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Engineering Sciences and Applications**

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Prepared by: A. Puckett
1997 July 15

FEA Stress Analysis for SAFKEG 2863B

June 1997

FEA Stress Analysis of Containment Vessels in SAFKEG 2863B

for Conformance to the Requirements of

NRC Regulatory Guide 7.6,

NRC Regulatory Guide 7.8,

and Appropriate Parts of the

ASME Boiler and Pressure Vessel Code

Prepared by: Anthony Puckett

Reviewed by: Jeff Hill

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1. Scope

The scope of this report is the evaluation of the structural design of the two stainless steel containment vessels in CROFT SAFKEG Model Number 2863B, for conformance to the design criteria of the NRC Regulatory Guide 7.6¹, NRC Regulatory Guide 7.8², and the applicable requirements of the ASME Boiler and Pressure Vessel Code, Section III³ and Section VIII⁴.

The two containment vessels are designated Cans 2870 and 2871 (Figures 1 & 2).

Each of these containment vessels was analyzed for the loadings specified in chapter 2, Section 2.1.2 of the SARP⁵. Structural assessment of Cans 2870 & 2871 due to loading considerations beyond the evaluation of pressure and temperature are presented in paragraph 9.

This report is organized as follows:

- Overview of the design of each containment vessel and pressure boundary.
- Brief description of both containment vessels.
- Discussion of normal and accident conditions.
- Analysis assumptions.
- Detailed structural evaluation of each component of each containment vessel.
- Demonstration of compliance to Regulatory Guide 7.6 stress evaluations.
- Demonstration of compliance to Regulatory Guide 7.8 loading combinations.
- Summary of the calculated stresses, comparison with design allowables, estimates of margins of safety and a summary of results and conclusions.

2. Design of the Containment Vessels and Boundaries

2.1 Containment Vessel Cans 2870 and 2871

The primary containment boundary for the SAFKEG is the Inner Containment Vessel (Can 2871). Can 2871 is placed inside of the Outer Containment Vessel (Can 2870), which provides a secondary containment boundary. Each containment vessel consists of a shell made from schedule 40S pipe components, an elliptical head on the lower end, a threaded closure flange, a lid, and a threaded retaining ring. Each retaining ring, when torqued against its respective lid, causes the lid to compress double O-rings between itself and the closure flange. The retaining ring is capable of resisting the combined O-ring compression and internal pressure forces to create a seal against pressure leakage. The lid of each containment vessel has a test port accessing the annulus between the double O-rings to allow testing for leakage past either O-ring. Each test port is sealed by a plug and O-ring when not being used for testing.

2.2 Construction Common to Both Containment Vessels

The SAFKEG 2863B package is uniquely defined by the drawings referenced in drawing list DL-OC-4318 Issue E.

Dimensions, part numbers and materials of construction of the containment

vessels are obtained from Croft drawings, 0C-4323 Issue E and 0C-4325 Issue E for Containment Vessel Cans 2870 and 2871, respectively.

2.3 Materials

All materials are 304L stainless steel except as noted below.

Each containment vessel has two EPDM O-rings, two affecting the primary seals between the lid and the closure flange and one Viton O-ring affecting the seal between the test plug and the lid.

The retaining rings are ASTM A 479 (UNS 21800), a 300 series stainless steel with reduced tendency to gall (compared to 304 SS) when used with 304L stainless steel.

The materials properties utilized in these calculations for the stainless steel components were obtained from the ASME B&PV Code Section II ⁶ and are specified in Tables 1A & 1B.

2.4 Piping Components

All materials of construction used below the closure flange are schedule 40S standard piping products conforming to ANSI B16.9. The piping products used are pipe, weld caps with the major axis equal to twice the minor axis, and a concentric reducer.

2.5 Closure Flanges

The closure flanges are machined from bar stock. The flanges have a cylindrical projection on both the upper and lower sides. The upper projection receives the mating internal threads to accommodate the screwed retaining ring while the lower projection is prepared for welding. A radius is provided where the projections join the flange to reduce stress concentrations at the change in cross-section. O-ring grooves are machined into the flange to position the rings and to provide a fixed amount of O-ring compression.

2.6 Lids

The plate lids are used to compress the O-rings and provide an access channel to permit leak testing of the annulus between the rings.

2.7 Threaded Retaining Rings and Closure Flange Threads

The retaining rings are made from bar stock and are threaded to British Standard 3643, Part 1, 1981, external thread⁷. This is a single start parallel screw thread with a pitch of 4 mm, and a thread angle of 60 degrees. The closure flange has mating internal threads to the same standard.

2.8 O-rings

The 0.118" (3 mm) cross-section diameter primary seal rings are compressed approximately 0.030 inches (0.75 mm) to nominally 0.088" (2.25 mm) giving a seal compression of 25%. The O-rings are EPDM with a shore hardness of Durometer 60 (Parker Handbook⁸, page A3-10 at 50°F). Based on this value of hardness, the force required for this compression is conservatively taken as 30

lb/inch of ring (Parker Handbook, pages A4-9 & A4-10). The specified compression of the O-rings is obtained by the depth of the ring groove with metal-to-metal contact between the lid and the flange.

2.9 Welds

All weld joints are ASME Code Category A or B, are full penetration butt welds, are visually and dye penetrant inspected and fully radiographed.

3. Construction Details of Containment Vessel Cans 2870 & 2871

3.1 Details of the Inner Containment Vessel - Can 2871

(See Drawing 0C-4325, Issue E)

Overall dimensions of this containment vessel are approximately 180 mm ϕ x 432 mm (7-1/8" x 17"). The bottom of this containment vessel, item #13, is a nominal 5" diameter elliptical pipe cap. The lower end of item #12, a nominal 5" diameter pipe shell, is welded to the cap and the upper end of the pipe is welded to the lower projection of the closure flange, item #10. The closure flange has an inside diameter of 127.7 mm (5.028") to match the normal inside diameter of the 5" pipe. The sealing surface of the closure flange has two O-ring grooves, one for a 134 mm ϕ (5.275") O-ring, item #6, and one for a 148 mm ϕ (5.826") O-ring, item #7. Item #2, a 162 mm ϕ (6.377") lid bears against the O-rings and the sealing surface of the closure flange. The lid is provided with a sealable leak test port accessing the annulus between the two O-rings to permit checking for leakage past either O-ring. A threaded test port plug, item #1, is fitted with a 3.6 mm ϕ (0.1417") O-ring, item #8, and is used to seal the test port opening. A threaded 172 mm ϕ (6.771") screw retaining ring, item #3, is used to compress the O-rings. The screw retaining ring is fitted into the threads in the upper projection of the closure flange forcing the lid to move towards the sealing surface of the closure flange to compress the O-rings and seal the opening.

3.2 Details of the Outer Containment Vessel - Can 2870

(See Drawing 0C-4323, Issue E)

Overall dimensions of this containment vessel are approximately 258 mm ϕ x 475 mm (10-1/8" x 18-3/4"). The bottom of this containment vessel, item #13, is a nominal 6" diameter elliptical pipe cap. The lower end of item #12, a nominal 6" diameter pipe shell, is welded to the cap and the upper end of the pipe is welded to the lower (and smaller) end of a 8X6" concentric reducer, item #11. The 8" end of the reducer is welded to the lower projection of the closure flange, item #10. The closure flange has a maximum outside diameter of 258 mm ϕ (10.157") and an inside diameter of 202 mm ϕ (7.953") to match the nominal inside diameter of an 8" pipe. The sealing surface of the closure flange has two O-ring grooves, one for a 209 mm ϕ (8.228") O-ring, item #6, and one for a 223 mm ϕ (8.779") O-ring, item #7. Item #2, a 235 mm ϕ (9.252") lid bears against the O-rings and the sealing surface of the closure flange. The lid is provided

with a sealable leak test port accessing the annulus between the two O-rings to permit checking for leakage past either O-ring. A threaded test port plug, item #1, is fitted with a 3.6 mm ϕ (0.1417") O-ring, item #8, and used to seal the test port opening. A threaded, 244 mm ϕ (9.606") screw retaining ring, item #3, is used to compress the O-rings. The screw retaining ring is fitted into the threads in the upper projection of the closure flange forcing the lid to move towards the sealing surface of the closure flange to compress the O-rings and the seal opening.

4. Design Requirements

For the temperature and internal pressure conditions, the values associated with the design conditions (as defined in the SARP, Ref. 5) were selected as:

Design Parameter	Bounding Design Parameter Value
Temperature (Minimum /Maximum)	-40°F / +450°F (-40°C / +232°C)
Pressure (Max. internal / Min. external)	120 psia / 0 psia (8 bar abs / 0 bar abs)
Pressure (Min. internal / Max. external)	0 psia / 30 psia (0 bar abs / 2 bar abs)

For each containment vessel, the FEA was used to evaluate the first loading case (maximum internal pressure) and the hand calculations in sections 6.2 & 7.2 were used to evaluate the minimum internal pressure case (i.e., buckling condition).

Material properties are taken from the ASME Code and presented in Tables 1 & 2.

The Containment Vessel Allowable Stresses are determined from the ASME code material properties in accordance with the requirements of Regulatory Guide 7.6. These are summarized in Table 2 for both Normal conditions of Transport and Hypothetical Accident Conditions.

The material shipped in the SAFKEG may be solid, pellet or powder packed in metal cans. Regardless of the form, the materials are placed inside the Inner Containment Vessel (Can 2871) at room temperature. The lid and retaining ring are positioned and the retaining ring is torqued to the specified value. Can 2871 is placed inside of the Outer Containment Vessel (Can 2870) at room temperature and the Can 2870 is sealed in a manner similar to Can 2871 and placed in the 2863 SAFKEG cavity. The SAFKEG is then closed and sealed and the package is ready for transport. The containment vessel cans are not pressurized except for changes in pressure due to temperature fluctuations after sealing and, for Can 2871, by gas generated from the contents. These temperature changes may be caused by heat generated by the contents or from external conditions during shipment.

5. General Analysis Assumptions, Methods and Input

The structural evaluations of the two containment vessels are based on the design criteria defined in NRC Regulatory Guide 7.6¹. These design criteria define those portions of Section III of the ASME Code³ which are applicable to the design of the containment vessels. These design criteria require the

evaluation of the containment boundaries against the following design criteria:

Normal Conditions of Transport

- S1 = Primary membrane
- S2 = Primary membrane & primary bending
- S3 = Primary membrane & primary bending & secondary (including peak)
- S4 = S3 / 2 (adjusted for temperature effects)
- S5 = Buckling

Hypothetical Accident Conditions

- S1 = Primary membrane
- S2 = Primary membrane & primary bending
- S5 = Buckling
- S6 = Extreme total stress intensity range

With the exception of the Thread Shear Stresses and the Buckling Analysis, the calculation of the above stresses were performed utilizing the finite element model.

For stresses S1 and S2, the results presented in the COSMOS output file were used directly.

S3 was computed from the COSMOS output as follows:

First, the total stresses in each x,y,z direction (and τ_{x12}) were computed as the algebraic sum of: "membrane + bending" + "peak"

The principal stresses SIGMA-1, SIGMA-2, and SIGMA-3 in Appendix A3 are:

$$\text{SIGMA} - 1 = \left[\frac{(\text{SIGMA_X1} + \text{SIGMA_X2})}{2} \right] + \sqrt{\left[\frac{(\text{SIGMA_X1} - \text{SIGMA_X2})}{2} \right]^2 + [\text{TAU_X12}]^2}$$

$$\text{SIGMA} - 2 = \left[\frac{(\text{SIGMA_X1} + \text{SIGMA_X2})}{2} \right] - \sqrt{\left[\frac{(\text{SIGMA_X1} - \text{SIGMA_X2})}{2} \right]^2 + [\text{TAU_X12}]^2}$$

$$\text{SIGMA} - 3 = \text{SIGMA_X3}$$

The total stress intensity is:

$$S3 = \text{Max}(\text{SIGMA-1}, \text{SIGMA-2}, \text{SIGMA-3}) - \text{Min}(\text{SIGMA-1}, \text{SIGMA-2}, \text{SIGMA-3}).$$

S4 is computed as S3 / 2. S4 is also adjusted for temperature effects, see paragraphs 6.1.4 & 7.1.4.

S6 is computed as S3 plus fabrication stresses. There are no fabrication stresses (see Regulatory Guide 7.6, B.9) for these vessels.

The buckling analysis associated with external pressurization, S5, was

performed by hand calculations utilizing the methods found in Ref. 3.

In addition to those design criteria specifically defined by Regulatory Guide 7.6, evaluation was also performed of shear stresses in the vessel and screw retaining ring threads.

5.1 Analysis Assumptions

The only loading condition analyzed was that with the pressure and temperatures associated with the design conditions (i.e. 120 psig @ 450 °F) which envelope the Normal Conditions of Transport and Hypothetical Accident Conditions. The normal conditions of transport temperature would be lower because there is no thermal test and therefore the pressure resulting from heating would also be lower.

When stresses were determined for internal pressure conditions, the external pressure was assumed to be 0 psia. When evaluating component adequacy for external pressure, the internal pressure was assumed to be 0 psia. All components were evaluated for both internal and external pressure.

5.2 Methods of Analysis

The analysis of the two containment vessels was performed using finite element structural analysis methods, supplemented with some hand calculations. The finite element models were developed and solved with the COSMOS finite element analysis software⁹.

The conditions associated with external pressurization were evaluated for structural buckling by and calculations utilizing the method defined by the ASME Code, Ref. 3 and 4.

5.3 Containment Vessel Can FEA Model Description

The COSMOS session files which were used to generate the finite element model and loadings, produce the solution, and generate the output are listed in Appendices A1 & B1 for Cans 2871 & 2870, respectively. The geometric parameters used in these input files represent the nominal values for the dimensions defined by the design drawings. The outer radius of the retaining ring and the inner radius of the thread were modeled with the nominal major radius of the thread, thus allowing for an accurate representation of the vessel wall thickness at the transition between the vessel threads and the sealing surface. The finite element mesh is shown in Figures 4 A & 4B for the vessels.

The vessel structures were modeled utilizing triangular, two-dimensional, axi-symmetric, 6-node elements with a series of gap elements to represent the contact interfaces between the lid, the retaining ring and the vessel itself. The nodes representing the threaded interface were offset vertically such that the 60 degree angle of the thread contact properly represented the radial component of force exerted by the vertical restraining force of the thread interface. The calculations assumed elastic behavior of the vessel materials with the material properties evaluated at a temperature that which bounds both the normal conditions of transport and hypothetical accident conditions.

At the locations of the O-ring grooves, forces were applied to the lid and the vessel flange to represent the reaction forces of the O-rings as they are fully compressed by the lid. No gap elements were modeled from the inner radius of the inner O-ring groove to the outer radius of the outer O-ring groove to accurately represent the bearing surface area which might come into contact with the lid. The finite element models of the two vessels analyzed are shown in Figures 4A and 4B.

The lid interface with the vessel flange was assumed to have no significant preload since the retaining ring is to be tightened just enough to fully compress the O-rings. Thus, the gap elements were all defined with no initial gap.

5.4 Applied Boundary Conditions

For the temperature and internal pressure conditions, the values associated with the boundary conditions (as defined in the SARP Ref. 5) are:

Design Parameter	Design Condition
Maximum Temperature	+450°F (+232°C)
Pressure (Max. internal / Min. external)	120 psia / 0 psia (8 bar abs / 0 bar abs)
Pressure (Min. internal / Max. external)	0 psia / 30 psia (0 bar abs / 2 bar abs)

For each containment vessel, the FEA was used to evaluate the first loading case (maximum internal pressure) and the hand calculations in sections 6.2 & 7.2 were used to evaluate the minimum internal pressure case.

Material properties from the ASME Code and presented in Tables 1 & 2.

The specific boundary conditions applied to the model for the normal and accident conditions are as follows:

5.4.1 Displacements

Various nodes within the axi-symmetric models of the containment vessels were constrained to prevent free-body motion:

- nodes at the centerline of the vessel and the lid were constrained from moving radially (global X-direction);
- one node on the outer wall of the pipe section was constrained from moving vertically (global Y-direction).

5.4.2 Forces

Forces were applied to the nodes of the vessel flange and the lid where the O-rings would contact as they are compressed at assembly. The forces applied were calculated based on the nominal centerline of the O-rings and a compression load of 30 pounds per inch of perimeter. The total force was determined as described in paragraph 2.9. Because the model is axisymmetric, the force used in the model is pounds per radian, i.e., $30\pi d/(2\pi)$.

5.4.3 Pressures

A pressure loading of 120 psig was applied to the bottom surface of the lid and to

the inside surface of the vessel as shown in Figure 4. The pressure acting on the lid and containment vessel is applied out to the inner radius of the outer O-ring groove. The effective external pressure for the calculations is 0 psia.

5.4.4 Temperatures

A uniform temperature of 450 °F was considered in the analysis in the value of the modulus of elasticity and the allowable stresses for the materials of construction. Since the coefficient for thermal expansion (CTE) is identical for both of the stainless steel materials, no thermal stresses would be calculated, thus no values for CTE were input into the model.

5.4.5 Initial Gap Values

All the gap values were defined as being initially at a zero value with no gap or preload defined. This is reflective of the installation process that requires that the lid be initially installed without the O-rings to identify the position of the retaining ring that will just result in metal-to-metal contact between the lid and the vessel at the sealing surface. With this ring position so marked, the O-rings will be installed, and the closure sealed without the application of significant excess preload.

5.5 FE Model Stress Results Output

Section III of the ASME code (Ref. 3) requires the evaluation of various stress categories produced by primary and secondary loadings against various acceptance criteria. Although several of the stress categories are defined at a point within the structure, the primary membrane and bending stress components are defined with respect to the variation of the stress through the structure at a section under consideration. To calculate the primary membrane and bending stress categories, stresses were evaluated between the nodes corresponding to the locations shown on Figure 7.

The detailed results of the stress calculations at each section under evaluation are presented in Appendices A2 (Can 2871) and B2 (Can 2870), with stress intensity summaries given in the Appendices A3 and B3. For Normal Conditions of Transport stress summary Tables 3A and 3B identify which of these locations produced the maximum stress magnitude for each specific stress category evaluated. For the Hypothetical Accident Conditions stress summary Tables 4A and 4B identify which of these locations produced the maximum stress magnitude for each specific stress category evaluated.

5.6 Code Validation

Acceptable operation of the COSMOS code was established by a combination of:

- running benchmark example problems;
- comparison of results of COSMOS with results from ANSYS; and
- comparisons of the COSMOS output with hand calculations for hoop and axial stresses.

These were conducted under the LANL Packaging Engineering Quality Plan.

6. Structural Evaluation of Inner Containment Vessel Can 2871

(See Drawing OC-4325, Issue E)

6.1 FEA Internal Pressure Stress Calculations

The finite element calculations performed on the model of Can 2871 were performed according to the methods discussed above. Figures 5A & 6A show the distribution of the calculated stress intensities throughout the inner can structure. The detailed stress criteria are discussed in the following sections.

6.1.1 Primary Membrane Stress Evaluation

The membrane stress is component of stress which is uniformly distributed and equal to the average value of stress across the thickness of the section under consideration. Regulatory Guide 7.6 1 requires that the value of the stress intensity resulting from the primary membrane stress at normal conditions be less than the design stress intensity, S_m , evaluated at the appropriate temperatures and loading associated with the normal service conditions. It is also required that under accident conditions, the value of the primary membrane stress intensities should be less than the lesser value of 2.4 times S_m and 0.7 times S_u (ultimate strength).

The output stresses for each of the stress evaluation locations shown in Figure 7 are listed in Appendices A2 and A3. The maximum calculated membrane stresses in the lid, ring and vessel model are listed in Tables 3A and 4A.

6.1.2 Primary Membrane Plus Bending Stress Evaluation

The bending stress is the component of stress that varies linearly across the thickness of the section under consideration. Regulatory Guide 7.6 1 requires that the value of the stress intensity resulting from the sum of the primary membrane plus the primary bending stresses at normal conditions be less than 1.5 times the design stress intensity, S_m , evaluated at the appropriate temperatures and loading. It is also required that under accident conditions, the sum of the primary membrane and primary bending stress intensities be less than the lesser value of 3.6 times S_m and S_u (ultimate strength).

The output stresses for each of the stress evaluation locations shown in Figure 7 are listed in Appendices A2 & A3. The maximum calculated membrane plus bending stress in the lid, ring and vessel model are listed in Tables 3A and 4A.

6.1.3 Primary Plus Secondary Stress Evaluation

The Primary Plus Secondary Stress Intensity is derived from the highest value at any point across the thickness of a section of the general or local primary membrane stresses, plus primary bending, plus secondary stresses, produced by the specified pressure and other specified mechanical loads and by general thermal effects associated with normal service conditions. Regulatory Guide 7.6 1 requires that under normal conditions, the allowable value of the maximum range of this stress intensity is three times the design stress intensity, S_m , evaluated at the appropriate temperatures at loading.

The total stress calculated from the COSMOS output files include, the effects of stress concentrations which is not required for Primary Plus Secondary stress evaluations. Thus, the use of the total stress results from COSMOS is conservative in this respect. The total stress results from the model are representative of the stress range considering the zero stress state prior to assembly of the closure.

The output stresses for each of the stress evaluation locations shown in Figure 7 are listed in Appendices A2 and A3. The maximum calculated Primary plus Secondary (i.e. Total) stresses in the lid, ring and vessel model are listed in Table 3A.

6.1.4 Fatigue Stress Evaluation

The evaluation of a structure's integrity under cyclic fatigue loading requires the determination of the range of stresses over which the component is to be cycled during normal operation. This alternating stress intensity, S_{alt} , includes consideration of the total of all primary and secondary stresses, including local stress concentrations. Finite element modeling includes the local stress concentrations in the output results because of the explicit definition of the structure's geometry. Therefore, the Total Stress category listing in Appendix A3 meets the definition of S_{alt} .

S_{alt} is defined by Regulatory Guide 7.6¹ as one-half of the maximum absolute value of the change in total stress intensity at a location in the structure.

The normal operation of these cans is assumed to start at a zero stress state prior to assembly of the closure and then proceed to the operating stress state analyzed by the FEA model. As a result, the value for the stress range, S_{alt} , for this fatigue evaluation is one-half of the total stress intensity calculated for normal conditions of transport.

In order to compare S_{alt} to the allowable S_a , Regulatory Guide 7.6¹ requires that the stress range, S_{alt} , be adjusted by the ratio of the modulus of elasticity given on the design fatigue curve to the modulus of elasticity used in the analysis:

$$S_4 = S_{alt} * (28.3 \text{ ksi} / 26.2 \text{ ksi}).$$

Regulatory Guide 7.6¹ requires that the allowable stress, S_a , shall be determined from the design fatigue curves in Appendix I of Section III of the ASME Boiler and Pressure Vessel Code (Ref. 3).

To verify acceptability of the calculated stress range, a design value for the stress range, $S_a = 28.2 \text{ ksi}$, for one-million cycles was obtained from Table I-9.2.2 (Ref. 1).

The output stresses for each stress evaluation location shown in Figure 7 are listed in Appendix A3. The maximum calculated fatigue stress ranges in the lid, ring and vessel are summarized in Table 3A.

6.1.5 Extreme Total Stress Intensity Range

Regulatory Guide 7.6 requires that the Extreme Total Stress Intensity Range between the initial state, fabrication state, normal operating conditions, and accident conditions shall be less than twice the adjusted value (adjusted to account for the modulus of elasticity at 450°F) of S_a at 10 cycles given by the appropriate design fatigue curve. A design value for the stress range, $S_a = 700$ ksi, for 10 cycles was obtained from Figure I-9.2.1 (Ref. 3). This was adjusted by the ratio of the modulus of elasticity given on the design fatigue curve to the modulus of elasticity used in the analysis:

$$2 S_a (@ 10 \text{ cycles}) = 2 * 700 \text{ ksi} * (26.2 \text{ ksi} / 28.3 \text{ ksi}) = 1300 \text{ ksi}.$$

The results presented in Table 4A show that this requirement is satisfied since:

- there are no fabrication stresses associated with this equipment; and
- the bounding conditions used for the operating range include the accident conditions.

The output stresses for each stress evaluation location shown in Figure 7 are listed in Appendix A3. The maximum calculated Extreme Total Stress Intensity Ranges in the lid, ring and vessel are summarized in Table 4A.

6.2 External Pressure Buckling Calculations.

The shell is evaluated for buckling margin due to external pressure, utilizing methods discussed in several ASME Code sections (Ref. 3 and 4).

6.2.1 Upper Vessel Shell

The upper, threaded portion of the vessel is not subject to differential pressure because the same pressure will be exerted on both the inside and outside of the part. The ring (thick section of the flange) is good for at least the same external pressure as the thinner shell below it (by inspection) and no analysis was performed. The cylindrical shell (Figure 7, Locations 7, 8, 9) is evaluated for external pressure using the procedure given in Ref. 3, paragraph NB-3133.3, for shells subjected to external pressure. The wall thickness is based on the nominal thickness for the specific size of pipe. Key input values include:

- effective shell length, $L_{eff} = 14.84$ in
- shell outer diameter: $D_{os} = 5.563$ in
- shell wall thickness, $t_{shell} = .258$ in

$$L_{eff} / D_{os} = 14.84 \text{ in} / 5.563 \text{ in} = 2.67; \text{ and } D_{os} / t_{shell} = 5.563 \text{ in} / 0.258 \text{ in} = 21.6$$

From Ref. 6, Figure G page 674, $A_0 = 0.005$

Reading $B_0 = 7000$ from HA-3, Ref. 3, the maximum allowable external pressure is:

$$P_{all} = 4 B_0 / (3 D_{os} / t_{shell}) = 4 * 7000 / (3 * 21.6) = 433 \text{ psi}$$

6.2.2 Lower Elliptical Head

Evaluation procedures for elliptical heads (Figure 7, Location 6) subjected to external pressure are not given in Ref. 3. Therefore, the procedure given in Ref. 4 was used. Using Paragraph UG-33, (d), equation 1, page 33 of Ref. 4 the minimum thickness required for internal pressure is calculated as follows:

- shell outer diameter, $D_{oh} = 5.563$
- head wall thickness, $t_{head} = 0.258$ in
- Spherical radius factor, $K_o = 0.9$ (from Table UG-33.1 with a 2:1 head)

$$A_o = 0.125 / K_o / (D_{oh} / t_{head}) = 0.125 / 0.9 / (5.563 / 0.258) = 0.0064$$

Reading $B_o = 7500$ from Figure HA-3, Ref. 6, the allowable external pressure is then calculated by:

$$P_{all} = B_o / (K_o D_{oh} / t_{head}) = 7500 / (0.9 * 5.563 / 0.258) = 386 \text{ psi}$$

6.3 Shear Stress Calculations at Threaded Restraint

Calculation of the shear stress in the threads of the flange (Figure 7, Location 14) and the screw retaining ring (Figure 7, Location 12) is calculated at the pitch diameter. One thread is subtracted from the number of threads for starting and stopping of the threads.

$$D_m = (172 \text{ mm} - 2 (1.299 \text{ mm})) / 25.4 = 169.4 / 25.4 = 6.669 \text{ in}$$

$$\text{No. of threads} = t_{ring} / p - 1 = 0.4843 / 0.1575 - 1 = 2.07$$

Thread area in shear:

$$A_{shear} = \pi D_m (p/2) (\text{no of threads}) = \pi (6.669) (0.1575 / 2) (2.07) = 3.42 \text{ in}^2$$

The vertical shear force at the threaded interface, F_t , is the force due to pressurization + force from O-ring compression.

$$D_i = \text{Diameter of Inner O-ring} = 135.65 + 3.8 + 4.1 = 143.55 \text{ mm} = 5.652 \text{ in}$$

$$D_o = \text{Diameter of Outer O-ring} = 149.65 + 3.8 + 4.1 = 157.55 \text{ mm} = 6.203 \text{ in}$$

$$F_i = \text{Force of Inner O-ring} = 30 \text{ \#/linear inch} * \pi * 5.652 \text{ in} = 532 \text{ lb}$$

$$F_o = \text{Force of Outer O-ring} = 30 \text{ \#/linear inch} * \pi * 6.203 \text{ in} = 584 \text{ lb}$$

$$F_p = \text{Force from pressurization} = 120 \text{ psia} * \pi / 4 * 6.203^2 = 3624 \text{ lb}$$

$$F_t = F_i + F_o + F_p = 532 + 584 + 3624 = 4741$$

Shear stress on the threads is:

$$\tau = F_t / A_{shear} = 4741 \text{ lb} / 3.42 \text{ in}^2 = 1386 \text{ psi}$$

7. Structural Evaluation of Outer container Vessel Can 2870

(See Drawing OC-4323, Issue E)

7.1 FEA Internal Pressure Stress Calculations

The finite element calculations performed on the model of Can 2870 were performed according to the methods discussed above. Figures 5B & 6B show the distribution of the calculated stress intensities throughout the outer can structure. The detailed stress criteria are discussed in the following sections.

7.1.1 Primary Membrane Stress Evaluation

The membrane stress is the component stress which is uniformly distributed and equal to the average value of stress across the thickness of the section under consideration. Regulatory Guide 7.6 1 requires that the value of the stress intensity resulting from the primary membrane stress at normal conditions should be less than the design stress intensity, S_m , evaluated at the appropriate temperatures at loading associated with the normal service conditions. It is also required that under accident conditions, the value of the primary membrane stress intensities should be less than the less value of 2.4 times S_m and 0.7 times S_u (ultimate strength).

The output stresses for each of the stress evaluation locations shown in Figure 7 are listed in Appendices B2 and B3. The maximum calculated membrane plus bending stresses in the lid, ring and vessel model are listed in Tables 3B and 4B.

7.1.2 Primary Membrane Plus Bending Stress Evaluation

The bending stress is the component of stress that varies linearly across the thickness of the section under consideration. Regulatory Guide 7.6 1 requires that the value of the stress intensity resulting from the sum of the primary membrane plus the primary bending stresses at normal conditions should be less than 1.5 times the design stress intensity, S_m , evaluated at the appropriate temperatures at loading. It is also required that under accident conditions, the sum of the primary membrane and primary bending stress intensities should be less than the lesser value of 3.6 times S_m and S_u (ultimate strength).

The output stresses for each of the stress evaluation locations shown in Figure 7 are listed in Appendices B2 and B3. The maximum membrane plus bending stresses in the lid, ring and vessel model are listed in Tables 3B and 4B.

7.1.3 Primary Plus Secondary Stress Evaluation

The Primary Plus Secondary Stress Intensity is derived from the highest value at any point across the thickness of a section of the general or local primary membrane stresses, plus primary bending, plus secondary stress, produced by the specified pressure and other specified mechanical loads and by general thermal effects associated with normal service conditions. Regulatory Guide 7.6 1 requires that under normal conditions, the allowable value of the maximum range of this stress intensity is three times the design stress intensity, S_m , evaluated at the appropriate temperatures at loading.

The total stress calculated from the COSMOS output files include the effects of stress concentrations which would not be required for Primary Plus Secondary stress evaluations. Thus, the use of the total stress results from COSMOS is conservative in this respect. The total stress results from the model are representative of the stress range considering the zero stress state prior to assembly of the closure.

The output stresses for each of the stress evaluation locations shown in Figure 7 are listed in Appendices B2 and B3. The maximum calculated Primary plus Secondary (i.e. Total) stresses in the lid, ring and vessel model are listed in Table 3B.

7.1.4 Fatigue Stress Evaluation

The evaluation of a structure's integrity under cyclic fatigue loading requires the determination of the range of stresses over which the component is to be cycled during normal operation. This alternating stress intensity, S_{alt} , includes consideration of the total of all primary and secondary stresses, including local stress concentrations. Finite element modeling includes the local stress concentrations in the output results because of the explicit definition of the structure's geometry. Therefore, the total stress category listing in Appendix B3 meets the definition of S_{alt} .

S_{alt} is defined by Regulatory Guide 7.6¹ as one-half of the maximum absolute value of the change in total stress intensity at a location in the structure.

The normal operation of these cans is assumed to start at a zero stress state prior to assembly of the closure and then proceed to the operating stress state analyzed by the FEA model. As a result, the value for the stress range, S_{alt} , for this fatigue evaluation is one-half of the total stress intensity calculated for normal conditions of transport.

In order to compare S_{alt} to the allowable S_a , Regulatory Guide 7.6¹ requires that the stress range, S_{alt} , be adjusted by the ratio of the modulus of elasticity given on the design fatigue curve to the modulus of elasticity used in the analysis:

$$S_4 = S_{alt} * (28.2 \text{ ksi} / 26.2 \text{ ksi}).$$

Regulatory Guide 7.6¹ requires that the allowable stress, S_a , shall be determined from the design fatigue curves in Appendix I of Section III of the ASME Boiler and Pressure Vessel Code (Ref. 3).

To verify acceptability of the calculated stress range, a design value for the stress range, $S_a = 28.3 \text{ ksi}$, for one-million cycles was obtained from Table I-9.2.2 (Ref. 3).

The output stresses for each of the stress evaluation locations shown in Figure 7 are listed in Appendix B3. The maximum calculated fatigue stress ranges in the lid, ring and vessel model are listed in Table 3B.

7.1.5 Extreme Total Stress Intensity Range

Regulatory Guide 7.6 requires that the Extreme Total Stress Intensity Range between the initial state, fabrication state, normal operating conditions, and accident conditions shall be less than twice the adjusted value (adjusted to account for the modulus of elasticity at 450°F) of S_a at 10 cycles given by the appropriate design fatigue curve. A design value for the stress range, $S_a = 700$ ksi, for 10 cycles was obtained from Figure I-9.2.1 (Ref. 3). This was adjusted by the ratio of the modulus of elasticity given on the design fatigue curve to the modulus of elasticity used in the analysis:

$$2 S_a (@ 10 \text{ cycles}) = 2 * 700 \text{ ksi} * (26.2 \text{ ksi} / 28.3 \text{ ksi}) = 1300 \text{ ksi}.$$

The results presented in Table 4B show that this requirement is satisfied since:

- there are no fabrication stresses associated with this equipment; and
- the bounding conditions used for the operating range include the accident conditions.

The output stresses for each stress evaluation location shown in Figure 7 are listed in Appendix B3. The maximum calculated Extreme Total Stress Intensity Ranges in the lid, ring and vessel are summarized in Table 4B.

7.2 External Pressure Buckling Calculations

The shell is evaluated for buckling margin due to external pressure, utilizing methods discussed in several ASME Code sections (Ref. 3 and 4).

7.2.1 Upper Vessel Shell

The upper, threaded portion of the vessel is not subject to differential pressure because the same pressure will be exerted on both the inside and outside of the part. The ring (thick section of the flange) is good for at least the same external pressure as the thinner shell below it (by inspection) and no analysis is performed. The upper cylindrical shell (Figure 7, Location 9) is evaluated for external pressure using the procedure given in Ref. 3, paragraph NB-3133.3, for shells subjected to external pressure. For these calculations, the effective length of the upper cylinder will be estimated to include approximately $\frac{1}{3}$ of the reducer length and $\frac{1}{2}$ of the flange thickness. The wall thickness is based on the nominal thickness for the specific size of pipe. Key input values include:

- effective shell length, $L_{\text{eff}} = 5$ in
 - shell outer Diameter, $D_{\text{os}} = 8.625$ in
 - shell wall thickness, $t_{\text{shell}} = 0.322$ in
- $$L_{\text{eff}} / D_{\text{os}} = 5 \text{ in} / 8.625 \text{ in} = 0.58; \text{ and } D_{\text{os}} / t_{\text{shell}} = 8.625 \text{ in} / 0.322 \text{ in} = 26.8$$

From Ref. 6, Figure G, page 675: $A_0 = 0.02$

From Figure HA-3, Ref. 6, page 681, for 304L at 450F: $B_0 = 8,900$ psi

The maximum allowable external pressure is then calculated by:

$$P_{\text{all}} = 4 B_0 / (3 D_{\text{os}} / t_{\text{shell}}) = 4 * 8900 / (3 * 26.8) = 443 \text{ psi}$$

7.2.2 Vessel Cone Transition

To evaluate the conical transition between the large and small cylindrical shell sections (Figure 7, Locations 8,9), the calculations will utilize dimensions which will tend to minimize the allowable external pressure, i.e. the larger diameter and the smaller wall thickness. These assumptions are consistent with the methods for conical sections discussed in Ref. 4.

- effective shell length, $L_{\text{eff}} = 6$ in
- shell outer diameter, $D_{\text{os}} = 8.625$ in
- shell wall thickness, $t_{\text{shell}} = 0.28$ in

$$L_{\text{eff}} / D_{\text{os}} = 6 \text{ in} / 8.625 \text{ in} = 0.7; \text{ and}$$

$$D_{\text{os}} / t_{\text{shell}} = 8.625 \text{ in} / 0.28 \text{ in} = 30.8$$

From Ref. 6, Figure G, page 675: $A_0 = 0.013$

From Ref. 6, Figure HA-3, page 681, for 304L at 450 °F: $B_0 = 8500$ psi

The maximum allowable external pressure is then calculated by:

$$P_{\text{all}} = 4 B_0 / (3 D_{\text{os}} / t_{\text{shell}}) = 4 * 8500 / (3 * 30.8) = 368 \text{ psi}$$

7.2.3 Lower Vessel Shell

The lower cylindrical shell (Figure 7, Locations 7,8) is evaluated for external pressure with the effective length of the lower cylinder estimated to include approximately $1/3$ of the lower head height. Key input values include:

- effective shell length, $L_{\text{eff}} = 10.5$ in
- shell outer diameter, $D_{\text{os}} = 6.625$ in
- shell wall thickness, $t_{\text{shell}} = 0.280$ in

$$L_{\text{eff}} / D_{\text{os}} = 10.5 \text{ in} / 6.625 \text{ in} = 1.58; \text{ and}$$

$$D_{\text{os}} / t_{\text{shell}} = 6.625 \text{ in} / 0.28 \text{ in} = 23.7$$

From Ref. 6, Figure G, page 674: $A_0 = 0.008$

From Figure HA-3, Ref. 6, page 681, for 304L at 450 F: $B_0 = 7,700$ psi

The maximum allowable external pressure is then calculated by:

$$P_{\text{all}} = 4 B_0 / (3 D_{\text{os}} / t_{\text{shell}}) = 4 * 7700 / (3 * 23.7) = 434 \text{ psi}$$

7.2.4 Lower Elliptical Head

Evaluation procedures for elliptical heads (Figure 7, Location 6) subjected to external pressure are not given in Ref. 3. Therefore, the procedure given in Ref. 4 was used. Using Paragraph UG-33, (d), equation 1, page 33 of Ref. 4, the minimum thickness required for internal pressure is calculated as follows:

- shell outer diameter, $D_{\text{oh}} = 6.625$ in
- head wall thickness, $t_{\text{head}} = 0.28$ in (same as 6 in pipe)

- Spherical radius factor, $K_o = 0.9$ (from Table UG-33.1 with 2:1 head)

$$A_o = 0.125 / (K_o * (D_{oh} / t_{head})) = 0.125 / (0.9 * (6.625 / 0.245)) = 0.0059$$

Reading $B_o = 7500$ psi from Figure HA-3, Ref. 6, the allowable external pressure is:

$$P_{all} = B_o / K_o / (D_{oh} / t_{head}) = 7500 / (0.9 * (6.625 / 0.28)) = 352 \text{ psi}$$

7.3 Shear Stress Calculations at Threaded Restraint

Calculation of the shear stress in the threads of the flange (Figure 7, Location 14) and the screw retaining ring (Figure 7, Location 12) is calculated at the pitch diameter (Figure 7). One thread is subtracted from the number of threads for starting and stopping of the threads.

$$D_m = (244 \text{ mm} - 2 (1.299 \text{ mm}) / 25.4 = 241.4 / 25.4 = 9.50 \text{ in}$$

$$\text{No. of threads} = t_{ring} / p - 1 = 0.622 / 0.1575 - 1 = 2.975$$

Thread area in shear:

$$A_{shear} = \pi D_m (p/2) (\text{no of threads}) = \pi (9.50) (0.1575 / 2) (2.94) = 6.99 \text{ in}^2$$

The vertical shear force at the threaded interface, F_t , is the force due to pressurization + force from O-ring compression.

$$D_i = \text{Diameter of Inner O-ring} = 210.85 + 3.8 + 4.1 = 218.75 \text{ mm} = 8.612 \text{ in}$$

$$D_o = \text{Diameter of Outer O-ring} = 224.85 + 3.8 + 4.1 = 232.75 \text{ mm} = 9.163 \text{ in}$$

$$F_i = \text{Force of Inner O-ring} = 30 \text{ \#/linear inch} * \pi * 8.612 \text{ in} = 811 \text{ lb}$$

$$F_o = \text{Force of Outer O-ring} = 30 \text{ \#/linear inch} * \pi * 9.163 \text{ in} = 863 \text{ lb}$$

$$F_p = \text{Force from pressurization} = 120 \text{ psia} * \pi / 4 * 9.163^2 = 7910 \text{ lb}$$

$$F_t = F_i + F_o + F_p = 811 + 863 + 7910 = 9584$$

Shear stress on the threads is:

$$\tau = F_t / A_{shear} = 9584 \text{ lb} / 6.99 \text{ in}^2 = 1371 \text{ psi}$$

8. Criteria for Structural Analysis {Reg. Guide 7.6}

The stresses in the containment vessel components have been calculated and shown to meet the criteria specified in NRC Reg. Guide 7.6 for NCT and HAC.

The Stress evaluation criteria of Regulatory Guide 7.6 are summarized as follows:

Stress Category	Symbol	Limits ^a	Regulatory Position ^b
Normal Conditions of Transport			
Primary Membrane	S1	S_m	C2
Primary Membrane + Primary Bending	S2	$1.5 S_m$	C2
Primary + Secondary	S3	$3 S_m$	C4
Fatigue	S4	$2 S_a @ 10^6$ cycles	C3
Buckling	S5	No buckling	C5
Hypothetical Accident Conditions			
Primary Membrane	S1	$< 2.4 S_m$ & $< 0.7 S_u$	C6
Primary Membrane + Primary Bending	S2	$< 3.6 S_m$ & $< S_u$	C6
Buckling	S5	No buckling	C5
Extreme Total Stress Intensity Range	S6	$< 2 S_a @ 10$ cycles	C7

a The material properties, design stress intensities (S_m) and design fatigue curves are taken from ASME B&PVC Subsection NA. This satisfies Regulatory position C1.

b Regulatory Guide 7.6, Paragraph C. "Regulatory Position"

Each of these criteria is evaluated in paragraphs 6 & 7 and the results summarized in Tables 3A, 3B, 4A, 4B, 5A and 5B. In each stress category (S1 to S6) the actual stress is shown to be less than the allowable stress.

9. Loading Combinations {Reg. Guide 7.8}

9.1 Normal Conditions of Transport(NCT)

The stresses in the containment vessel components have been evaluated for the Load Combinations specified in NRC Reg. Guide 7.8.

The loading combinations required by Regulatory Guide 7.8 and demonstration of compliance with the requirements are summarized as follows:

Load Combination	Requirement	Operating Conditions	Evaluation Conditions	Evaluated in:
Hot Environment	- insolation - decay heat - Max internal pressure	+147°C 1.66 bar int. 1.01 bar ext.	+232°C 8 bar int. 0 bar ext. (a)	Para. 6.1.1, 6.1.2, 6.1.3, 7.1.1, 7.1.2, 7.1.3 Tables 3A, 3B
Cold Environment	- No insolation - No decay heat - Min internal pressure	-40°C 0.46 bar int. 1.01 bar ext.	-40°C 0 bar int. 2 bar ext. (a)	Para. 6.2.1, 6.2.2, 7.2.1, 7.2.2, 7.2.3, 7.2.4 Tables 3A, 3B
Increased External Pressure	- No insolation - No decay heat - Min internal pressure	-40°C 0.46 bar int. 1.38 bar ext.	-40°C 0 bar int. 2 bar ext. (a)	Para. 6.2.1, 6.2.2, 7.2.1, 7.2.2, 7.2.3, 7.2.4 Tables 5A, 5B
Minimum External Pressure	- insolation - decay heat - Max internal pressure	+147°C 1.66 bar int. 0.25 bar ext.	+232°C 8 bar int. 0 bar ext. (a)	Para. 6.1.1, 6.1.2, 6.1.3, 7.1.1, 7.1.2, 7.1.3 Tables 3A,3B
Vibration and Shock (Hot Environment)	- insolation - decay heat - Max internal pressure	+147°C 1.66 bar int. 1.01 bar ext.	+232°C 8 bar int. 0 bar ext. (a)	Para 6.1.4, 7.1.4 Tables 3A,3B
Vibration and Shock (Cold Environment)	- No insolation - No decay heat - Min internal pressure	-40°C 0.46 bar int. 1.01 bar ext.	-40°C 0 bar int. 2 bar ext. (b)	Para 6.1.4, 7.1.4, 9.1.2 Tables 3A,3B
Free Drop (Hot Environment)	- insolation - decay heat - Max internal pressure	+147°C 1.66 bar int. 1.01 bar ext.	+232°C 8 bar int. 0 bar ext. (a)	Para. 9.1.1 Tables 6A, 6B
Free Drop (Cold Environment)	- No insolation - No decay heat - Min internal pressure	-40°C 0.46 bar int. 1.01 bar ext.	-40°C 0 bar int. 2 bar ext. (b)	Para. 9.1.1, 9.1.2 Tables 6A, 6B

- The evaluation conditions are always as extreme as, if not more extreme than, the operating conditions; therefore since allowable stresses at the evaluation conditions were not exceeded then allowable stresses at the operating conditions were not exceeded.
- The stresses from external pressures were always less than the maximum stress from internal pressures. The Vibration and Shock, and the Free Drop requirements for the external pressure are satisfied because the requirements are satisfied for the internal pressure.

9.1.1 Free Drop

The 1.2 m (4 ft) Free Drop loading condition is a combination of:

- stresses due to the NCT drop test of 1.2m (4ft); and
- maximum internal pressure, minimum external pressure at the maximum temperature.

The stress contribution from the NCT 1.2m (4ft) drop test has been conservatively estimated from the assessment that the stresses occurring in the containment vessel components, as a result of the Hypothetical Accident Conditions, did not exceed the yield stress (see SARP Ref. 5). Therefore, the maximum stresses that could result from the NCT 1.2m (4ft) drop test can be conservatively taken to be a factor "f" times the yield stress, where:

$$f = \sqrt{1.2m \div 9m} = 0.365.$$

Stress contribution from the NCT (1.2 m) Drop Test:

Stress Category		Maximum Stress due to HAC (9 m) Drop Test	Maximum Stress Contribution due to NCT (1.2 m) Drop Test
S1	Primary membrane	$< S_y$	$< 0.365 \times S_y$
S2	Primary membrane + bending	$< S_y$	$< 0.365 \times S_y$
S3	Primary + secondary range	$< S_y$	$< 0.365 \times S_y$
S4	Fatigue (10^6 cycles)	$< S_y$	$< 0.365 \times S_y$

The maximum stress contribution from the maximum internal pressure and minimum external pressure is reported in paragraphs 6 & 7 and summarized in Tables 3A & 3B.

The 1.2 m (4 ft) Free Drop loading condition is satisfied as shown in Tables 6A & 6B. These tables also show the resulting margin of safety in the containment vessel components. The margin of safety referred to in the ASME Code and this report is defined as:

$$\text{Margin of Safety} = \text{Allowable Stress/Actual Stress} - 1$$

The buckling stresses for the containment vessel components have been analyzed for the bounding temperature conditions of 232°C (450°F) and pressure conditions of 2 bar absolute (30 psia).

9.1.2 Cold Environment

The Cold environment condition evaluation is satisfied because the allowable stresses increase with decreasing temperature (Table 1A & 1B) and the steels used are austenitic stainless steels which do not suffer brittle fracture at temperatures down to and below -40°C (-40°F).

9.2 Hypothetical Accident Conditions (HAC)

The stresses in the containment vessel components have also been evaluated for the Load Combinations specified in NRC Reg. Guide 7.8.

The HAC loading conditions specified in Reg. Guide 7.8 are enveloped by the bounding conditions used in the stress analysis for the high pressure and high temperature conditions that can exist during the HAC test sequence:

- 9 m (30 ft) Free Drop;
- 1 m (40 in) Puncture; and
- Thermal Test.

The loading combinations required by Regulatory Guide 7.8 and demonstration of compliance with the requirements are summarized as follows:

Load Combination	Requirement	Operating Conditions	Evaluation Conditions	Reference of accordance
Free Drop (Hot Environment)	- insolation - decay heat - Max internal pressure	+200°C 1.85 bar int. 1.01 bar ext.	+232°C 8 bar int. 0 bar ext. a	para 9.2.1 Tables 7A, 7B
Free Drop (Cold Environment)	- No insolation - No decay heat - Min internal pressure	-40°C 0.46 bar int. 1.01 bar ext.	-40°C 0 bar int. 2 bar ext. b	para 9.2.1, 9.2.2 Tables 7A, 7B
Puncture (Hot Environment)	- insolation - decay heat - Max internal pressure	+200°C 1.85 bar int. 1.01 bar ext.	+232°C 8 bar int. 0 bar ext. a	para 9.2.1, 9.2.2 Tables 7A, 7B
Puncture (Cold environment)	- No insolation - No decay heat - Min internal pressure	-40°C 0.46 bar int. 1.01 bar ext.	-40°C 0 bar int. 2 bar ext. b	para 9.2.1 Tables 7A, 7B
Thermal Fire Accident	- insolation - decay heat - Max internal pressure	+200°C 1.85 bar int. 1.01 bar ext.	+232°C 8 bar int. 0 bar ext. a	para 9.2.1 Tables 4A, 4B

- The evaluation conditions are always as extreme as, if not more extreme than, the operating conditions; therefore since allowable stresses at the evaluation conditions were not exceeded then allowable stresses at the operating conditions were not exceeded.
- The stresses from external pressures were always less than the maximum stress from internal pressures. The Vibration and Shock, and the Free Drop requirements for the external pressure are satisfied because the requirements are satisfied for the internal pressure.
- The effects on the containment vessels from the 1 m puncture drop test (since there was no penetration of the outer skin of the keg) are enveloped by the evaluation of the 9 m drop test.

9.2.1 Free Drop

The 9 m (30 ft) Free Drop loading condition is a combination of:

- stresses due to the HAC drop test of 9 m (30 ft); and
- maximum internal pressure, minimum external pressure at the maximum temperature.

The stress contribution due to the HAC 9m drop test has been conservatively taken as the yield stress on the basis that there was no plastic deformation in the containment vessel components as a result of the 9m drop test (see SARP Ref. 5).

Stress contribution from the HAC (9m) drop test:

Stress Category		Maximum Stress Contribution due to HAC Drop Test
S1	Primary membrane	$< S_y$
S2	Primary membrane + bending	$< S_y$
S6	Extreme total stress intensity range	$< S_y$

The maximum stress contribution from the maximum internal pressure and minimum external pressure is reported in paragraphs 6 & 7 and summarized in Tables 4A & 4B.

The 9 m Free Drop loading condition is satisfied as shown in Tables 7A & 7B. These tables also show the resulting margin of safety in the containment vessel components. The margin of safety referred to in the ASME Code and this report is defined as:

$$\text{Margin of Safety} = \text{Allowable Stress/Actual Stress} - 1$$

The buckling stresses for the containment vessel components have been analyzed for the bounding temperature conditions of 232°C (450°F) and pressure conditions of 2 bar absolute (30 psia).

9.2.2 Cold Environment

The Cold environment condition evaluation is satisfied because the allowable stresses increase with decreasing temperature (Table 1A & 1B) and the steels used are austenitic stainless steels which do not suffer brittle fracture at temperatures down to and below -40°C (-40°F).

10. Summary and Conclusions

These calculations demonstrate that the Croft SAFKEG Containment Vessels (Cans 2870 and 2871) meet the structural design requirements of NRC Regulatory Guide 7.6 1. The stresses in the containment vessel components have also been shown to meet the Load Combinations specified in NRC Reg. Guide 7.8. Tables 3A, 3B, 4A, 4B, 5A, 5B, 6A, 6B, 7A, & 7B provide a complete summary of the calculated stresses, stress limits and margins of safety determined in this analysis.

11. References

1. Regulatory Guide 7.6, Design Criteria for the Structure Analysis of Shipping Cask Containment Vessel, Revision 1, March 1978.
2. Regulatory Guide 7.8, Load Combinations for the Structural Analysis of Shipping Casks for Radioactive material, Proposed Revision 1, Sept. 1988
3. American Society of Mechanical Engineers Code Section III, Rules of Construction of Nuclear Power Plant Components, Division 1, Subsections NB and NC.
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6. American Society of Mechanical Engineers, Boiler and Pressure Vessel Code, Section II, Part D.
7. Specification for ISO Metric Screw Threads, BS 3643: Part 1: 1981.
8. Parker O-ring Handbook #ORD 5700, 1992 Edition. Parker Seal Group: O-ring Division, P.O. Box 11751, Lexington, KY 40512.
9. COSMOS/M Star Linear Stress Module version 1.75.

Table 1A Material Properties for Stainless Steel ASTM A-240 and A479, 304L

Stainless Steel ASTM A-240, 304L and ASTM A-479, 304L				Values at Different Temperatures					
				-40°C -40°F	20°C 68°F	149°C 300°F	204°C 400°F	232°C 450°F	260°C 500°F
Material Properties				a	b	c	d	e	d
Design Stress Intensity	S_m	MN/m ²	f	115.1	115.1	115.1	108.9	105.4	102.0
		ksi	g	16.7	16.7	16.7	15.8	15.3	14.8
Yield Strength	S_y	MN/m ²	f	172.3	172.3	131.6	120.6	116.4	112.3
		ksi	h	25	25	19.1	17.5	16.9	16.3
Tensile Strength	S_u	MN/m ²	f	482.3	482.3	419.6	403.1	400.7	398.2
		ksi	i	70	70	60.9	58.5	58.2	57.8
Coefficient of Thermal Expansion (Mean)	a_m	10 ⁻⁶ m/m °C	f	14.4	15.2	16.2	16.5	16.7	16.9
		in/in °F	j	8.0	8.47	9.0	9.19	9.3	9.37
Thermal Conductivity	k	W/m K	f	13.9	14.9	17.0	18.0	18.5	18.9
		BTU/h ft °F	k	8.04	8.6	9.8	10.4	10.7	10.9
Modulus of Elasticity	E	GN/m ²	f	198.4	195.0	186.0	182.6	180.2	177.8
		Mpsi	l	28.8	28.3	27	26.5	26.2	25.8
Fatigue Strength @ 10 ⁶ cycles	S_a	MN/m ²	f	194.3					
		ksi	m	28.2					

Some values are extrapolated or interpolated

- a -40°F is the lowest temperature to be considered for packaging
- b This data is used for calculations at normal ambient temperatures
- c The temperature for this data is close to the maximum NCT temperature (Section 2.6.1.1)
- d This data is used to calculate the data at the maximum HAC (Section 2.7.1.1)
- e This data is interpolated from 400°F & 500°F
- f Calculated from the data in imperial units
- g ASME Section II (1992), Part D, Subpart 2, Table 2A (pages 350-353)
- h ASME Section II (1992), Part D, Subpart 2, Table Y-1 (pages 570-573)
- i ASME Section II (1992), Part D, Subpart 2, Table U (pages 494-495)
- j ASME Section II (1992), Part D, Subpart 2, Table TE-1 18 Cr-8 Ni (pages 640-641)
- k ASME Section II (1992), Part D, Subpart 2, Table TCD 18 Cr-8 Ni (page 656)
- l ASME Section II (1992), Part D, Subpart 2, Table TM-1 Material Group G - Austenitic steels (page 664)
- m ASME Section III (1992), Appendix 1, Fig 1-9.2.1 @ 10⁶ cycles (page 9)

Table 1B Material Properties for Stainless Steel ASTM A-479, S21800

Stainless Steel ASTM A-479, S21800				Values at Different Temperatures					
				-40°C -40°F	20°C 68°F	149°C 300°F	204°C 400°F	232°C 450°F	260°C 500°F
Material Properties				a	b	c	d	e	d
Design Stress Intensity	S_m	MN/m ²	f	218.4	218.4	152.3	135.7	131.6	127.5
		ksi	g	31.7	31.7	22.1	19.7	19.1	18.5
Yield Strength	S_y	MN/m ²	f	344.5	344.5	228.1	203.9	197.4	190.8
		ksi	h	50	50	33.1	29.6	28.7	27.7
Tensile Strength	S_u	MN/m ²	f	654.6	654.6	601.5	565	555.3	545.6
		ksi	i	95	95	87.3	82	80.6	79.2
Coefficient of Thermal Expansion (Mean)	α_m	10 ⁻⁶ m/m °C	f	14.4	15.2	16.2	16.5	16.7	16.9
		in/in °F	j	8.0	8.47	9.0	9.19	9.3	9.37
Thermal Conductivity	k	W/m K	f	13.9	14.9	17	18	18.5	18.9
		BTU/h ft °F	k	8.04	8.6	9.8	10.4	10.7	10.9
Modulus of Elasticity	E	GN/m ²	f	197.1	195	186	182.6	180.2	177.8
		Mpsi	l	28.6	28.3	27	26.5	26.2	25.8
Fatigue Strength @ 10 ⁶ cycles	S_a	MN/m ²	f	194.3					
		ksi	m	28.2					

Some values are extrapolated or interpolated

- a -40°F is the lowest temperature to be considered for packaging
- b This data is used for calculations at normal ambient temperatures
- c The temperature for this data is close to the maximum NCT temperature (Section 2.6.1.1)
- d This data is used to calculate the data at the maximum HAC (Section 2.7.1.1)
- e This data is interpolated from the data at 400°F & 500°F
- f Calculated from the data in imperial units
- g ASME Section II (1992), Part D, Subpart 2, Table 2A (pages 362-365)
- h ASME Section II (1992), Part D, Subpart 2, Table Y-1 (pages 578-581)
- i ASME Section II (1992), Part D, Subpart 2, Table U (pages 498-499)
- j ASME Section II (1992), Part D, Subpart 2, Table TE-1 18 Cr-8 Ni (pages 640-641) Material 18Cr-8Ni & 18Cr-11Ni
- k ASME Section II (1992), Part D, Subpart 2, Table TCD 18 Cr-8 Ni (page 656)
- l ASME Section II (1992), Part D, Subpart 2, Table TM-1 Material Group G - Austenitic steels (page 664)
- m ASME Section III (1992), Appendix 1, Fig 1-9.2.1 @ 10⁶ cycles (page 9)

Table 2 Containment Vessel Allowable Stress

Stress Ref. #	Stress Category	Maximum allowable stress	Reference NRC RG 7.6 paragraph	Maximum allowable stress psi @ 232°C (450°F)	
				A479, 304L	A479, S21800
Normal Conditions of Transport					
S1	Primary membrane stress intensity	S_m	C2	15,300	19,100
S2	Primary membrane + primary bending stress intensity	$1.5 S_m$	C2	22,950	28,650
S3	Range of primary + secondary stress intensity	$3.0 S_m$	C4	45,900	57,300
S4	Fatigue stress range (a)	$S_a @ 10^6$ cycles	C3	28,300	28,300 (c)
S5	Buckling	No buckling	C5	No buckling allowed	No buckling allowed
Hypothetical Accident Conditions					
S1	Primary membrane stress intensity	Lesser of $2.4 S_m$ and $0.7 S_u$	C6	36,720	45,840
S2	Primary membrane + primary bending stress intensity	Lesser of $3.6 S_m$ and S_u	C6	55,080	68,760
S5	Buckling	No buckling	C5	No buckling allowed	No buckling allowed
S6	Extreme Total Stress Intensity Range (d)	$2 S_a @ 10$ cycles	C7	1,300,000	1,300,000

- a 10^6 cycles taken as being the appropriate number of cycles as recommended in ASME NB 3222.4(d)(2)(a).
- b 10 cycles per Reg. Guide 7.6 para C7 with adjustment for maximum (450°F) temperature.
- c Temperature adjustment is not required, see paragraphs 6.1.4 & 7.1.4.
- d Extreme Total Stress Intensity Range is discussed in paragraphs 6.1.5 & 7.1.5

Table 3A Stress Summary - NCT, Inner C/V (Can 2871), Internal Pressurization (maximum internal & minimum external pressure)

Location of stress	Fig 5	Stress Type		Stress Intensity due to Pressure (psi)	Allowable (psi)
Lid:					
- Center	1	S1	Primary membrane	2022	15300
- Body interface	5	S2	Primary membrane + bending	4586	22950
- Body interface	5	S3	Primary + secondary range	9936	45900
- Body interface	5	S4	Fatigue (10 ⁶ cycles)	5376	26200
Screw ring:					
- Inner radius	13	S1	Primary membrane	1109	19100
- Inner radius	12	S2	Primary membrane + bending	4831	28650
- Inner radius	12	S3	Primary + secondary range	4815	57300
- Inner radius	12	S4	Fatigue (10 ⁶ cycles)	2605	26200
CV head /body:					
- Head/body	10	S1	Primary membrane	1855	15300
- Head	11	S2	Primary membrane + bending	6556	22950
- Head	11	S3	Primary + secondary range	9701	45900
- Head	11	S4	Fatigue (10 ⁶ cycles)	5249	26200

Table 3B Stress Summary - NCT, Outer C/V (Can 2870), Internal Pressurization (maximum internal & minimum external pressure)

Location of stress	Fig 5	Stress Type		Stress Intensity due to Pressure (psi)	Allowable (psi)
Lid:					
- Center	1	S1	Primary membrane	1805	15300
- Body interface	5	S2	Primary membrane + bending	5002	22950
- Body interface	5	S3	Primary + secondary range	9174	45900
- Body interface	5	S4	Fatigue (10 ⁶ cycles)	4964	26200
Screw ring:					
- Inner radius	13	S1	Primary membrane	1088	19100
- Inner radius	12	S2	Primary membrane + bending	4955	28650
- Inner radius	12	S3	Primary + secondary range	4941	57300
- Inner radius	12	S4	Fatigue (10 ⁶ cycles)	2674	26200
CV head /body:					
- Head/body	10	S1	Primary membrane	1665	15300
- Head	11	S2	Primary membrane + bending	8201	22950
- Head	11	S3	Primary + secondary range	10031	45900
- Head	11	S4	Fatigue (10 ⁶ cycles)	5428	26200

Table 4A Stress Summary - HAC, Inner C/V (Can 2871), Internal Pressurization (maximum internal & minimum external pressure)

Location of stress	Fig 5	Stress Type	Stress Intensity due to pressure (psi)	Allowable (psi)
Lid:				
- Center	1	S1 Primary membrane	2022	36720
- Body interface	5	S2 Primary membrane + bending	4586	55080
- Body interface	5	S6 Extreme Total Stress Intensity Range	9936	1300000
Screw ring:				
- Inner radius	13	S1 Primary membrane	1109	45840
- Inner radius	12	S2 Primary membrane + bending	4831	68760
- Inner radius	12	S6 Extreme Total Stress Intensity Range	4815	1300000
CV head /body:				
- head/body	10	S1 Primary membrane	1855	36720
- head	11	S2 Primary membrane + bending	6556	55080
- Head	11	S6 Extreme Total Stress Intensity Range	9701	1300000

Table 4B Stress Summary - HAC, Outer C/V (Can 2870), Internal Pressurization (maximum internal & minimum external pressure)

Location of stress	Fig 5	Stress Type	Stress Intensity due to pressure (psi)	Allowable (psi)
Lid:				
- Center	1	S1 Primary membrane	1805	36720
- Body interface	5	S2 Primary membrane + bending	5002	55080
- Body interface	5	S6 Extreme Total Stress Intensity Range	9174	1300000
Screw ring:				
- Inner radius	13	S1 Primary membrane	1088	45840
- Inner radius	12	S2 Primary membrane + bending	4955	68760
- Inner radius	12	S6 Extreme Total Stress Intensity Range	4149	1300000
CV head /body:				
- head/body	10	S1 Primary membrane	1665	36720
- head	11	S2 Primary membrane + bending	8201	55080
- Head	11	S6 Extreme Total Stress Intensity Range	10031	1300000

Table 5A Stress Summary - NCT & HAC, Inner Containment Vessel (Can 2871), External Pressurization (minimum internal & maximum external pressure)

Location of Stress	Fig 5	Failure Mode		Pressure (psi)	
				Design	Allowable ^a
Body section (5"Ø) between head and elliptical end	7-8-9	S5	Collapse	30	433
Elliptical end	6	S5	Collapse	30	386

a Section 6.2

Table 5B Stress Summary - NCT & HAC, Outer Containment Vessel (Can 2870), External Pressurization (minimum internal and maximum external pressure)

Location of Stress	Fig 5	Failure Mode		Pressure (psi)	
				Design	Allowable ^a
Body section (8"Ø) between tapered body and head	9-10	S5	Collapse	30	443
Body - tapered body between head and tubular section	8-9	S5	Collapse	30	368
Body section (6"Ø) between tapered body and elliptical end	7-8	S5	Collapse	30	434
Elliptical end	6	S5	Collapse	30	352

a Section 7.2

Table 6A Loading Combination - 1.2 m NCT Drop Test with Internal Pressurization for Inner C/V (Can 2871)

Location of stress	Fig 5	Stress Type	Stress Intensity (psi)			Allowable (psi)	Margin of Safety	
			Pressure ^a	NCT ^b	Total			
Lid:								
- Center	1	S1	Primary membrane	2022	9125	11147	15300	0.37
- Body interface	5	S2	Primary membrane + bending	4586	9125	13711	22950	0.67
- Body interface	5	S3	Primary + secondary range	9936	9125	19061	45900	1.41
- Body interface	5	S4	Fatigue (10 ⁶ cycles)	5376	9125	14501	28200	0.94
Screw ring:								
- Inner radius	13	S1	Primary membrane	1109	9125	10234	19100	0.87
- Inner radius	12	S2	Primary membrane + bending	4831	9125	13956	28650	1.05
- Inner radius	12	S3	Primary + secondary range	4815	9125	28385	57300	1.02
- Inner radius	12	S4	Fatigue (10 ⁶ cycles)	2605	9125	11730	28200	1.40
CV head /body:								
- Head/body	10	S1	Primary membrane	1855	9125	10980	15300	0.39
- Head	11	S2	Primary membrane + bending	6556	9125	15681	22950	0.46
- Head	11	S3	Primary + secondary range	9701	9125	18826	45900	1.44
- Head	11	S4	Fatigue (10 ⁶ cycles)	5249	9125	14374	28200	0.96

a From Table 3A.

b Maximum stress contribution from NCT drop test is limited to: $f \times S_y$. Where $f = \pm(1.2/9) = 0.365$ and $S_y = 17297$ psi (see paragraph 9.1).

Table 6B Loading Combination - 1.2 m NCT Drop Test with Internal Pressurization for Outer C/V (Can 2870)

Location of stress	Fig 5	Stress Type		Stress Intensity (psi)			Allowable (psi)	Margin of Safety
				Pressure ^a	NCT ^b	Total		
Lid:								
- Center	1	S1	Primary membrane	1805	9125	10930	15300	0.40
- Body interface	5	S2	Primary membrane + bending	5002	9125	14127	22950	0.62
- Body interface	5	S3	Primary + secondary range	9174	9125	18299	45900	1.51
- Body interface	5	S4	Fatigue (10 ⁶ cycles)	4964	9125	14089	28200	1.00
Screw ring:								
- Inner radius	13	S1	Primary membrane	1088	9125	10213	19100	0.87
- Inner radius	12	S2	Primary membrane + bending	4955	9125	14080	28650	1.03
- Inner radius	12	S3	Primary + secondary range	4941	9125	14066	57300	3.07
- Inner radius	12	S4	Fatigue (10 ⁶ cycles)	2674	9125	11799	28200	1.39
CV head /body:								
- Head/body	10	S1	Primary membrane	1665	9125	10790	15300	0.42
- Head	11	S2	Primary membrane + bending	8201	9125	17326	22950	0.32
- Head	11	S3	Primary + secondary range	10031	9125	19156	45900	1.40
- Head	11	S4	Fatigue (10 ⁶ cycles)	5428	9125	14553	28200	0.94

a From Table 3B.

b Maximum stress contribution from NCT drop test is limited to: $f \times S_y$. Where $f = \pm(1.2/9) = 0.365$ and $S_y = 17297$ psi (see paragraph 9.1).

Table 7A Stress Summary - HAC, Inner C/V (Can 2871), Internal Pressurization (maximum internal & minimum external pressure)

Location of stress	Fig 5	Stress Type	Stress Intensity (psi)			Allowable (psi)	Margin of Safety	
			Pressure a	HAC b	Total			
Lid:								
- Center	1	S1	Primary membrane	2022	25000	27022	36720	0.36
- Body interface	5	S2	Primary membrane + bending	4586	25000	29586	55080	0.86
- Body interface	5	S6	Extreme Total Stress Intensity Range (c)	9936	25000	34936	1300000	36
Screw ring:								
- Inner radius	13	S1	Primary membrane	1109	25000	26109	45840	0.76
- Inner radius	12	S2	Primary membrane + bending	4831	25000	29831	68760	1.30
- Inner radius	12	S6	Extreme Total Stress Intensity Range (c)	4815	25000	29815	1300000	42
CV head /body:								
- head/body	10	S1	Primary membrane	1855	25000	26855	36720	0.37
- head	11	S2	Primary membrane + bending	6556	25000	31556	55080	0.75
- head	11	S6	Extreme Total Stress Intensity Range (c)	9701	25000	34701	1300000	36

a From Table 4A

b Maximum stress contribution due to HAC drop test is less than the yield stress: $S_y = 17297$ psi (paragraph 9.2)

c Extreme Total Stress Intensity Range is discussed in paragraphs 6.1.5 & 7.1.5

Table 7B Loading Combination - 9 m HAC Drop Test with Internal Pressurization for Outer C/V (Can 2870)

Location of stress	Fig 5	Stress Type	Stress Intensity (psi)			Allowable (psi)	Margin of Safety	
			Pressure ^a	HAC ^b	Total			
Lid:								
- Center	1	S1	Primary membrane	1805	25000	26805	36720	0.37
- Body interface	5	S2	Primary membrane + bending	5002	25000	30002	55080	0.84
- Body interface	5	S4	Extreme Total Stress Intensity Range (c)	9174	25000	34174	1300000	37
Screw ring:								
- Inner radius	13	S1	Primary membrane	1088	25000	26088	45840	0.76
- Inner radius	12	S2	Primary membrane + bending	4955	25000	29955	68760	1.30
- Inner radius	12	S4	Extreme Total Stress Intensity Range (c)	4941	25000	29941	1300000	42
CV head /body:								
- head/body	10	S1	Primary membrane	1665	25000	26665	36720	0.38
- head	11	S2	Primary membrane + bending	8201	25000	33201	55080	0.66
- head	11	S4	Extreme Total Stress Intensity Range (c)	10031	25000	35031	1300000	36

^a From Table 4B^b Maximum stress contribution due to HAC drop test is less than the yield stress: $S_y = 17297$ psi (paragraph 9.2)^c Extreme Total Stress Intensity Range is discussed in paragraphs 6.1.5 & 7.1.5

Figure 1 SAFKEG 2863B Assembly

Dimension	Can 2870		Can 2871	
Outside Diameter (max)	258 mm	10.157 in	180 mm	7.087 in
Outside Height (max)	475 mm	18.701 in	433 mm	17.047 in
Inside Diameter (min)	154 mm	6.063 in	127.6 mm	5.024 in
Inside Height (Rt. Cyl)			366 mm	14.409 in
Inside Height (max)	440 mm	17.323 in	401 mm	15.787 in

Figure 2 Cross-section of Inner & Outer Containment Vessels

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Figure 3B Finite Element Model Points Can 2870

Figure 4A FEA Mesh w/ Pressure & O-ring Loads (Can 2871)

Figure 4B Finite Element Model Mesh w/ Pressure & O-ring Loads (Can 2870)

Figure 5A Lid, Ring and C/V Stress Intensities (Can 2871)

Figure 5B Lid, Ring and C/V Stress Intensities (Can 2870)

GeoStar 1.75 : 2871-120 - [Main]

Lin STRESS Lc=1

Intens

Figure 6A C/V Lower Region Stress Intensities (Can 2871)

Figure6B C/V Lower Region Stress Intensities (Can 2870)

Figure 7 Finite Element Stress Evaluation Locations

Appendices

Appendix A1 COSMOS Session File - Can 2871

COSMOS SESSION FILE - 2871-120.SES
C* COSMOS/M Geostar V1.75
C* Problem : ICV120b Date : 7- 3-97 Time : 15: 6:10
C* FILE,icv1.ses,1,1,1,1
VIEW,0,0,1,0
PLANE,Z,0,1

C* Containment Vessel Geometry

PT,1,3.543,.914,0
PT,2,3.543,-.858,0
PT,3,2.781,-.858,0
PT,4,2.781,-3.574,0
PT,5,2.781,-7.826,0
PT,6,2.781,-14.565,0
PT,7,0,-16.094,0
SCALE,0
PT,8,3.386,.919,0
PT,9,3.386,.431,0
PT,10,3.386,0,0
PT,11,3.189,0,0
PT,12,2.514,0,0
PT,13,2.514,-3.574,0
PT,14,2.514,-7.826,0
PT,15,2.514,-14.565,0
PT,16,0,-15.827,0
PT,17,0,-14.565,0
CRLINE,1,1,2
CRLINE,2,2,3
CRLINE,3,3,4
CRLINE,4,4,5
CRLINE,5,5,6
CRLINE,6,1,8
CRLINE,7,8,9
CRLINE,8,9,10
CRLINE,9,10,11
CRLINE,10,11,12
CRLINE,11,12,13
CRLINE,12,13,14
CRLINE,13,14,15
CRELLIPSE,14,15,16,17,4
CRELLIPSE,18,6,7,17,4
CRDEL,15,17,1
CRDEL,19,21,1
CRLINE,19,7,16
CRFILLET,20,2,3,.226,1,0,1E-006
CRFILLET,21,8,9,.039,1,0,1E-006

C* Lid Geometry

FEA Stress Analysis for SAFKEG 2863B
Appendix A1 COSMOS Session File - Can 2871

AR-97-01
97/07/15

PT,24,0,-.146,0
PT,25,2.506,-.146,0
PT,26,2.506,.01,0
PT,27,2.514,.01,0
PT,28,3.189,.01,0
PT,29,3.189,.404,0
PT,30,1.988,.404,0
PT,31,1.949,.404,0
PT,32,1.949,.616,0
PT,33,.886,.616,0
PT,34,.886,.902,0
PT,35,.236,.902,0
PT,36,.236,-.004,0
PT,37,0,-.004,0
CRLINE,22,25,26
CRLINE,23,26,27
CRLINE,24,27,28
CRLINE,25,28,29
CRLINE,26,29,30
CRLINE,27,30,31
CRLINE,28,31,32
CRLINE,29,32,33
CRLINE,30,33,34
CRLINE,31,34,35
CRLINE,32,35,36
CRLINE,33,36,37
CRLINE,34,37,24
CRLINE,35,24,25

C* Screw Ring Geometry

PT,38,1.988,.414,0
PT,39,3.189,.414,0
PT,40,3.376,.414,0
PT,41,3.376,.902,0
PT,42,1.988,.902,0
CRLINE,36,38,39
CRLINE,37,39,40
CRLINE,38,40,41
CRLINE,39,41,42
CRLINE,40,42,38

C* Meshing

CT,1,0,.08,1,2,0
CT,2,0,.08,1,29,0
CT,3,0,.08,1,39,0
RG,1,1,1,0
RG,2,1,2,0
RG,3,1,3,0
EGROUP,1,TRIANG,0,1,1,0,0,0,0,0
PICK_MAT,1,ST_304,FPS
C* MATL:ST_304 : STEEL,AISI 304 (SHEET)

FEA Stress Analysis for SAFKEG 2863B
Appendix A1 COSMOS Session File - Can 2871

AR-97-01
97/07/15

C* EX 0.28E+08 psi
C* NUXY 0.29
C* GXY 0.11E+08 psi
C* ALPX 0.99E-05 /Fahrenheit
C* DENS 0.75E-03 lbf*s*s/in**4
C* KX 0.22E-03 BTU/in/s/F
C* C (Cp) 46. BTU*in/lbf/s/s/F
RGDENSITY,1,3,1,.05,0.0001,1,0,1
MA_RG,1,3,1,3,1,0

C* Creating Gap Elements

EGROUP,2,GAP,1,0,0,0,0,0,0
RCONST,2,1,1,7,0,0,10049875,0,1E+008,0,1
RCONST,2,2,1,7,0,0,10E6,0,1E+008,0,1
ACTSET,RC,1
EL,7079,CR,0,2,3748,757,0,0,0,0,0,0
EL,7080,CR,0,2,3823,756,0,0,0,0,0,0
EL,7081,CR,0,2,3822,755,0,0,0,0,0,0
EL,7082,CR,0,2,3821,754,0,0,0,0,0,0
EL,7083,CR,0,2,3820,753,0,0,0,0,0,0
EL,7084,CR,0,2,3819,752,0,0,0,0,0,0
EL,7085,CR,0,2,3818,751,0,0,0,0,0,0
EL,7086,CR,0,2,3817,750,0,0,0,0,0,0
EL,7087,CR,0,2,3816,749,0,0,0,0,0,0
EL,7088,CR,0,2,3815,748,0,0,0,0,0,0
EL,7089,CR,0,2,3814,747,0,0,0,0,0,0
ACTSET,RC,2
EL,7090,CR,0,2,719,2932,0,0,0,0,0,0
EL,7091,CR,0,2,720,2933,0,0,0,0,0,0
EL,7092,CR,0,2,721,2934,0,0,0,0,0,0
EL,7093,CR,0,2,722,2935,0,0,0,0,0,0
EL,7098,CR,0,2,731,2944,0,0,0,0,0,0
EL,7099,CR,0,2,732,2945,0,0,0,0,0,0
EL,7100,CR,0,2,733,2946,0,0,0,0,0,0
EL,7101,CR,0,2,2978,3786,0,0,0,0,0,0
EL,7102,CR,0,2,2977,3787,0,0,0,0,0,0
EL,7103,CR,0,2,2976,3788,0,0,0,0,0,0
EL,7104,CR,0,2,2975,3789,0,0,0,0,0,0
EL,7105,CR,0,2,2974,3790,0,0,0,0,0,0
EL,7106,CR,0,2,2973,3791,0,0,0,0,0,0
EL,7107,CR,0,2,2972,3792,0,0,0,0,0,0
EL,7108,CR,0,2,2971,3793,0,0,0,0,0,0
EL,7109,CR,0,2,2970,3794,0,0,0,0,0,0
EL,7110,CR,0,2,2969,3795,0,0,0,0,0,0
EL,7111,CR,0,2,2968,3796,0,0,0,0,0,0
EL,7112,CR,0,2,2967,3797,0,0,0,0,0,0
EL,7113,CR,0,2,2966,3798,0,0,0,0,0,0
EL,7114,CR,0,2,2965,3799,0,0,0,0,0,0
EL,7115,CR,0,2,2964,3800,0,0,0,0,0,0
EL,7116,CR,0,2,2963,3801,0,0,0,0,0,0
EL,7117,CR,0,2,2962,3802,0,0,0,0,0,0
EL,7118,CR,0,2,2961,3803,0,0,0,0,0,0
EL,7119,CR,0,2,2960,3804,0,0,0,0,0,0

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EL,7120,CR,0,2,2959,3805,0,0,0,0,0,0
EL,7121,CR,0,2,2958,3806,0,0,0,0,0,0
EL,7122,CR,0,2,2957,3807,0,0,0,0,0,0
EL,7123,CR,0,2,2956,3808,0,0,0,0,0,0
EL,7124,CR,0,2,2955,3809,0,0,0,0,0,0
EL,7125,CR,0,2,2954,3810,0,0,0,0,0,0
CLS,1

C* Applying Pressures

PCR,10,120,14,1,120,4
PCR,35,120,35,1,120,4
PCR,22,120,24,1,120,4
PEDEL,6249,2,6249,1
PEDEL,6301,2,6301,1
PEDEL,6340,2,6340,1
PEDEL,684,3,684,1
PEDEL,729,3,729,1
PEDEL,771,3,771,1
PEDEL,6196,2,6196,1
PEDEL,811,3,811,1
DND,166,UY,0,166,1,

C* Defining Stress Evaluation Locations

ASMESECDEF,1,2876,2873,25,0
ASMESECDEF,2,2883,2849,25,1000,1
ASMESECDEF,2,2849,2883,25,1000,1
ASMESECDEF,3,2830,2894,25,0
ASMESECDEF,4,2979,2916,25,0
ASMESECDEF,5,2932,2968,25,0
ASMESECDEF,6,360,366,25,0
ASMESECDEF,7,419,301,25,1.7,1
ASMESECDEF,8,562,155,25,-1,1
ASMESECDEF,9,647,70,25,-1,1
ASMESECDEF,10,698,19,25,-1,1
ASMESECDEF,11,738,4677,25,-1,1
ASMESECDEF,12,3786,3776,25,-1,1
ASMESECDEF,13,3814,3748,25,-1,1
ASMESECDEF,211,739,779,25,-1,1
ECHANGE,1,7089,1,1,0

C* Applying O-ring Forces

FND,2937,FY,82.44,2937,1
FND,724,FY,-82.44,724,1
FND,13833,FY,90.72,13833,1
FND,5342,FY,-90.72,5342,1
NTND,1,450,20000,1
MPROP,1,EX,26.15E6

C* Additional Gap Elements

EL,7126,CR,0,2,13450,14671,0,0,0,0,0,0

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EL,7127,CR,0,2,13539,14640,0,0,0,0,0,0
EL,7128,CR,0,2,13628,14609,0,0,0,0,0,0
CLS,1
ACTSET,RC,1
EL,7129,CR,0,2,14330,5780,0,0,0,0,0,0
EL,7130,CR,0,2,14338,5756,0,0,0,0,0,0
EL,7131,CR,0,2,14347,5725,0,0,0,0,0,0
EL,7132,CR,0,2,14359,5696,0,0,0,0,0,0
EL,7133,CR,0,2,14374,5666,0,0,0,0,0,0
EL,7134,CR,0,2,14392,5631,0,0,0,0,0,0
EL,7135,CR,0,2,14413,5593,0,0,0,0,0,0
EL,7136,CR,0,2,14437,5552,0,0,0,0,0,0
EL,7137,CR,0,2,14464,5506,0,0,0,0,0,0
EL,7138,CR,0,2,14516,5456,0,0,0,0,0,0
ACTSET,RC,2
EL,7139,CR,0,2,5665,13025,0,0,0,0,0,0
EL,7140,CR,0,2,5630,13026,0,0,0,0,0,0
EL,7141,CR,0,2,5592,13117,0,0,0,0,0,0
EL,7142,CR,0,2,5551,13207,0,0,0,0,0,0
EL,7146,CR,0,2,5215,13994,0,0,0,0,0,0
EL,7147,CR,0,2,5145,14054,0,0,0,0,0,0
EL,7148,CR,0,2,11817,15207,0,0,0,0,0,0
EL,7149,CR,0,2,11858,15202,0,0,0,0,0,0
EL,7150,CR,0,2,11905,15193,0,0,0,0,0,0
EL,7151,CR,0,2,11958,15181,0,0,0,0,0,0
EL,7152,CR,0,2,12017,15166,0,0,0,0,0,0
EL,7153,CR,0,2,12082,15148,0,0,0,0,0,0
EL,7154,CR,0,2,12153,15127,0,0,0,0,0,0
EL,7155,CR,0,2,12230,15103,0,0,0,0,0,0
EL,7156,CR,0,2,12314,15074,0,0,0,0,0,0
EL,7157,CR,0,2,12401,15043,0,0,0,0,0,0
EL,7158,CR,0,2,12484,15012,0,0,0,0,0,0
EL,7159,CR,0,2,12564,14981,0,0,0,0,0,0
EL,7160,CR,0,2,12644,14950,0,0,0,0,0,0
EL,7161,CR,0,2,12726,14919,0,0,0,0,0,0
EL,7162,CR,0,2,12810,14888,0,0,0,0,0,0
EL,7163,CR,0,2,12893,14857,0,0,0,0,0,0
EL,7164,CR,0,2,12983,14826,0,0,0,0,0,0
EL,7165,CR,0,2,13078,14795,0,0,0,0,0,0
EL,7166,CR,0,2,13170,14764,0,0,0,0,0,0
EL,7167,CR,0,2,13262,14733,0,0,0,0,0,0
EL,7168,CR,0,2,13354,14702,0,0,0,0,0,0
A_STATIC,N,0,1,1E-006,1E+010,0,0,0,0,0,0
A_STRESS,0,0,0,0,1,0,0,1

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| A. S. M. E.   S T R E S S   C H E C K |
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**** LINEARIZED & PEAK STRESSES FOR SECTION: 1 ****

Section end nodes:                2876 & 2873
Section orientation angle from X-axis: 90.00 (degree)
No. of integration pts.:          25
Curvature-radius (RHO):           .00000
KBR flag:                           0

Membrane Stresses (Section Coord.):
NODE   SIGMA-X1   SIGMA-X2   SIGMA-X3   TAU-X12
2876   -59.02    -2081.    -2075.     .8539
2873   -59.02    -2081.    -2075.     .8539

Bending Stresses (Section Coord.):
NODE   SIGMA-X1   SIGMA-X2   SIGMA-X3   TAU-X12
2876   -75.84    -398.5    -382.5     3.806
2873    75.84     398.5     382.5    -3.806

Linear (Membrane + Bending) Stresses (Section Coord.):
NODE   SIGMA-X1   SIGMA-X2   SIGMA-X3   TAU-X12
2876   -134.9    -2480.    -2458.     4.660
2873    16.82    -1683.    -1693.    -2.952

Peak (Actual-Linear) Stresses (Section Coord.):
NODE   SIGMA-X1   SIGMA-X2   SIGMA-X3   TAU-X12
2876    13.01     -20.76    -4.882     -4.617
2873   -2.129     .6249     4.824     -3.388
Center -2.720     5.033     .1444E-01  2.001

Membrane Stresses (Global Cart. Coord.):
NODE   SIGMA-X1   SIGMA-X2   SIGMA-X3   TAU-X12
2876   -2081.    -59.02    -2075.     -.8539
2873   -2081.    -59.02    -2075.     -.8539

Bending Stresses (Global Cart. Coord.):
NODE   SIGMA-X1   SIGMA-X2   SIGMA-X3   TAU-X12
2876   -398.5    -75.84    -382.5     -3.806
2873   398.5     75.84     382.5      3.806

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):
NODE   SIGMA-X1   SIGMA-X2   SIGMA-X3   TAU-X12
2876   -2480.    -134.9    -2458.     -4.660
2873   -1683.     16.82    -1693.      2.952

Peak (Actual-Linear) Stresses (Global Cart. Coord.):
NODE   SIGMA-X1   SIGMA-X2   SIGMA-X3   TAU-X12
2876   -20.76     13.01    -4.882      4.617
2873    .6249    -2.129     4.824      3.388
Center  5.033    -2.720     .1444E-01 -2.001

Principal Membrane Stresses:
NODE   SIGMA-1   SIGMA-2   SIGMA-3
2876   -59.02    -2081.    -2075.
2873   -59.02    -2081.    -2075.

Principal Linear (Membrane+Bending) Stresses:
NODE   SIGMA-1   SIGMA-2   SIGMA-3
2876   -134.9    -2480.    -2458.
2873    16.82    -1683.    -1693.

Principal Peak (Actual-Linear) Stresses:
NODE   SIGMA-1   SIGMA-2   SIGMA-3
2876    13.63    -21.38    -4.882
2873    2.905    -4.409     4.824
Center  5.519    -3.206     .1444E-01

Membrane Stress Intensity:
NODE   Intensity
2876    2022.
2873    2022.

Linear (Membrane+Bending) Stress Intensity:
NODE   Intensity
2876    2345.
2873    1709.

Peak (Actual-Linear) Stress Intensity:
NODE   Intensity
2876    35.00
2873    9.233
Center   8.725

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 2 ****

Section end nodes: 2849 & 2883
Section orientation angle from X-axis: -84.12 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): 1000.0
KBR flag: 1

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2849	-376.8	-325.0	414.2	-12.03
2883	-376.8	-325.0	414.2	-12.03

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2849	.0000	1027.	2736.	.0000
2883	.0000	-906.8	-2735.	.0000

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2849	-376.8	701.8	3150.	-12.03
2883	-376.8	-1232.	-2321.	-12.03

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2849	381.1	-674.0	-37.56	8.504
2883	233.6	-1066.	1.860	-211.2
Center	-308.6	450.2	75.05	31.78

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2849	-328.0	-373.8	414.2	17.05
2883	-328.0	-373.8	414.2	17.05

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2849	1016.	10.78	2736.	104.7
2883	-897.3	-9.522	-2735.	-92.44

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2849	688.1	-363.0	3150.	121.7
2883	-1225.	-383.3	-2321.	-75.38

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2849	-661.2	368.3	-37.56	-115.9
2883	-1095.	263.0	1.860	74.32
Center	448.7	-307.1	75.05	46.24

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
2849	-322.3	-379.4	414.2
2883	-322.3	-379.4	414.2

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
2849	702.0	-376.9	3150.
2883	-376.6	-1232.	-2321.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
2849	381.2	-674.0	-37.56
2883	267.1	-1099.	1.860
Center	451.6	-309.9	75.05

Membrane Stress Intensity:

NODE	Intensity
2849	793.6
2883	793.6

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
2849	3527.
2883	1944.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
2849	1055.
2883	1366.
Center	761.5

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 3 ****

Section end nodes: 2894 & 2830
Section orientation angle from X-axis: 89.89 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): .00000
KBR flag: 0

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2894	360.8	75.19	32.31	48.88
2830	360.8	75.19	32.31	48.88

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2894	-930.1	-3176.	-2761.	-387.9
2830	930.1	3176.	2761.	387.9

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2894	-569.3	-3101.	-2728.	-339.1
2830	1291.	3251.	2793.	436.8

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2894	448.9	274.1	167.0	343.9
2830	2228.	2549.	1147.	1758.
Center	-264.7	-199.6	-89.23	-187.6

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2894	74.99	361.0	32.31	-48.30
2830	74.99	361.0	32.31	-48.30

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2894	-3174.	-931.7	-2761.	392.4
2830	3174.	931.7	2761.	-392.4

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2894	-3099.	-570.7	-2728.	344.1
2830	3249.	1293.	2793.	-440.7

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2894	272.7	450.2	167.0	-343.6
2830	2542.	2235.	1147.	-1758.
Center	-198.9	-265.4	-89.23	187.5

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
2894	368.9	67.05	32.31
2830	368.9	67.05	32.31

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
2894	-524.7	-3145.	-2728.
2830	3344.	1198.	2793.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
2894	716.3	6.592	167.0
2830	4153.	623.0	1147.
Center	-41.72	-422.6	-89.23

Membrane Stress Intensity:

NODE	Intensity
2894	336.6
2830	336.6

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
2894	2620.
2830	2146.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
2894	709.7
2830	3530.
Center	380.9

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 4 ****

Section end nodes: 2979 & 2916
Section orientation angle from X-axis: -88.28 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): .00000
KBR flag: 0

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2979	607.1	-72.59	-284.3	183.2
2916	607.1	-72.59	-284.3	183.2

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2979	1251.	3890.	3016.	619.7
2916	-1251.	-3890.	-3016.	-619.7

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2979	1858.	3818.	2732.	802.9
2916	-643.5	-3963.	-3300.	-436.5

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2979	2470.	1747.	1111.	1673.
2916	514.2	200.2	178.1	324.3
Center	-284.6	-214.8	-122.7	-211.9

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2979	-61.01	595.6	-284.3	-203.2
2916	-61.01	595.6	-284.3	-203.2

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2979	3925.	1216.	3016.	-539.5
2916	-3925.	-1216.	-3016.	539.5

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2979	3864.	1811.	2732.	-742.8
2916	-3986.	-620.3	-3300.	336.3

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2979	1848.	2369.	1111.	-1692.
2916	219.9	494.5	178.1	-333.1
Center	-227.5	-271.8	-122.7	213.6

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
2979	653.4	-118.8	-284.3
2916	653.4	-118.8	-284.3

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
2979	4105.	1571.	2732.
2916	-587.0	-4019.	-3300.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
2979	3820.	396.6	1111.
2916	717.5	-3.106	178.1
Center	-34.90	-464.5	-122.7

Membrane Stress Intensity:

NODE	Intensity
2979	937.7
2916	937.7

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
2979	2534.
2916	3432.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
2979	3424.
2916	720.6
Center	429.6

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 5 ****

Section end nodes: 2968 & 2932
Section orientation angle from X-axis: -86.28 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): .00000
KBR flag: 0

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2968	-651.3	-59.89	-67.45	370.9
2932	-651.3	-59.89	-67.45	370.9

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2968	1030.	5021.	3170.	-453.7
2932	-1030.	-5021.	-3170.	453.7

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2968	378.6	4962.	3102.	-82.74
2932	-1681.	-5081.	-3237.	824.6

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2968	-355.8	-613.5	-270.4	361.1
2932	709.9	-5785.	-1434.	965.1
Center	222.4	420.7	175.5	-204.4

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2968	-14.41	-696.8	-67.45	-329.6
2932	-14.41	-696.8	-67.45	-329.6

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2968	4946.	1105.	3170.	708.0
2932	-4946.	-1105.	-3170.	-708.0

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2968	4932.	408.6	3102.	378.4
2932	-4960.	-1802.	-3237.	-1038.

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2968	-565.7	-403.6	-270.4	-374.8
2932	-5633.	557.8	-1434.	-1377.
Center	393.4	249.7	175.5	215.5

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
2968	118.8	-830.0	-67.45
2932	118.8	-830.0	-67.45

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
2968	4963.	377.1	3102.
2932	-1492.	-5271.	-3237.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
2968	-101.2	-868.1	-270.4
2932	850.3	-5925.	-1434.
Center	548.7	94.41	175.5

Membrane Stress Intensity:

NODE	Intensity
2968	948.8
2932	948.8

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
2968	4586.
2932	3779.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
2968	766.9
2932	6776.
Center	454.3

FEA Stress Analysis for SAFKEG 2863B

Appendix A2 COSMOS Output File - Can 2871

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 6 ****

Section end nodes: 360 & 366
Section orientation angle from X-axis: 90.00 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): .00000
KBR flag: 0

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
360	-68.30	1007.	1007.	.4732
366	-68.30	1007.	1007.	.4732

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
360	61.61	545.9	544.2	-.4336
366	-61.61	-545.9	-544.2	.4336

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
360	-6.686	1553.	1551.	-.3958E-01
366	-129.9	461.2	462.9	.9067

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
360	8.906	-7.614	-16.12	-.9006
366	6.845	-12.21	-4.787	-.5874
Center	-3.736	5.627	5.575	.3587E-01

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
360	1007.	-68.30	1007.	-.4732
366	1007.	-68.30	1007.	-.4732

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
360	545.9	61.61	544.2	.4336
366	-545.9	-61.61	-544.2	-.4336

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
360	1553.	-6.686	1551.	-.3958E-01
366	461.2	-129.9	462.9	-.9067

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
360	-7.614	8.906	-16.12	.9006
366	-12.21	6.845	-4.787	.5874
Center	5.627	-3.736	5.575	-.3587E-01

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
360	1007.	-68.30	1007.
366	1007.	-68.30	1007.

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
360	1553.	-6.686	1551.
366	461.2	-129.9	462.9

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
360	8.955	-7.663	-16.12
366	6.863	-12.23	-4.787
Center	5.627	-3.736	5.575

Membrane Stress Intensity:

NODE	Intensity
360	1075.
366	1075.

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
360	1560.
366	592.8

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
360	25.07
366	19.09
Center	9.363

FEA Stress Analysis for SAFKEG 2863B

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 7 ****

Section end nodes: 419 & 301
Section orientation angle from X-axis: -26.66 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): 1.7000
KBR flag: 1

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
419	-2.157	592.4	-19.15	-17.82
301	-2.157	592.4	-19.15	-17.82

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
419	.0000	1006.	304.7	.0000
301	.0000	-975.6	-289.4	.0000

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
419	-2.157	1598.	285.6	-17.82
301	-2.157	-383.2	-308.6	-17.82

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
419	-108.0	124.2	26.71	-95.30
301	1.878	80.08	17.50	25.94
Center	24.18	-32.12	-2.677	15.95

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
419	103.2	487.0	-19.15	227.8
301	103.2	487.0	-19.15	227.8

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
419	202.5	803.3	304.7	403.3
301	-196.4	-779.2	-289.4	-391.2

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
419	305.7	1290.	285.6	631.0
301	-93.15	-292.2	-308.6	-163.4

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
419	-137.6	153.9	26.71	36.17
301	38.43	43.54	17.50	46.86
Center	25.64	-33.58	-2.677	-13.04

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
419	593.0	-2.691	-19.15
301	593.0	-2.691	-19.15

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
419	1598.	-2.356	285.6
301	-1.326	-384.0	-308.6

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
419	158.3	-142.1	26.71
301	87.91	-5.944	17.50
Center	28.38	-36.33	-2.677

Membrane Stress Intensity:

NODE	Intensity
419	612.1
301	612.1

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
419	1601.
301	382.7

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
419	300.4
301	93.85
Center	64.71

FEA Stress Analysis for SAFKEG 2863B

Appendix A2 COSMOS Output File - Can 2871

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 8 ****

Section end nodes: 562 & 155
Section orientation angle from X-axis: .00 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): -1.0000
KBR flag: 1

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
562	-56.98	536.5	1130.	-.7728E-02
155	-56.98	536.5	1130.	-.7728E-02

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
562	.0000	-.4762E-01	60.10	.0000
155	.0000	.4605E-01	-60.10	.0000

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
562	-56.98	536.4	1190.	-.7728E-02
155	-56.98	536.5	1070.	-.7728E-02

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
562	-62.92	.9351E-01	2.843	.8009E-02
155	57.05	-.9293E-01	3.044	.7643E-02
Center	1.582	.6761E-03	-1.582	-.4100E-02

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
562	536.5	-56.98	1130.
155	536.5	-56.98	1130.

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
562	536.4	-56.98	1190.
155	536.5	-56.98	1070.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
562	.9351E-01	-62.92	2.843
155	57.05	-.9293E-01	3.044
Center	1.582	.6655E-03	-1.582

Membrane Stress Intensity:

NODE	Intensity
562	1187.
155	1187.

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
562	1247.
155	1127.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
562	65.77
155	57.14
Center	3.165

FEA Stress Analysis for SAFKEG 2863B

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 9 ****

Section end nodes: 647 & 70
Section orientation angle from X-axis: .00 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): -1.0000
KBR flag: 1

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
647	-56.90	536.5	1102.	-5.074
70	-56.90	536.5	1102.	-5.074

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
647	.0000	26.19	65.71	.0000
70	.0000	-25.32	-65.71	.0000

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
647	-56.90	562.6	1168.	-5.074
70	-56.90	511.1	1037.	-5.074

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
647	-63.04	-.3349	2.847	4.936
70	57.00	.5941	3.241	4.949
Center	1.630	.3563	-1.637	-2.674

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
647	536.5	-56.94	1102.
70	536.5	-56.94	1102.

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
647	562.7	-56.94	1168.
70	511.2	-56.94	1037.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
647	.5134E-01	-63.42	2.847
70	57.43	.1632	3.241
Center	3.742	-1.755	-1.637

Membrane Stress Intensity:

NODE	Intensity
647	1159.
70	1159.

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
647	1225.
70	1094.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
647	66.27
70	57.27
Center	5.497

FEA Stress Analysis for SAFKEG 2863B

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 10 ****

Section end nodes: 698 & 19
Section orientation angle from X-axis: .84 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): -1.0000
KBR flag: 1

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
698	166.6	524.9	1876.	270.5
19	166.6	524.9	1876.	270.5

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
698	.0000	-2559.	-700.6	.0000
19	.0000	2473.	700.6	.0000

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
698	166.6	-2034.	1175.	270.5
19	166.6	2998.	2576.	270.5

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
698	-292.4	148.5	38.94	-295.7
19	82.09	687.6	132.3	554.9
Center	24.98	-194.2	-34.77	-66.36

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
698	158.8	532.7	1876.	265.2
19	158.8	532.7	1876.	265.2

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
698	-.5445	-2558.	-700.6	37.32
19	.5262	2472.	700.6	-36.07

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
698	158.2	-2025.	1175.	302.5
19	159.3	3005.	2576.	229.1

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
698	-283.7	139.8	38.94	-302.0
19	66.03	703.7	132.3	545.8
Center	26.87	-196.1	-34.77	-63.13

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
698	670.2	21.27	1876.
19	670.2	21.27	1876.

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
698	199.4	-2066.	1175.
19	3023.	141.0	2576.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
698	296.9	-440.8	38.94
19	1017.	-247.2	132.3
Center	43.50	-212.7	-34.77

Membrane Stress Intensity:

NODE	Intensity
698	1854.
19	1854.

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
698	3241.
19	2882.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
698	737.7
19	1264.
Center	256.2

FEA Stress Analysis for SAFKEG 2863B

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 11 ****

Section end nodes: 738 & 4677
Section orientation angle from X-axis: -2.73 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): -1.0000
KBR flag: 1

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
738	926.7	1151.	-95.47	93.05
4677	926.7	1151.	-95.47	93.05

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
738	.0000	6329.	2160.	.0000
4677	.0000	-6227.	-2160.	.0000

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
738	926.7	7479.	2064.	93.05
4677	926.7	-5076.	-2255.	93.05

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
738	4600.	843.8	1207.	5790.
4677	-951.5	369.4	212.8	38.18
Center	-60.59	-149.4	-82.12	-672.1

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
738	936.1	1141.	-95.47	103.3
4677	936.1	1141.	-95.47	103.3

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
738	14.37	6314.	2160.	301.2
4677	-14.14	-6213.	-2160.	-296.4

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
738	950.5	7456.	2064.	404.5
4677	922.0	-5072.	-2255.	-193.1

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
738	5142.	301.2	1207.	5585.
4677	-944.9	362.7	212.8	100.9
Center	-124.8	-85.22	-82.12	-673.3

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
738	1184.	893.1	-95.47
4677	1184.	893.1	-95.47

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
738	7481.	925.4	2064.
4677	928.2	-5078.	-2255.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
738	8809.	-3365.	1207.
4677	370.5	-952.6	212.8
Center	568.6	-778.6	-82.12

Membrane Stress Intensity:

NODE	Intensity
738	1280.
4677	1280.

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
738	6555.
4677	6006.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
738	.1217E+05
4677	1323.
Center	1347.

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 12 ****

Section end nodes: 3786 & 3776
Section orientation angle from X-axis: 90.00 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): -1.0000
KBR flag: 1

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
3786	-.1323	-.3413E-01	-756.9	-.9028E-02
3776	-.1323	-.3413E-01	-756.9	-.9028E-02

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
3786	.0000	-1.521	-4074.	.0000
3776	.0000	1.521	4074.	.0000

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
3786	-.1323	-1.555	-4831.	-.9028E-02
3776	-.1323	1.487	3317.	-.9028E-02

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
3786	.1190	-3.238	15.81	.3983
3776	.5803E-01	2.999	-15.80	.5581
Center	-.4079E-01	.3482	-.3723	.2260E-01

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
3786	-.3413E-01	-.1323	-756.9	.9028E-02
3776	-.3413E-01	-.1323	-756.9	.9028E-02

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
3786	-1.521	.0000	-4074.	.9312E-16
3776	1.521	.0000	4074.	-.9312E-16

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
3786	-1.555	-.1323	-4831.	.9028E-02
3776	1.487	-.1323	3317.	.9028E-02

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
3786	-3.238	.1190	15.81	-.3983
3776	2.999	.5803E-01	-15.80	-.5581
Center	.3482	-.4079E-01	-.3723	-.2260E-01

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
3786	-.3331E-01	-.1331	-756.9
3776	-.3331E-01	-.1331	-756.9

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
3786	-.1322	-1.555	-4831.
3776	1.487	-.1324	3317.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
3786	.1656	-3.285	15.81
3776	3.101	-.4434E-01	-15.80
Center	.3495	-.4210E-01	-.3723

Membrane Stress Intensity:

NODE	Intensity
3786	756.9
3776	756.9

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
3786	4831.
3776	3317.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
3786	19.10
3776	18.90
Center	.7218

FEA Stress Analysis for SAFKEG 2863B

Appendix A2 COSMOS Output File - Can 2871

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 13 ****

Section end nodes: 3814 & 3748
Section orientation angle from X-axis: 90.00 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): -1.0000
KBR flag: 1

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
3814	446.3	-255.8	-374.4	429.2
3748	446.3	-255.8	-374.4	429.2

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
3814	.0000	-185.6	-2206.	.0000
3748	.0000	185.6	2206.	.0000

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
3814	446.3	-441.3	-2580.	429.2
3748	446.3	-70.23	1831.	429.2

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
3814	-185.4	-147.9	-292.9	-141.7
3748	-532.5	36.53	6.000	-386.5
Center	100.3	-19.20	32.73	55.63

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
3814	-255.8	446.3	-374.4	-429.2
3748	-255.8	446.3	-374.4	-429.2

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
3814	-185.6	.0000	-2206.	.1136E-13
3748	185.6	.0000	2206.	-.1136E-13

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
3814	-441.3	446.3	-2580.	-429.2
3748	-70.23	446.3	1831.	-429.2

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
3814	-147.9	-185.4	-292.9	141.7
3748	36.53	-532.5	6.000	386.5
Center	-19.20	100.3	32.73	-55.63

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
3814	649.7	-459.2	-374.4
3748	649.7	-459.2	-374.4

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
3814	619.9	-614.9	-2580.
3748	688.9	-312.9	1831.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
3814	-23.75	-309.6	-292.9
3748	232.0	-728.0	6.000
Center	122.2	-41.09	32.73

Membrane Stress Intensity:

NODE	Intensity
3814	1109.
3748	1109.

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
3814	3200.
3748	2144.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
3814	285.8
3748	959.9
Center	163.3

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Appendix A2 COSMOS Output File - Can 2871

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 211 ****

Section end nodes: 739 & 779
Section orientation angle from X-axis: -4.01 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): -1.0000
KBR flag: 1

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
739	723.9	1360.	-91.33	192.5
779	723.9	1360.	-91.33	192.5

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
739	.0000	7561.	2370.	.0000
779	.0000	-7448.	-2370.	.0000

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
739	723.9	8922.	2279.	192.5
779	723.9	-6088.	-2462.	192.5

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
739	508.2	1712.	430.8	1679.
779	-771.1	836.1	244.9	111.9
Center	156.2	-732.2	-190.9	-465.1

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
739	753.9	1330.	-91.33	235.0
779	753.9	1330.	-91.33	235.0

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
739	36.94	7524.	2370.	527.2
779	-36.38	-7412.	-2370.	-519.3

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
739	790.8	8855.	2279.	762.2
779	717.5	-6082.	-2462.	-284.3

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
739	748.3	1472.	430.8	1747.
779	-747.7	812.7	244.9	222.8
Center	87.03	-663.0	-190.9	-522.5

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
739	1414.	670.2	-91.33
779	1414.	670.2	-91.33

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
739	8926.	719.4	2279.
779	729.3	-6093.	-2462.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
739	2894.	-673.7	430.8
779	843.9	-778.9	244.9
Center	355.2	-931.1	-190.9

Membrane Stress Intensity:

NODE	Intensity
739	1505.
779	1505.

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
739	8207.
779	6823.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
739	3568.
779	1623.
Center	1286.

SOLUTION TIME LOG IN SEC FOR STRESS CALCULATIONS

READING GENERAL INFORMATION AND ELEMENT DATA.	2
STRESS CALCULATION AND PRINTOUT	305
UPDATING DATABASE	0
TOTAL SOLUTION TIME	307

Appendix A3 Q_n Calculations - Can 2871

SECTION 1									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	2876	-2081	-59	-2075	-1	-59	-2081	-2075	2022
	2873	-2081	-59	-2075	-1	-59	-2081	-2075	2022
Bending	2876	-399	-76	-383	-4	-76	-399	-383	323
	2873	399	76	383	4	399	76	383	323
Membrane	2876	-2480	-135	-2458	-5	-135	-2480	-2458	2345
+ Bending	2873	-1683	17	-1693	3	17	-1683	-1693	1710
Peak	2876	-21	13	-5	5	14	-21	-5	35
	2873	1	-2	5	3	3	-4	5	9
	Center	5	-3	0	-2	6	-3	0	9
Total	2876	-2501	-122	-2463	0	-122	-2501	-2463	2379
	2873	-1682	15	-1688	6	15	-1682	-1688	1703
SECTION 2									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	2849	-328	-374	414	17	-322	-379	414	794
	2883	-328	-374	414	17	-322	-379	414	794
Bending	2849	1016	11	2736	105	1027	11	2736	2725
	2883	-897	-10	-2735	-92	0	-897	-2735	2735
Membrane	2849	688	-363	3150	122	702	-377	3150	3527
+ Bending	2883	-1225	-383	-2321	-75	-377	-1232	-2321	1944
Peak	2849	-661	368	-38	-116	381	-674	-38	1055
	2883	-1095	263	2	74	267	-1099	2	1366
	Center	449	-307	75	46	452	-310	75	762
Total	2849	27	5	3112	6	28	5	3112	3107
	2883	-2320	-120	-2319	-1	-120	-2320	-2319	2200
SECTION 3									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	2894	75	361	32	-48	369	67	32	337
	2830	75	361	32	-48	369	67	32	337
Bending	2894	-3174	-932	-2761	392	-865	-3174	-2761	2309
	2830	3174	932	2761	-392	3241	932	2761	2309
Membrane	2894	-3099	-571	-2728	344	-525	-3145	-2728	2620
+ Bending	2830	3249	1293	2793	-441	3344	1198	2793	2146
Peak	2894	273	450	167	-344	716	7	167	710
	2830	2542	2235	1147	-1758	4153	623	1147	3530
	Center	-199	-265	-89	188	-42	-423	-89	381
Total	2894	-2826	-121	-2561	1	-120	-2826	-2561	2706
	2830	5791	3528	3940	-2199	7132	3528	3940	3604

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SECTION 4									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	2979	-61	596	-284	-203	653	-119	-284	938
	2916	-61	596	-284	-203	653	-119	-284	938
Bending	2979	3925	1216	3016	-540	4028	1216	3016	2812
	2916	-3925	-1216	-3016	540	-1113	-3925	-3016	2812
Membrane	2979	3864	1811	2732	-743	4105	1571	2732	2534
+ Bending	2916	-3986	-620	-3300	336	-587	-4019	-3300	3432
Peak	2979	1848	2369	1111	-1692	3820	397	1111	3423
	2916	220	495	178	-333	718	-3	178	721
	Center	-228	-272	-123	214	-35	-465	-123	430
Total	2979	5712	4180	3843	-2435	7498	4180	3843	3655
	2916	-3766	-126	-3122	3	-126	-3766	-3122	3640
SECTION 5									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	2968	-14	-697	-67	-330	119	-830	-67	949
	2932	-14	-697	-67	-330	119	-830	-67	949
Bending	2968	4946	1105	3170	708	5072	1105	3170	3967
	2932	-4946	-1105	-3170	-708	-979	-4946	-3170	3967
Membrane	2968	4932	409	3102	378	4963	377	3102	4586
+ Bending	2932	-4960	-1802	-3237	-1038	-1492	-5271	-3237	3779
Peak	2968	-566	-404	-270	-375	-101	-868	-270	767
	2932	-5633	558	-1434	-1377	850	-5925	-1434	6775
	Center	393	250	176	216	549	94	176	454
Total	2968	4366	5	2832	4	4366	5	2832	4361
	2932	-10593	-1244	-4671	-2415	-657	-10593	-4671	9936
SECTION 6									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	360	1007	-68	1007	0	1007	-68	1007	1075
	366	1007	-68	1007	0	1007	-68	1007	1075
Bending	360	546	62	544	0	546	62	544	484
	366	-546	-62	-544	0	-62	-546	-544	484
Membrane	360	1553	-7	1551	0	1553	-7	1551	1560
+ Bending	366	461	-130	463	-1	461	-130	463	593
Peak	360	-8	9	-16	1	9	-8	-16	25
	366	-12	7	-5	1	7	-12	-5	19
	Center	6	-4	6	0	6	-4	6	9
Total	360	1545	2	1535	1	1545	2	1535	1543
	366	449	-123	458	0	449	-123	458	581

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SECTION 7									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	419	103	487	-19	228	593	-3	-19	612
	301	103	487	-19	228	593	-3	-19	612
Bending	419	203	803	305	403	1006	203	305	803
	301	-196	-779	-289	-391	0	-779	-289	779
Membrane	419	306	1290	286	631	1598	-2	286	1600
+ Bending	301	-93	-292	-309	-163	-1	-384	-309	383
Peak	419	-138	154	27	36	158	-142	27	300
	301	38	44	18	47	88	-6	18	94
	Center	26	-34	-3	-13	28	-36	-3	65
Total	419	168	1444	312	667	1729	168	312	1561
	301	-55	-249	-291	-117	0	-249	-291	291
SECTION 8									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	562	-57	537	1130	0	537	-57	1130	1187
	155	-57	537	1130	0	537	-57	1130	1187
Bending	562	0	0	60	0	0	0	60	60
	155	0	0	-60	0	0	0	-60	60
Membrane	562	-57	536	1190	0	536	-57	1190	1247
+ Bending	155	-57	537	1070	0	537	-57	1070	1127
Peak	562	-63	0	3	0	0	-63	3	66
	155	57	0	3	0	57	0	3	57
	Center	2	0	-2	0	2	0	-2	3
Total	562	-120	536	1193	0	536	-120	1193	1313
	155	0	536	1073	0	536	0	1073	1073
SECTION 9									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	647	-57	537	1102	-5	537	-57	1102	1159
	70	-57	537	1102	-5	537	-57	1102	1159
Bending	647	0	26	66	0	26	0	66	66
	70	0	-25	-66	0	0	-25	-66	66
Membrane	647	-57	563	1168	-5	563	-57	1168	1225
+ Bending	70	-57	511	1037	-5	511	-57	1037	1094
Peak	647	-63	0	3	5	0	-63	3	66
	70	57	1	3	5	57	0	3	57
	Center	2	0	-2	-3	4	-2	-2	5
Total	647	-120	562	1171	0	562	-120	1171	1291
	70	0	512	1040	0	512	0	1040	1040

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SECTION 10									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	698	159	533	1876	265	670	21	1876	1855
	19	159	533	1876	265	670	21	1876	1855
Bending	698	-1	-2558	-701	37	0	-2558	-701	2558
	19	1	2472	701	-36	2473	1	701	2472
Membrane	698	158	-2025	1175	303	199	-2066	1175	3241
+ Bending	19	159	3005	2576	229	3023	141	2576	2882
Peak	698	-284	140	39	-302	297	-441	39	738
	19	66	704	132	546	1017	-247	132	1264
	Center	27	-196	-35	-63	44	-213	-35	256
Total	698	-126	-1885	1214	1	-125	-1885	1214	3099
	19	225	3709	2708	775	3873	225	2708	3648
SECTION 11									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	738	936	1141	-95	103	1184	893	-95	1279
	4677	936	1141	-95	103	1184	893	-95	1279
Bending	738	14	6314	2160	301	6328	14	2160	6314
	4677	-14	-6213	-2160	-296	0	-6213	-2160	6213
Membrane	738	951	7456	2064	405	7481	925	2064	6556
+ Bending	4677	922	-5072	-2255	-193	928	-5078	-2255	6006
Peak	738	5142	301	1207	5585	8809	-3365	1207	12174
	4677	-945	363	213	101	371	-953	213	1323
	Center	-125	-85	-82	-673	569	-779	-82	1347
Total	738	6093	7757	3271	5990	12972	6093	3271	9701
	4677	-23	-4709	-2042	-92	-21	-4709	-2042	4688
SECTION 12									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	3786	0	0	-757	0	0	0	-757	757
	3776	0	0	-757	0	0	0	-757	757
Bending	3786	-2	0	-4074	0	0	-2	-4074	4074
	3776	2	0	4074	0	2	0	4074	4074
Membrane	3786	-2	0	-4831	0	0	-2	-4831	4831
+ Bending	3776	1	0	3317	0	1	0	3317	3317
Peak	3786	-3	0	16	0	0	-3	16	19
	3776	3	0	-16	-1	3	0	-16	19
	Center	0	0	0	0	0	0	0	1
Total	3786	-5	0	-4815	0	0	-5	-4815	4815
	3776	4	0	3301	-1	5	0	3301	3301

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SECTION 13									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	3814	-256	446	-374	-429	650	-459	-374	1109
	3748	-256	446	-374	-429	650	-459	-374	1109
Bending	3814	-186	0	-2206	0	0	-186	-2206	2206
	3748	186	0	2206	0	186	0	2206	2206
Membrane	3814	-441	446	-2580	-429	620	-615	-2580	3200
+ Bending	3748	-70	446	1831	-429	689	-313	1831	2144
Peak	3814	-148	-185	-293	142	-24	-310	-293	286
	3748	37	-533	6	387	232	-728	6	960
	Center	-19	100	33	-56	122	-41	33	163
Total	3814	-589	261	-2873	-288	349	-589	-2873	3222
	3748	-34	-86	1837	-43	-10	-86	1837	1923
SECTION 11a									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	739	754	1330	-91	235	1414	670	-91	1505
	779	754	1330	-91	235	1414	670	-91	1505
Bending	739	37	7524	2370	527	7561	37	2370	7524
	779	-36	-7412	-2370	-519	0	-7412	-2370	7412
Membrane	739	791	8855	2279	762	8926	719	2279	8207
+ Bending	779	718	-6082	-2462	-284	729	-6093	-2462	6822
Peak	739	748	1472	431	1747	2894	-674	431	3568
	779	-748	813	245	223	844	-779	245	1623
	Center	87	-663	-191	-523	355	-931	-191	1286
Total	739	1539	10327	2710	2509	10993	1539	2710	9454
	779	-30	-5269	-2217	-62	-29	-5269	-2217	5240

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Appendix B1 COSMOS Session File - Can 2870

COSMOS SESSION FILE - 2870-120.SES

C*

C* COSMOS/M Geostar V1.75

C* Problem : OCV120a Date : 7- 3-97 Time : 14:21: 8

C*

C* FILE,ocv1.ses,1,1,1,1

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PLANE,Z,0,1

C* Containment Vessel Geometry

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PT,3,4.313,-.862,0

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PT,5,3.313,-7.712,0

PT,6,3.313,-15.933,0

PT,7,0,-17.673,0

SCALE,0

PT,8,4.803,1.057,0

PT,9,4.803,.431,0

PT,10,4.803,0,0

PT,11,4.626,0,0

PT,12,3.976,0,0

PT,13,3.976,-3.460,0

PT,14,3.031,-7.712,0

PT,15,3.031,-15.933,0

PT,16,0,-17.391,0

PT,17,0,-15.933,0

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CRLINE,2,2,3

CRLINE,3,3,4

CRLINE,4,4,5

CRLINE,5,5,6

CRLINE,6,1,8

CRLINE,7,8,9

CRLINE,8,9,10

CRLINE,9,10,11

CRLINE,10,11,12

CRLINE,11,12,13

CRLINE,12,13,14

CRLINE,13,14,15

CRLINE,14,7,16

CRELLIPSE,15,15,16,17,4

CRELLIPSE,19,6,7,17,4

CRDEL,16,18,1

CRDEL,20,22,1

CRFILLET,20,2,3,.266,1,0,1E-006

CRFILLET,21,8,9,.039,1,0,1E-006

C* Lid Geometry

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PT,24,0,-.185,0
PT,25,3.9690,-.185,0
PT,26,3.9690,.01,0
PT,27,3.976,.01,0
PT,28,4.626,.01,0
PT,29,4.626,.404,0
PT,30,3.207,.404,0
PT,31,3.150,.404,0
PT,32,3.150,.675,0
PT,33,1.575,1.032,0
PT,34,1.575,.675,0
PT,35,.236,1.032,0
PT,36,.236,.126,0
PT,37,0,.126,0
CRLINE,22,24,25
CRLINE,23,25,26
CRLINE,24,26,27
CRLINE,25,27,28
CRLINE,26,28,29
CRLINE,27,29,30
CRLINE,28,30,31
CRLINE,29,31,32
CRLINE,30,32,34
CRLINE,31,34,33
CRLINE,32,33,35
CRLINE,33,35,36
CRLINE,34,36,37
CRLINE,35,37,24

C* Screw Ring Geomtry

PT,38,3.207,.414,0
PT,39,4.626,.414,0
PT,40,4.793,.414,0
PT,41,4.793,1.040,0
PT,42,3.207,1.040,0
CRLINE,36,42,41
CRLINE,37,41,40
CRLINE,38,40,39
CRLINE,39,39,38
CRLINE,40,38,42

C* Meshing

CT,1,0,.08,1,1,0
CT,2,0,.08,1,32,0
CT,3,0,.08,1,36,0
RG,1,1,1,0
RG,2,1,2,0
RG,3,1,3,0
EGROUP\,1,TRIANG,0,1,1,0,0,0,0,0
PICK_MAT,1,ST_304,FPS
C* MATL:ST_304 : STEEL,AISI 304(SHEET)

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C* EX 0.28E+08 psi
C* NUXY 0.29
C* GXY 0.11E+08 psi
C* ALPX 0.99E-05 /Fahrenheit
C* DENS 0.75E-03 lbf*s*s/in**4
C* KX 0.22E-03 BTU/in/s/F
C* C (Cp) 46. BTU*in/lbf/s/s/F
MA_RG,1,2,1,3,1,0
MA_RG,3,3,1,3,1,0

C* Creating Gap Elements

EGROUP,2,GAP,1,0,0,0,0,0,0
RCONST,2,1,1,7,0,0,0,0,1E+008,0,1
RCONST,2,1,1,7,0,0,10049875,0,1E+008,0,1
RCONST,2,2,1,7,0,0,10E6,0,1E+008,0,1
ACTSET,RC,1
EL,3779,CR,0,2,2105,554,0,0,0,0,0,0
EL,3780,CR,0,2,2106,553,0,0,0,0,0,0
EL,3781,CR,0,2,2107,552,0,0,0,0,0,0
EL,3782,CR,0,2,2108,551,0,0,0,0,0,0
EL,3783,CR,0,2,2109,550,0,0,0,0,0,0
EL,3784,CR,0,2,2110,549,0,0,0,0,0,0
EL,3785,CR,0,2,2111,548,0,0,0,0,0,0
EL,3786,CR,0,2,2112,547,0,0,0,0,0,0
EL,3787,CR,0,2,2113,546,0,0,0,0,0,0
ACTSET,RC,2
EL,3788,CR,0,2,529,1496,0,0,0,0,0,0
EL,3789,CR,0,2,530,1497,0,0,0,0,0,0
EL,3790,CR,0,2,531,1498,0,0,0,0,0,0
EL,3791,CR,0,2,532,1499,0,0,0,0,0,0
EL,3792,CR,0,2,537,1504,0,0,0,0,0,0
EL,3793,CR,0,2,538,1505,0,0,0,0,0,0
EL,3794,CR,0,2,1528,2134,0,0,0,0,0,0
EL,3795,CR,0,2,1527,2133,0,0,0,0,0,0
EL,3796,CR,0,2,1526,2132,0,0,0,0,0,0
EL,3797,CR,0,2,1525,2131,0,0,0,0,0,0
EL,3798,CR,0,2,1524,2130,0,0,0,0,0,0
EL,3799,CR,0,2,1523,2129,0,0,0,0,0,0
EL,3800,CR,0,2,1522,2128,0,0,0,0,0,0
EL,3801,CR,0,2,1521,2127,0,0,0,0,0,0
EL,3802,CR,0,2,1520,2126,0,0,0,0,0,0
EL,3803,CR,0,2,1519,2125,0,0,0,0,0,0
EL,3804,CR,0,2,1518,2124,0,0,0,0,0,0
EL,3805,CR,0,2,1517,2123,0,0,0,0,0,0
EL,3806,CR,0,2,1516,2122,0,0,0,0,0,0
EL,3807,CR,0,2,1515,2121,0,0,0,0,0,0
EL,3808,CR,0,2,1514,2120,0,0,0,0,0,0
EL,3809,CR,0,2,1513,2119,0,0,0,0,0,0
EL,3810,CR,0,2,1512,2118,0,0,0,0,0,0
EL,3811,CR,0,2,1511,2117,0,0,0,0,0,0
EL,3812,CR,0,2,1510,2116,0,0,0,0,0,0
CLS,1

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C* Applying Pressures

PCR,22,120,25,1,120,4
PCR,10,120,13,1,120,4
PCR,15,120,15,1,120,4
PEDEL,147,3,147,1
PEDEL,130,3,130,1
PEDEL,3793,2,3793,1
PEDEL,3455,2,3455,1
PEDEL,3450,2,3450,1
DND,156,UY,0,156,1,
ECHANGE,1,3812,1,1,0
NTND,1,450,20000,1
CLS,1
A_STATIC,N,0,1,1E-006,1E+010,0,0,0,0,0

C* Defining Stress Evaluation Locations

ASMESECDEF,1,1438,1442,25,0
ASMESECDEF,2,1423,1447,25,0
ASMESECDEF,2,1423,1447,25,1000,1
ASMESECDEF,3,1553,1462,25,0
ASMESECDEF,4,1529,1482,25,0
ASMESECDEF,5,1495,7619,25,0
ASMESECDEF,6,281,277,25,0
ASMESECDEF,7,322,5420,25,1.74,1
ASMESECDEF,8,430,123,25,-1,1
ASMESECDEF,9,487,66,25,-1,1
ASMESECDEF,10,37,515,25,-1,1
ASMESECDEF,11,541,2399,25,-1,1
ASMESECDEF,12,2134,2085,25,0
ASMESECDEF,13,2113,2105,25,0
ASMESECDEF,14,497,56,25,-1,1
ASMESECDEF,15,387,166,25,-1,1
A_STRESS,0,0,0,0,1,0,0,1
MPROP,1,EX,26.15E6

C* Applying O-ring Forces

FND,7738,FY,126.84,7738,1
FND,2659,FY,-126.84,2659,1
FND,7803,FY,135.12,7803,1
FND,2521,FY,-135.12,2521,1
CLS,1

C* Additional Gap Elements

ACTSET,RC,2
ACTSET,EG,2
EL,3813,CR,0,2,2774,7726,0,0,0,0,0,0
EL,3814,CR,0,2,2740,7712,0,0,0,0,0,0
EL,3815,CR,0,2,2701,7713,0,0,0,0,0,0
EL,3818,CR,0,2,2494,7811,0,0,0,0,0,0

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EL,3819,CR,0,2,7378,7941,0,0,0,0,0,0
EL,3820,CR,0,2,7416,7967,0,0,0,0,0,0
EL,3821,CR,0,2,7449,7993,0,0,0,0,0,0
EL,3822,CR,0,2,7479,8009,0,0,0,0,0,0
EL,3823,CR,0,2,7504,8034,0,0,0,0,0,0
EL,3824,CR,0,2,7529,8059,0,0,0,0,0,0
EL,3825,CR,0,2,7551,8084,0,0,0,0,0,0
EL,3826,CR,0,2,7573,8109,0,0,0,0,0,0
EL,3827,CR,0,2,7595,8134,0,0,0,0,0,0
EL,3828,CR,0,2,7619,8159,0,0,0,0,0,0
EL,3829,CR,0,2,7644,8184,0,0,0,0,0,0
EL,3830,CR,0,2,7671,8209,0,0,0,0,0,0
EL,3831,CR,0,2,7702,8234,0,0,0,0,0,0
EL,3832,CR,0,2,7734,8257,0,0,0,0,0,0
EL,3833,CR,0,2,7754,8277,0,0,0,0,0,0
EL,3834,CR,0,2,7770,8292,0,0,0,0,0,0
EL,3835,CR,0,2,7786,8304,0,0,0,0,0,0
EL,3836,CR,0,2,7802,8313,0,0,0,0,0,0
ACTSET,RC,1
EL,3837,CR,0,2,8236,2311,0,0,0,0,0,0
EL,3838,CR,0,2,8244,2310,0,0,0,0,0,0
EL,3839,CR,0,2,8258,2318,0,0,0,0,0,0
EL,3840,CR,0,2,8266,2324,0,0,0,0,0,0
EL,3841,CR,0,2,8283,2334,0,0,0,0,0,0
EL,3842,CR,0,2,8297,2344,0,0,0,0,0,0
EL,3843,CR,0,2,8308,2354,0,0,0,0,0,0
EL,3844,CR,0,2,8318,2364,0,0,0,0,0,0
A_STRESS,0,0,0,0,1,0,0,1

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| A. S. M. E.   S T R E S S   C H E C K   |
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**** LINEARIZED & PEAK STRESSES FOR SECTION: 1 ****

Section end nodes: 1438 & 1442
Section orientation angle from X-axis: -90.00 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): .00000
KBR flag: 0

Membrane Stresses (Section Coord.):
NODE   SIGMA-X1   SIGMA-X2   SIGMA-X3   TAU-X12
1438   -70.78     -1876.     -1875.     -1.640
1442   -70.78     -1876.     -1875.     -1.640

Bending Stresses (Section Coord.):
NODE   SIGMA-X1   SIGMA-X2   SIGMA-X3   TAU-X12
1438   78.60      658.8     654.7     -1.937
1442  -78.60     -658.8    -654.7      1.937

Linear (Membrane + Bending) Stresses (Section Coord.):
NODE   SIGMA-X1   SIGMA-X2   SIGMA-X3   TAU-X12
1438   7.823     -1218.     -1220.     -3.577
1442  -149.4     -2535.     -2530.      .2969

Peak (Actual-Linear) Stresses (Section Coord.):
NODE   SIGMA-X1   SIGMA-X2   SIGMA-X3   TAU-X12
1438   18.01      19.54     19.41     -5.973
1442   25.36     -1.606     3.404     -.7953E-01
Center -18.02     -1.131     .2316E-01  .9691

Membrane Stresses (Global Cart. Coord.):
NODE   SIGMA-X1   SIGMA-X2   SIGMA-X3   TAU-X12
1438   -1876.     -70.78     -1875.      1.640
1442   -1876.     -70.78     -1875.      1.640

Bending Stresses (Global Cart. Coord.):
NODE   SIGMA-X1   SIGMA-X2   SIGMA-X3   TAU-X12
1438   658.8      78.60     654.7      1.937
1442  -658.8     -78.60    -654.7     -1.937

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):
NODE   SIGMA-X1   SIGMA-X2   SIGMA-X3   TAU-X12
1438  -1218.      7.823     -1220.      3.577
1442  -2535.     -149.4     -2530.     -.2969

Peak (Actual-Linear) Stresses (Global Cart. Coord.):
NODE   SIGMA-X1   SIGMA-X2   SIGMA-X3   TAU-X12
1438   19.54     18.01     19.41      5.973
1442  -1.606     25.36     3.404     .7953E-01
Center -1.131    -18.02     .2316E-01  -.9691

Principal Membrane Stresses:
NODE   SIGMA-1     SIGMA-2     SIGMA-3
1438   -70.77     -1876.     -1875.
1442   -70.77     -1876.     -1875.

Principal Linear (Membrane+Bending) Stresses:
NODE   SIGMA-1     SIGMA-2     SIGMA-3
1438   7.833     -1218.     -1220.
1442  -149.4     -2535.     -2530.

Principal Peak (Actual-Linear) Stresses:
NODE   SIGMA-1     SIGMA-2     SIGMA-3
1438   24.80     12.75     19.41
1442   25.36     -1.606     3.404
Center -1.075     -18.07     .2316E-01

Membrane Stress Intensity:
NODE   Intensity
1438   1806.
1442   1806.

Linear (Membrane+Bending) Stress Intensity:
NODE   Intensity
1438   1228.
1442   2386.

Peak (Actual-Linear) Stress Intensity:
NODE   Intensity
1438   12.04
1442   26.96
Center 18.09

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 2 ****

Section end nodes: 1423 & 1447
Section orientation angle from X-axis: -82.47 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): 1000.0
KBR flag: 1

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1423	-74.66	-481.5	722.7	-39.91
1447	-74.66	-481.5	722.7	-39.91

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1423	.0000	1480.	3748.	.0000
1447	.0000	-1249.	-3747.	.0000

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1423	-74.66	998.7	4471.	-39.91
1447	-74.66	-1730.	-3024.	-39.91

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1423	75.42	-925.1	708.0	50.73
1447	-86.61	-751.7	495.9	-270.6
Center	-7.681	627.7	-335.3	30.29

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1423	-484.9	-71.28	722.7	-14.33
1447	-484.9	-71.28	722.7	-14.33

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1423	1455.	25.43	3748.	192.3
1447	-1227.	-21.46	-3747.	-162.3

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1423	969.9	-45.85	4471.	178.0
1447	-1712.	-92.73	-3024.	-176.6

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1423	-894.7	45.05	708.0	-179.0
1447	-810.6	-27.70	495.9	174.9
Center	624.6	-4.636	-335.3	53.31

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
1423	-70.78	-485.4	722.7
1447	-70.78	-485.4	722.7

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
1423	1000.	-76.14	4471.
1447	-73.70	-1731.	-3024.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
1423	77.98	-927.7	708.0
1447	9.606	-847.9	495.9
Center	629.1	-9.121	-335.3

Membrane Stress Intensity:

NODE	Intensity
1423	1208.
1447	1208.

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
1423	4547.
1447	2950.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
1423	1636.
1447	1344.
Center	964.4

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 3 ****

Section end nodes: 1553 & 1462
Section orientation angle from X-axis: -89.16 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): .00000
KBR flag: 0

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1553	614.9	123.2	-9.958	86.26
1462	614.9	123.2	-9.958	86.26

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1553	1364.	4543.	3547.	692.7
1462	-1364.	-4543.	-3547.	-692.7

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1553	1979.	4666.	3537.	779.0
1462	-749.5	-4420.	-3557.	-606.5

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1553	3057.	2732.	1433.	2484.
1462	624.1	309.1	224.9	544.2
Center	-366.9	-259.0	-134.3	-303.8

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1553	125.9	612.2	-9.958	-93.42
1462	125.9	612.2	-9.958	-93.42

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1553	4563.	1345.	3547.	-645.9
1462	-4563.	-1345.	-3547.	645.9

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1553	4689.	1957.	3537.	-739.3
1462	-4437.	-732.5	-3557.	552.5

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1553	2805.	2984.	1433.	-2488.
1462	325.1	608.1	224.9	-548.6
Center	-267.9	-358.0	-134.3	305.3

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
1553	629.6	108.5	-9.958
1462	629.6	108.5	-9.958

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
1553	4876.	1770.	3537.
1462	-651.8	-4518.	-3557.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
1553	5384.	404.8	1433.
1462	1033.	-99.94	224.9
Center	-4.378	-621.5	-134.3

Membrane Stress Intensity:

NODE	Intensity
1553	639.5
1462	639.5

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
1553	3106.
1462	3866.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
1553	4980.
1462	1133.
Center	617.2

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 4 ****

Section end nodes: 1529 & 1482
Section orientation angle from X-axis: -87.55 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): .00000
KBR flag: 0

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1529	908.8	-49.07	-452.9	284.5
1482	908.8	-49.07	-452.9	284.5

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1529	1851.	5364.	3908.	1025.
1482	-1851.	-5364.	-3908.	-1025.

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1529	2760.	5315.	3455.	1310.
1482	-942.6	-5413.	-4361.	-740.8

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1529	2697.	2950.	1542.	1981.
1482	805.3	316.0	296.6	516.6
Center	-469.7	-287.9	-196.8	-313.6

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1529	-23.02	882.8	-452.9	-324.4
1482	-23.02	882.8	-452.9	-324.4

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1529	5445.	1770.	3908.	-871.6
1482	-5445.	-1770.	-3908.	871.6

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1529	5422.	2653.	3455.	-1196.
1482	-5468.	-887.5	-4361.	547.2

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
1529	3119.	2529.	1542.	-1963.
1482	361.0	760.2	296.6	-535.7
Center	-315.0	-442.5	-196.8	320.2

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
1529	986.9	-127.2	-452.9
1482	986.9	-127.2	-452.9

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
1529	5867.	2208.	3455.
1482	-823.0	-5532.	-4361.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
1529	4809.	838.4	1542.
1482	1132.	-11.00	296.6
Center	-52.26	-705.3	-196.8

Membrane Stress Intensity:

NODE	Intensity
1529	1440.
1482	1440.

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
1529	3659.
1482	4709.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
1529	3971.
1482	1143.
Center	653.0

FEA Stress Analysis for SAFKEG 2863B

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 5 ****

Section end nodes: 7619 & 1495
Section orientation angle from X-axis: -88.10 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): .00000
KBR flag: 0

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
7619	-875.7	7.585	-106.5	553.5
1495	-875.7	7.585	-106.5	553.5

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
7619	1398.	5498.	3535.	-770.7
1495	-1398.	-5498.	-3535.	770.7

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
7619	522.1	5506.	3429.	-217.2
1495	-2274.	-5490.	-3642.	1324.

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
7619	-508.3	-643.3	-321.3	367.6
1495	-1856.	-6606.	-2402.	2389.
Center	275.0	455.1	200.8	-182.5

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
7619	43.33	-911.5	-106.5	-523.0
1495	43.33	-911.5	-106.5	-523.0

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
7619	5442.	1453.	3535.	905.0
1495	-5442.	-1453.	-3535.	-905.0

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
7619	5486.	542.0	3429.	382.0
1495	-5399.	-2365.	-3642.	-1428.

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
7619	-618.8	-532.8	-321.3	-371.2
1495	-6442.	-2019.	-2402.	-2541.
Center	442.8	287.3	200.8	188.1

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
7619	274.0	-1142.	-106.5
1495	274.0	-1142.	-106.5

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
7619	5515.	512.6	3429.
1495	-1799.	-5965.	-3642.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
7619	-202.1	-949.5	-321.3
1495	-862.3	-7599.	-2402.
Center	568.6	161.6	200.8

Membrane Stress Intensity:

NODE	Intensity
7619	1416.
1495	1416.

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
7619	5002.
1495	4167.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
7619	747.4
1495	6737.
Center	407.0

FEA Stress Analysis for SAFKEG 2863B

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 6 ****

Section end nodes: 281 & 277
Section orientation angle from X-axis: -90.00 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): .00000
KBR flag: 0

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
281	-68.53	1226.	1228.	.5175
277	-68.53	1226.	1228.	.5175

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
281	-61.87	-642.3	-632.2	-.1560E-01
277	61.87	642.3	632.2	.1560E-01

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
281	-130.4	584.1	595.6	.5019
277	-6.662	1869.	1860.	.5331

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
281	9.841	-13.66	-4.313	-3.236
277	9.979	-8.432	-18.37	-2.738
Center	-4.561	6.212	5.901	.5089E-02

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
281	1226.	-68.53	1228.	-.5175
277	1226.	-68.53	1228.	-.5175

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
281	-642.3	-61.87	-632.2	.1560E-01
277	642.3	61.87	632.2	-.1560E-01

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
281	584.1	-130.4	595.6	-.5019
277	1869.	-6.662	1860.	-.5331

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
281	-13.66	9.841	-4.313	3.236
277	-8.432	9.979	-18.37	2.738
Center	6.212	-4.561	5.901	-.5089E-02

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
281	1226.	-68.53	1228.
277	1226.	-68.53	1228.

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
281	584.1	-130.4	595.6
277	1869.	-6.662	1860.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
281	10.28	-14.09	-4.313
277	10.38	-8.830	-18.37
Center	6.212	-4.561	5.901

Membrane Stress Intensity:

NODE	Intensity
281	1296.
277	1296.

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
281	726.0
277	1875.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
281	24.37
277	28.75
Center	10.77

FEA Stress Analysis for SAFKEG 2863B

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 7 ****

Section end nodes: 322 & 5420
Section orientation angle from X-axis: -21.29 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): 1.7400
KBR flag: 1

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
322	6.069	674.4	-96.53	27.06
5420	6.069	674.4	-96.53	27.06

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
322	.0000	1199.	361.6	.0000
5420	.0000	-1166.	-342.9	.0000

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
322	6.069	1873.	265.1	27.06
5420	6.069	-491.7	-439.4	27.06

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
322	-115.7	139.4	28.35	-63.37
5420	-5.269	100.7	20.41	-28.43
Center	30.04	-40.48	-2.897	25.56

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
322	112.5	568.0	-96.53	246.1
5420	112.5	568.0	-96.53	246.1

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
322	158.1	1041.	361.6	405.6
5420	-153.8	-1012.	-342.9	-394.6

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
322	270.6	1609.	265.1	651.7
5420	-41.26	-444.4	-439.4	-148.5

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
322	-124.9	148.7	28.35	39.65
5420	-10.53	106.0	20.41	14.94
Center	38.03	-48.48	-2.897	-5.043

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
322	675.5	4.975	-96.53
5420	675.5	4.975	-96.53

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
322	1874.	5.677	265.1
5420	7.536	-493.2	-439.4

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
322	154.3	-130.5	28.35
5420	107.9	-12.41	20.41
Center	38.33	-48.77	-2.897

Membrane Stress Intensity:

NODE	Intensity
322	772.0
5420	772.0

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
322	1868.
5420	500.7

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
322	284.8
5420	120.3
Center	87.10

FEA Stress Analysis for SAFKEG 2863B

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 8 ****

Section end nodes: 430 & 123
Section orientation angle from X-axis: .00 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): -1.0000
KBR flag: 1

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
430	-28.96	615.2	1690.	81.36
123	-28.96	615.2	1690.	81.36

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
430	.0000	-563.9	-91.18	.0000
123	.0000	547.4	91.18	.0000

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
430	-28.96	51.30	1599.	81.36
123	-28.96	1163.	1781.	81.36

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
430	-94.02	23.37	10.23	-60.06
123	86.51	142.2	40.22	68.45
Center	.5091	-38.00	-9.970	-2.452

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
430	625.3	-39.07	1690.
123	625.3	-39.07	1690.

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
430	101.9	-79.55	1599.
123	1168.	-34.49	1781.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
430	48.65	-119.3	10.23
123	188.2	40.45	40.22
Center	.6647	-38.16	-9.970

Membrane Stress Intensity:

NODE	Intensity
430	1729.
123	1729.

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
430	1679.
123	1816.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
430	168.0
123	148.0
Center	38.82

FEA Stress Analysis for SAFKEG 2863B

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 9 ****

Section end nodes: 487 & 66
Section orientation angle from X-axis: -.31 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): -1.0000
KBR flag: 1

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
487	-48.78	680.8	1110.	57.76
66	-48.78	680.8	1110.	57.76

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
487	.0000	617.1	219.6	.0000
66	.0000	-600.6	-219.6	.0000

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
487	-48.78	1298.	1329.	57.76
66	-48.78	80.22	890.0	57.76

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
487	-77.68	-3.408	-.2782	-64.99
66	49.81	6.209	3.531	-55.43
Center	11.73	3.349	-1.279	34.05

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
487	-48.14	680.2	1110.	61.67
66	-48.14	680.2	1110.	61.67

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
487	.1774E-01	617.1	219.6	3.309
66	-.1727E-01	-600.6	-219.6	-3.220

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
487	-48.12	1297.	1329.	64.98
66	-48.16	79.60	890.0	58.45

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
487	-78.38	-2.713	-.2782	-64.59
66	49.22	6.804	3.531	-55.66
Center	12.09	2.984	-1.279	34.00

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
487	685.4	-53.32	1110.
66	685.4	-53.32	1110.

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
487	1300.	-51.25	1329.
66	102.3	-70.86	890.0

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
487	34.31	-115.4	-.2782
66	87.57	-31.55	3.531
Center	41.84	-26.76	-1.279

Membrane Stress Intensity:

NODE	Intensity
487	1163.
66	1163.

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
487	1380.
66	960.9

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
487	149.7
66	119.1
Center	68.61

FEA Stress Analysis for SAFKEG 2863B

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 10 ****

Section end nodes: 515 & 37
Section orientation angle from X-axis: 7.18 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): -1.0000
KBR flag: 1

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
515	188.7	614.5	1745.	241.0
37	188.7	614.5	1745.	241.0

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
515	.0000	-2028.	-588.9	.0000
37	.0000	1973.	588.9	.0000

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
515	188.7	-1414.	1156.	241.0
37	188.7	2587.	2334.	241.0

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
515	-337.6	70.36	36.67	-396.9
37	429.0	367.1	112.7	955.7
Center	-20.59	-114.1	-29.91	-117.2

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
515	135.6	667.6	1745.	180.7
37	135.6	667.6	1745.	180.7

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
515	-31.65	-1997.	-588.9	251.4
37	30.78	1942.	588.9	-244.5

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
515	103.9	-1329.	1156.	432.1
37	166.3	2609.	2334.	-63.77

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
515	-232.9	-34.37	36.67	-435.0
37	191.1	605.0	112.7	933.5
Center	7.005	-141.7	-29.91	-102.0

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
515	723.2	80.00	1745.
37	723.2	80.00	1745.

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
515	224.1	-1449.	1156.
37	2611.	164.7	2334.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
515	312.6	-579.8	36.67
37	1354.	-558.1	112.7
Center	58.85	-193.5	-29.91

Membrane Stress Intensity:

NODE	Intensity
515	1665.
37	1665.

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
515	2605.
37	2446.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
515	892.4
37	1912.
Center	252.4

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 11 ****

Section end nodes: 541 & 2399
Section orientation angle from X-axis: .96 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): -1.0000
KBR flag: 1

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
541	1216.	1033.	563.9	345.2
2399	1216.	1033.	563.9	345.2

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
541	.0000	8139.	2818.	.0000
2399	.0000	-7989.	-2818.	.0000

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
541	1216.	9172.	3382.	345.2
2399	1216.	-6956.	-2254.	345.2

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
541	2302.	2648.	945.1	3633.
2399	-1259.	789.6	383.6	-531.1
Center	-239.6	-477.9	-236.5	-594.6

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
541	1204.	1044.	563.9	348.0
2399	1204.	1044.	563.9	348.0

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
541	2.285	8137.	2818.	-136.4
2399	-2.243	-7987.	-2818.	133.8

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
541	1207.	9181.	3382.	211.7
2399	1202.	-6943.	-2254.	481.9

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
541	2180.	2769.	945.1	3625.
2399	-1241.	771.2	383.6	-565.1
Center	-219.7	-497.8	-236.5	-590.3

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
541	1481.	767.2	563.9
2399	1481.	767.2	563.9

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
541	9187.	1201.	3382.
2399	1230.	-6971.	-2254.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
541	6111.	-1162.	945.1
2399	919.0	-1389.	383.6
Center	247.6	-965.2	-236.5

Membrane Stress Intensity:

NODE	Intensity
541	917.6
2399	917.6

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
541	7986.
2399	8201.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
541	7274.
2399	2308.
Center	1213.

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 12 ****

Section end nodes: 2134 & 2085
Section orientation angle from X-axis: 90.00 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): .00000
KBR flag: 0

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2134	.5136E-01	-2.015	-995.2	.9546E-01
2085	.5136E-01	-2.015	-995.2	.9546E-01

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2134	-.6813E-01	-1.860	-3960.	.2282E-01
2085	.6813E-01	1.860	3960.	-.2282E-01

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2134	-.1677E-01	-3.875	-4955.	.1183
2085	.1195	-.1550	2965.	.7264E-01

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2134	.2099	-1.842	14.30	.2741
2085	.7172	2.639	-14.93	-.9224
Center	-.2628	-.5710E-01	-.4004E-01	.3019E-01

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2134	-2.015	.5136E-01	-995.2	-.9546E-01
2085	-2.015	.5136E-01	-995.2	-.9546E-01

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2134	-1.860	-.6813E-01	-3960.	-.2282E-01
2085	1.860	.6813E-01	3960.	.2282E-01

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2134	-3.875	-.1677E-01	-4955.	-.1183
2085	-.1550	.1195	2965.	-.7264E-01

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2134	-1.842	.2099	14.30	-.2741
2085	2.639	.7172	-14.93	.9224
Center	-.5710E-01	-.2628	-.4004E-01	-.3019E-01

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
2134	.5576E-01	-2.019	-995.2
2085	.5576E-01	-2.019	-995.2

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
2134	-.1315E-01	-3.879	-4955.
2085	.1375	-.1730	2965.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
2134	.2459	-1.878	14.30
2085	3.010	.3462	-14.93
Center	-.5277E-01	-.2671	-.4004E-01

Membrane Stress Intensity:

NODE	Intensity
2134	995.2
2085	995.2

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
2134	4955.
2085	2965.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
2134	16.17
2085	17.94
Center	.2271

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 13 ****

Section end nodes: 2113 & 2105
Section orientation angle from X-axis: 90.00 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): .00000
KBR flag: 0

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2113	-773.2	-291.0	-934.7	488.0
2105	-773.2	-291.0	-934.7	488.0

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2113	661.0	271.6	-2224.	-429.7
2105	-661.0	-271.6	2224.	429.7

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2113	-112.3	-19.35	-3158.	58.32
2105	-1434.	-562.6	1289.	917.8

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2113	164.0	75.46	73.85	-113.6
2105	580.0	312.2	287.2	-306.9
Center	-45.53	-49.61	-34.10	107.5

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2113	-291.0	-773.2	-934.7	-488.0
2105	-291.0	-773.2	-934.7	-488.0

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2113	271.6	661.0	-2224.	429.7
2105	-271.6	-661.0	2224.	-429.7

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2113	-19.35	-112.3	-3158.	-58.32
2105	-562.6	-1434.	1289.	-917.8

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
2113	75.46	164.0	73.85	113.6
2105	312.2	580.0	287.2	306.9
Center	-49.61	-45.53	-34.10	-107.5

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
2113	12.26	-1076.	-934.7
2105	12.26	-1076.	-934.7

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
2113	8.743	-140.4	-3158.
2105	17.60	-2014.	1289.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
2113	241.7	-2.168	73.85
2105	781.0	111.3	287.2
Center	59.92	-155.1	-34.10

Membrane Stress Intensity:

NODE	Intensity
2113	1089.
2105	1089.

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
2113	3167.
2105	3303.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
2113	243.8
2105	669.6
Center	215.0

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 14 ****

Section end nodes: 497 & 56
Section orientation angle from X-axis: -1.84 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): -1.0000
KBR flag: 1

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
497	-59.06	679.5	1484.	12.91
56	-59.06	679.5	1484.	12.91

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
497	.0000	.6581	67.22	.0000
56	.0000	-.6405	-67.22	.0000

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
497	-59.06	680.2	1552.	12.91
56	-59.06	678.9	1417.	12.91

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
497	-59.98	-2.469	2.020	-36.21
56	59.60	-4.165	2.136	-32.63
Center	.4284E-01	3.788	-.8206	20.75

Membrane Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
497	-57.46	677.9	1484.	36.61
56	-57.46	677.9	1484.	36.61

Bending Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
497	.6798E-03	.6574	67.22	.2114E-01
56	-.6616E-03	-.6398	-67.22	-.2058E-01

Linear (Membrane + Bending) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
497	-57.46	678.6	1552.	36.63
56	-57.46	677.3	1417.	36.59

Peak (Actual-Linear) Stresses (Global Cart. Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
497	-62.24	-.2017	2.020	-34.29
56	57.43	-2.003	2.136	-34.61
Center	1.380	2.451	-.8206	20.83

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
497	679.7	-59.28	1484.
56	679.7	-59.28	1484.

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
497	680.4	-59.28	1552.
56	679.1	-59.28	1417.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
497	15.01	-77.46	2.020
56	73.33	-17.90	2.136
Center	22.75	-18.92	-.8206

Membrane Stress Intensity:

NODE	Intensity
497	1544.
56	1544.

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
497	1611.
56	1476.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
497	92.47
56	91.23
Center	41.67

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**** LINEARIZED & PEAK STRESSES FOR SECTION: 15 ****

Section end nodes: 387 & 166
Section orientation angle from X-axis: .00 (degree)
No. of integration pts.: 25
Curvature-radius (RHO): -1.0000
KBR flag: 1

Membrane Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
387	-57.36	616.2	1285.	.2025
166	-57.36	616.2	1285.	.2025

Bending Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
387	.0000	-5.358	58.35	.0000
166	.0000	5.201	-58.35	.0000

Linear (Membrane + Bending) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
387	-57.36	610.9	1344.	.2025
166	-57.36	621.4	1227.	.2025

Peak (Actual-Linear) Stresses (Section Coord.):

NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12
387	-62.45	.2463E-01	2.326	-.1904
166	57.46	-.5340E-01	2.667	-.1944
Center	1.386	-.6045E-01	-1.383	.1048

Principal Membrane Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
387	616.2	-57.36	1285.
166	616.2	-57.36	1285.

Principal Linear (Membrane+Bending) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
387	610.9	-57.36	1344.
166	621.4	-57.36	1227.

Principal Peak (Actual-Linear) Stresses:

NODE	SIGMA-1	SIGMA-2	SIGMA-3
387	.2521E-01	-62.45	2.326
166	57.46	-.5405E-01	2.667
Center	1.394	-.6800E-01	-1.383

Membrane Stress Intensity:

NODE	Intensity
387	1343.
166	1343.

Linear (Membrane+Bending) Stress Intensity:

NODE	Intensity
387	1401.
166	1284.

Peak (Actual-Linear) Stress Intensity:

NODE	Intensity
387	64.78
166	57.51
Center	2.777

SOLUTION TIME LOG IN SEC FOR STRESS CALCULATIONS

READING GENERAL INFORMATION AND ELEMENT DATA.	=	1
STRESS CALCULATION AND PRINTOUT	=	128
UPDATING DATABASE	=	0
TOTAL SOLUTION TIME	=	129

Appendix B3 Q_n Calculations - Can 2870

SECTION 1									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	1438	-1876	-71	-1875	2	-71	-1876	-1875	1805
	1442	-1876	-71	-1875	2	-71	-1876	-1875	1805
Bending	1438	659	79	655	2	659	79	655	580
	1442	-659	-79	-655	-2	-79	-659	-655	580
Membrane	1438	-1218	8	-1220	4	8	-1218	-1220	1228
+ Bending	1442	-2535	-149	-2530	0	-149	-2535	-2530	2386
Peak	1438	20	18	19	6	25	13	19	12
	1442	-2	25	3	0	25	-2	3	27
	Center	-1	-18	0	-1	-1	-18	0	18
Total	1438	-1198	26	-1201	10	26	-1198	-1201	1226
	1442	-2537	-124	-2527	0	-124	-2537	-2527	2413
SECTION 2									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	1423	-485	-71	723	-14	-71	-485	723	1208
	1447	-485	-71	723	-14	-71	-485	723	1208
Bending	1423	1455	25	3748	192	1480	25	3748	3723
	1447	-1227	-21	-3747	-162	0	-1227	-3747	3747
Membrane	1423	970	-46	4471	178	1000	-76	4471	4547
+ Bending	1447	-1712	-93	-3024	-177	-74	-1731	-3024	2950
Peak	1423	-895	45	708	-179	78	-928	708	1636
	1447	-811	-28	496	175	10	-848	496	1344
	Center	625	-5	-335	53	629	-9	-335	964
Total	1423	75	-1	5179	-1	75	-1	5179	5180
	1447	-2523	-120	-2528	-2	-120	-2523	-2528	2408
SECTION 3									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	1553	126	612	-10	-93	630	109	-10	640
	1462	126	612	-10	-93	630	109	-10	640
Bending	1553	4563	1345	3547	-646	4688	1345	3547	3343
	1462	-4563	-1345	-3547	646	-1220	-4563	-3547	3343
Membrane	1553	4689	1957	3537	-739	4876	1770	3537	3106
+ Bending	1462	-4437	-733	-3557	553	-652	-4518	-3557	3866
Peak	1553	2805	2984	1433	-2488	5384	405	1433	4979
	1462	325	608	225	-549	1033	-100	225	1133
	Center	-268	-358	-134	305	-4	-622	-134	617
Total	1553	7494	4941	4970	-3227	9688	4941	4970	4747
	1462	-4112	-124	-3332	4	-124	-4112	-3332	3988

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SECTION 4									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	1529	-23	883	-453	-324	987	-127	-453	1440
	1482	-23	883	-453	-324	987	-127	-453	1440
Bending	1529	5445	1770	3908	-872	5641	1770	3908	3871
	1482	-5445	-1770	-3908	872	-1574	-5445	-3908	3871
Membrane	1529	5422	2653	3455	-1196	5867	2208	3455	3659
+ Bending	1482	-5468	-888	-4361	547	-823	-5532	-4361	4709
Peak	1529	3119	2529	1542	-1963	4809	838	1542	3971
	1482	361	760	297	-536	1132	-11	297	1143
	Center	-315	-443	-197	320	-52	-705	-197	653
Total	1529	8541	5182	4997	-3159	10439	5182	4997	5442
	1482	-5107	-127	-4064	12	-127	-5107	-4064	4980
SECTION 5									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	7619	43	-912	-107	-523	274	-1142	-107	1416
	1495	43	-912	-107	-523	274	-1142	-107	1416
Bending	7619	5442	1453	3535	905	5638	1453	3535	4185
	1495	-5442	-1453	-3535	-905	-1257	-5442	-3535	4185
Membrane	7619	5486	542	3429	382	5515	513	3429	5002
+ Bending	1495	-5399	-2365	-3642	-1428	-1799	-5965	-3642	4166
Peak	7619	-619	-533	-321	-371	-202	-950	-321	747
	1495	-6442	-2019	-2402	-2541	-862	-7599	-2402	6737
	Center	443	287	201	188	569	162	201	407
Total	7619	4867	9	3108	11	4867	9	3108	4858
	1495	-11841	-4384	-6044	-3969	-2667	-11841	-6044	9174
SECTION 6									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	281	1226	-69	1228	-1	1226	-69	1228	1297
	277	1226	-69	1228	-1	1226	-69	1228	1297
Bending	281	-642	-62	-632	0	-62	-642	-632	580
	277	642	62	632	0	642	62	632	580
Membrane	281	584	-130	596	-1	584	-130	596	726
+ Bending	277	1869	-7	1860	-1	1869	-7	1860	1876
Peak	281	-14	10	-4	3	10	-14	-4	24
	277	-8	10	-18	3	10	-9	-18	29
	Center	6	-5	6	0	6	-5	6	11
Total	281	570	-121	591	3	570	-121	591	712
	277	1861	3	1842	2	1861	3	1842	1857

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SECTION 7									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	322	113	568	-97	246	676	5	-97	772
	5420	113	568	-97	246	676	5	-97	772
Bending	322	158	1041	362	406	1199	158	362	1041
	5420	-154	-1012	-343	-395	0	-1012	-343	1012
Membrane	322	271	1609	265	652	1874	6	265	1868
+ Bending	5420	-41	-444	-439	-149	8	-493	-439	501
Peak	322	-125	149	28	40	154	-131	28	285
	5420	-11	106	20	15	108	-12	20	120
	Center	38	-48	-3	-5	38	-49	-3	87
Total	322	146	1758	293	691	2014	146	293	1868
	5420	-52	-338	-419	-134	1	-338	-419	420
SECTION 8									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	430	-29	615	1690	81	625	-39	1690	1729
	123	-29	615	1690	81	625	-39	1690	1729
Bending	430	0	-564	-91	0	0	-564	-91	564
	123	0	547	91	0	547	0	91	547
Membrane	430	-29	51	1599	81	102	-80	1599	1679
+ Bending	123	-29	1163	1781	81	1168	-34	1781	1815
Peak	430	-94	23	10	-60	49	-119	10	168
	123	87	142	40	68	188	40	40	148
	Center	1	-38	-10	-2	1	-38	-10	39
Total	430	-123	75	1609	21	77	-123	1609	1732
	123	58	1305	1821	150	1323	58	1821	1764
SECTION 9									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	487	-48	680	1110	62	685	-53	1110	1163
	66	-48	680	1110	62	685	-53	1110	1163
Bending	487	0	617	220	3	617	0	220	617
	66	0	-601	-220	-3	0	-601	-220	601
Membrane	487	-48	1297	1329	65	1300	-51	1329	1380
+ Bending	66	-48	80	890	58	102	-71	890	961
Peak	487	-78	-3	0	-65	34	-115	0	150
	66	49	7	4	-56	88	-32	4	119
	Center	12	3	-1	34	42	-27	-1	69
Total	487	-127	1294	1329	0	1294	-127	1329	1455
	66	1	86	894	3	86	1	894	892

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SECTION 10									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	515	136	668	1745	181	723	80	1745	1665
	37	136	668	1745	181	723	80	1745	1665
Bending	515	-32	-1997	-589	251	0	-1997	-589	1997
	37	31	1942	589	-245	1973	31	589	1942
Membrane	515	104	-1329	1156	432	224	-1449	1156	2605
+ Bending	37	166	2609	2334	-64	2611	165	2334	2446
Peak	515	-233	-34	37	-435	313	-580	37	892
	37	191	605	113	934	1354	-558	113	1912
	Center	7	-142	-30	-102	59	-194	-30	252
Total	515	-129	-1363	1193	-3	-129	-1363	1193	2556
	37	357	3214	2447	870	3458	357	2447	3101
SECTION 11									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	541	1204	1044	564	348	1481	767	564	917
	2399	1204	1044	564	348	1481	767	564	917
Bending	541	2	8137	2818	-136	8139	2	2818	8137
	2399	-2	-7987	-2818	134	0	-7987	-2818	7987
Membrane	541	1207	9181	3382	212	9187	1201	3382	7986
+ Bending	2399	1202	-6943	-2254	482	1230	-6971	-2254	8201
Peak	541	2180	2769	945	3625	6111	-1162	945	7273
	2399	-1241	771	384	-565	919	-1389	384	2308
	Center	-220	-498	-237	-590	248	-965	-237	1213
Total	541	3387	11950	4327	3837	13418	3387	4327	10031
	2399	-39	-6172	-1870	-83	-38	-6172	-1870	6134
SECTION 12									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	2134	-2	0	-995	0	0	-2	-995	995
	2085	-2	0	-995	0	0	-2	-995	995
Bending	2134	-2	0	-3960	0	0	-2	-3960	3960
	2085	2	0	3960	0	2	0	3960	3960
Membrane	2134	-4	0	-4955	0	0	-4	-4955	4955
+ Bending	2085	0	0	2965	0	0	0	2965	2965
Peak	2134	-2	0	14	0	0	-2	14	16
	2085	3	1	-15	1	3	0	-15	18
	Center	0	0	0	0	0	0	0	0
Total	2134	-6	0	-4941	0	0	-6	-4941	4941
	2085	2	1	2950	1	3	1	2950	2949

FEA Stress Analysis for SAFKEG 2863B
Appendix B3 Q_n Calculations - Can 2870

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SECTION 13									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	2113	-291	-773	-935	-488	12	-1076	-935	1088
	2105	-291	-773	-935	-488	12	-1076	-935	1088
Bending	2113	272	661	-2224	430	938	272	-2224	3162
	2105	-272	-661	2224	-430	5	-661	2224	2885
Membrane	2113	-19	-112	-3158	-58	9	-140	-3158	3167
+ Bending	2105	-563	-1434	1289	-918	18	-2014	1289	3303
Peak	2113	75	164	74	114	242	-2	74	244
	2105	312	580	287	307	781	111	287	670
	Center	-50	-46	-34	-108	60	-155	-34	215
Total	2113	56	52	-3084	55	109	52	-3084	3193
	2105	-250	-854	1576	-611	129	-854	1576	2430
SECTION 14									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	497	-57	678	1484	37	680	-59	1484	1543
	56	-57	678	1484	37	680	-59	1484	1543
Bending	497	0	1	67	0	1	0	67	67
	56	0	-1	-67	0	0	-1	-67	67
Membrane	497	-57	679	1552	37	680	-59	1552	1611
+ Bending	56	-57	677	1417	37	679	-59	1417	1476
Peak	497	-62	0	2	-34	15	-77	2	92
	56	57	-2	2	-35	73	-18	2	91
	Center	1	2	-1	21	23	-19	-1	42
Total	497	-120	678	1554	2	678	-120	1554	1674
	56	0	675	1419	2	675	0	1419	1419
SECTION 15									
	NODE	SIGMA-X1	SIGMA-X2	SIGMA-X3	TAU-X12	SIGMA-1	SIGMA-2	SIGMA-3	Intensity
Membrane	387	-57	616	1285	0	616	-57	1285	1342
	166	-57	616	1285	0	616	-57	1285	1342
Bending	387	0	-5	58	0	0	-5	58	64
	166	0	5	-58	0	5	0	-58	64
Membrane	387	-57	611	1344	0	611	-57	1344	1401
+ Bending	166	-57	621	1227	0	621	-57	1227	1284
Peak	387	-62	0	2	0	0	-62	2	65
	166	57	0	3	0	57	0	3	58
	Center	1	0	-1	0	1	0	-1	3
Total	387	-120	611	1346	0	611	-120	1346	1466
	166	0	621	1230	0	621	0	1230	1230