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ENGINEERING CALCULATIONS

PROJECT: MANWAY

CLIENT: F.I.A.S.S. PTY. LTD.

DOCUMENT TITLE: MANWAY CALCS TO AS 1210 CODE

DOCUMENT NO: A09-0682-EC-01

Rev	Description	Date	Prepared	Checked	Approved
A	Issued for Information	16/12/09	YD		

Project: *MANWAY*

Subject: DESIGN DATA Page: 1

Prepared: yd Date: 9-12-2009 Checked: Date: 16/12/09

CLIENT **F.I.A.S.S. PTY. LTD.**

DOCUMENT TITLE **MANWAY CALCULATIONS TO AS 1210 CODE**

ITEM No.

JOB DESCRIPTION: F.I.A.S.S. Pty Ltd have commissioned AML Consultants to prepare calculations for the manway to AS 1210 Code.

DATA

DESIGN CODE:	AS 1210-1997 (Amdt. 3)	
CLASS OF CONSTRUCTION:	3	
DESIGN PRESSURE:	810 kPag	
DESIGN TEMPERATURE:	100 °C	
CORROSION ALLOWANCE:	0 mm	
RADIOGRAPHY:	NIL	
POSTWELD HEAT TREATMENT:	NIL	
HYDROSTATIC TEST PRESSURE:	1215 kPag	[top of vessel]

MATERIAL SPECIFICATION (Refer drawing for other materials)

HEAD	ASTM A 240 - 316
FLANGE	ASTM A 240 - 316

REFERENCE DOCUMENTS

Drawings: Art. P.I.P.S 45 (Manway door specs)

Other: -

AML CONSULTANTS — Calculation Sheet

Project: *MANWAY*

Subject: DESIGN STRESS / TEST PRESSURE — Page: 2

Prepared: yd — Date: 09-12-2009 — Checked: — Date: 14/12/09

DESIGN TENSILE STRENGTHS / TEST PRESSURE (AS 1210-1997 Clause 3.3 & 5.10)

Part	Pressure Part ?	Material Specification	Design Temp.		Struct. Steel ?	Welded Pipe ?	Tensile Strength			Yield Strength						Design Tensile Strength		fh / f
							Test Temperature			Test Temperature			Design Temperature			min. f-1, f-2, f-3		
			°C	°F			Rm MPa	SF	f-1 MPa	Re MPa	SF	f-2 MPa	Re(T) MPa	SF	f-3 MPa	Test Temp fh (MPa)	Design Temp f (MPa)	
FLANGE	Y	*ASTM A 240 - 316*	*100*	212	*N*	*N*										*138.00*	*138.00*	1.00
HEAD	Y	*ASTM A 240 - 316*	*100*	212	*N*	*N*										*138.00*	*138.00*	1.00

Hydrostatic or Pneumatic ? *Hydrostatic*

Design Pressure : *810* kPag

Lowest Ratio fh / f : 1.00

Test Pressure : 1215 kPag (min) [1.5 * P * fh / f] at top of vessel

Notes: -

NARROW-FACE SLIP-ON FLANGES WITH RING GASKET (AS 1210-1997 Clause 3.21.6)

Loose / Optional - type ?		*Loose*					
Int. design pressure	P =	*0.810*	MPa(g)	Flange ridigity to ASME VIII Div. 1		*No*	
Ext. design pressure	Pe =	*0.000*	MPa(g)	Flange to withstand full bolt force		*No*	
External moment	M =	*0.00*	kNm	Design temperature	Temp =	*100.00*	°C
Axial force	F =	*0.00*	kN	Int. corrosion allowance	c =	*0.00*	mm
Static liquid head	LH =	*0*	mm	Material density :	ρ =	*8027*	kg/m³
Specific gravity	SG =	*1.00*		Equivalent pressure	Pe =	0.000	MPa(g)
DP + static head	P' =	0.810	MPa(g)	Calculation pressure	Pt =	0.810	MPa(g)

		Design stress (MPa) (design)	(test)
Flange	*ASTM A 240 - 316*	*138.00*	*138.00*
Bolts	*ASTM A193 B8M (316)*	*129.00*	*129.00*
Gasket	*o-ring*		

Flange outside dia.	A =	*470.00*	mm	Facing sketch :	*1(a)*	Column II	
Inside diameter	B =	*450.00*	mm	Nubbin width	w =	*n/a*	
Bolt circle diameter	C =	*510.00*	mm	Gasket factor	m =	*0.00*	
[1-metric (AS 1110), 2-metric (TEMA), 3-UNC/UN8]				Gasket seating stress	y =	*0.00*	MPa
Bolt type : *1*	Size :	*M16*		Gasket width	N =	*10.00*	mm
Bolt outside diameter	Db =	*16.00*	mm	Outside diameter	God =	*470.00*	mm
Area at root of thread	Ar =	144.00	mm²	Inside diameter	Gid =	450.00	mm
Total reqd. bolt area	Am =	1042.99	mm²	Basic gasket seat. width	bo =	5.00	mm
Actual total bolt area	Ab =	1152.00	mm²	Eff.gasket seating width	b =	5.00	mm
		< Bolting O.K. >		Gasket-force diameter	G =	460.00	mm
Reqd. no of bolts	n.req =	7.2		P/partition length	L =	*0.00*	mm
Actual no of bolts	n.act =	*8*		P/partition gasket width	Np =	*0.00*	mm
Corr. inside diameter	Bc =	450.00	mm	P/part. seating width	bop =	0.00	mm
				P/part.eff.gask.seat.width	bp =	0.00	mm
Bolt Spacing (Pb) :	Min :	44	mm	Gasket width check	Nmin =	N/A	
	Max :	1232	mm				
	Actual :	200	mm				
Factor	K =	1.044		Y =	44.204		

Load		Force (N)	Moment Arm (mm)		CF	Moment (Nmm)	
Total hydro. end-force	H =	1.345E+05					
Hydrostatic end-force	HD =	1.288E+05	hD =	30.00	1.00	MD =	3.863E+06
Difference (H - HD)	HT =	5.786E+03	hT =	27.50	1.00	MT =	1.591E+05
Total comp. force	HP =	0.000E+00					
Bolt force-hydro. force	HG =	0.000E+00	hG =	25.00	1.00	MG =	0.000E+00

		operating	gask. seating	
Bolt Forces (N) :	Wm1,2 =	134546	0	[3.21.6.4.1(1),(2)]
Mating flange loads (N) :	=	*0*	*0*	
Reqd Area of Bolts (mm²) :	Am1,2 =	1043	0	[3.21.6.4.3]
Flange Design Bolt Forces (N) :	W =	134546	141577	[3.21.6.4.4(1),(2)]
Alternative Design Bolt Load (N) :	Wnew =	*0*		
Total Moments (Nmm) :	M =	4.022E+06	3.539E+06	
Reqd Thickness (mm) :	t1,2 =	53.51	50.19	
Thickness selected	T =	*100.00* mm		(excl. of added allowance for raised face)

Flange Stresses (MPa) :	operating		gasket seating	
	Actual	Allowable	Actual	Allowable
Tangential - S_T	39.51	138.00	34.77	138.00
Bolt Stress	116.79	129.00	0.00	129.00

External Pressure: < Not Applicable >

H =	0.00E+00 N	HT =	0.00E+00 N	Wm1 =	0.00E+00 N
HD =	0.00E+00 N	Hp =	0.00E+00 N	Wm2 =	0.00E+00 N
Am2 =	0.00 mm^2	W =	1.42E+05 N		
Mo (op) =	0.00E+00 Nmm	t (op) =	0.00 mm		
Mo (gkst) =	0.00E+00 Nmm	t (gskt) =	0.00 mm		

Flange Rigidity - ASME VIII Div. 1 (2-14)

Rigidity factor	KI =	n/a
Rigidity index	J =	n/a

Estimated weight : 12 kg

Note: -

TORISPHERICAL ENDS - (AS 1210-1997 Clause 3.12)

Material specification:		*ASTM A 240 - 316*					
Class of construction	Class	*3*					
Design pressure @ top	P =	*0.810*	MPa(g)	Pext =	*n/a*		
Design temperature	Temp =	*100.00*	°C				
Design strength - test temp.	fh =	*138.00*	MPa				
Design strength - design temp.	f =	*138.00*	MPa				
Static liquid head	LH =	*0*	mm				
Specific gravity	SG =	*1.000*					
Weld joint efficiency - longitudinal	ηl =	*1.00*					
Weld joint efficiency - circumferential	ηc =	*0.60*					
Corrosion allowance - internal	ci =	*0.00*	mm				
Corrosion allowance - external	ce =	*0.00*	mm				
Outside diameter	Do =	*436.00*	mm				
Inside crown radius	R =	*419.50*	mm				
Inside knuckle radius	r =	*3.50*	mm				
Straight flange	SF =	*32.40*	mm				
Nominal thickness	T =	*5.00*	mm				
After forming allowance	AF =	*10.00*	%				
Inside tangential height	h =	60.10	mm	M =	3.487		
Inside diameter	ID =	426.00	mm	Rc =	419.50	mm	
Corroded dimensions :	IDc =	426.00	mm	rc =	3.50	mm	
Liquid head pressure	PLH =	0.000	MPa(g)				
Calculation pressure	P' =	0.810	MPa(g)				

Minimum Calculated Thickness:		Pint			
(a) End thickness	t =	4.30	mm		
Design thickness :	t + ci,e =	4.30	mm		
Min. thickness after forming	Taf =	4.50	mm		
(b) Straight flange portion	tSF,l =	1.25	mm	[long. joint]	[3.7.3(1)]
	tSF,c =	1.04	mm	[circ. joint]	
Design thickness :	tSF + ci,e =	1.25	mm		
Thickness selected	T =	5.00	mm		
Stress at given P' & Tc	f' =	131.85	MPa		
Membrane stress (corroded)	fm =	38.34	MPa		

MAP - New & Cold : 0.835 MPa(g) MAWP - Hot & Corr. : 0.835 MPa(g)

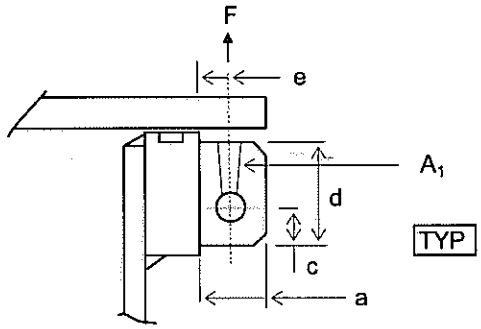
Shape checks: (i) r approaching 6% : D/T > 100 No (or) P>690 Yes

(ii) D/tk > 300 No tk = 4.50 mm

	Spherical Portion	Straight Flange
Est. inside volume :	0.005 m^3	0.005 m^3
Est. empty weight :	7 kg	2 kg
Est. fully flooded weight :	11 kg	6 kg

Note: -

SWING BOLTS ASSEMBLY (AS 1210-1997 Clause 3.27.3 & AS 3990-1993)



t-lug =	*10.00*	mm	
a =	*55.00*	mm	
c =	*15.00*	mm	
d =	*30.00*	mm	
e =	*22.00*	mm	
weld =	*12.00*	mm	
No. of lugs =	*2*		
Hole dia =	*16.50*	mm	

Number of bolts		N =	*8*	Bolt diameter		D =	*18.00* mm
Total bolt load		F =	*135.00* kN	Load on one bolt		F' =	16.88 kN
Metric	*M16*	Ar =	144.00 mm^2	UNC/UN 8	-	Ar =	0.00 mm^2

PIN *ASTM A193 B8M (316)*

Diameter	dp =	*16.00* mm		Yied stress		FY =	*205.00* MPa
Eyebolt width	b =	*29.00* mm		Lug spacing		L =	*30.00* mm
Bending moment	M =	46.41 kNmm		Section modulus		Z =	402.12 mm^3
Bearing allowable	Ba =	0.514 FY		Cross-sectional area		Ap =	201.06 mm^2
Bearing width	Bw =	5.00 mm					
Shear stress	fs =	41.96 MPa	<	75.85 MPa	[0.37 FY]		
Bearing stress	fp =	36.37 MPa	<	105.47 MPa	[T 9.5.2]		
Bending stress	fb =	115.40 MPa	<	135.30 MPa	[0.66 FY]		

Washers provided ? *No*

LUG *ASTM A 182 F316*

Tensile Stress	Fu =	*515.00* MPa		FY =	*205.00* MPa		
Cross-sectional area	A1 =	2.70E+02 mm^2		Z-lug =	1.50E+03 mm^3		
Moment per lug	M =	185.63 kNmm		ed =	11.52 mm		
Bearing stress in lug pin holes	fbr =	52.73 MPa	<	105.47 MPa	[T 9.5.2]		
Bending stress in lug	fb-lug =	61.88 MPa	<	135.30 MPa	[0.66 FY]		
Shear stress in hole area	fs =	62.50 MPa	<	75.85 MPa	[0.37 FY]		

WELD

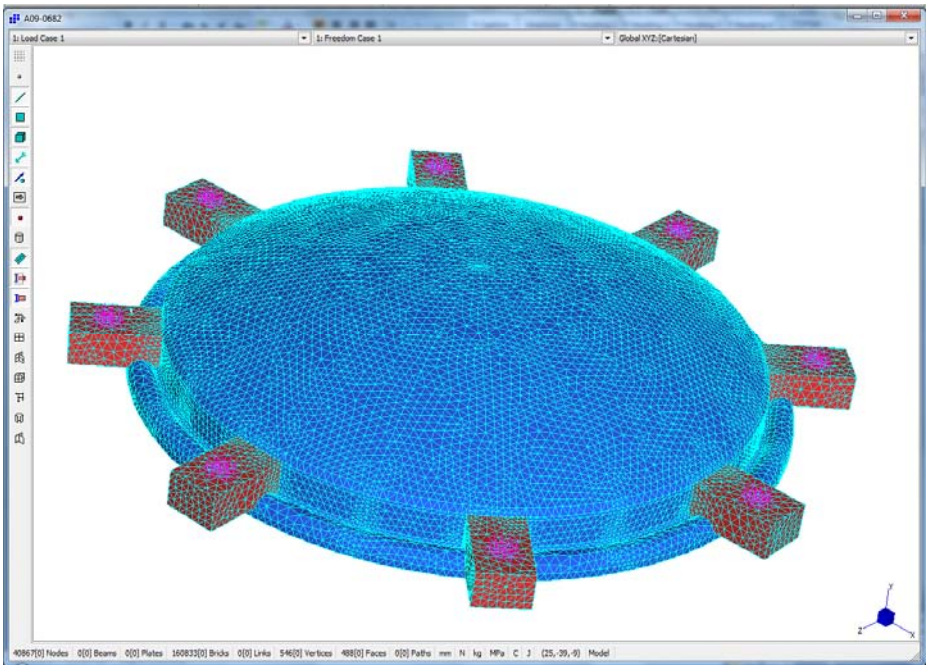
1 side or 2 sides weld per lug		*1*	[accessible on outer side only]		
Total weld throat	wt =	8.49 mm	Zw =	1.27E+03 mm^3	
Bending stress in weld	fbw =	145.84 MPa			
Shear stress in weld	fsw =	66.29 MPa			
Combined stress in weld	fw =	160.20 MPa	<	169.95 MPa	[0.33 Fuw]

Note: -

1. RESULTS

1.1 Strand7 Computer Results In Accordance with AS 1210-1997 Clause B6

The Strand7 results are tabulated as follows to comply with the requirements of Clause B6 in AS 1210-1997.



1.1.1 Manway Geometry and Boundary Conditions.

a) Model description and the assumptions.

The manway was created using brick elements. By inputting gravity as a vertical acceleration, Strand7 calculates the self-weight of the vessel based on the brick properties, which is included in the output stress results.

b) Software package and version

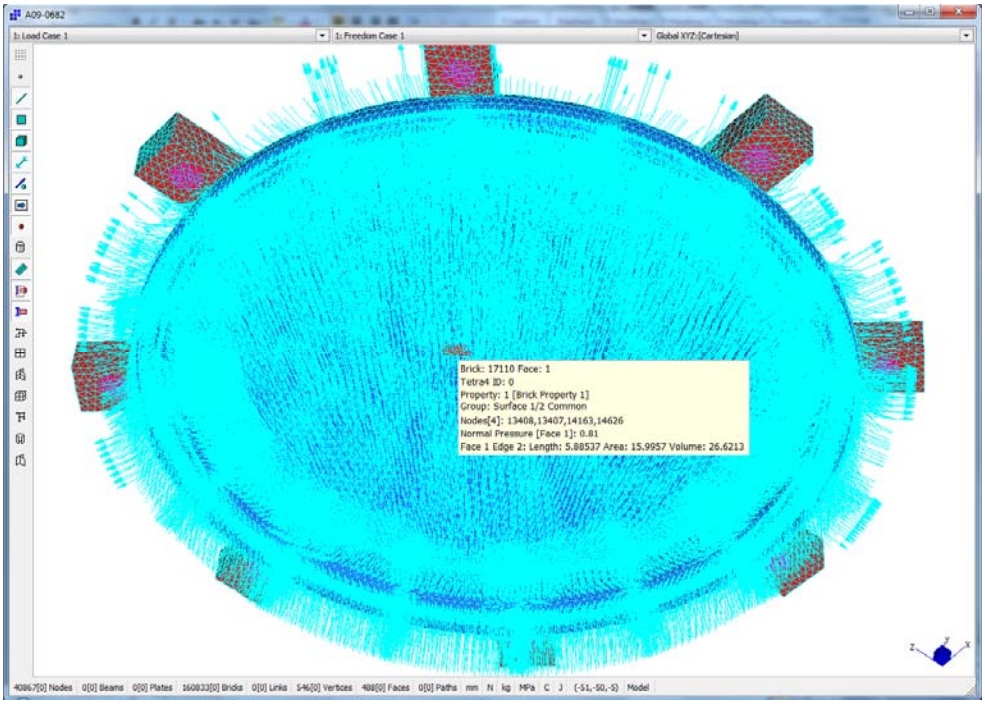
The Finite Element Analysis (FEA) was completed using the computer software package Strand7 version R2.4.

c) Type of mesh

The model was created using tetra four brick elements.

d) Loads

The loading was applied as normal pressures.



1.1.2 Internal Pressure Loading.

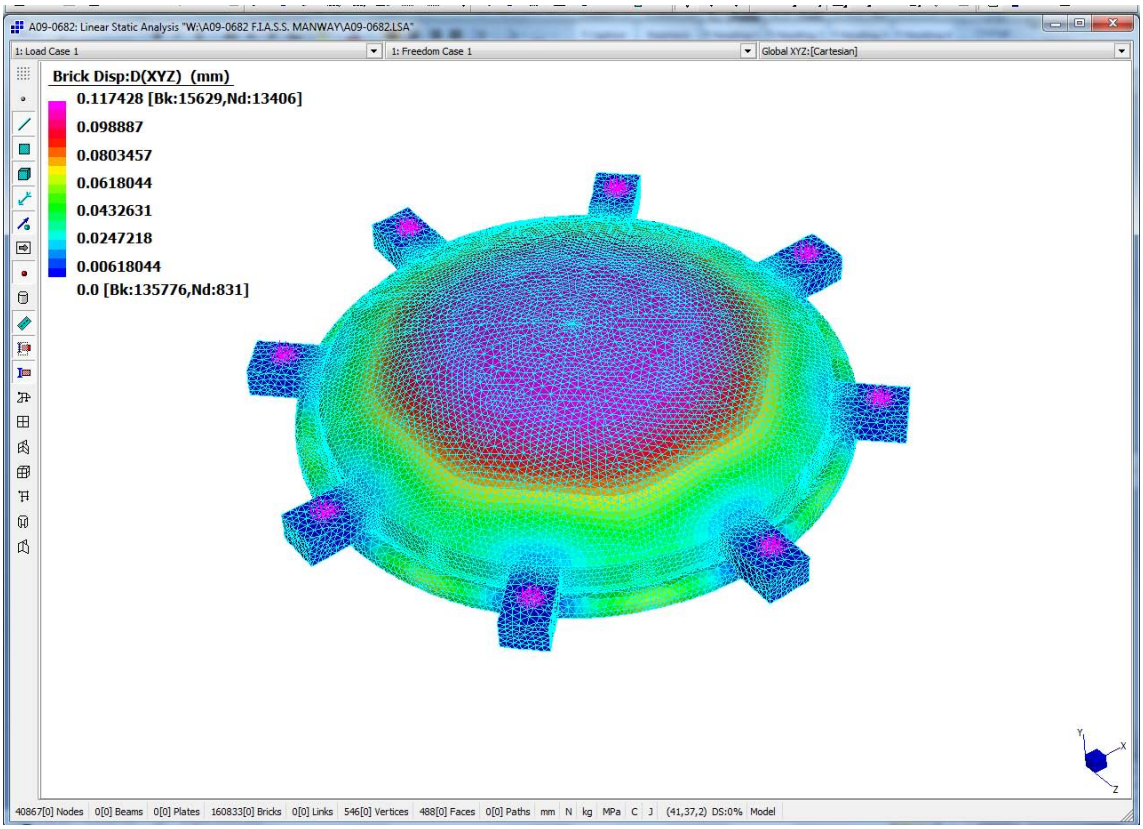
e) Boundary conditions

The manway is supported on eight bolts by restraining nodes representing the bolts.

f) Evidence that the solution has converged

Refer to attached linear static solver summary showing the resultant loads applied to the tank.

g) Plot of deflected shape under relevant loading condition



1.1.3 Deflected shape under combined load.

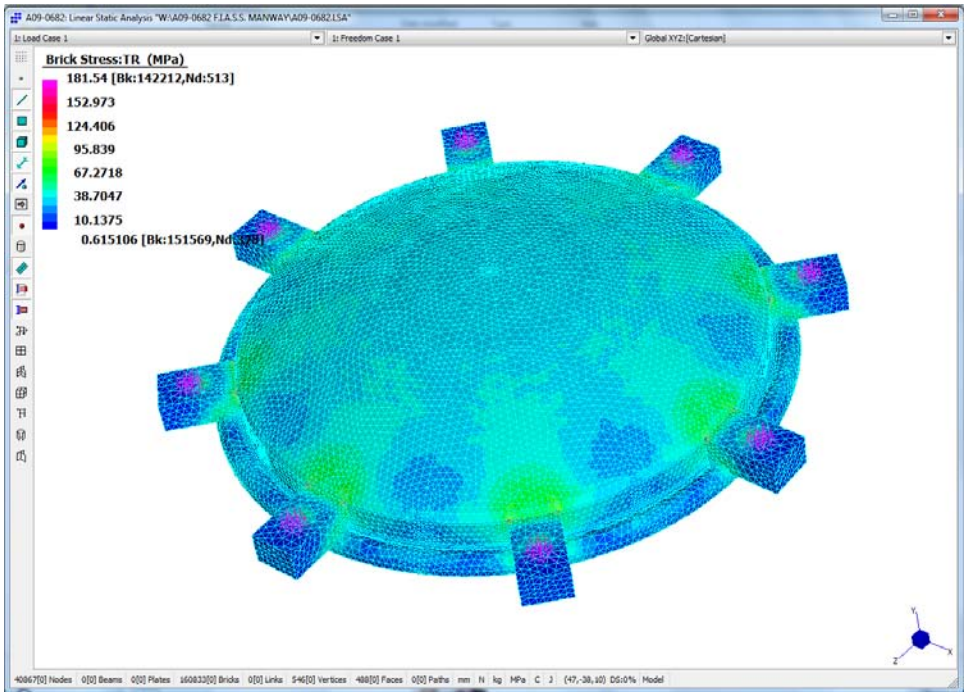
h) Sufficient data to show that away from structural discontinuities the stresses are those of simple shell or strut models

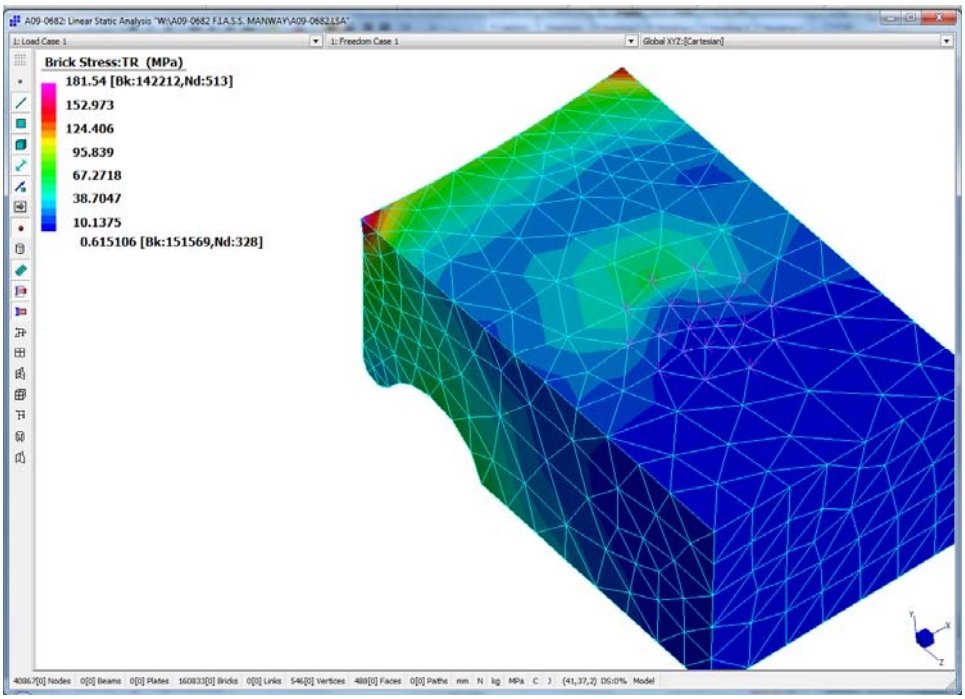
Refer to stress plot 1.1.6 of the tank showing that the average hoop stress is 40 MPa. This is approximately the same as the manually calculated value in the spreadsheet of the calculations.

i) Stress Plot Summary

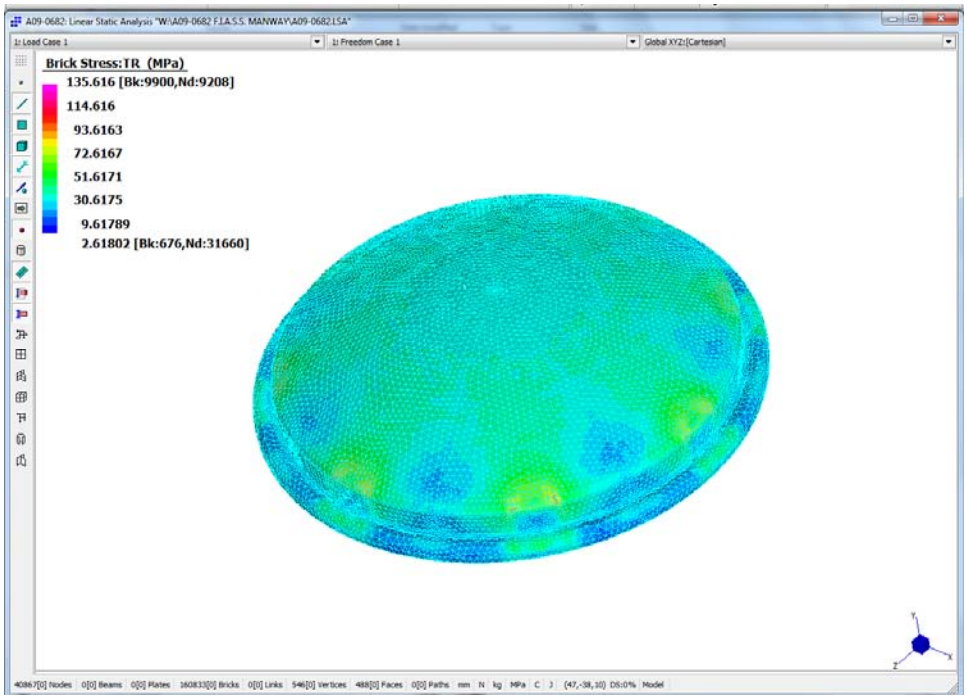
The maximum local stress in the base cone/comp pad region is 188 MPa. This value is less than 2f = 258 MPa and Fy = 207 MPa. Therefore the stresses are acceptable and the silo complies with the requirements of AS 1210.

j) Stress Plots of the silo

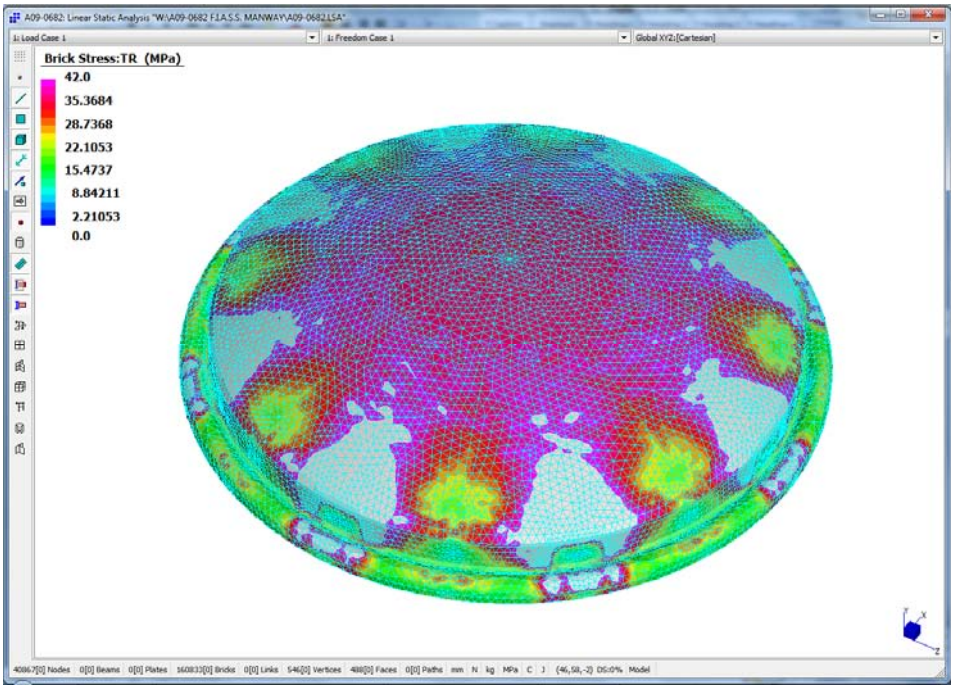




1.1.4 <u>Maximum Primary & Secondary Membrane & Bending Stress = 182 MPa <3.0f</u>



1.1.5 Maximum Primary Membrane & Bending Stress = 136 MPa <1.5f



1.1.6 Maximum Primary Membrane Stress = 40 MPa <1.0f