Step IV - Engineering

Jason Tarrant – Integration Engineering

- PRY – SS Stand-Offs

Thanks to Steve Virostek, Josef Boehm, John Cobb, Colin Whyte, Tom Bradshaw, Alan Bross & Steve Plate for their help & quick responses regarding the following work

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PRY SS Stand-Off

- Potential Loads on the Devices & PRY
  - Steady operational magnetic attraction loads – balanced w.r.t PRY
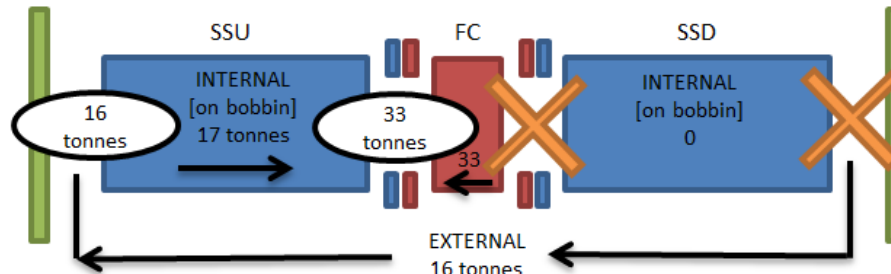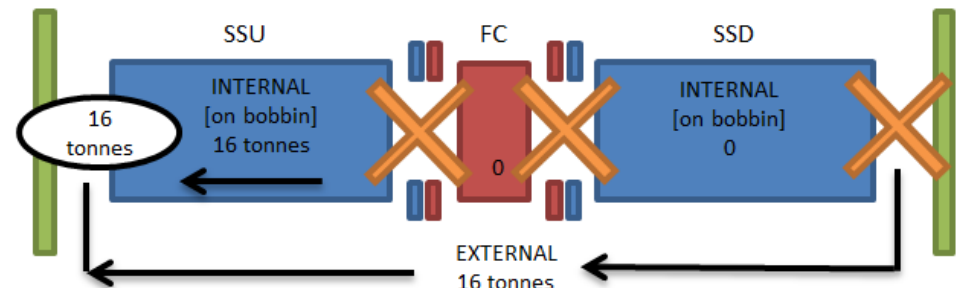
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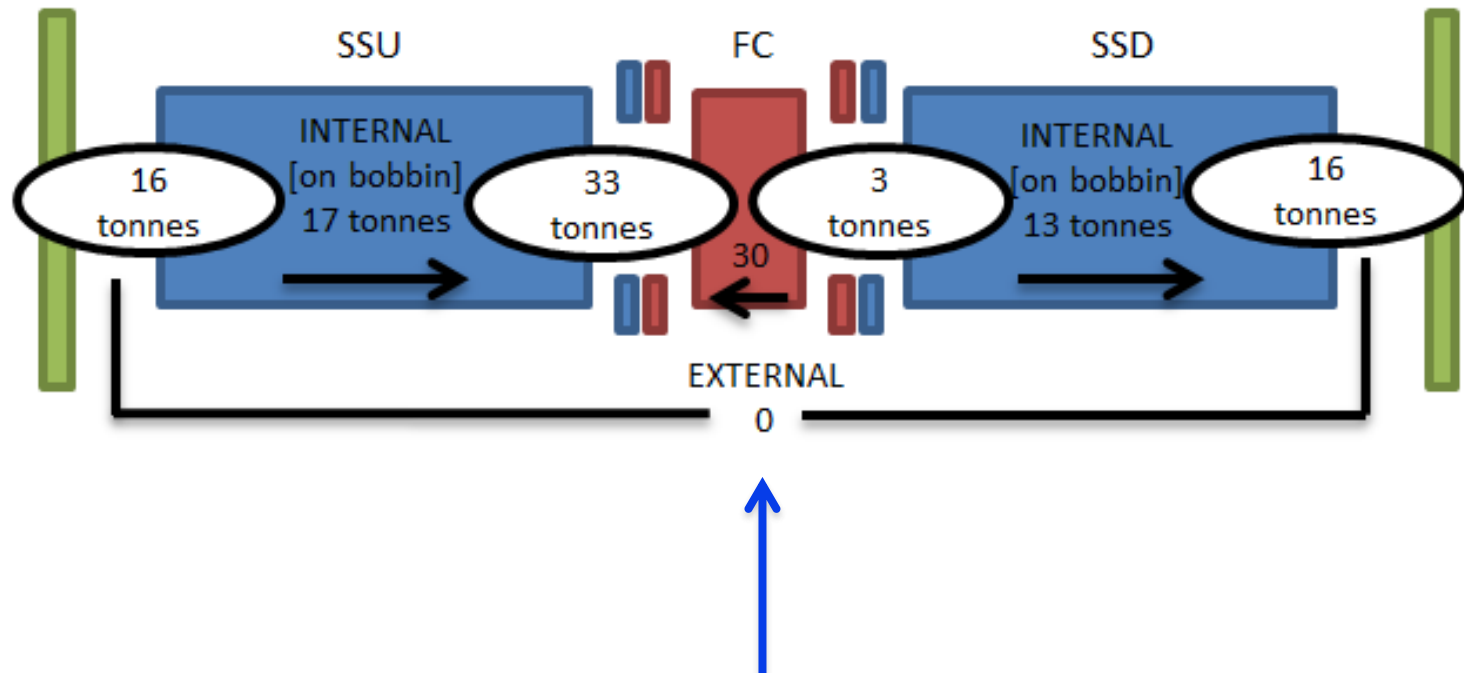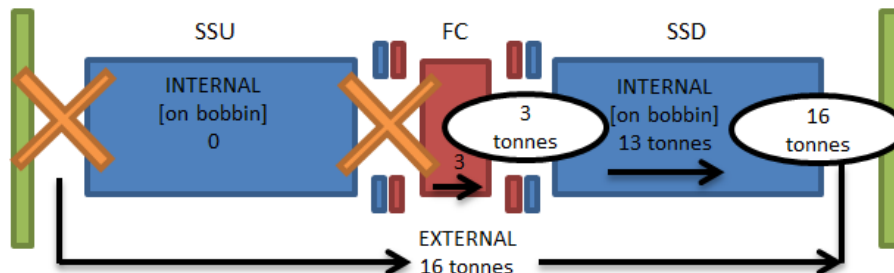
PRY SS Stand-Off

- Potential Loads on the Devices & PRY
  - Operational / fault scenarios - imbalanced
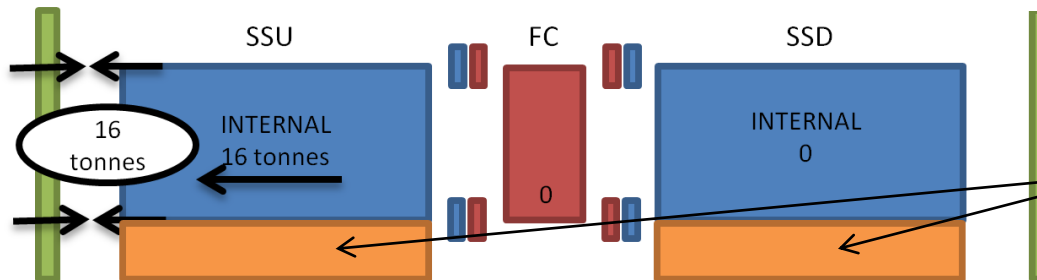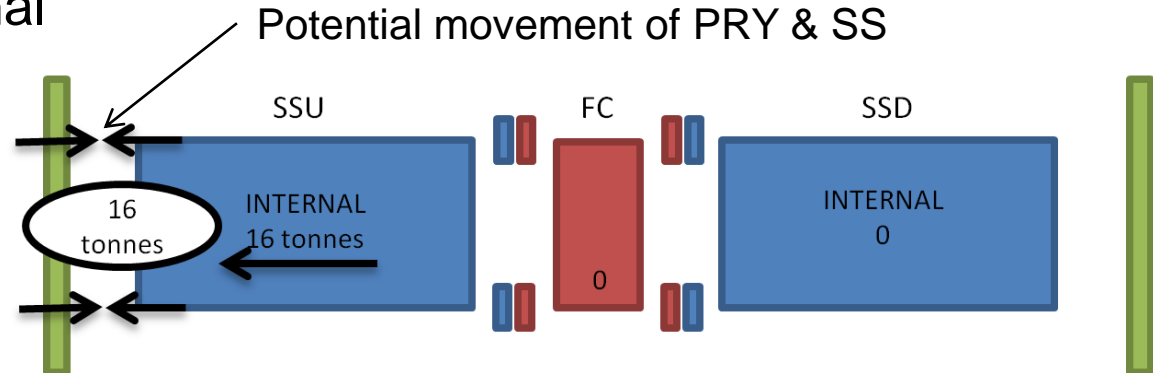
SSU only operational

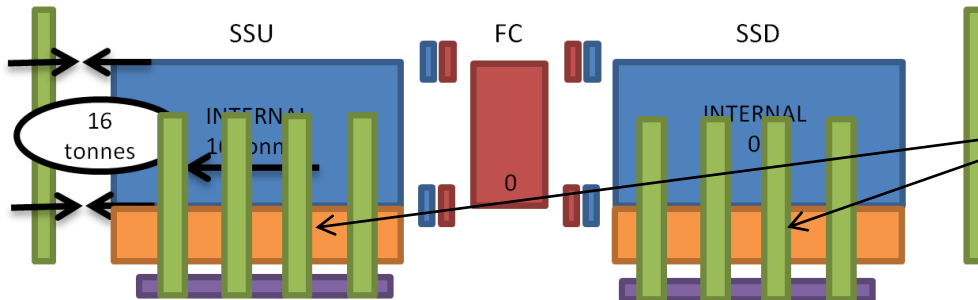SSD not operational

SSU not operational

PRY SS Stand-Off

- Resistance to movement
  - e.g. SSU operational

We've run magnets & they are not clashing with PRY

Potential movement of PRY & SS

SSU

INTERNAL 16 tonnes

16 tonnes

FC

0

SSD

INTERNAL 0

SSU

INTERNAL 16 tonnes

16 tonnes

FC

0

SSD

INTERNAL 0

Device movement resisted by:
- Jack screws
- Base
- Tie-downs
- Moving platforms
- Hall floor

SSU

INTERNAL 16 tonnes

16 tonnes

FC

0

SSD

INTERNAL 0

PRY Movement resisted by:
- PRY Legs
- Upstands / Bases
- Hall floor

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PRY SS Stand-Off

- Resistance to movement
    - e.g. SSU operational

T Millington survey 25/08/16 @ ~3T Devices: 1-1.5 mm PRY: 1.5-2 mm
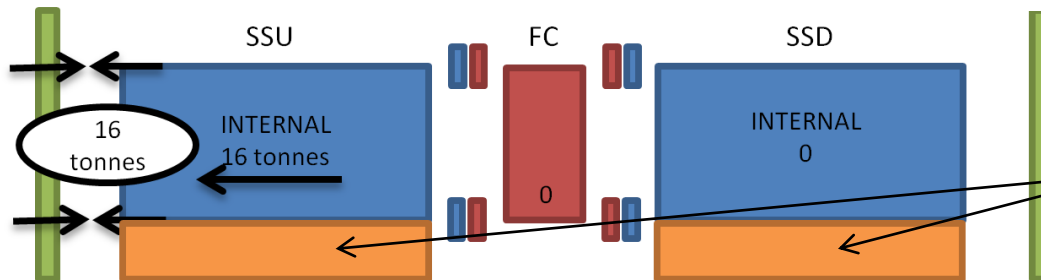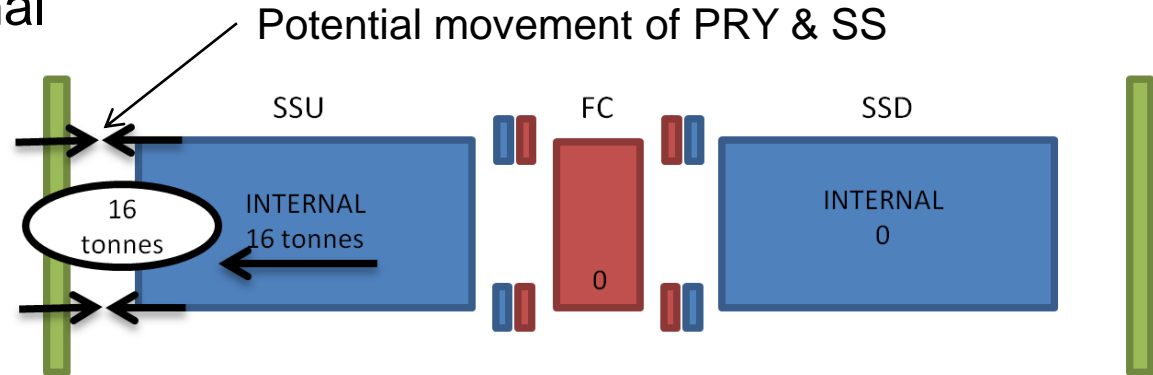
Potential movement of PRY & SS

SSU — INTERNAL 16 tonnes
16 tonnes

FC — 0

SSD — INTERNAL 0

SSU — INTERNAL 16 tonnes
16 tonnes

FC — 0

SSD — INTERNAL 0

Device movement resisted by:
- Jack screws
- Base
- Tie-downs
- Moving platforms
- Hall floor

SSU — INTERNAL 16 tonnes
16 tonnes

FC — 0
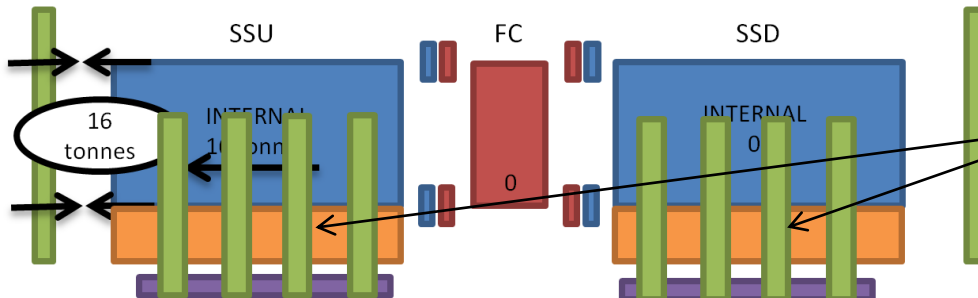
SSD — INTERNAL 0

PRY Movement resisted by:
- PRY Legs
- Upstands / Bases
- Hall floor

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PRY SS Stand-Off

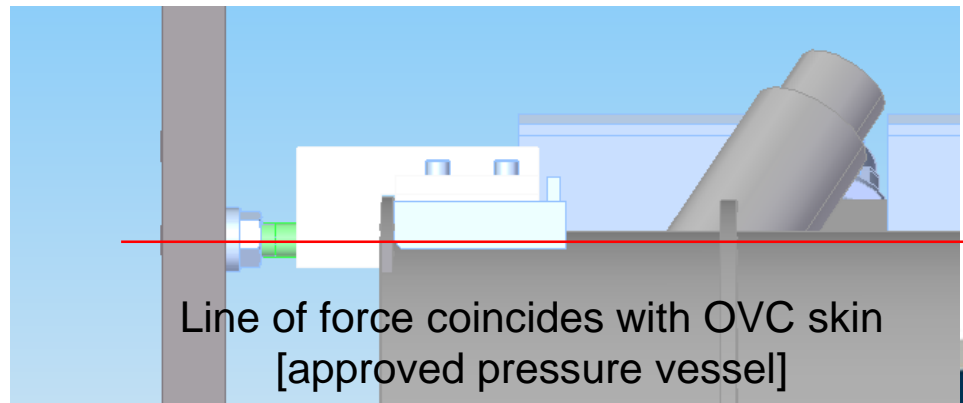- Solution to prevent movement
  - Brace PRY & SS OVC using stand-offs
  - Use 3 of 4 existing welded V-plate pads ~120 deg

1-piece aluminium alloy block
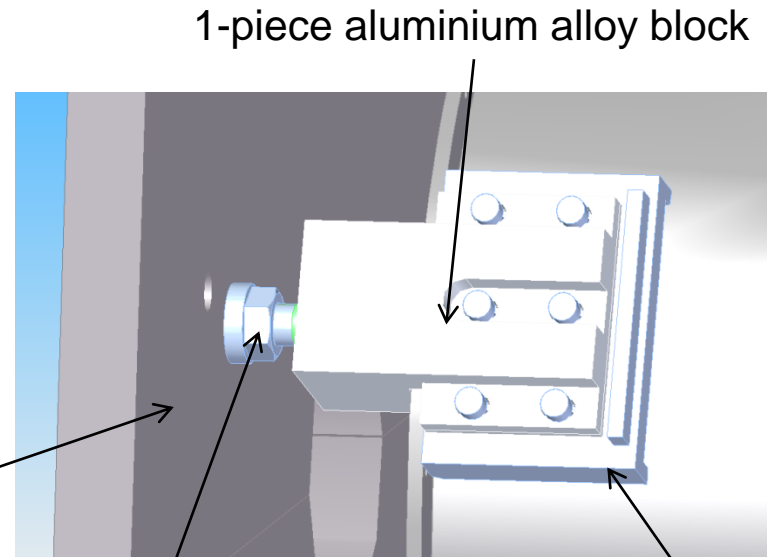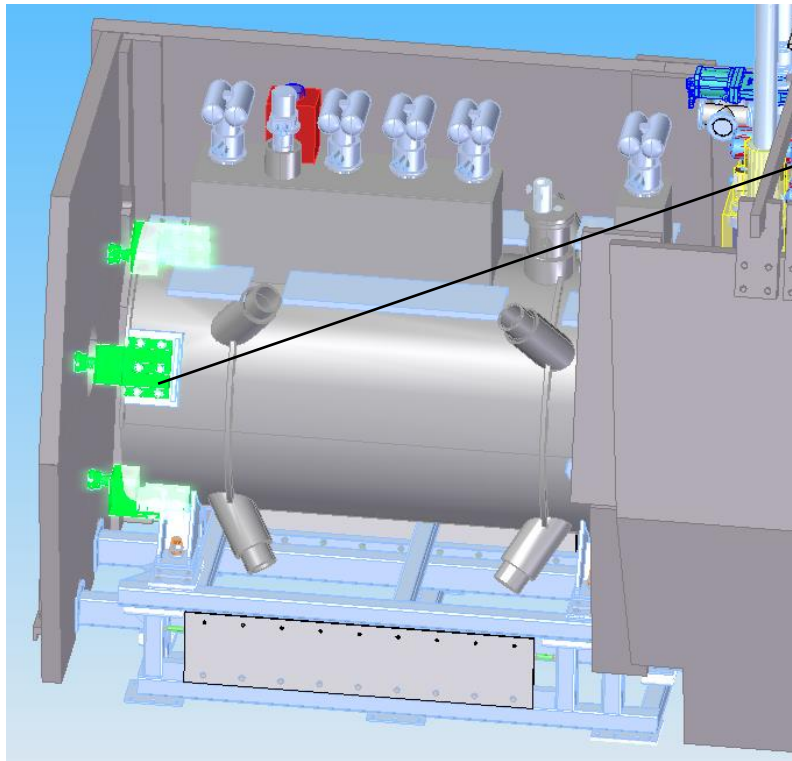
Screw jack (to touch on)

Existing V-plate pad

Line of force coincides with OVC skin [approved pressure vessel]

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PRY SS Stand-Off

- Prove stand-off solution
  - Stand-off mechanically compatible & installable?
  - Stand-off strong & stiff enough?
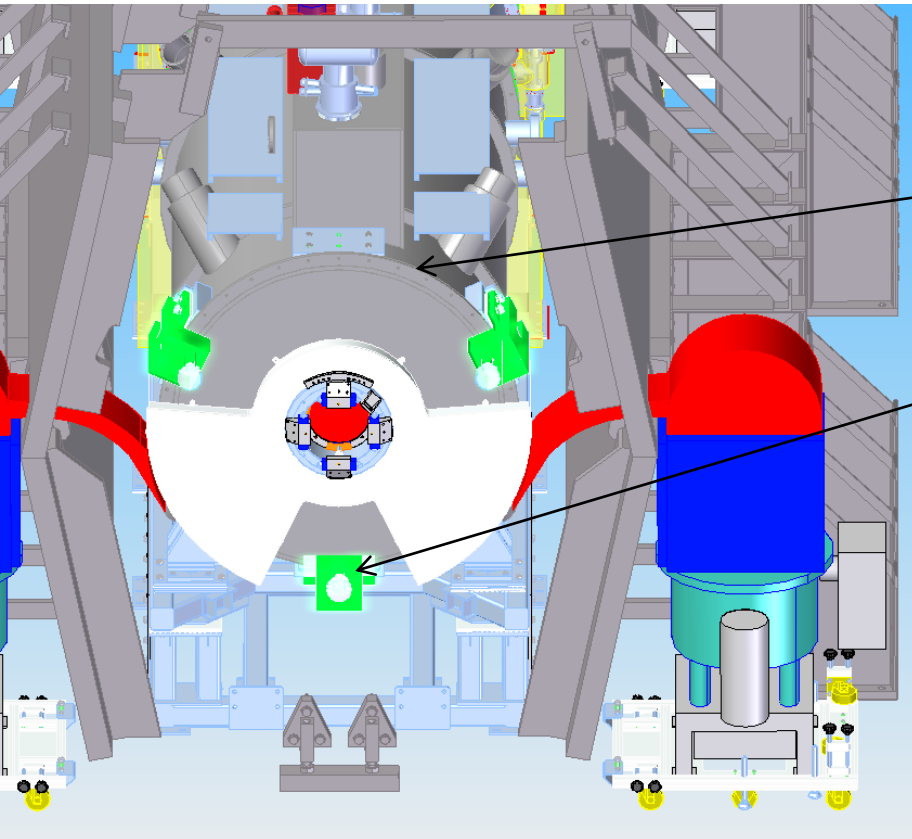 - OVC strong & stiff enough?
  - PRY OK?

CAD / Procedure

Analysis

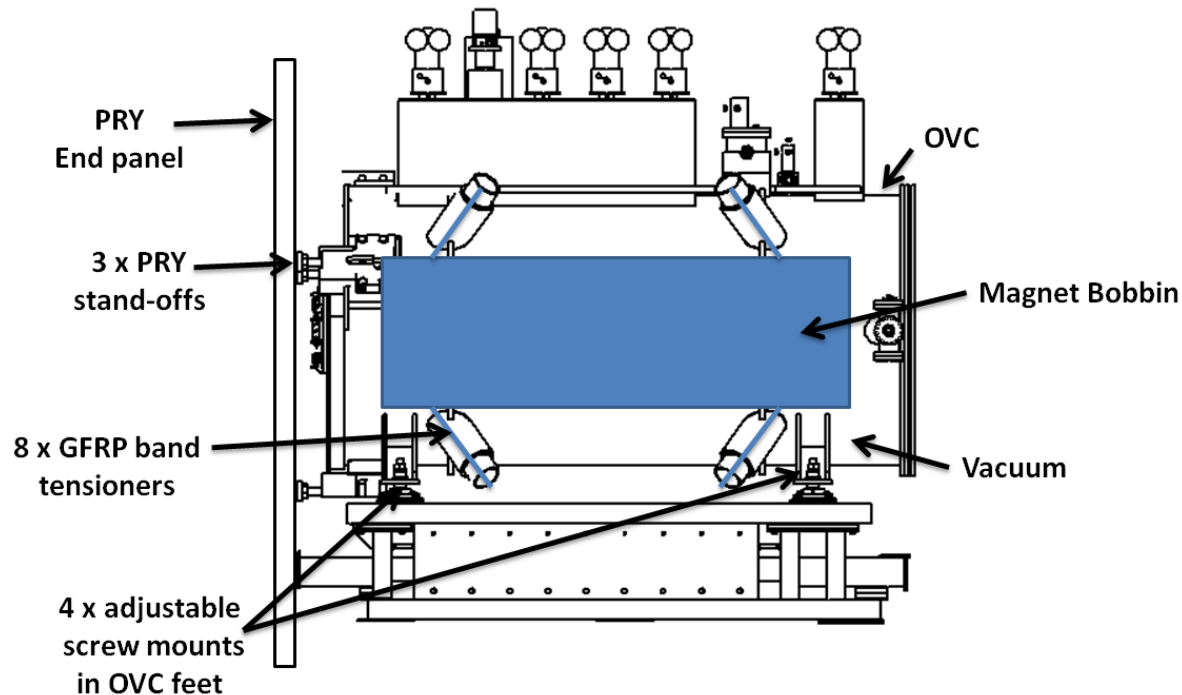SS OVC approved pressure vessel, changes need approval

Access limited

Confined space working

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PRY SS Stand-Off

- Prove stand-off solution
    - Stand-off strong & stiff enough?
    - OVC strong & stiff enough?
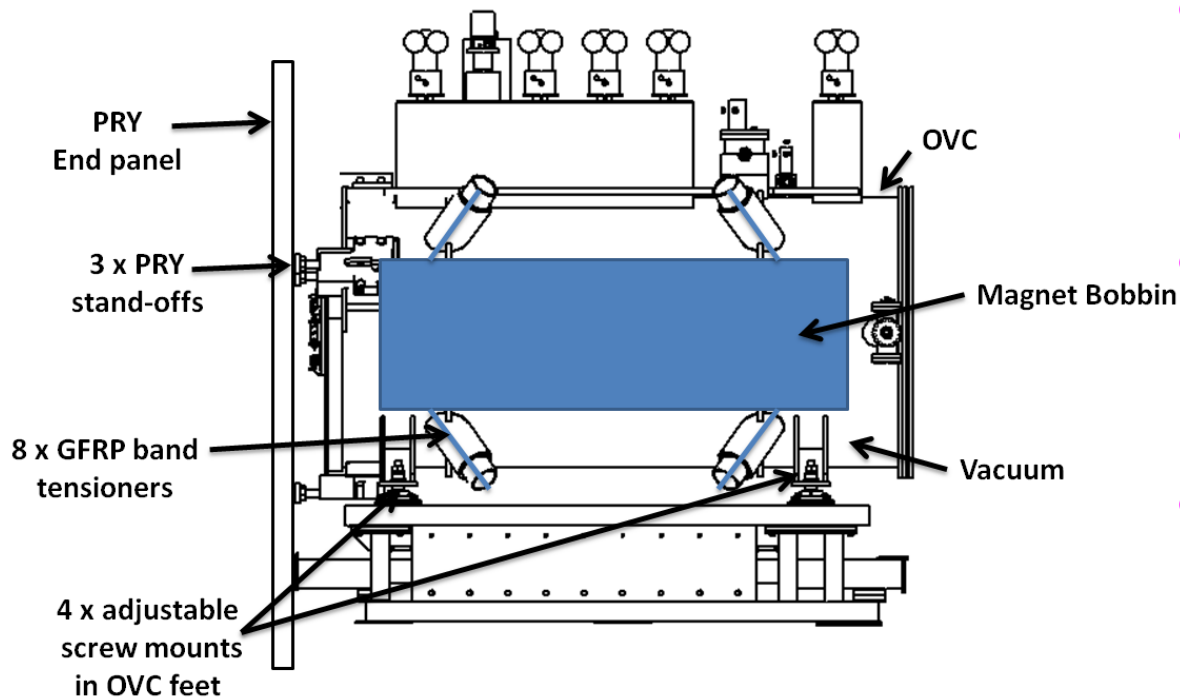   - PRY OK?

Analysis

PRY SS Stand-Off

- Prove stand-off solution

  - Stand-off strong & stiff enough?
  - OVC strong & stiff enough?
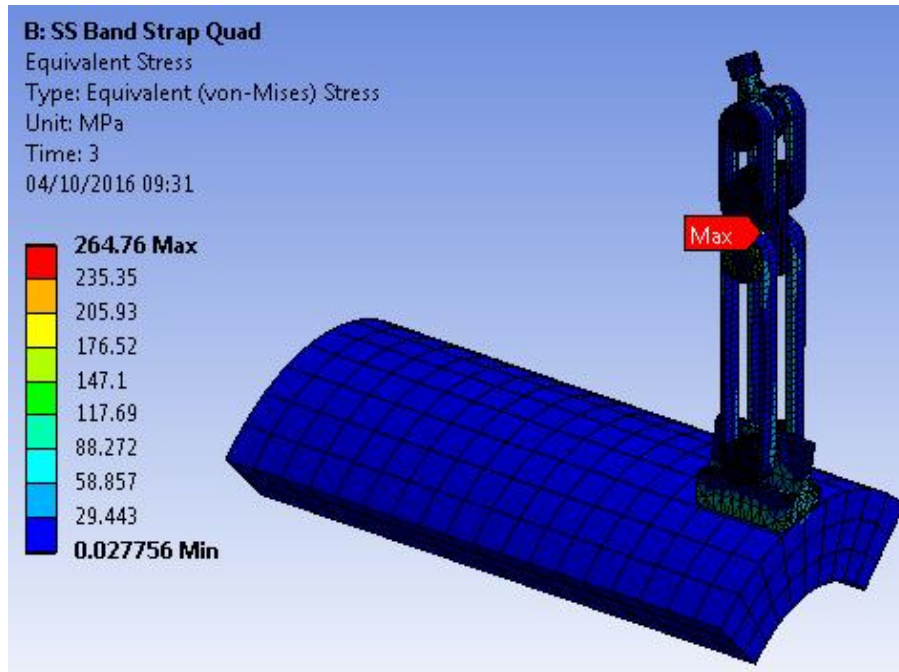 - PRY OK?

  Analysis

  - Loads

    - Bobbin strap pretension [OVC]
    - External pressure / internal vacuum [OVC]
    - Magnetic attraction force [OVC/SS Bases/Other devices via bellows/Stand-offs/PRY]
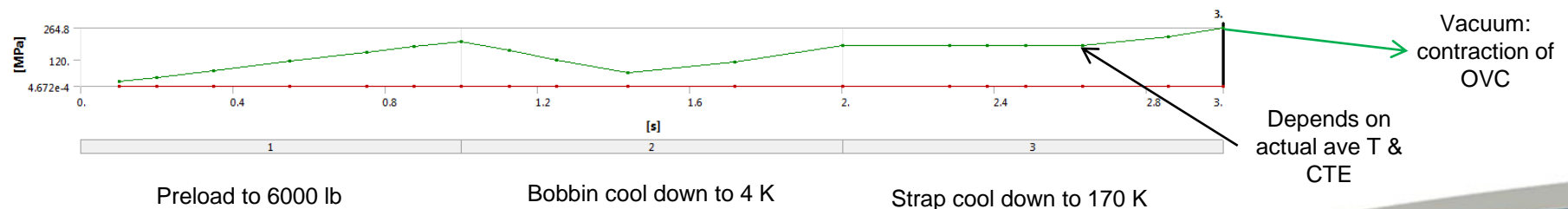   - Thermal expansion & contraction [PRY/Stand-offs/OVC/SS Bases/Other devices]

PRY End panel

3 x PRY stand-offs

8 x GFRP band tensioners

4 x adjustable screw mounts in OVC feet

OVC

Magnet Bobbin

Vacuum

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PRY SS Stand-Off

- Loads
  - Bobbin strap pre-tension / pre-load

B: SS Band Strap Quad
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 3
04/10/2016 09:31

264.76 Max	
235.35	
205.93	
176.52	
147.1	
117.69	
88.272	
58.857	
29.443	
0.027756 Min	

6000 lb pre-load / strap warm, not change when cold (S Virostek)

Preload to 6000 lb   Bobbin cool down to 4 K   Strap cool down to 170 K

Vacuum: contraction of OVC

Depends on actual ave T & CTE

Use 2x = 12000 lb / 54 kN

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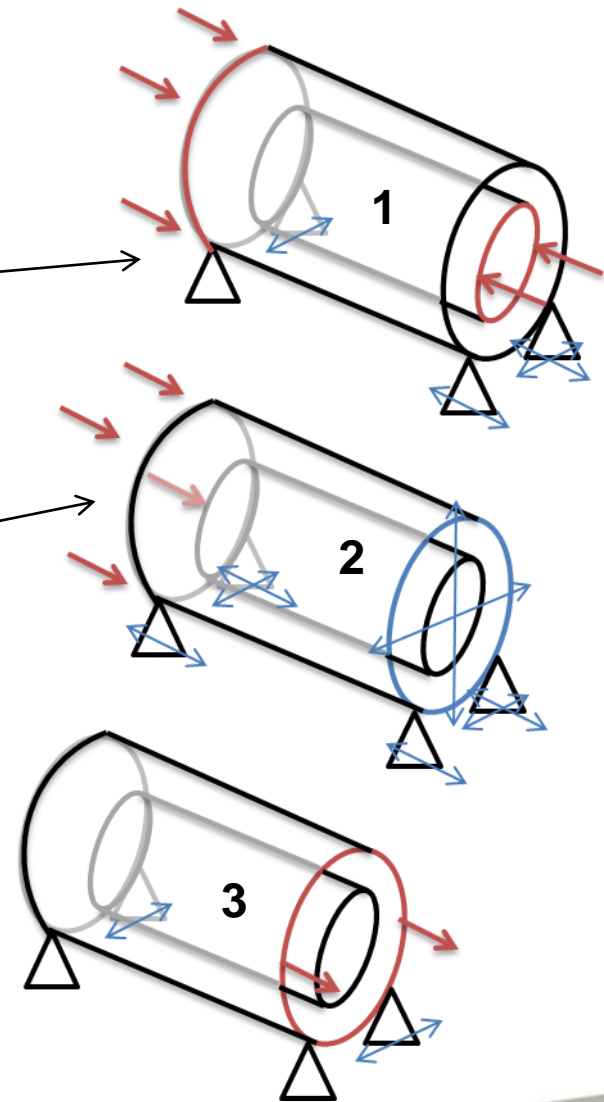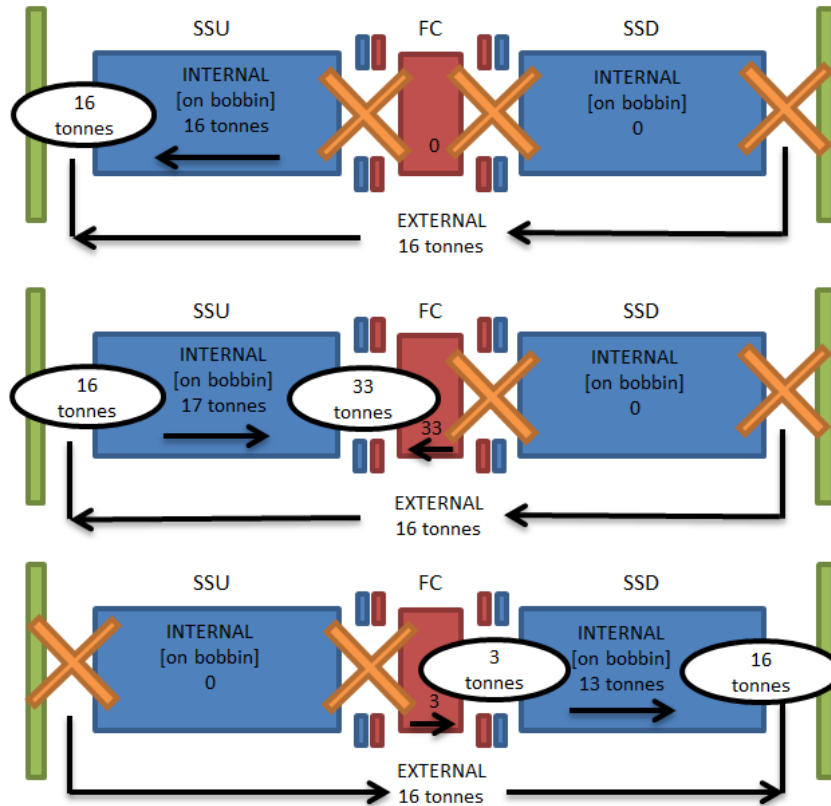
PRY SS Stand-Off

- Loads

  - Magnetic attraction load cases

SSU constraint & load conditions 'C&Lx'

Flexible axial restraint on PRY = worst case axial

Use 200 kN load PRY – SS attraction
Use 200 kN load SS – FC magnets

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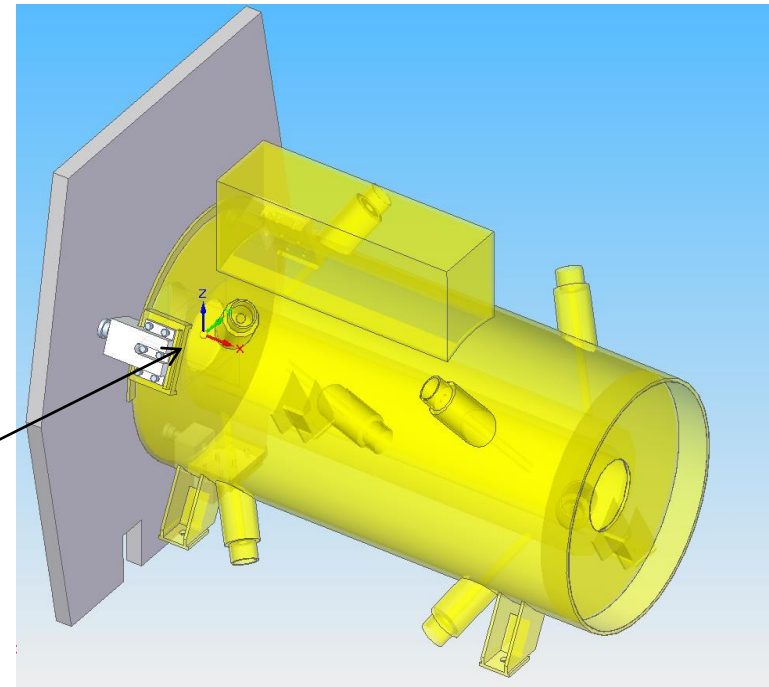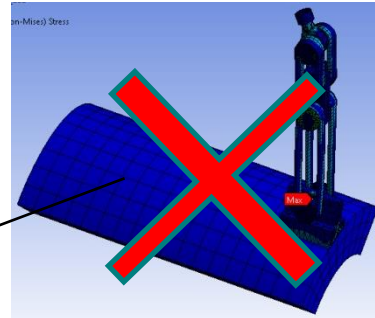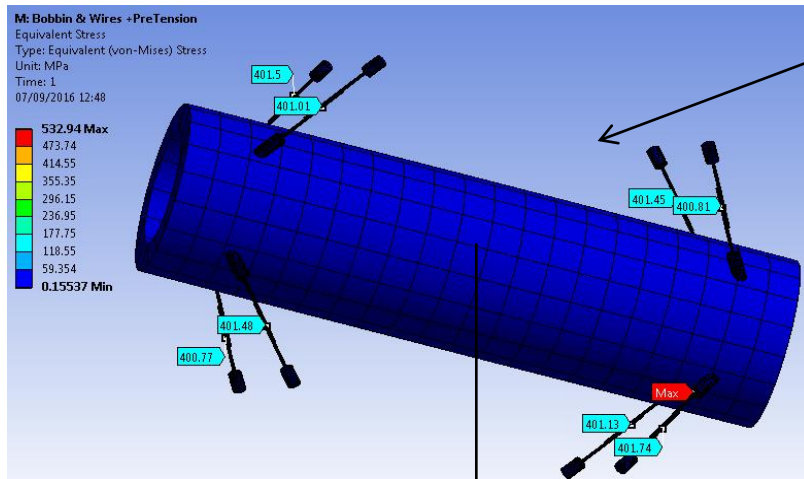# PRY SS Stand-Off

- Loads
  - Vacuum
    - 1 Bar / 0.1 MPa

  - Thermal strain / deformation
    - Distance between PRY end plates = 7302
      - PRY contraction e.g. 10 degrees = ~ 0.95 mm [based on magnet steel @ CTE 13 ppm/degC]
      - Device expansion e.g. 10 degrees = ~ 1.25 mm [based on stainless steel @ CTE 17 ppm/degC]
    - Potential T differences TBD & not included in following yet
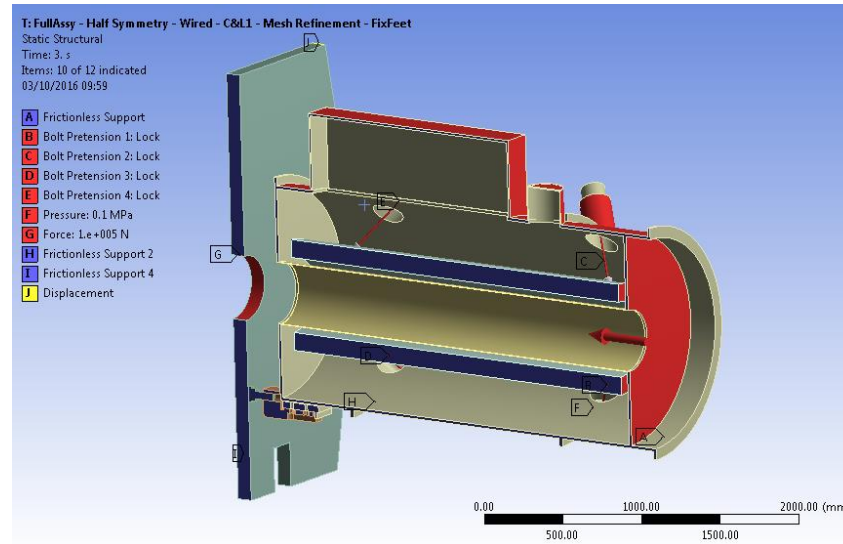
Science & Technology
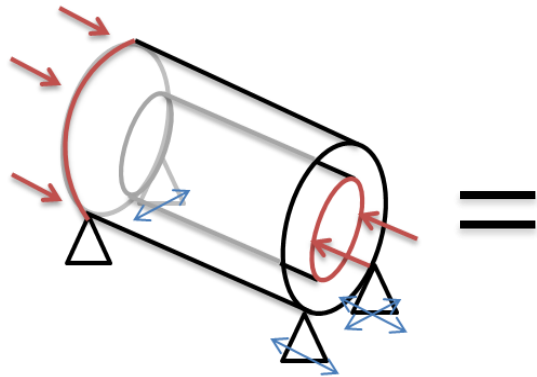Facilities Council

PRY SS Stand-Off
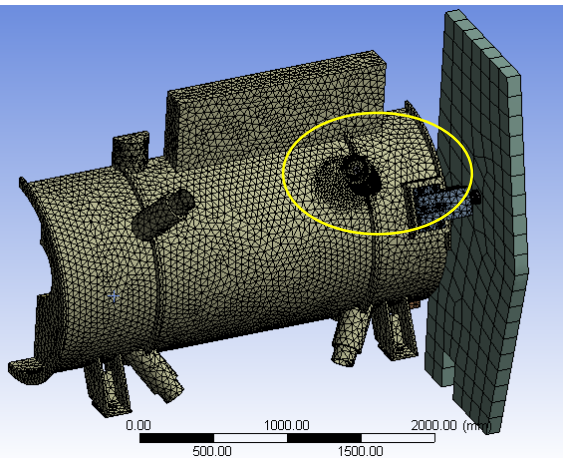
- Analysis
  - CAD-Analysis Model
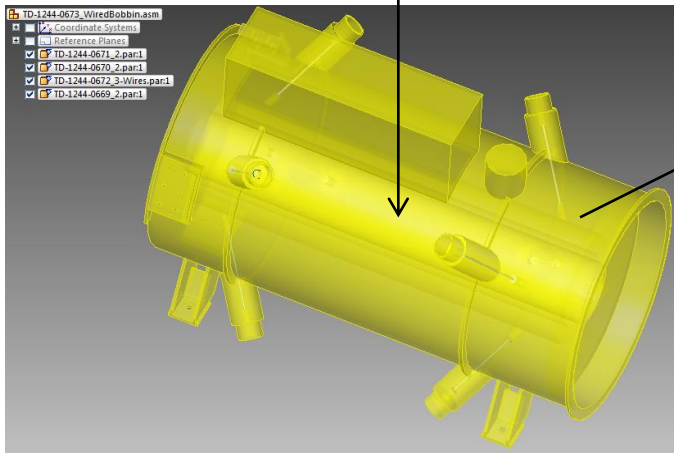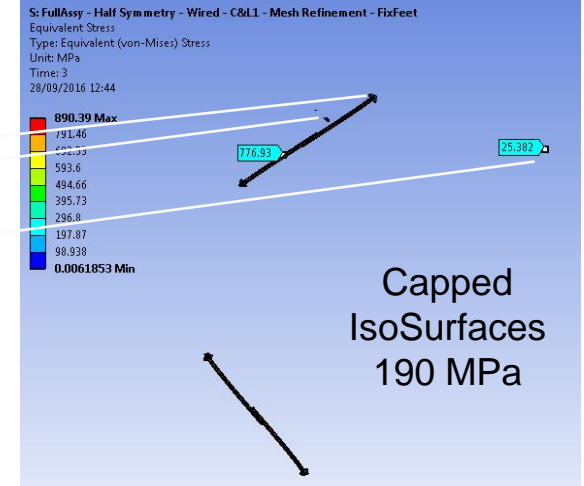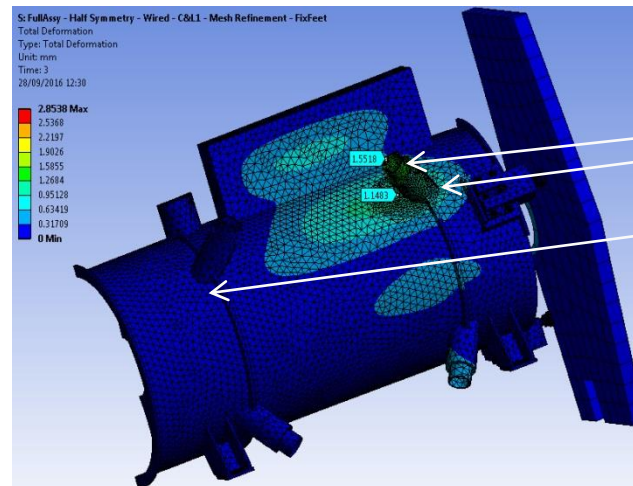
PRY SS Stand-Off

- Analysis
  - C&L1

- Bolt pretension 54 kN
- Ext' Press' 0.1 MPa
- 200 kN (100 kN*) PRY end plate +ve X
- 200 kN (100 kN*) kN Bobbin –ve X
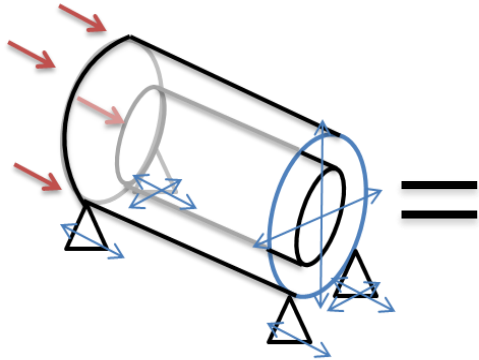
- No thermal strain load
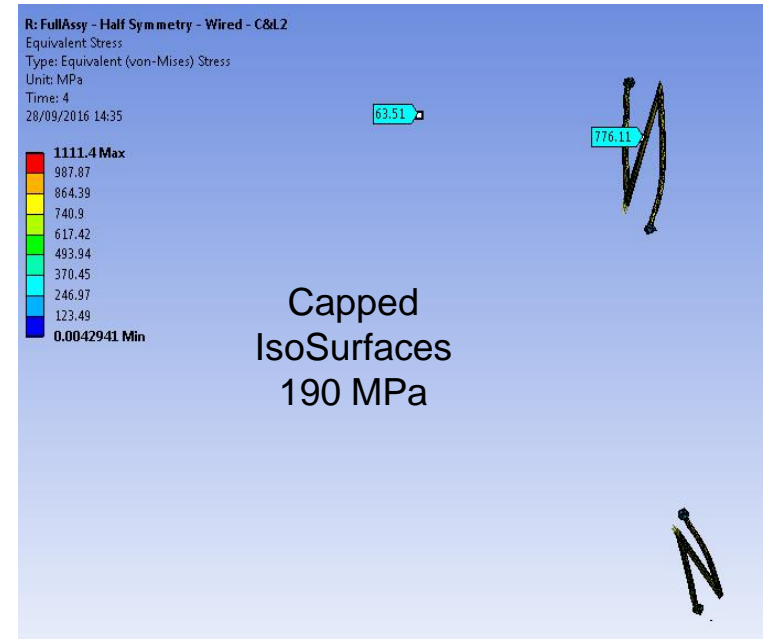- *Loads halved for ½ model

Refined mesh for more accurate deformation

Capped IsoSurfaces 190 MPa

PRY SS Stand-Off

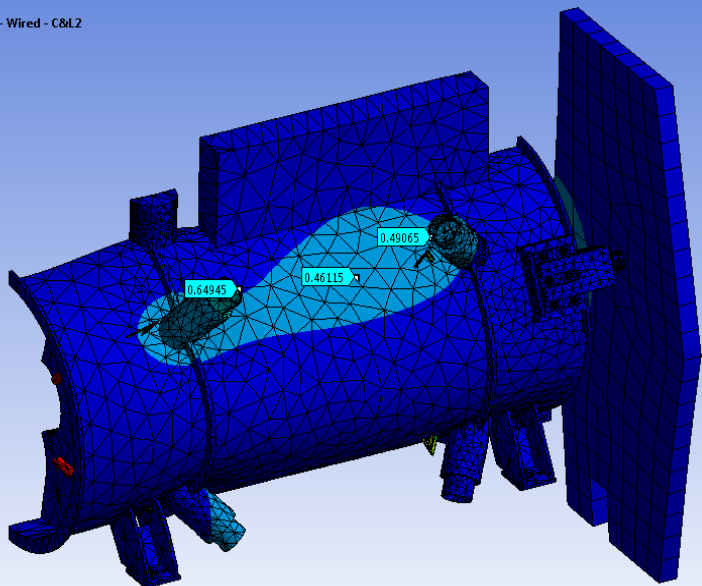- **Analysis**
  - **C&L2**

- Bolt pretension 54 kN
- Ext' Press' 0.1 MPa
- 200 kN (100 kN*) PRY end plate +ve X
- 200 kN (100 kN*) Bobbin +ve X

- No thermal strain load

R: FullAssy - Half Symmetry - Wired - C&L2
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 4
28/09/2016 14:35

1111.4 Max
987.87
864.39
740.9
617.42
493.94
370.45
246.97
123.49
0.0042941 Min

63.51
776.11

Capped
IsoSurfaces
190 MPa

R: FullAssy - Half Symmetry - Wired - C&L2
Total Deformation
Type: Total Deformation
Unit: mm
Time: 4
28/09/2016 14:27

2.646 Max
2.352
2.058
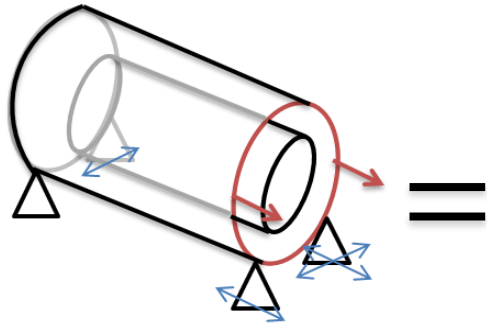1.764
1.47
1.176
0.88206
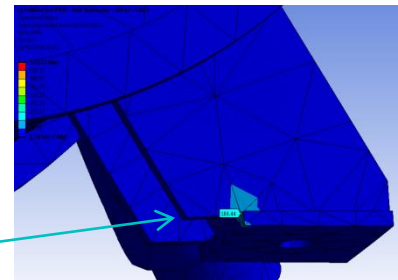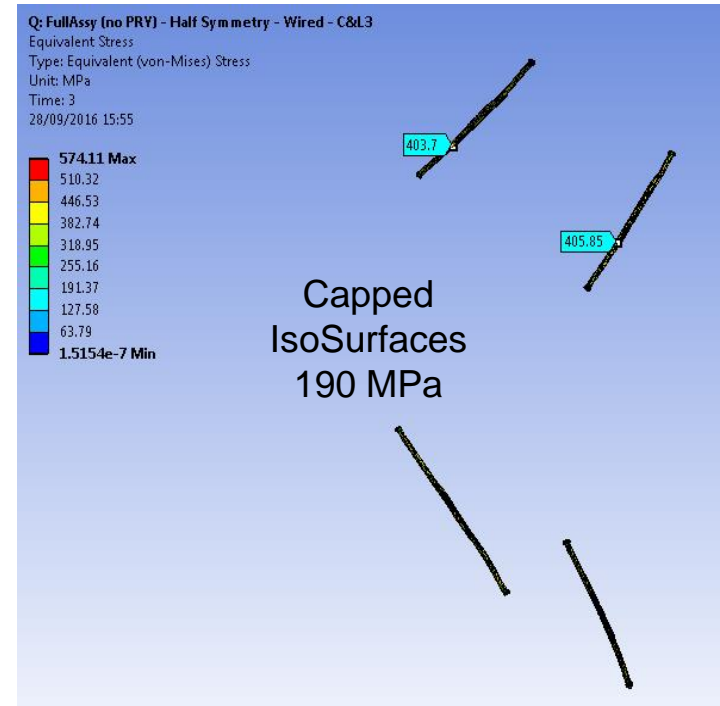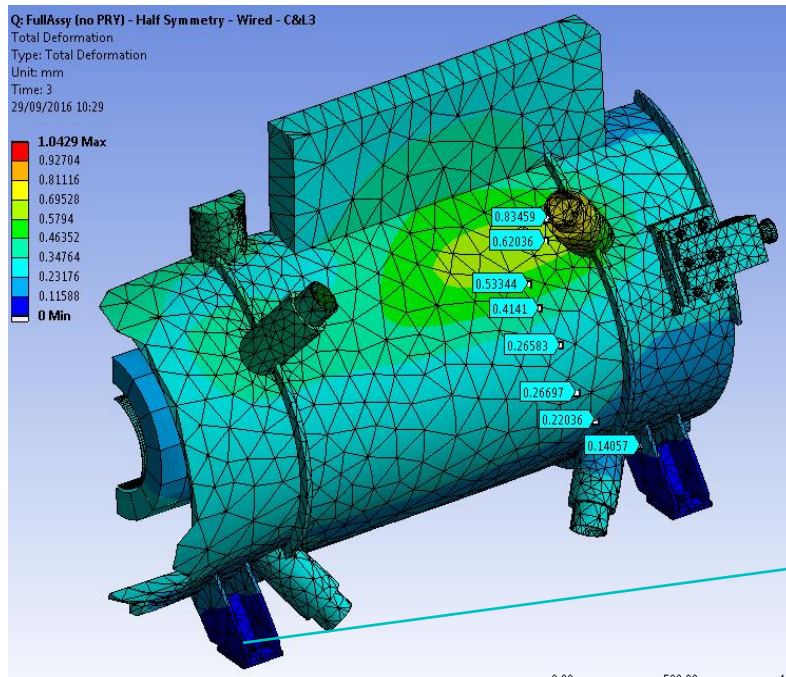0.58807
0.29409
0.00010703 Min

0.49065
0.46115
0.64945

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PRY SS Stand-Off

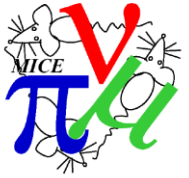- **Analysis**
  - **C&L3**

- Bolt pretension 54 kN
- Ext' Press' 0.1 MPa
- 200 kN (100 kN*) OVC flange +ve X

- No thermal strain load

Q: FullAssy (no PRY) - Half Symmetry - Wired - C&L3
Equivalent Stress
Type: Equivalent (von-Mises) Stress
Unit: MPa
Time: 3
28/09/2016 15:55

574.11 Max
510.32
446.53
382.74
318.95
255.16
191.37
127.58
63.79
1.5154e-7 Min

403.7

405.85

Capped
IsoSurfaces
190 MPa

Q: FullAssy (no PRY) - Half Symmetry - Wired - C&L3
Total Deformation
Type: Total Deformation
Unit: mm
Time: 3
29/09/2016 10:29

1.0429 Max
0.92704
0.81116
0.69528
0.5794
0.46352
0.34764
0.23176
0.11588
0 Min

0.83459
0.62036
0.53344
0.4141
0.26583
0.26697
0.22036
0.14057

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PRY SS Stand-Off

- Conclusion
  - Models set-up & run, results looking OK
  - Include thermal strains? – or – guarantee T control?
  - Pressure vessel acceptance
    - Application of standard safety factors & stress limits