FEA Component Report

Job Number: **PVE-1388**

Project: **Sample Vessel 8**

Vessel: **PVE-Sample 8**

Part: **Nozzle A**

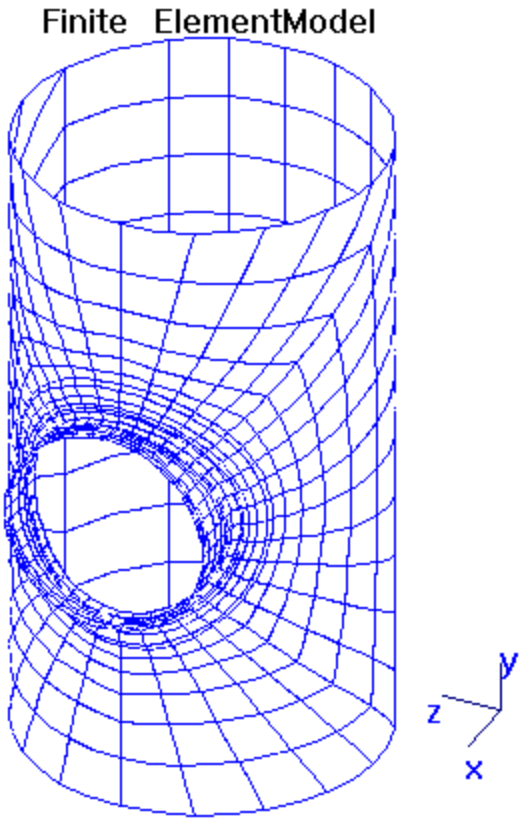
FEA run by: **Charles Liu**

Software used: **Nozzle/Pro 6.0**

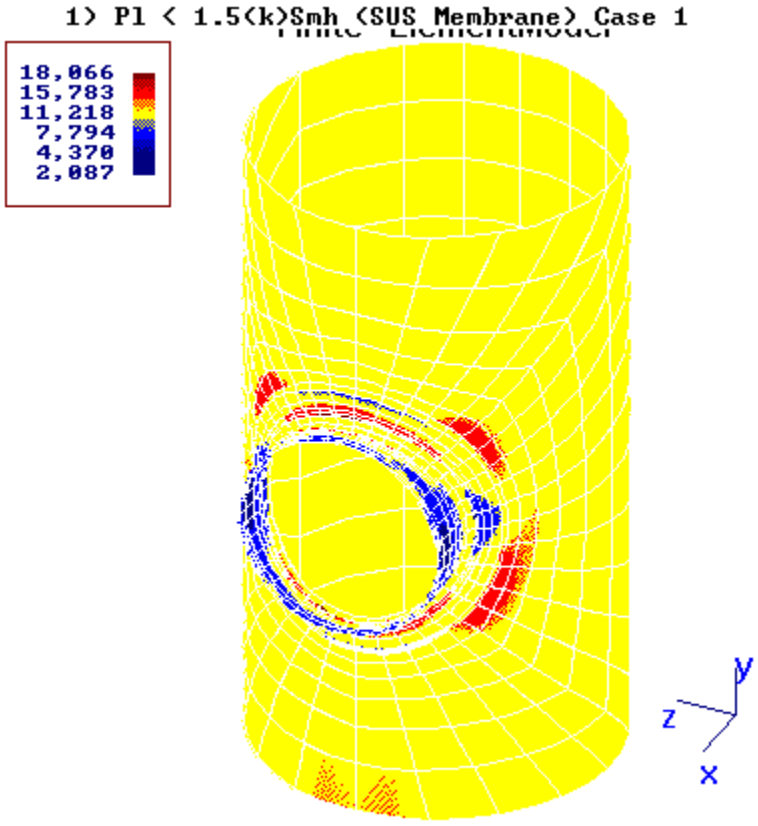
Date: **April. 26 2007**

ASME code rules met: **Yes**

Notes:

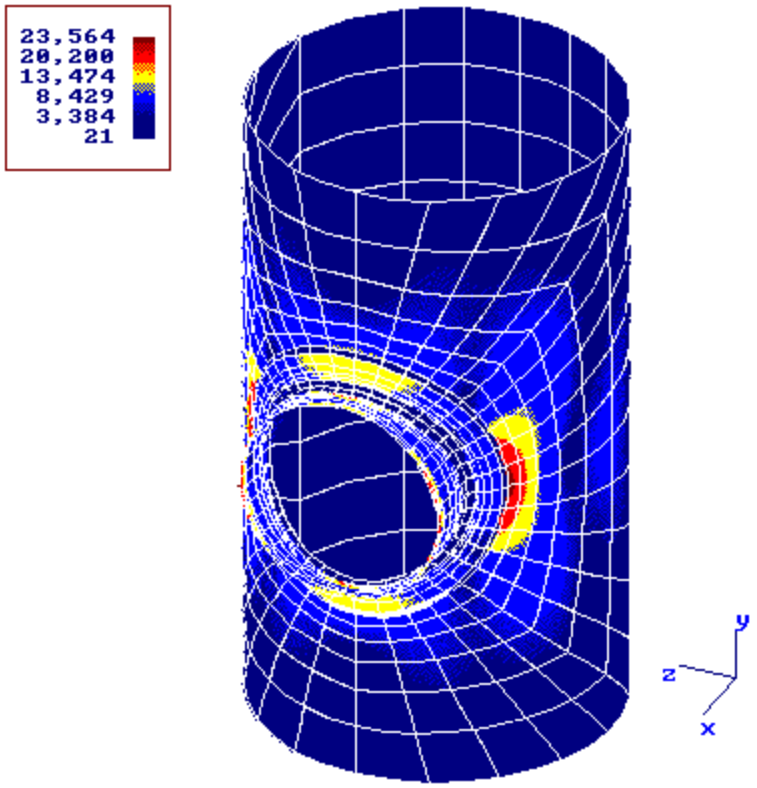


3d



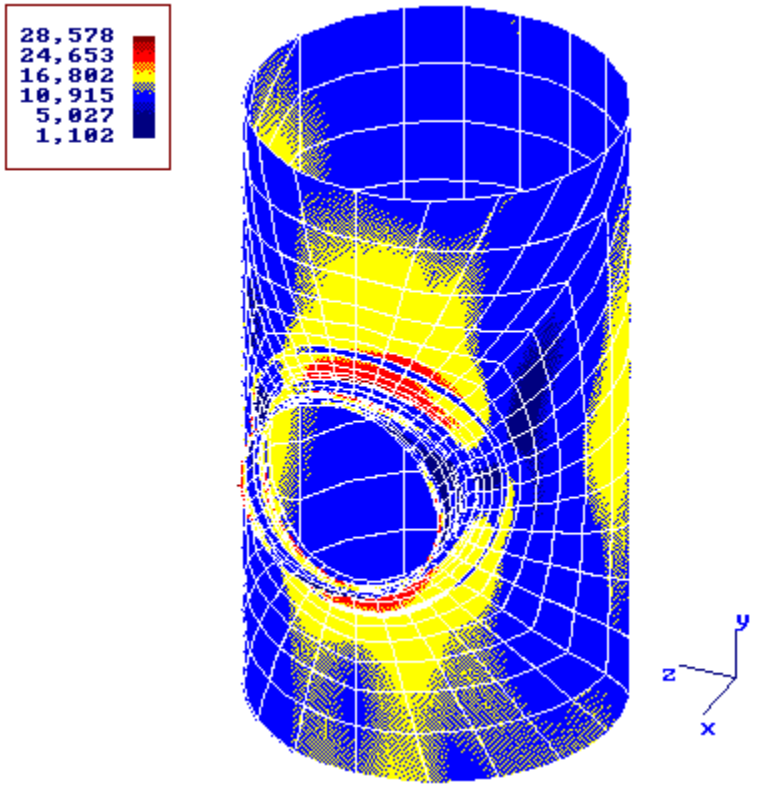
3d 3d(Deformed)

2) Qb < 3(Smh) (SUS Bending) Case 1



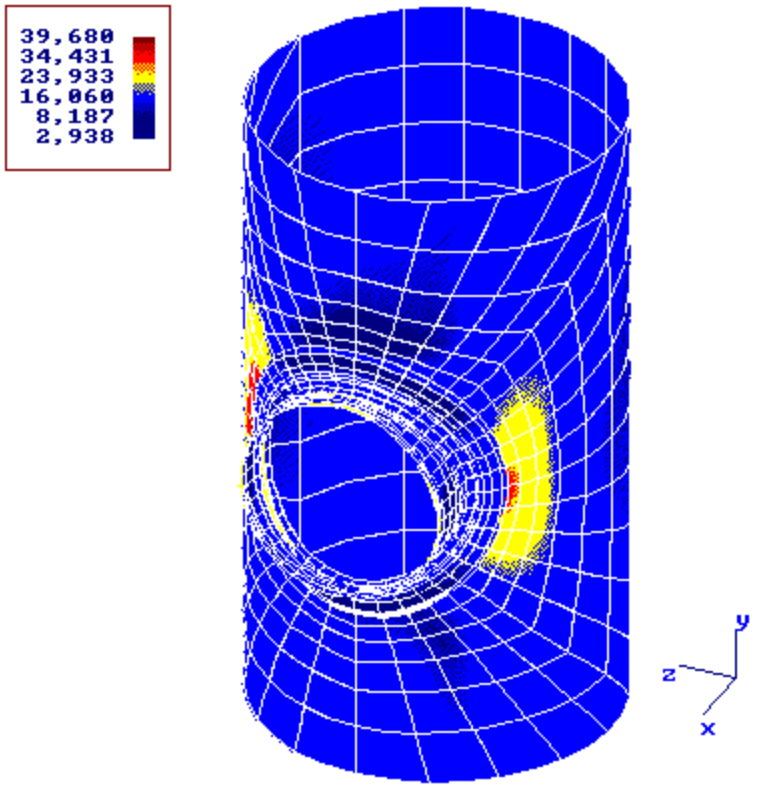
3d 3d(Deformed)

3) Pl+Pb+Q < 3(Smavg) (OPE Inside) Case 2



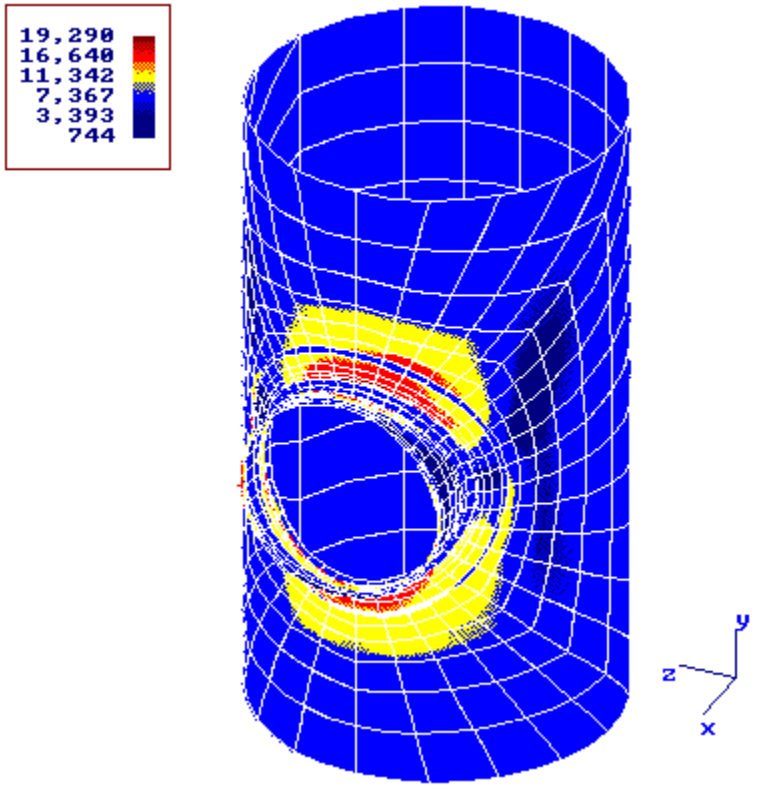
3d 3d(Deformed)

4) Pl+Pb+Q < 3(Smavg) (OPE Outside) Case 2



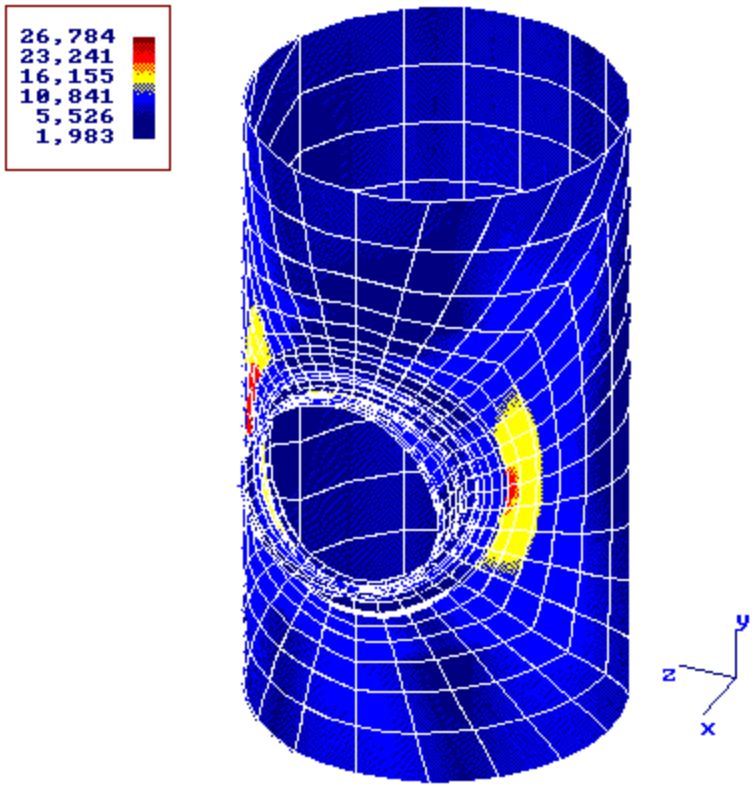
3d 3d(Deformed)

5) Pl+Pb+Q+F < Sa (EXP Inside) Case 2



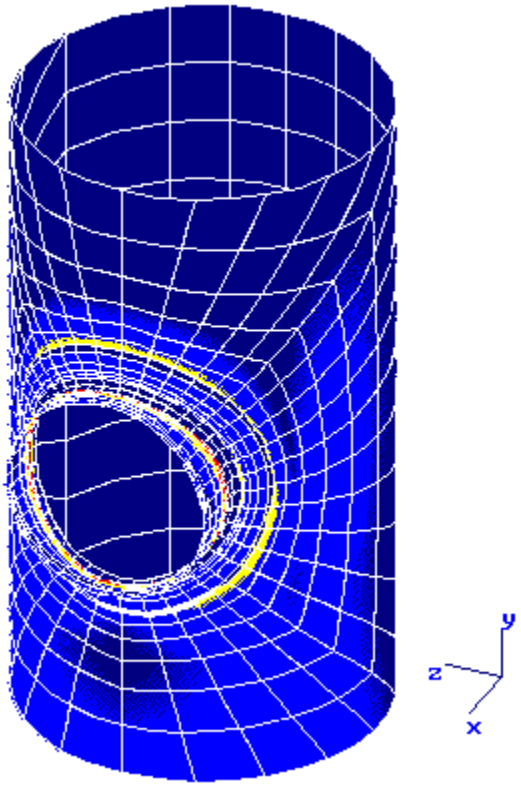
3d 3d(Deformed)

6) Pl+Pb+Q+F < Sa (EXP Outside) Case 2



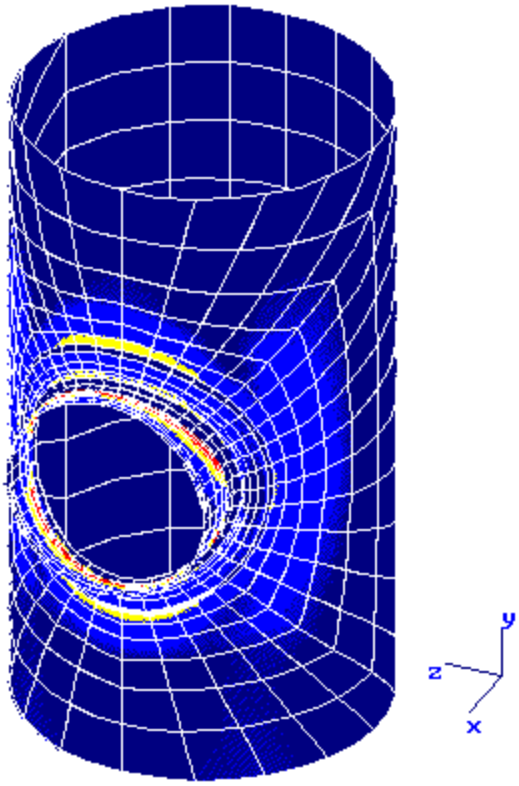
3d 3d(Deformed)

7) Pl+Pb+Q+F < Sa (SIF Outside) Case 3



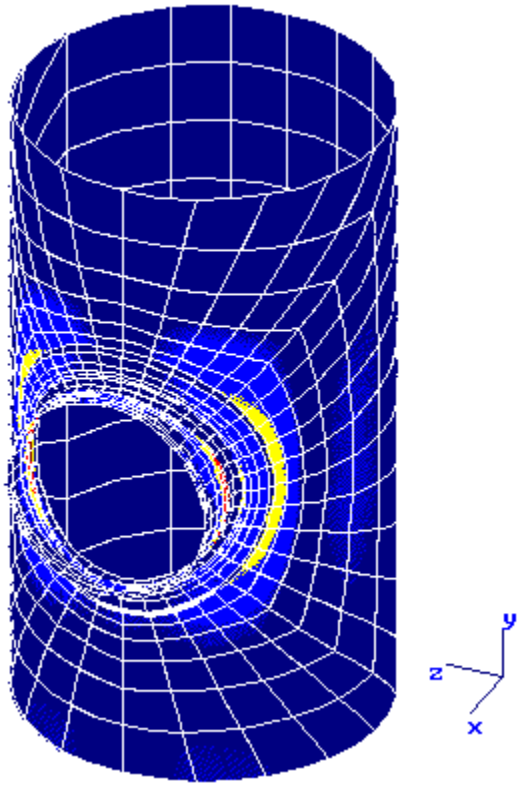
3d 3d(Deformed)

8) Pl+Pb+Q+F < Sa (SIF Outside) Case 4



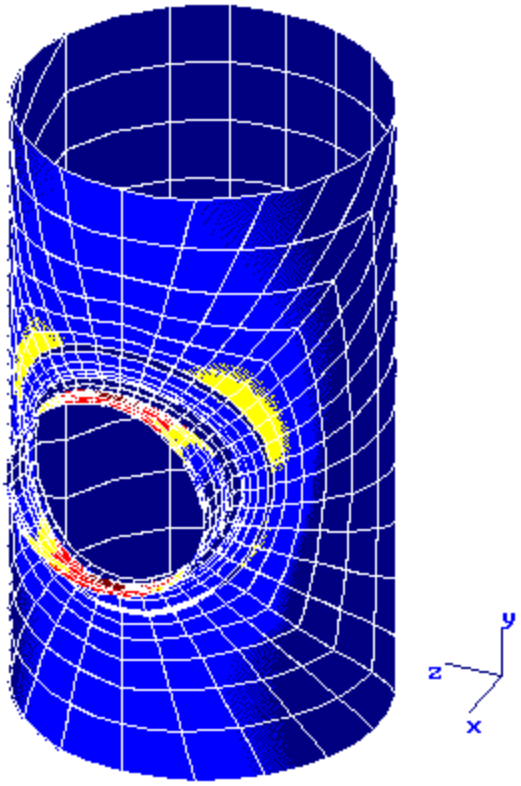
3d 3d(Deformed)

9) Pl+Pb+Q+F < Sa (SIF Outside) Case 5



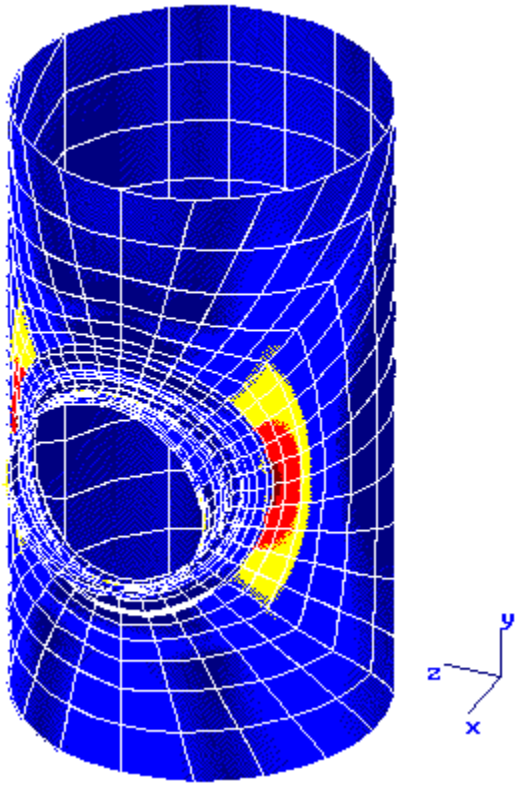
3d 3d(Deformed)

10) Pl+Pb+Q+F < Sa (SIF Outside) Case 6



3d 3d(Deformed)

11) Pl+Pb+Q+F < Sa (SIF Outside) Case 7



3d 3d(Deformed)

Tabular Results

Results were generated with the finite element program FE/Pipe®. Stress results are post-processed in accordance with the rules specified in ASME Section III and ASME Section VIII, Division 2.

Analysis Time Stamp: Thu Apr 26 11:18:05 2007.

```
Model Notes

  Input Echo:

  Description:

         Sample Vessel 8

  Model Type                    : Cylindrical Shell

  Parent Outside Diameter       :      42.000 in.
         Thickness              :       0.750 in.
         Fillet Along Shell     :       0.563 in.

         Parent Properties:
         Cold Allowable         :     20000.0 psi
         Hot  Allowable         :     16200.0 psi
         Material ID #4         :  Austenitic Stainless Steel
         Elastic Modulus (Amb)  :  28300000.0 psi
         Poissons Ratio         :       0.300
         Expansion Coefficient  :  0.9900E-05 in./in./deg.

  Nozzle Outside Diameter       :      24.000 in.
         Thickness              :       0.688 in.
         Length                 :       4.000 in.
         Nozzle Weld Length     :       0.563 in.
         RePad Width            :       3.000 in.
         RePad Thickness        :       0.750 in.
         RePad Weld Leg         :       0.688 in.
         Nozzle Tilt Angle      :       0.000 deg.
         Distance from Top      :       0.000 in.
         Distance from Bottom   :      72.000 in.
```

```
        Nozzle Properties
        Cold Allowable         :     20000.0 psi
        Hot  Allowable         :     16200.0 psi
        Material ID #4         :  Austenitic Stainless Steel
        Elastic Modulus (Amb)  :  28300000.0 psi
        Poissons Ratio         :       0.300
        Expansion Coefficient  :  0.9900E-05 in./in./deg.

  Design Operating Cycles      :       7000.
  Ambient Temperature (Deg.)   :       70.00
  Nozzle Pressure              :       353.9 psi
  Vessel Pressure              :       353.9 psi

  User Defined Load Input Echo:
  Loads are given at the Nozzle/Header Junction
  Loads are defined in Global Coordinates

  Forces(lb.)  Moments( ft-lb

  Load Case        FX         FY         FZ         MX         MY         MZ
  ------------------------------------------------------------------------------
     OPER:     6475.0     6475.0     4856.0    38206.0    25520.0    33117.0


  FEA Model Loads:
  These are the actual loads applied to the FEA model.
  These are the User Defined Loads translated to the
  end of the nozzle and reported in global coordinates.

  Forces(lb.)  Moments( ft-lb

  Load Case        FX         FY         FZ         MX         MY         MZ
  ------------------------------------------------------------------------------
     OPER:     6475.0     6475.0     4856.0    38206.0    27138.7    30958.7

  Both ends of the model are "fixed," except that one end
  is free axially so that longitudinal pressure stresses
  may be developed in the geometry.

  Stresses ARE nodally AVERAGED.

  Vessel Centerline  Vector     :  0.000   1.000   0.000
  Nozzle Orientation Vector     :  1.000   0.000   0.000
```

Table of Contents

```
Load Case Report

Inner and outer element temperatures are the same
throughout the model.  No thermal ratcheting
calculations will be performed.

THE   7  LOAD CASES ANALYZED ARE:

  1   Sustained

      Sustained case run to satisfy Pl<1.5Sm limit,  and
```

```
        Qb, the bending stress due to primary loads must
        be less than 3Smh as per Note 3 of Fig. NB-3222-1,
        and Table 4-120.1

        /-------- Loads in Case   1
        Pressure Case    1

    2   Operating      (Fatigue Calc Performed)

        Operating case run to compute the extreme operating
        stress state to be used in the shakedown and peak
        stress calculations.

        /-------- Loads in Case   2
        Pressure Case    1
        Force Case (Operating)

    3   Program Generated -- Force Only

        Case run to compute sif's and flexibilities.

        /-------- Loads in Case   3
        Force Case (Axial)

    4   Program Generated -- Force Only

        Case run to compute sif's and flexibilities.

        /-------- Loads in Case   4
        Force Case (Inplane)

    5   Program Generated -- Force Only

        Case run to compute sif's and flexibilities.

        /-------- Loads in Case   5
        Force Case (Outplane)

    6   Program Generated -- Force Only

        Case run to compute sif's and flexibilities.

        /-------- Loads in Case   6
        Force Case (Torsion)

    7   Program Generated -- Force Only

        Case run to compute sif's and flexibilities.

        /-------- Loads in Case   7
        Pressure Case    1
```

Table of Contents

Solution Data

```
  Maximum Solution Row Size =    1068
  Number of Nodes           =    2651
  Number of Elements        =     860
  Number of Solution Cases  =       7

  Largest On-Diagonal Stiffness   =    6086013811662.
  Smallest On-Diagonal Stiffness  =                4.

  Largest Off-Diagonal Stiffness  =    3036761612734.
  Smallest Off-Diagonal Stiffness =                1.

  Summation of Loads per Case
```

Case #	FX	FY	FZ
1	-9267.	456017.	0.
2	-2792.	462495.	4854.
3	3112438.	0.	0.
4	0.	25.	0.
5	0.	0.	-18.
6	0.	0.	0.
7	-9267.	456017.	0.

Equation Coefficient (Stiffness) Distribution)

OnDiagonal Percentile	Number of Coefficients	Average Stiffness
90-to-100%	40	6030334227983.
70-to-90%	0	0.
50-to-70%	0	0.
30-to-50%	160	2113955662492.
10-to-30%	240	753767842602.
1-to-10%	292	232397510703.
.1-to- 1%	392	26238558446.
.01-to-.1%	132	1604051223.
.001-to-.01%	6542	144753316.
.0001-TO-.001%	8108	23623147.

OFF Diagonal Percentile	Number of Coefficients	Average Stiffness
90-to-100%	80	3008858196847.
70-to-90%	0	0.
50-to-70%	0	0.
30-to-50%	240	1208892589947.
10-to-30%	544	554702272215.
1-to-10%	3332	102931983310.
.1-to- 1%	11592	10677218964.
.01-to-.1%	13184	1267600938.
.001-to-.01%	19910	78381476.
.0001-TO-.001%	675874	2429327.

Table of Contents

ASME Code Stress Output Plots

1) Pl < 1.5(k)Smh (SUS,Membrane) Case 1

2) Qb < 3(Smh) (SUS,Bending) Case 1

3) Pl+Pb+Q < 3(Smavg) (OPE,Inside) Case 2

4) Pl+Pb+Q < 3(Smavg) (OPE,Outside) Case 2

5) Pl+Pb+Q+F < Sa (EXP,Inside) Case 2

6) Pl+Pb+Q+F < Sa (EXP,Outside) Case 2

7) Pl+Pb+Q+F < Sa (SIF,Outside) Case 3

8) Pl+Pb+Q+F < Sa (SIF,Outside) Case 4

9) Pl+Pb+Q+F < Sa (SIF,Outside) Case 5

10) Pl+Pb+Q+F < Sa (SIF,Outside) Case 6

11) Pl+Pb+Q+F < Sa (SIF,Outside) Case 7

Table of Contents

ASME Overstressed Areas

*** NO OVERSTRESSED NODES IN THIS MODEL ***

Table of Contents

Highest Primary Stress Ratios

Pad/Header at Junction

Pl	1.5(k)Smh	
18,066 psi	24,300 psi	Primary Membrane Load Case 1 Plot Reference: 1) Pl < 1.5(k)Smh (SUS,Membrane) Case 1

74%

Branch at Junction

Pl	1.5(k)Smh	
13,619 psi	24,300 psi	Primary Membrane Load Case 1 Plot Reference: 1) Pl < 1.5(k)Smh (SUS,Membrane) Case 1

56%

Branch Transition

Qb	3(Smh)	Primary Bending Load Case 1
23,031 psi	48,600 psi	Plot Reference: 2) Qb < 3(Smh) (SUS,Bending) Case 1

47%

Pad Outer Edge Weld

Pl	1.5(k)Smh	Primary Membrane Load Case 1
13,501 psi	24,300 psi	Plot Reference: 1) Pl < 1.5(k)Smh (SUS,Membrane) Case 1

55%

Header Outside Pad Area

Pl	1.5(k)Smh	Primary Membrane Load Case 1
11,152 psi	24,300 psi	Plot Reference: 1) Pl < 1.5(k)Smh (SUS,Membrane) Case 1

45%

Table of Contents

Highest Secondary Stress Ratios

Pad/Header at Junction

Pl+Pb+Q	3(Smavg)	Primary+Secondary (Inner) Load Case 2
28,578 psi	54,300 psi	Plot Reference: 3) Pl+Pb+Q < 3(Smavg) (OPE,Inside) Case 2

52%

Branch at Junction

Pl+Pb+Q	3(Smavg)	Primary+Secondary (Inner) Load Case 2
27,219 psi	54,300 psi	Plot Reference: 3) Pl+Pb+Q < 3(Smavg) (OPE,Inside) Case 2

50%

Branch Transition

Pl+Pb+Q	3(Smavg)	Primary+Secondary (Inner) Load Case 2
26,843 psi	54,300 psi	Plot Reference: 3) Pl+Pb+Q < 3(Smavg) (OPE,Inside) Case 2

49%

Pad Outer Edge Weld

Pl+Pb+Q	3(Smavg)	Primary+Secondary (Outer) Load Case 2
39,680	54,300	Plot Reference:
psi	psi	4) Pl+Pb+Q < 3(Smavg) (OPE,Outside) Case 2

73%

Header Outside Pad Area

Pl+Pb+Q	3(Smavg)	Primary+Secondary (Outer) Load Case 2
16,716	54,300	Plot Reference:
psi	psi	4) Pl+Pb+Q < 3(Smavg) (OPE,Outside) Case 2

30%

Table of Contents

Highest Fatigue Stress Ratios

Pad/Header at Junction

Pl+Pb+Q+F	Sa	Primary+Secondary+Peak (Inner) Load Case 2
19,290	69,917	Stress Concentration Factor = 1.350
psi	psi	Strain Concentration Factor = 1.000
		Cycles Allowed for this Stress = 4086064.7
27%		"B31" Fatigue Stress Allowable = 45250.0
		Markl Fatigue Stress Allowable = 47828.5
		WRC 474 Mean Cycles to Failure = 253320.
		WRC 474 99% Probability Cycles = 58850.
		WRC 474 95% Probability Cycles = 81706.
		BS5500 Allowed Cycles(Curve F) = 67275.
		Membrane-to-Bending Ratio = 1.541
		Bending-to-PL+PB+Q Ratio = 0.393
		Plot Reference:
		5) Pl+Pb+Q+F < Sa (EXP,Inside) Case 2

Branch at Junction

Pl+Pb+Q+F	Sa	Primary+Secondary+Peak (Inner) Load Case 2
18,373	69,917	Stress Concentration Factor = 1.350
psi	psi	Strain Concentration Factor = 1.000
		Cycles Allowed for this Stress = 5045018.0
26%		"B31" Fatigue Stress Allowable = 45250.0
		Markl Fatigue Stress Allowable = 47828.5
		WRC 474 Mean Cycles to Failure = 560166.
		WRC 474 99% Probability Cycles = 130134.
		WRC 474 95% Probability Cycles = 180677.
		BS5500 Allowed Cycles(Curve F) = 117547.
		Membrane-to-Bending Ratio = 0.625
		Bending-to-PL+PB+Q Ratio = 0.615
		Plot Reference:
		5) Pl+Pb+Q+F < Sa (EXP,Inside) Case 2

Branch Transition

Pl+Pb+Q+F	Sa	
13,421 psi	69,917 psi	Primary+Secondary+Peak (Inner) Load Case 2
		Stress Concentration Factor = 1.000
		Strain Concentration Factor = 1.000
		Cycles Allowed for this Stress = 99999997952.
19%		"B31" Fatigue Stress Allowable = 45250.0
		Markl Fatigue Stress Allowable = 47828.5
		WRC 474 Mean Cycles to Failure = 614931.
		WRC 474 99% Probability Cycles = 142857.
		WRC 474 95% Probability Cycles = 198342.
		BS5500 Allowed Cycles(Curve F) = 122559.
		Membrane-to-Bending Ratio = 0.200
		Bending-to-PL+PB+Q Ratio = 0.833
		Plot Reference:
		5) Pl+Pb+Q+F < Sa (EXP,Inside) Case 2

Pad Outer Edge Weld

Pl+Pb+Q+F	Sa	
26,784 psi	69,917 psi	Primary+Secondary+Peak (Outer) Load Case 2
		Stress Concentration Factor = 1.350
		Strain Concentration Factor = 1.000
		Cycles Allowed for this Stress = 1182959.6
38%		"B31" Fatigue Stress Allowable = 45250.0
		Markl Fatigue Stress Allowable = 47828.5
		WRC 474 Mean Cycles to Failure = 160654.
		WRC 474 99% Probability Cycles = 37322.
		WRC 474 95% Probability Cycles = 51818.
		BS5500 Allowed Cycles(Curve F) = 37941.
		Membrane-to-Bending Ratio = 0.404
		Bending-to-PL+PB+Q Ratio = 0.712
		Plot Reference:
		6) Pl+Pb+Q+F < Sa (EXP,Outside) Case 2

Header Outside Pad Area

Pl+Pb+Q+F	Sa	
8,358 psi	69,917 psi	Primary+Secondary+Peak (Outer) Load Case 2
		Stress Concentration Factor = 1.000
		Strain Concentration Factor = 1.000
		Cycles Allowed for this Stress = 99999997952.
11%		"B31" Fatigue Stress Allowable = 45250.0
		Markl Fatigue Stress Allowable = 47828.5
		WRC 474 Mean Cycles to Failure = 2175395.
		WRC 474 99% Probability Cycles = 505374.
		WRC 474 95% Probability Cycles = 701658.
		BS5500 Allowed Cycles(Curve F) = 507467.
		Membrane-to-Bending Ratio = 1.873
		Bending-to-PL+PB+Q Ratio = 0.348
		Plot Reference:
		6) Pl+Pb+Q+F < Sa (EXP,Outside) Case 2

Table of Contents

Stress Intensification Factors

Branch/Nozzle Sif Summary

	Peak	Primary	Secondary
Axial :	6.749	3.911	9.999
Inplane :	2.800	1.830	4.148
Outplane:	7.112	3.305	10.536
Torsion :	2.862	3.483	4.240
Pressure:	2.207	1.823	3.270

The above stress intensification factors are to be used in a beam-type analysis of the piping system. Inplane, Outplane and Torsional sif's should be used with the matching branch pipe whose diameter and thickness is given below. The axial sif should be used to intensify the axial stress in the branch pipe calculated by F/A. The pressure sif should be used to intensify the nominal pressure stress in the PARENT or HEADER, calculated from PD/2T.

Pipe OD :	24.000	in.
Pipe Thk:	0.688	in.
Z approx:	293.655	cu.in.
Z exact :	285.485	cu.in.

B31.3		
Peak Stress Sif	0.000	Axial
	3.099	Inplane
	3.827	Outplane
	1.000	Torsional
B31.1		
Peak Stress Sif	0.000	Axial
	3.827	Inplane
	3.827	Outplane
	3.827	Torsional
WRC 330		
Peak Stress Sif	0.000	Axial
	4.172	Inplane
	3.827	Outplane
	4.172	Torsional

Table of Contents

Allowable Loads

SECONDARY Load Type (Range):		Maximum Individual Occuring	Conservative Simultaneous Occuring	Realistic Simultaneous Occuring
Axial Force	(lb.)	273628.	61847.	92770.
Inplane Moment	(in. lb.)	3737234.	592871.	1257669.
Outplane Moment	(in. lb.)	1471320.	235151.	498831.
Torsional Moment	(in. lb.)	3655739.	733385.	1100078.
Pressure	(psi)	593.02	353.90	353.90

PRIMARY Load Type:		Maximum Individual Occuring	Conservative Simultaneous Occuring	Realistic Simultaneous Occuring
Axial Force	(lb.)	313085.	45871.	68807.
Inplane Moment	(in. lb.)	3791574.	278194.	590138.
Outplane Moment	(in. lb.)	2099122.	217470.	461324.

Torsional Moment	(in. lb.)	1991751.	294726.	442089.
Pressure	(psi)	476.02	353.90	353.90

NOTES:

1) Maximum Individual Occuring Loads are the maximum allowed values of the respective loads if all other load components are zero, i.e. the listed axial force may be applied if the inplane, outplane and torsional moments, and the pressure are zero.

2) The Conservative Allowable Simultaneous loads are the maximum loads that can be applied simultaneously. A conservative stress combination equation is used that typically produces stresses within 50-70% of the allowable stress.

3) The Realistic Allowable Simultaneous loads are the maximum loads that can be applied simultaneously. A more realistic stress combination equation is used based on experience at Paulin Research. Stresses are typically produced within 80-105% of the allowable.

4) Secondary allowable loads are limits for expansion and operating piping loads.

5) Primary allowable loads are limits for weight, primary and sustained type piping loads.

Table of Contents

Flexibilities

The following stiffnesses should be used in a piping, "beam-type" analysis of the intersection. The stiff-nesses should be inserted at the surface of the branch/header or nozzle/vessel junction. The general characteristics used for the branch pipe should be:

Outside Diameter = 24.000 in.
Wall Thickness = 0.688 in.

Axial Translational Stiffness	=	7037671.	lb./in.
Inplane Rotational Stiffness	=	25848404.	in.lb./deg
Outplane Rotational Stiffness	=	7578548.	in.lb./deg
Torsional Rotational Stiffness	=	102405560.	in.lb./deg

Table of Contents