

E N G I N E E R I N G N O T E

AUTHOR

DEPARTMENT

LOCATION

DATE

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PROGRAM-PROJECT-JOB

US - LHC COLLABORATION

LUMI PRESSURE VESSEL DESIGN DETAILS

This vessel is designed to be used at up to 10 atmospheres absolute (9 atmospheres gauge), using a mix of 96% argon, 4% nitrogen (inert gas) with a total stored energy of less than 100k joules, thereby placing it in the low-hazard pressure systems category (see section 7.5.1 of PUB-3000 Rev'd 1/99)

Design Features:

- Vessel stored energy is less than 5000 joules without contents, less than 2600 joules with its contents
- Constructed of 0.125 inch [3mm] stainless steel sheet and Prodec plate entirely with full penetration butt welds
- Tank maximum stress is less than 24000 psi: safety factor on ultimate strength is 3
(Type 304 stainless steel tensile strength = 75400 psi)
- Top and bottom of vessel are machined at corners so welds are removed from high stress areas [see drawing], All welds are strategically located at low stress transition regions and are less than 9000 psi
- All units are hydrostatically tested at 1.5 design pressure
- Pressure delivery system is limited to 10 atmospheres absolute (9 atmospheres gauge) by an overpressure safety valve.
- Vessel will normally be used in a non-manned area.

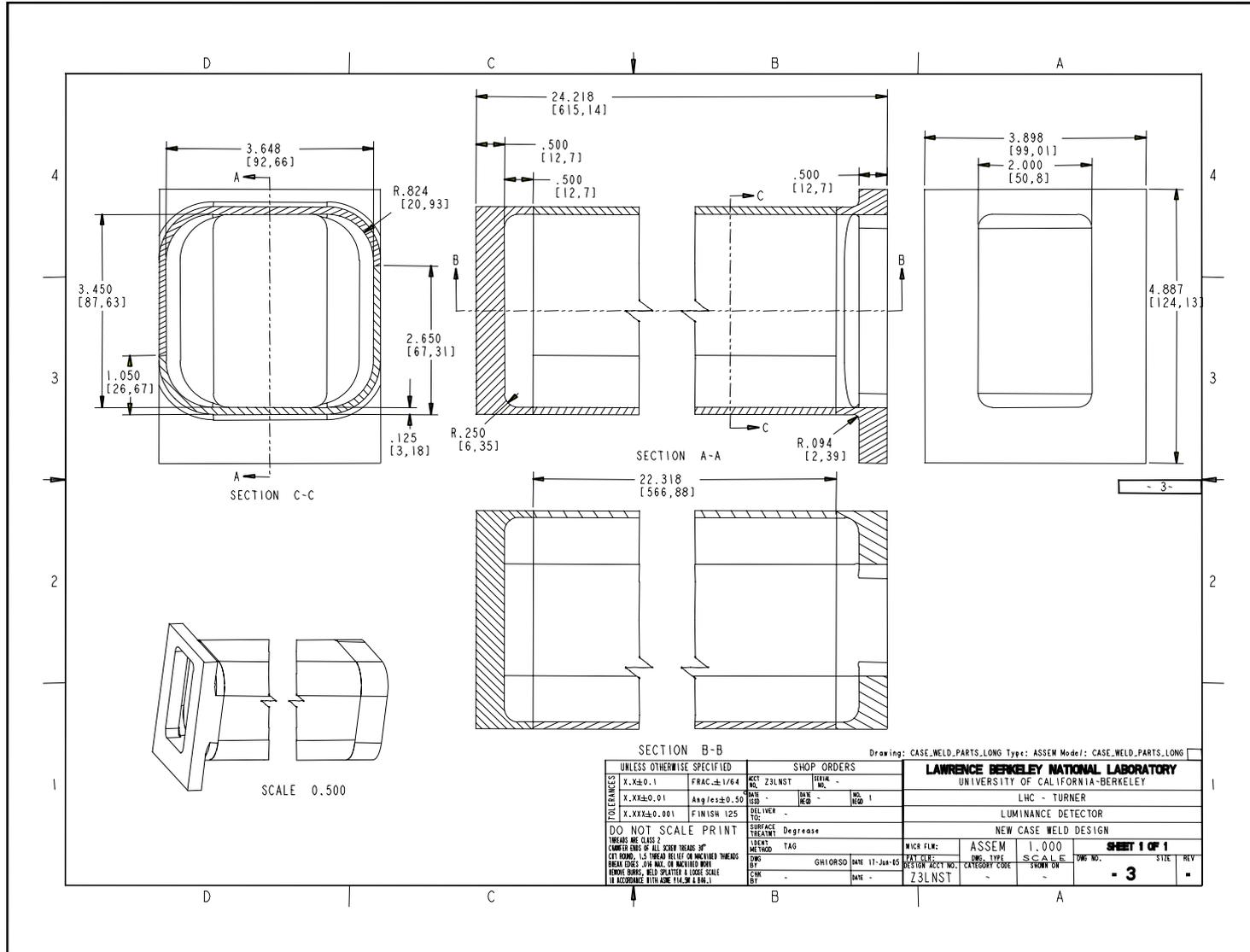
Refer to the following pages:

2) Mechanical drawing

3) Stored energy calculation

4) Pre-weld assembly exploded view showing weld seam locations

5-7) Stress plots showing stress at weld seam locations as well as maximum stress in model



UNLESS OTHERWISE SPECIFIED

TOLERANCES	X.X±0.1	FRAC ±1/64
	X.XX±0.01	Angles ±0.50
	X.XXX±0.001	FINISH 125

DO NOT SCALE PRINT
 UNLESS AS CLASS 2
 CHECKED DIMS OF ALL SHOP TREATS 3P
 CUT POINTS - 15 TREAD BELT OR INCHES THINGS
 BREAK EDGES - 0.063 IN. OR MACHINED EDGE
 BROWN EDGES - WELD SPATTERS & LOCAL SCALE
 10 RECORDING 1/16 IN. DIA. (0.1588)

SHOP ORDERS

RECT	Z3LNST	WELK	-
DATE	DATE	DATE	NO. 1
DELIVER	-	-	-
SURFACE	Degrease	-	-
TREAT	TAG	-	-
DATE	GH10RSO	DATE	17-Jun-85
DATE	-	DATE	-

Lawrence Berkeley National Laboratory
 UNIVERSITY OF CALIFORNIA-BERKELEY
 LHC - TURNER
 LUMINESCENCE DETECTOR
 NEW CASE WELD DESIGN

MICR FILM:	ASSEM	1.000	SHEET 1 OF 1
DATE:	DESIGN	SCALE	TWF NO.
Z3LNST	CATEGORY CODE	SHOWN ON	SIZE
-	-	-	REV
-	-	-	-

- 3 -

ENGINEERING NOTE

Appendix E STORED ENERGY OF A PRESSURED GAS VESSEL

Although the pressure section of this publication is not intended to be a primer on pressure calculation, the following formula is used sufficiently frequently, but is obscure enough, that it has been included.

When a gas is compressed, energy is stored in it. If the energy is released in an unfavorable way, it will cause damage. Stored energies in excess of 100 kJ are considered high hazard. Sometimes it is helpful to think of stored energy in terms of grams of TNT. One gram of TNT contains 4.62 kJ of energy.

Vh = The volume of the vessel.

value	units	metric	units
283	in ³	0.004637539	m ³

Ph = The absolute pressure of the vessel.

147	LB in ²	1013529.279	Pa
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PI = The absolute pressure to which the vessel would drop if it burst. Generally this would be one atmosphere (14.696 psi or 101,300 pascals). A pascal is a newton per square meter.

14.7	LB in ²	101352.9279	Pa
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γ = The adiabatic exponent or ratio of specific heats, Cp/Cv. The value is 1.666 for monatomic gases such as argon and helium; 1.4 for diatomic gases such as nitrogen, oxygen, hydrogen, and air; and variable for polyatomic gases such as methane, water, and carbon dioxide but generally very nearly 1.3.

$$U = \frac{P_h V_h}{\gamma - 1} \left[1 - \left(\frac{P_1}{P_h} \right)^{\frac{\gamma - 1}{\gamma}} \right]$$

1.6667	(argon)		
[B]	Ph Vh / y-1	7050.422509	Nm
[C]	PI / Ph	0.1	
[D]	(y-1)/y	0.4	
[E]	C^D	0.398107171	
[F]	1-E	0.601892829	
[A]	B*F	4243.598753	Nm

Note that the bracketed value is dimensionless but that Ph Vh is not. Therefore, the length units used in Ph and Vh must match.

Example:

The gas is air (γ = 1.4)

Vh = 1.0 stere (1.0 cubic meter) or 35.3 cubic feet

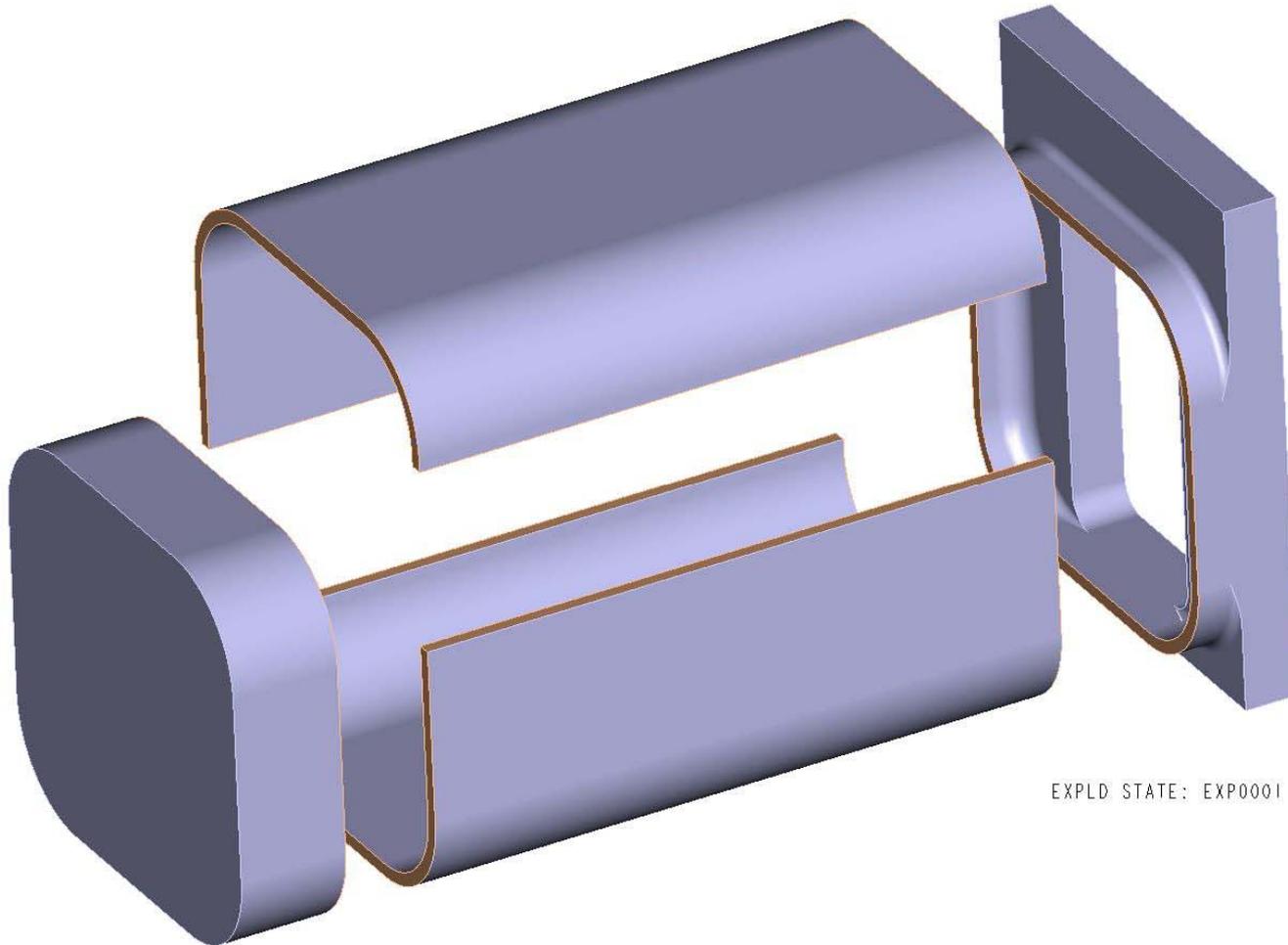
Ph = 10 atmospheres (150 psi) gage or 11 atm absolute or 1.1 mPa

PI = 1 atmosphere or 100 kPa or 14.7 psi

$$U = \frac{(11 \times 10^5 \text{ N/m}^2)(1.0 \text{ m}^3)}{1.4 - 1} \left[1 - \left(\frac{1 \times 10^5 \text{ N/m}^2}{11 \times 10^5 \text{ N/m}^2} \right)^{\frac{1.4 - 1}{1.4}} \right] = 1.4 \times 10^6 \text{ N} \cdot \text{m}$$

N·m is a joule, so the stored energy is 1.4 MJ, which is equivalent to somewhat more than half a pound of TNT.

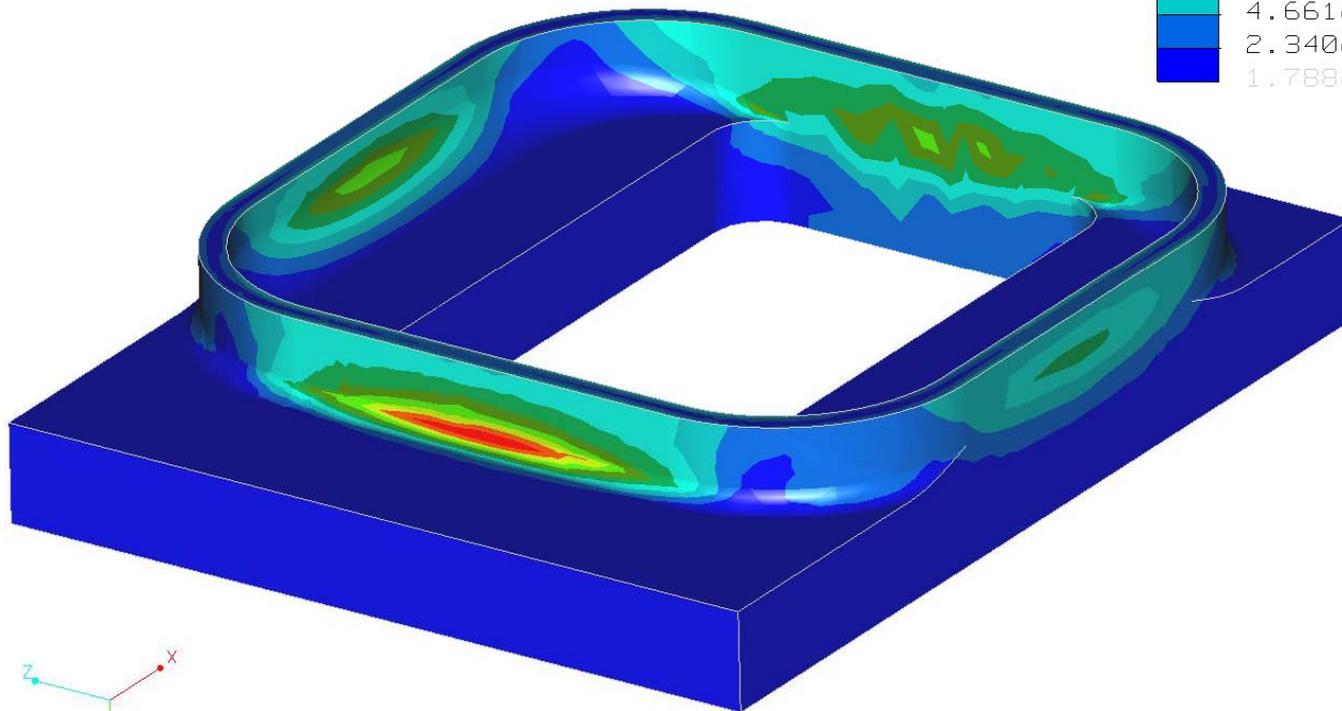
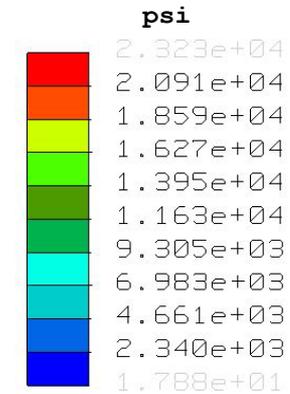
Note: This is an absolute maximum value because the volume of vessel is reduced by the internal contents.



EXPLD STATE: EXP0001

Pressure vessel components

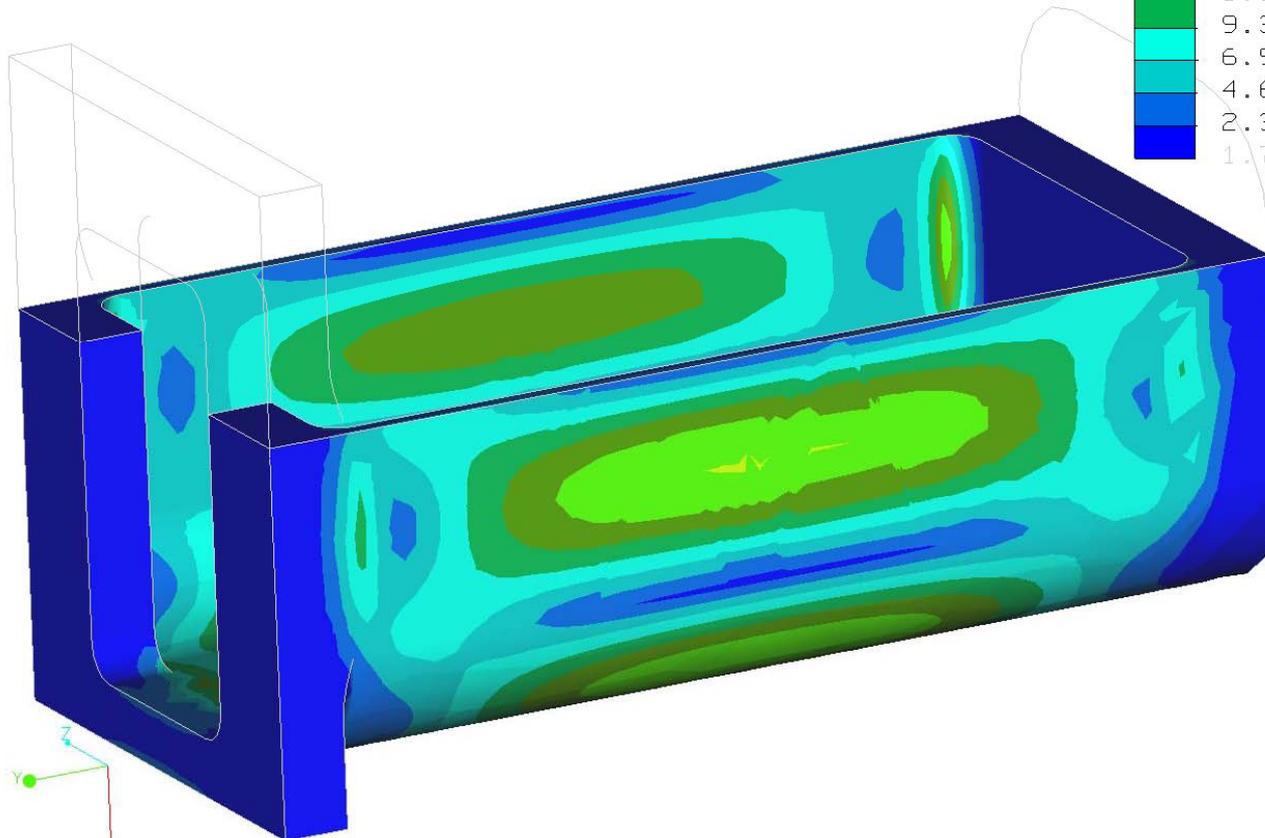
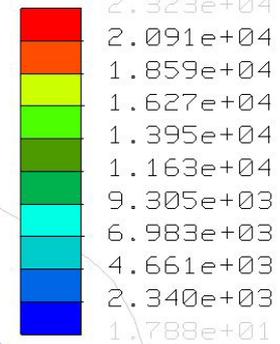
Stress von Mises (Maximum)
 Averaged Values
 Original Model
 LoadSet1
 Principal Units:
 Inch Pound Second (IPS)



Pressure vessel top at 132 psi showing weld seam stress < 9300 psi

Stress von Mises (Maximum)
Averaged Values
Original Model
LoadSet1
Principal Units:
Inch Pound Second (IPS)

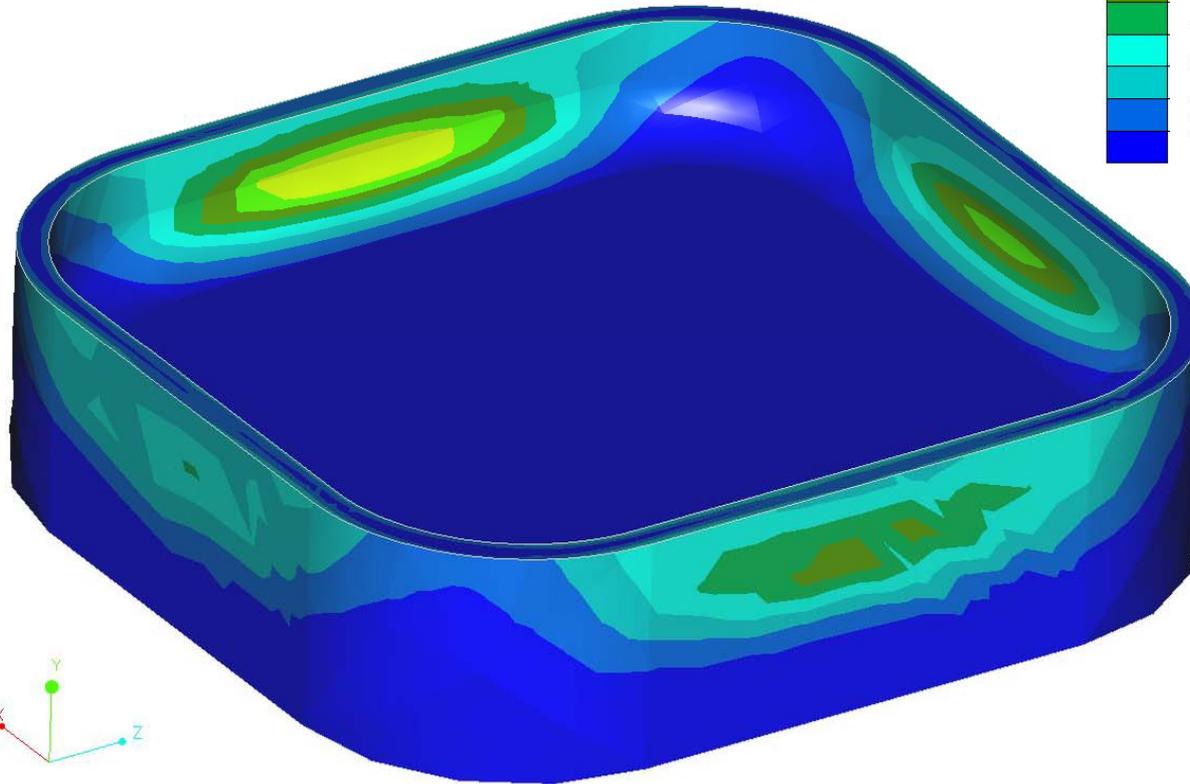
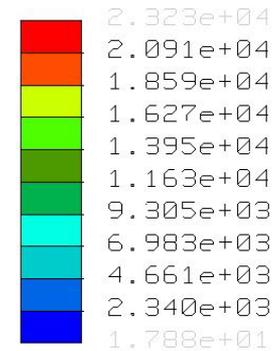
psi



Pressure vessel side at 132 psi showing weld seam stress < 9300 psi

Stress von Mises (Maximum)
Averaged Values
Original Model
LoadSet1
Principal Units:
Inch Pound Second (IPS)

psi



Pressure vessel bottom at 132 psi showing weld seam stress < 9300 psi