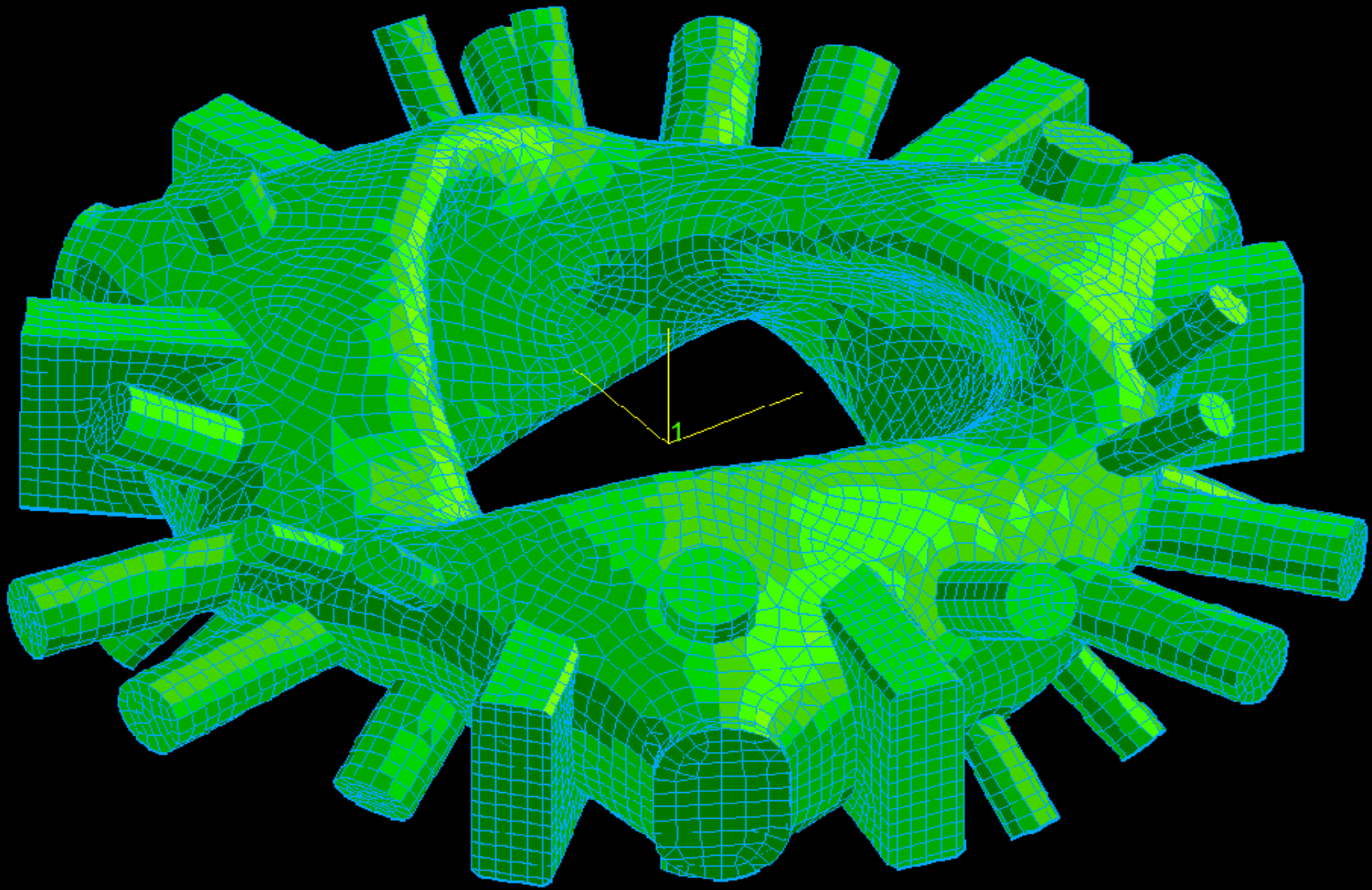
NCSX-Vessel Buckling

LI386-1 atmosphere, free radial b.c.

Fred Dahlgren - 26 April 2001

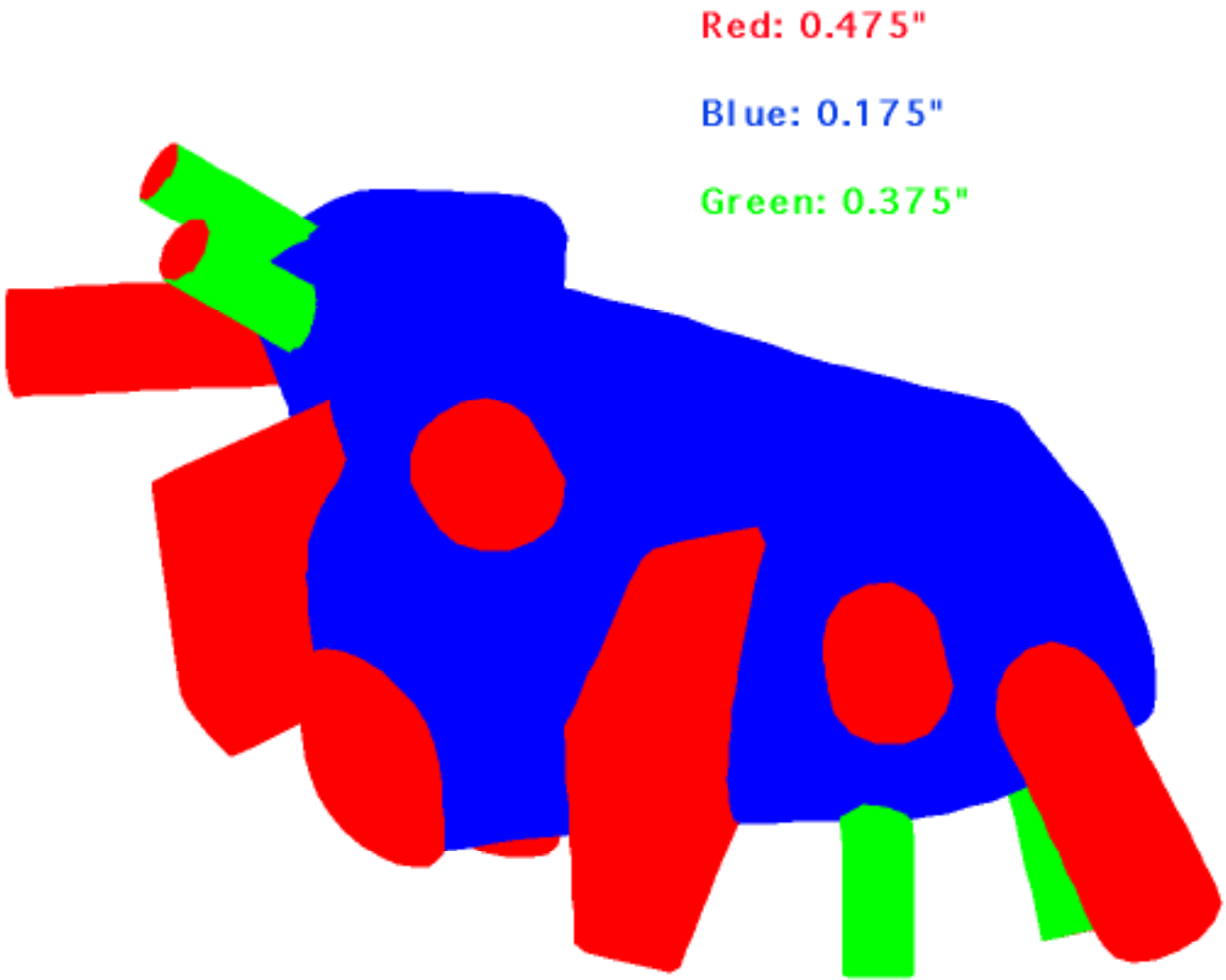
NCSX Vacuum Vessel - Nastran Shell Element Model



FEA Model Details:

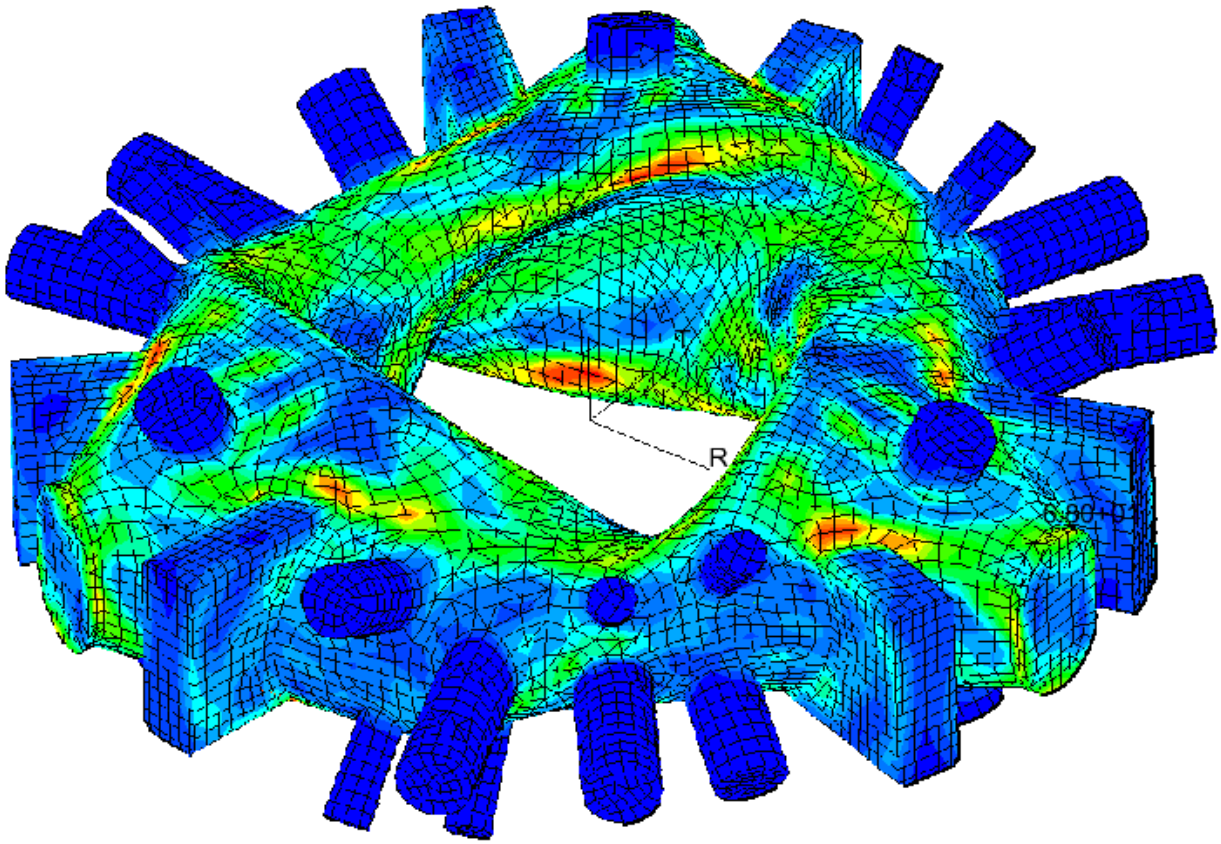
1. Elements: CQUAD4 9,876
   CTRIA3 4,104
   Total: 13,980
2. Nodes: GRIDS 11,928
   (DOF's) 71,568 (-6)
3. B.C.s: Vertical & Circumferential SPCs
   @ NB Port Centerline
   (6 DOFs, constraining R.B. modes)
4. Full 360 degrees model – Static pressure load
5. Lanzcos Eigenvalue problem using differential Stiffness derived from static analysis.

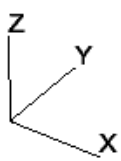
Model A Thicknesses



MSC/PATRAN Version 8.0 23-Apr-01 18:21:01
Fringe: 1 ATMOSPHERE (LI386 MODEL), Static Subcase: Stress Tensor, -At Z1 (TRESCA)

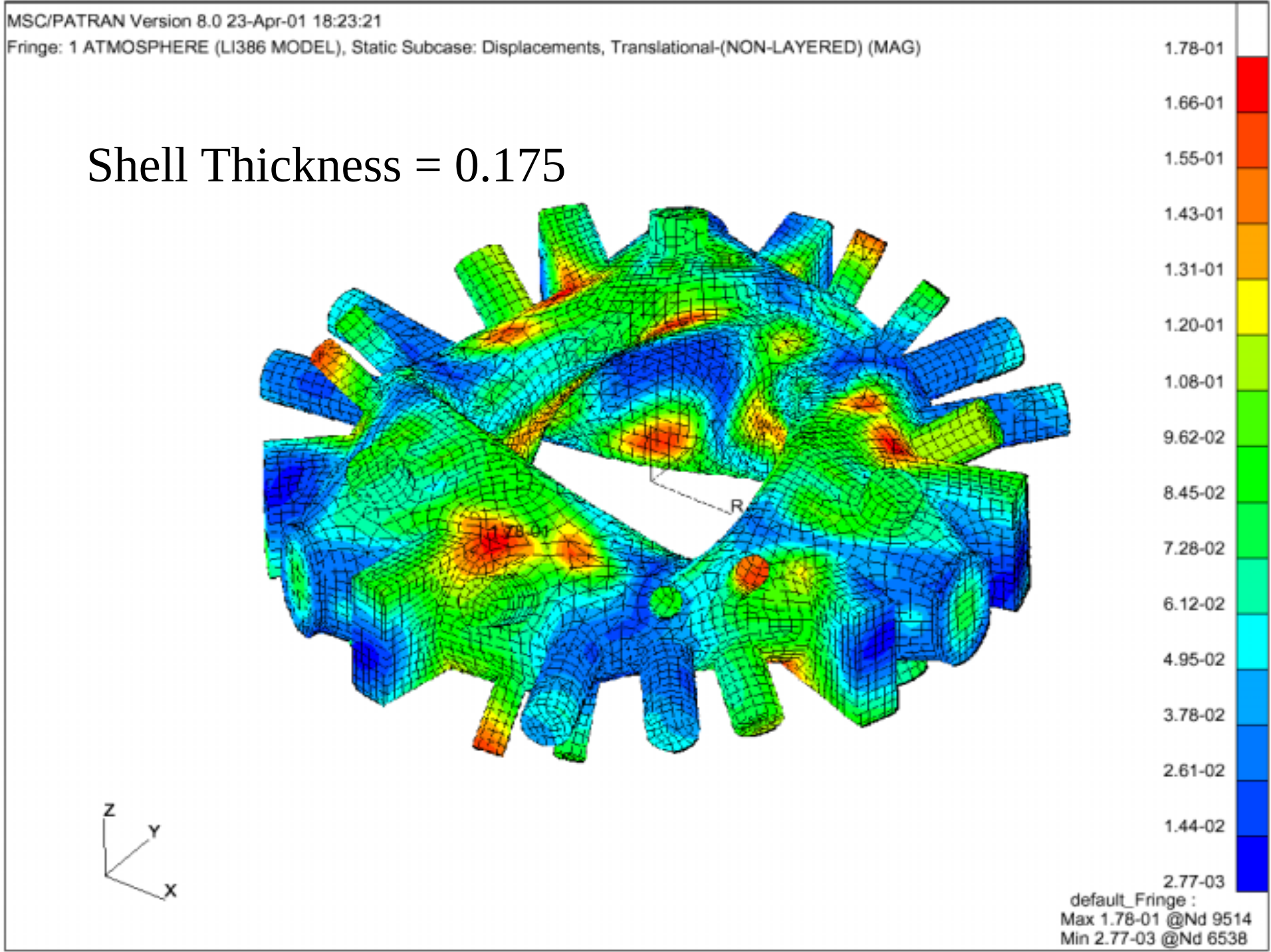
Shell Thickness = 0.175





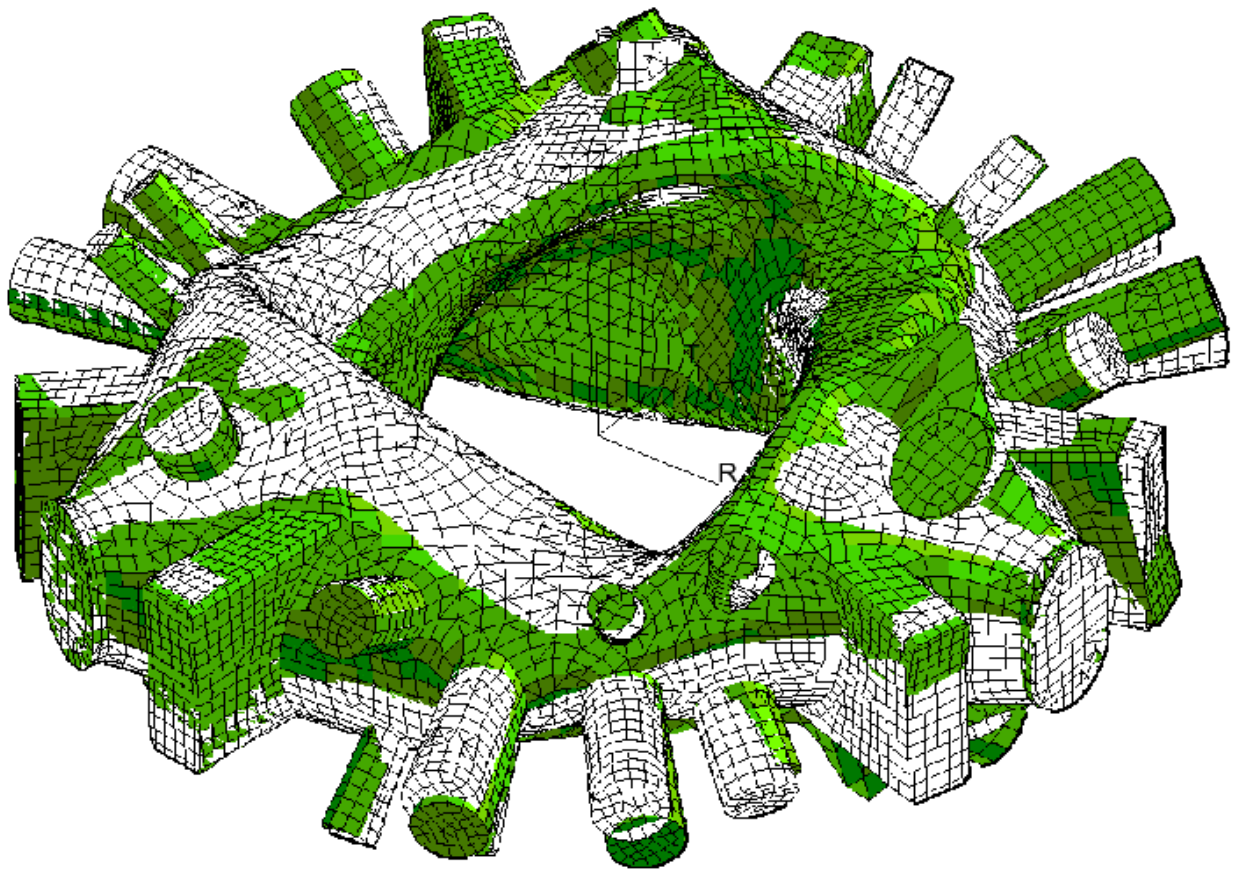
2.03+04
1.90+04
1.76+04
1.63+04
1.49+04
1.36+04
1.22+04
1.09+04
9.51+03
8.16+03
6.81+03
5.47+03
4.12+03
2.77+03
1.42+03
6.80+01

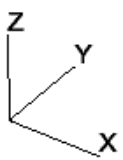
default_Fringe :
Max 2.03+04 @Nd 1329
Min 6.80+01 @Nd 577


MSC/PATRAN Version 8.0 23-Apr-01 18:23:21
Fringe: 1 ATMOSPHERE (LI386 MODEL), Static Subcase: Displacements, Translational-(NON-LAYERED) (MAG)
Shell Thickness = 0.175
1.78-01
1.66-01
1.55-01
1.43-01
1.31-01
1.20-01
1.08-01
9.62-02
8.45-02
7.28-02
6.12-02
4.95-02
3.78-02
2.61-02
1.44-02
2.77-03
default_Fringe :
Max 1.78-01 @Nd 9514
Min 2.77-03 @Nd 6538
Z
Y
X

MSC/PATRAN Version 8.0 23-Apr-01 18:26:51
Deform: 1 ATMOSPHERE (LI386 MODEL), Mode 1 : Factor=2.936: Eigenvectors, Translational

Shell Thickness = 0.175



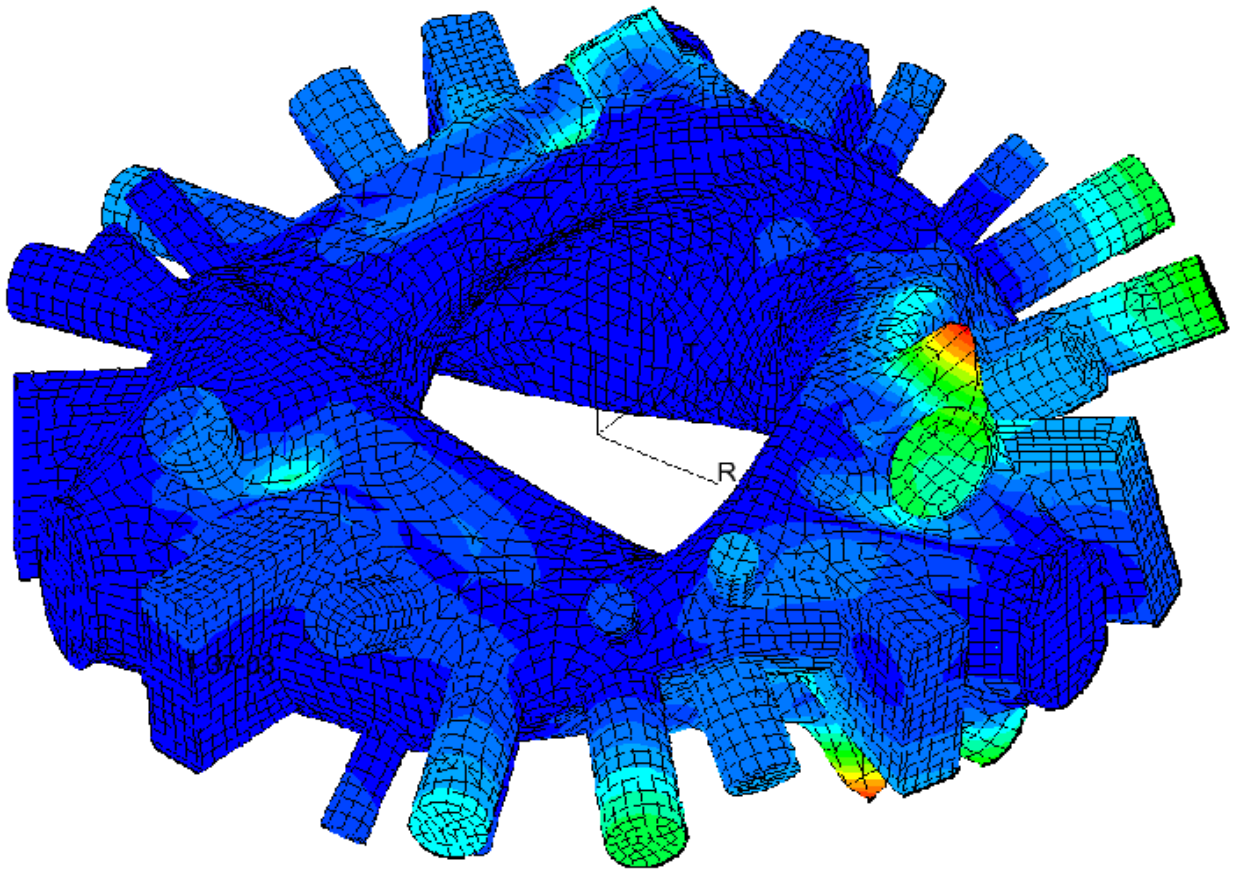


1st BucklingMode

default_Deformation :
Max 1.06+00 @Nd 1769

MSC/PATRAN Version 8.0 23-Apr-01 18:35:08
Fringe: 1 ATMOSPHERE (LI386 MODEL), Mode 1 : Factor=2.936: Eigenvectors, Translational-(NON-LAYERED) (MAG)
Deform: 1 ATMOSPHERE (LI386 MODEL), Mode 1 : Factor=2.936: Eigenvectors, Translational

Shell Thickness = 0.175



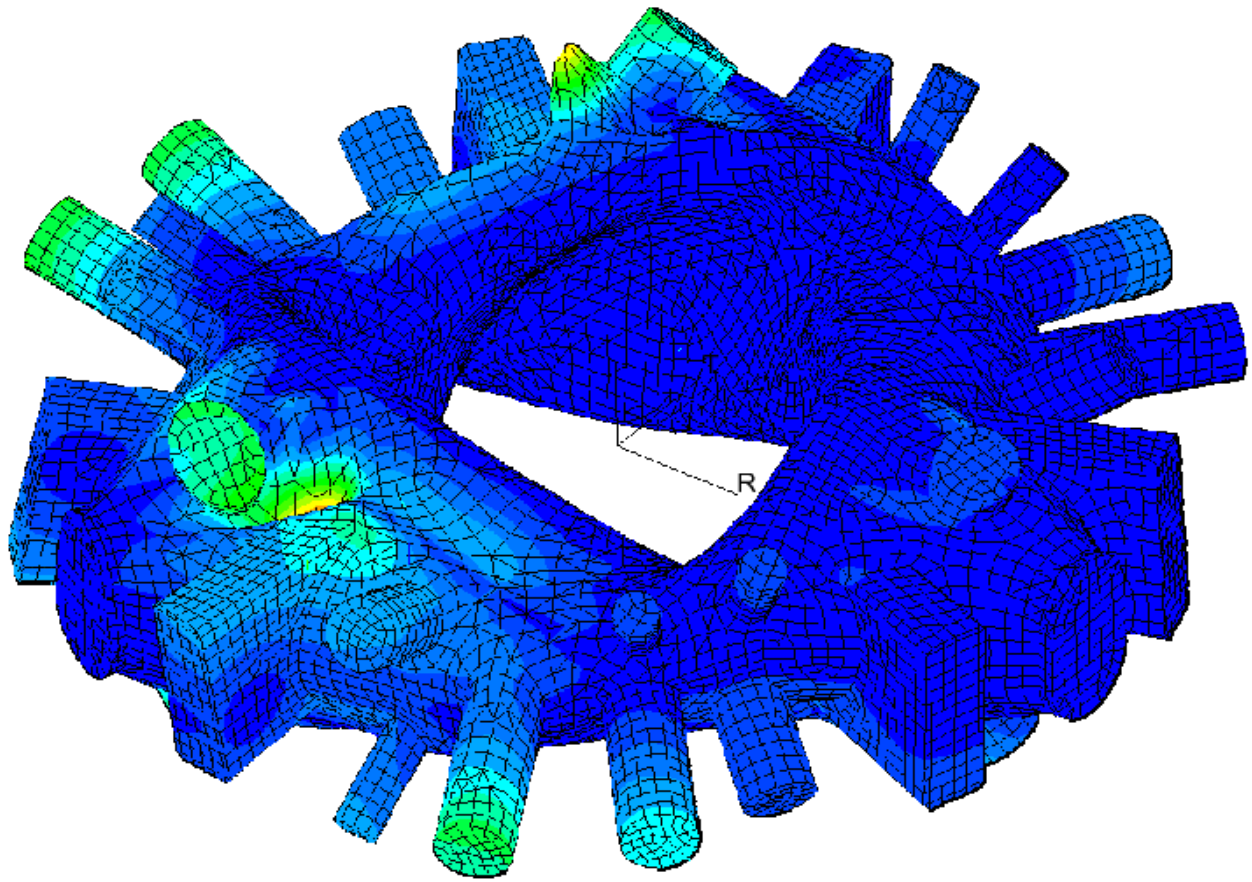
1.06+00
9.88-01
9.18-01
8.47-01
7.77-01
7.06-01
6.36-01
5.65-01
4.95-01
4.24-01
3.54-01
2.83-01
2.13-01
1.42-01
7.19-02
1.37-03

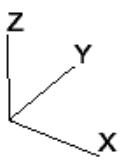
default_Fringe :
Max 1.06+00 @Nd 1769
Min 1.37-03 @Nd 10143
default_Deformation :
Max 1.06+00 @Nd 1769

Z
Y
X

MSC/PATRAN Version 8.0 23-Apr-01 18:36:34
Fringe: 1 ATMOSPHERE (LI386 MODEL), Mode 2 : Factor=2.937: Eigenvectors, Translational-(NON-LAYERED) (MAG)
Deform: 1 ATMOSPHERE (LI386 MODEL), Mode 2 : Factor=2.937: Eigenvectors, Translational

Shell Thickness = 0.175



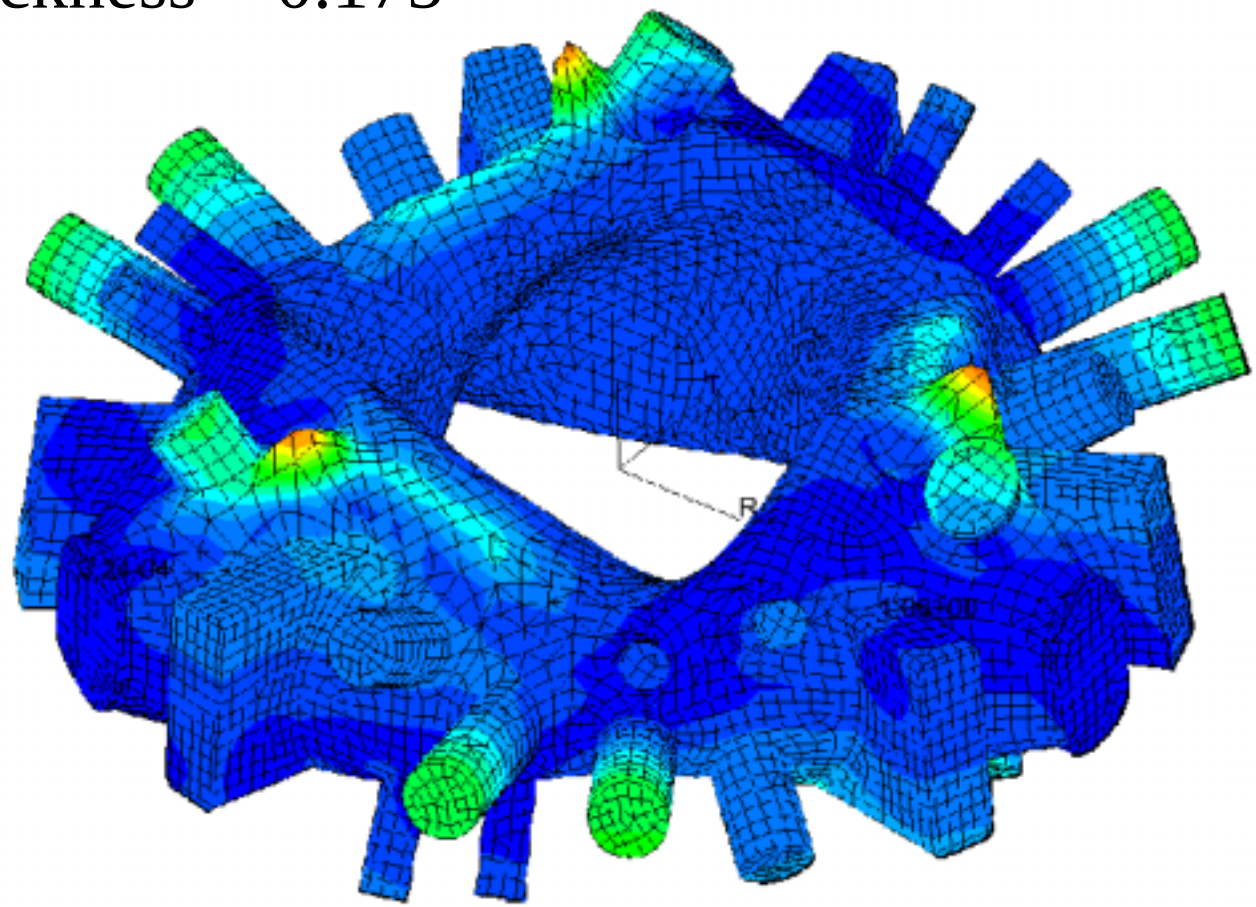


1.06+00
9.89-01
9.19-01
8.48-01
7.78-01
7.07-01
6.36-01
5.66-01
4.95-01
4.25-01
3.54-01
2.84-01
2.13-01
1.42-01
7.19-02
1.33-03

default_Fringe :
Max 1.06+00 @Nd 11727
Min 1.33-03 @Nd 1531
default_Deformation :
Max 1.06+00 @Nd 11727

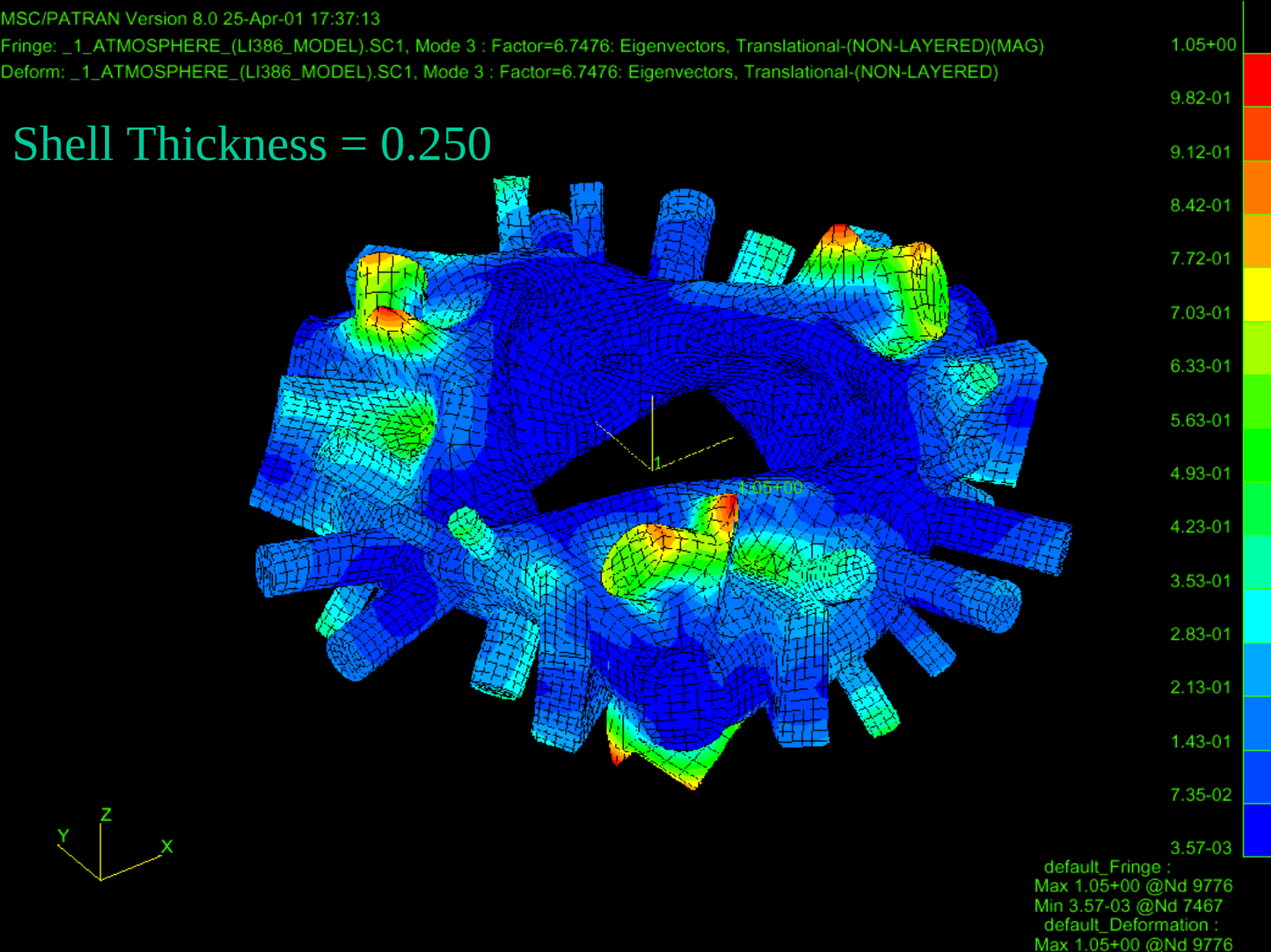
Fringe: 1 ATMOSPHERE (LI386 MODEL), Mode 3 : Factor=2.9624: Eigenvectors, Translational-(NON-LAYERED) (MAG)
Deform: 1 ATMOSPHERE (LI386 MODEL), Mode 3 : Factor=2.9624: Eigenvectors, Translational

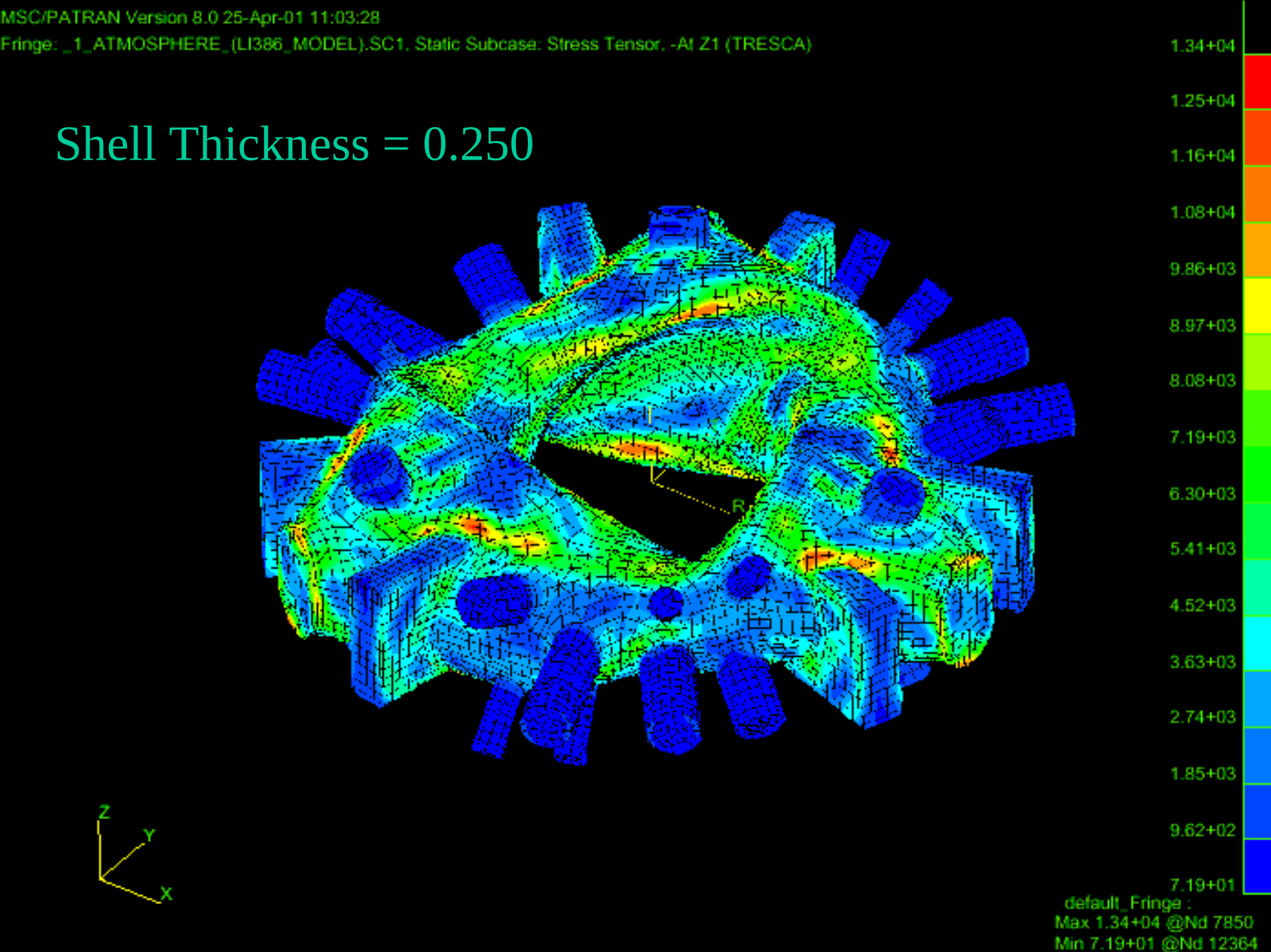
Shell Thickness = 0.175



1.06+00
9.89-01
9.18-01
8.48-01
7.77-01
7.06-01
6.36-01
5.65-01
4.95-01
4.24-01
3.53-01
2.83-01
2.12-01
1.42-01
7.09-02
3.24-04

default_Fringe :
Max 1.06+00 @Nd 3814
Min 3.24-04 @Nd 11983
default_Deformation :
Max 1.06+00 @Nd 3814


MSC/PATRAN Version 8.0 25-Apr-01 17:37:13
Fringe: _1_ATMOSPHERE_(LI386_MODEL).SC1, Mode 3 : Factor=6.7476: Eigenvectors, Translational-(NON-LAYERED)(MAG)
Deform: _1_ATMOSPHERE_(LI386_MODEL).SC1, Mode 3 : Factor=6.7476: Eigenvectors, Translational-(NON-LAYERED)
Shell Thickness = 0.250
1.05+00
9.82-01
9.12-01
8.42-01
7.72-01
7.03-01
6.33-01
5.63-01
4.93-01
4.23-01
3.53-01
2.83-01
2.13-01
1.43-01
7.35-02
3.57-03
Z
Y
X
default_Fringe :
Max 1.05+00 @Nd 9776
Min 3.57-03 @Nd 7467
default_Deformation :
Max 1.05+00 @Nd 9776


MSC/PATRAN Version 8.0 25-Apr-01 11:03:28
Fringe: _1_ATMOSPHERE_(LI386_MODEL).SC1. Static Subcase: Stress Tensor. -At Z1 (TRESCA)
Shell Thickness = 0.250
1.34+04
1.25+04
1.16+04
1.08+04
9.86+03
8.97+03
8.08+03
7.19+03
6.30+03
5.41+03
4.52+03
3.63+03
2.74+03
1.85+03
9.62+02
7.19+01
default_Fringe :
Max 1.34+04 @Nd 7850
Min 7.19+01 @Nd 12364
Z
Y
X

Conclusions:

- Stresses are generally at or below allowables (ASME-Grade1 annealed Inconel-625: 27.5ksi, ASTM-B-443).

- Local buckling at NB port nozzle to shell transition $\lambda = 2.9$ for 0.175” thk. Shell

- $\lambda = 6.7$ for 0.250” thick Shell

- May need to increase shell thickness to a 0.220” minimum thickness to meet code S.F. of 5x