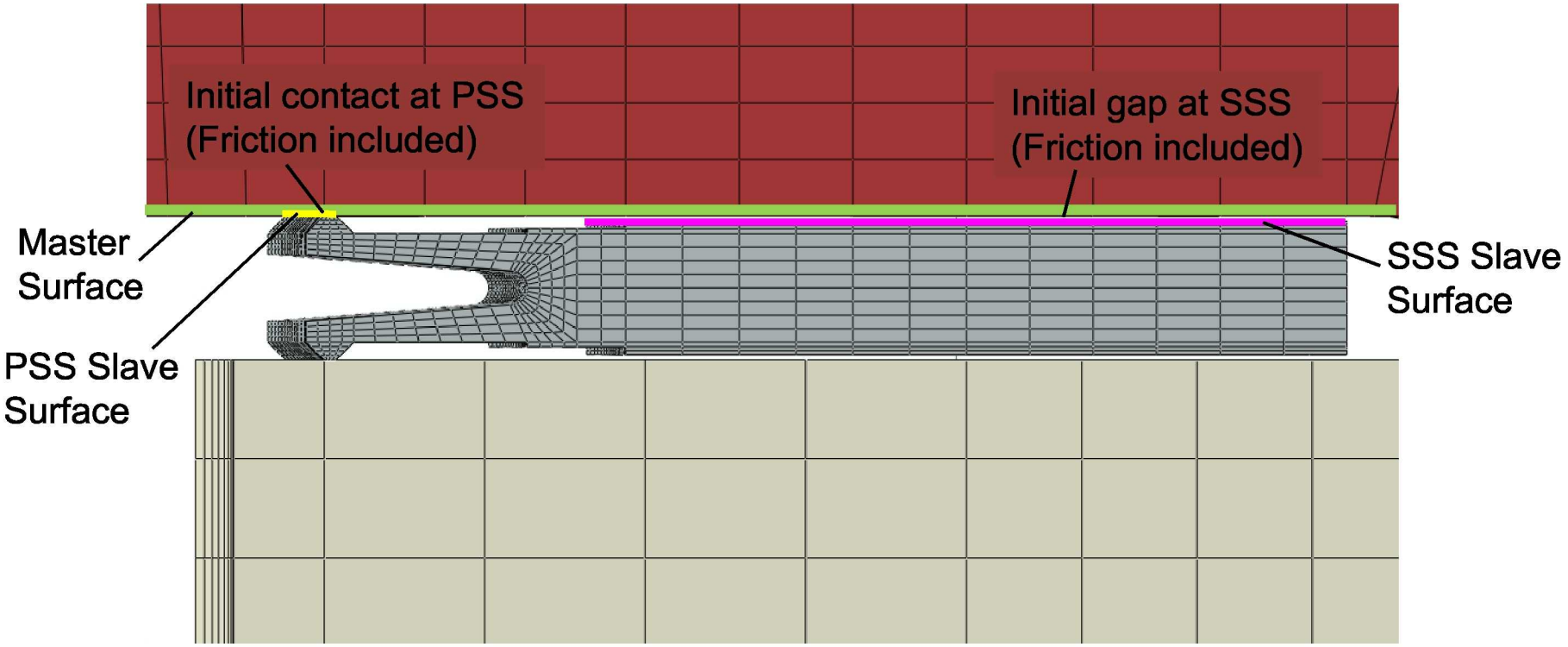
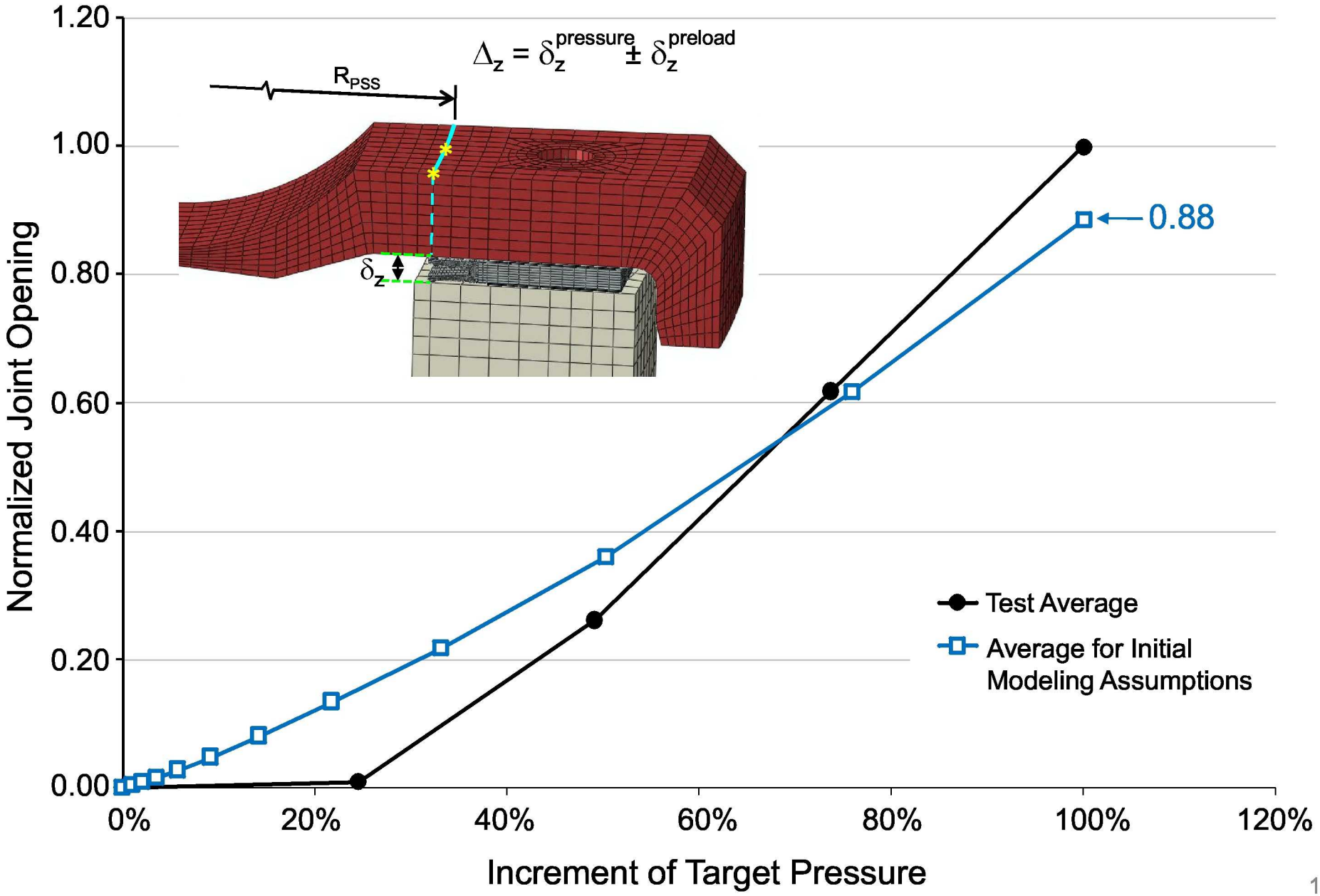


ET Seal Test Finite Element Model

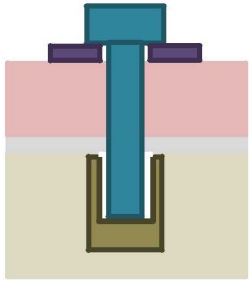
Contact

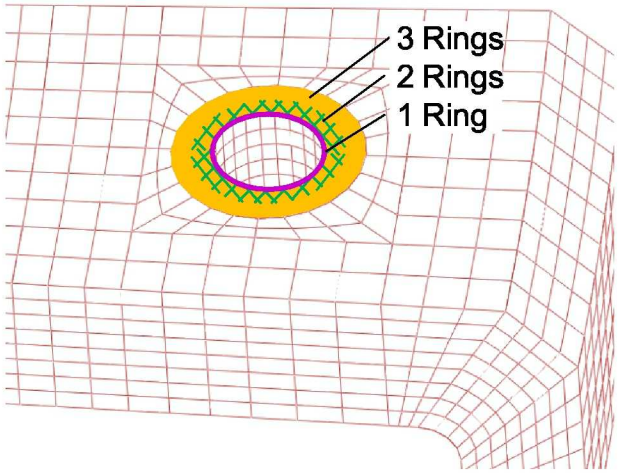


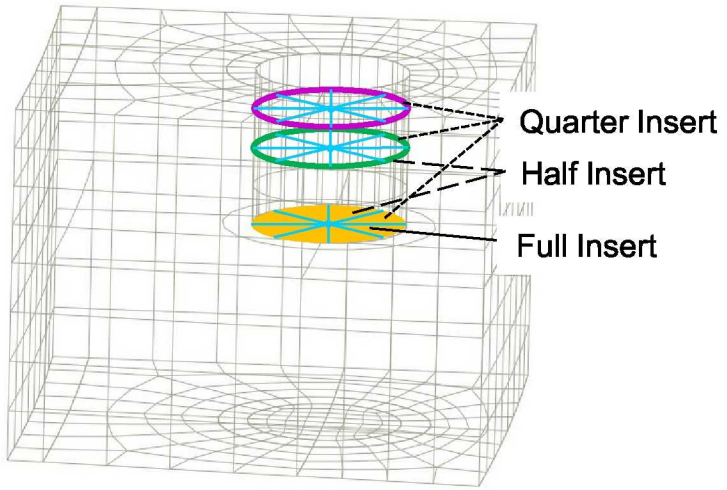
ET Seal Test-Analysis Correlation



ET Seal Test-Analysis Correlation



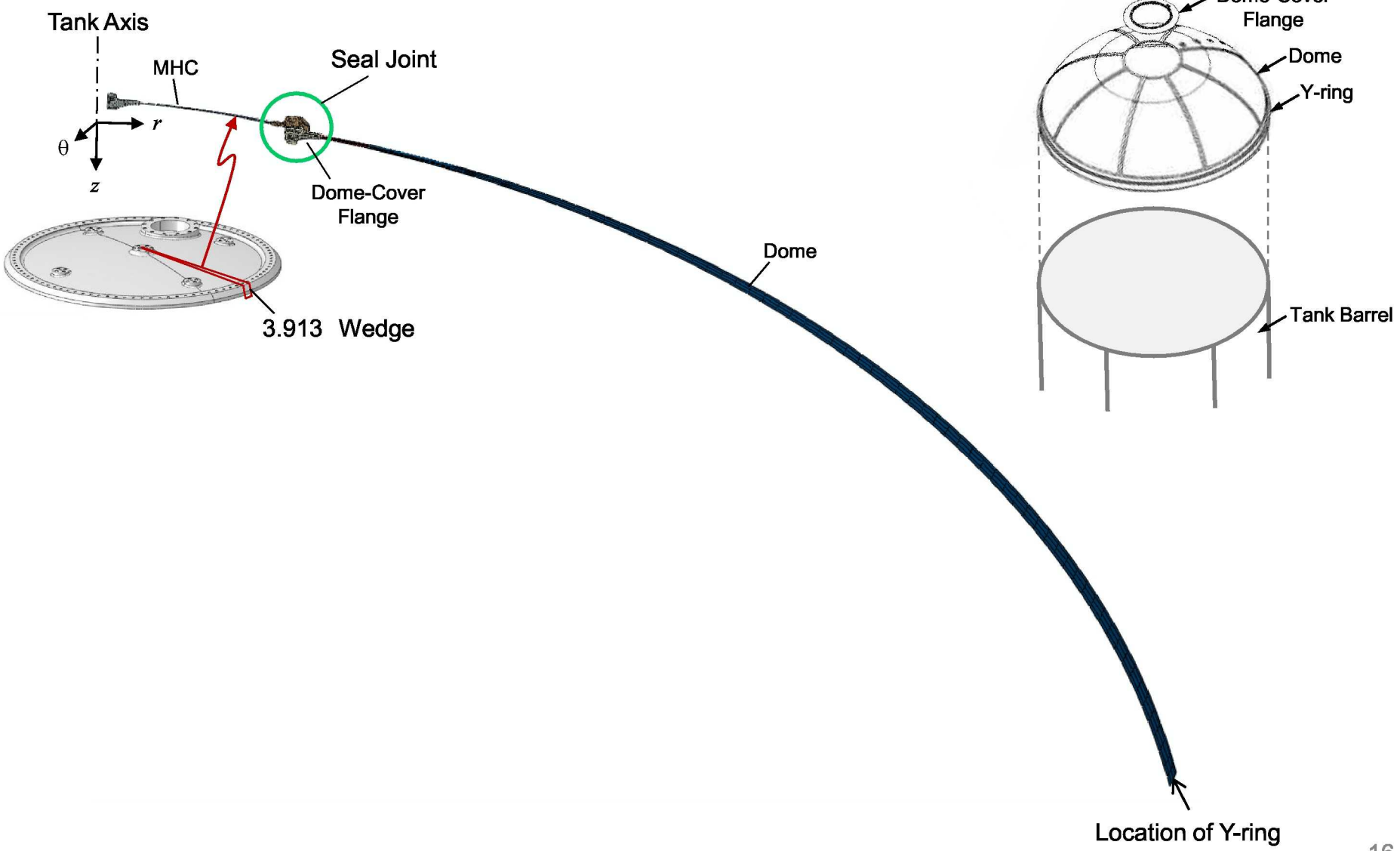




Initial Modeling Assumptions →

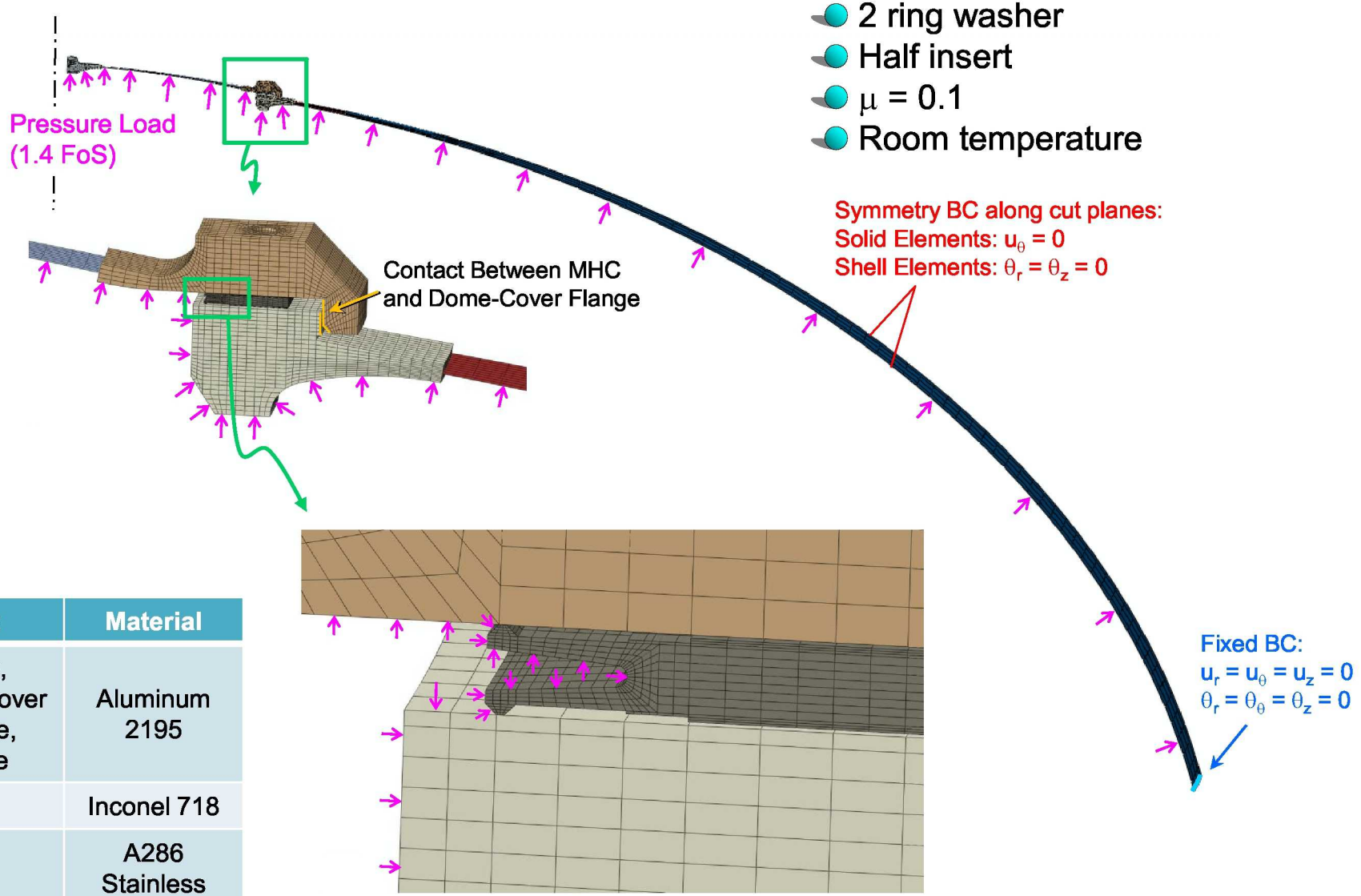
Washer	Insert	Friction	Prediction
3 Rings	Full	0.1	**0.88**
2 Rings	Full	0.1	**0.98**
1 Ring	Full	0.1	**1.15**
3 Rings	Half	0.1	**0.91**
3 Rings	Quarter	0.1	**0.93**
3 Rings	Full	0.04	**0.88**
3 Rings	Full	0.2	**0.89**
2 Rings	Half	0.1	**1.02**

Upper Stage LH2 Tank MHC Seal Joint Analyses



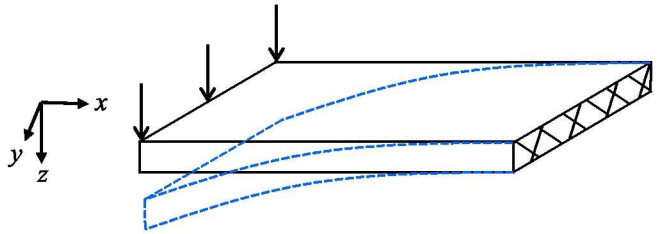
Upper Stage Seal Joint Finite Element Model

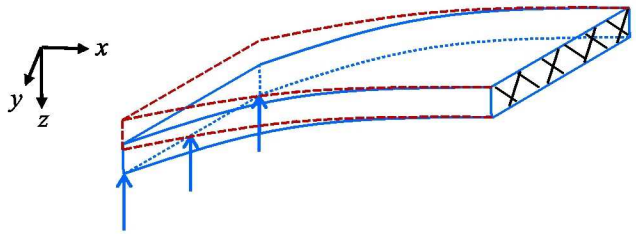
- Solid / shell combined modeling
- 2 ring washer
- Half insert
- $\mu = 0.1$
- Room temperature



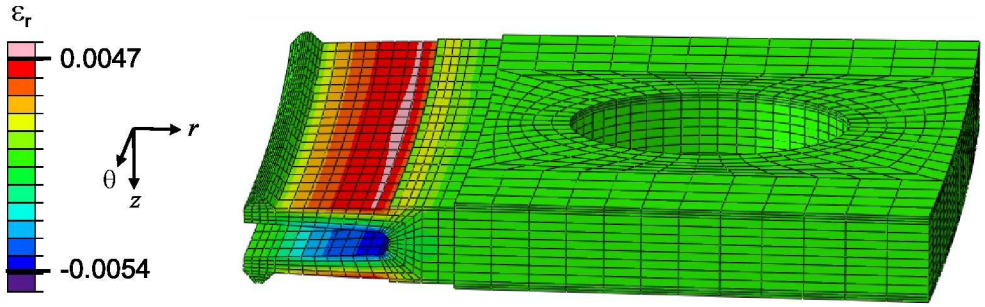
Part	Material
MHC, Dome-Cover Flange, Dome	Aluminum 2195
Seal	Inconel 718
Bolt	A286 Stainless Steel

Upper Stage Seal Joint Results

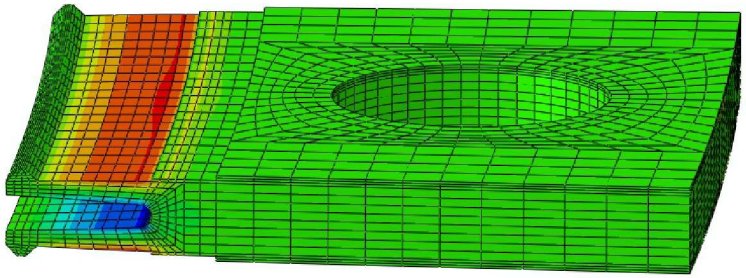


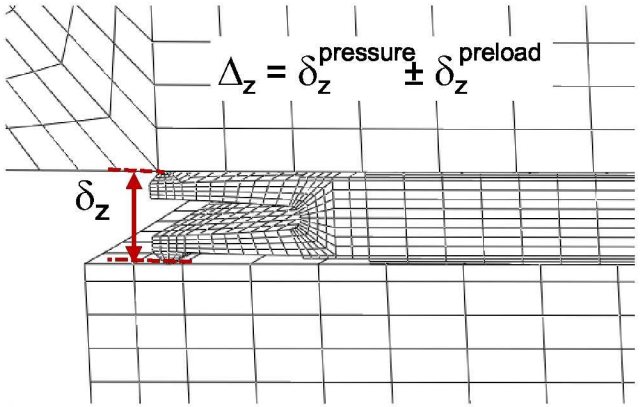


Radial Strain After Preload



Radial Strain After Pressure Load





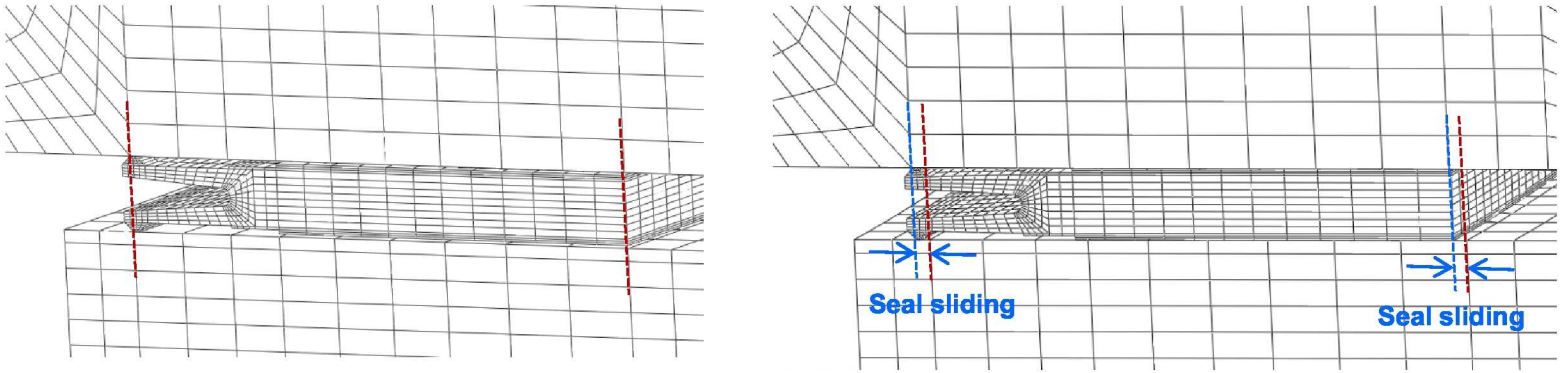
- Δ_z / Allowable = 0.39 (at Room Temp.)
- Preliminary results for cryogenic temperature indicate that joint opening is also within allowable.

Upper Stage Seal Joint Results

Radial Restraint

- Negligible effect on joint opening
- Δ_z / Allowable = 0.39 (at Room Temp.)

Friction



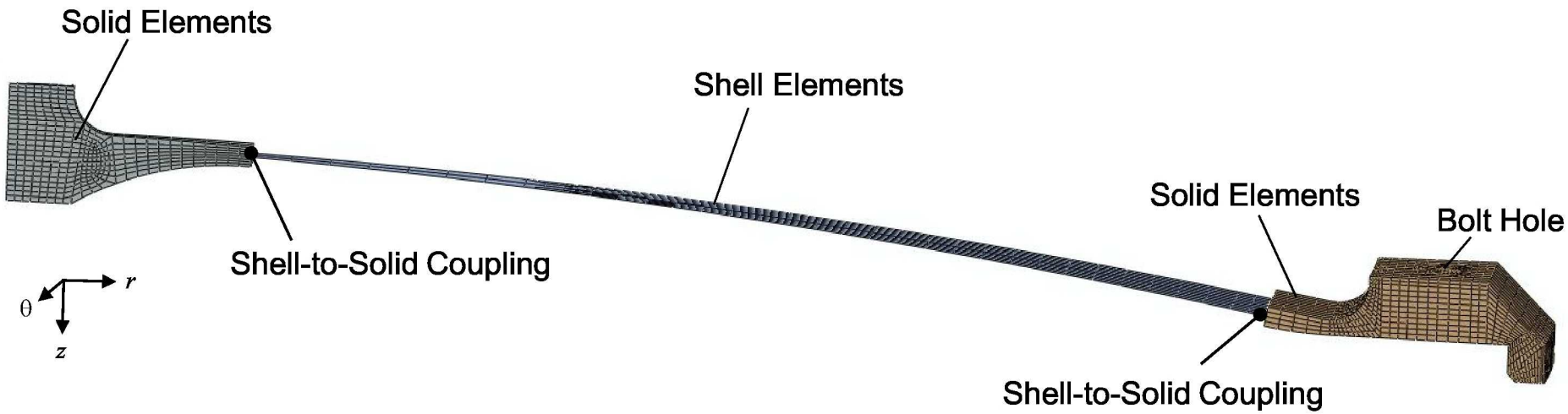
- Negligible effect on joint opening
- Δ_z / Allowable = 0.39 (at Room Temp.)

Summary

Analysis Observations

- 3D finite element modeling correlates well with test data
- Demonstrated effects of modeling assumptions

Wedge Model of MHC



Wedge Model of Dome-Cover Flange