4 CONTAINMENT

This chapter identifies the AOS Transport Packaging System containment systems and describes how the Packages comply with the containment requirements of *10 CFR 71* **[4.1]**, under Normal Conditions of Transport (NCT) and Hypothetical Accident Conditions (HAC) of Transport, as well as *49 CFR 173* **[4.2]**, and the *International Atomic Energy Agency Safety Standards Series No. TS-R-1 (IAEA TS-R-1)* **[4.3]**.

4.1 DESCRIPTION OF THE CONTAINMENT SYSTEM

This section identifies and describes the AOS Transport Package containment systems, including the welds, seals, lids, cover plates, and closure devices. The AOS Transport Packaging System is designed to meet the "leak-tight" criteria specified the American National Standards Institute, *ANSI N14.5-2014* **[4.4]**, for the transportation of activated material in *Normal* and *Special Form*.

When the radioactive contents are encapsulated in *Special Form* sources, containment is provided by the sealed source. For *Normal Form* material, containment is provided by the cask's Containment Boundary, as described in the following section.

4.1.1 Containment Boundary

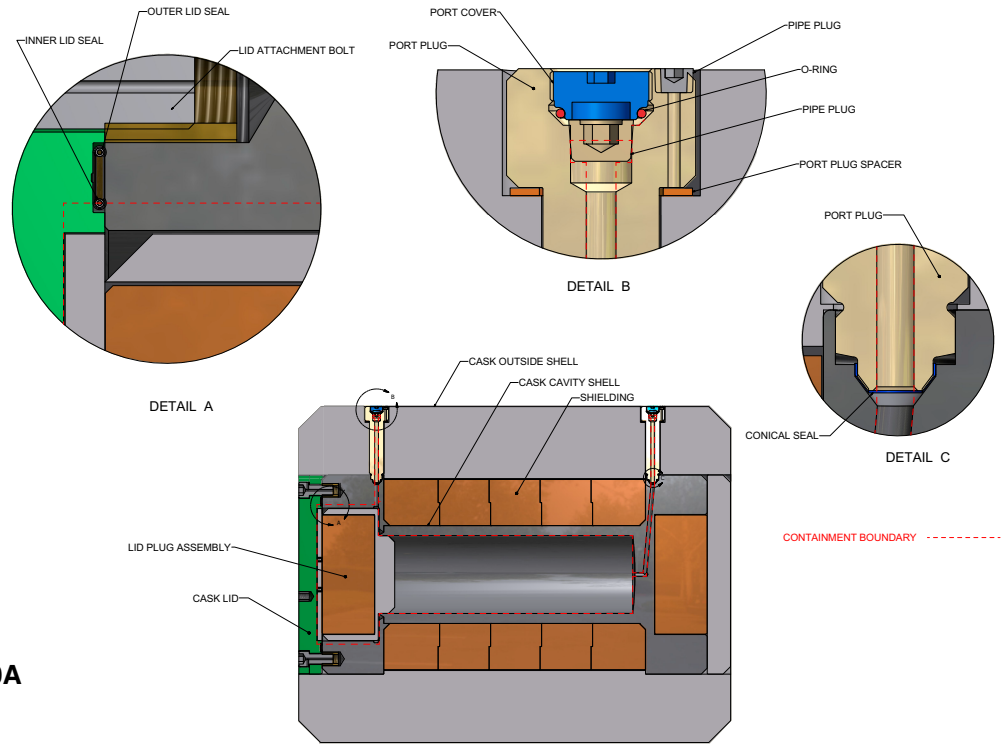
The AOS transport package containment boundary (located within the cask of the transport package) is composed of the following:

- Cask cavity shell
- Containment penetrations or port plug sub-assemblies
- Cask lid elastomeric and metallic seal components of the AOS Transport Packaging System cask

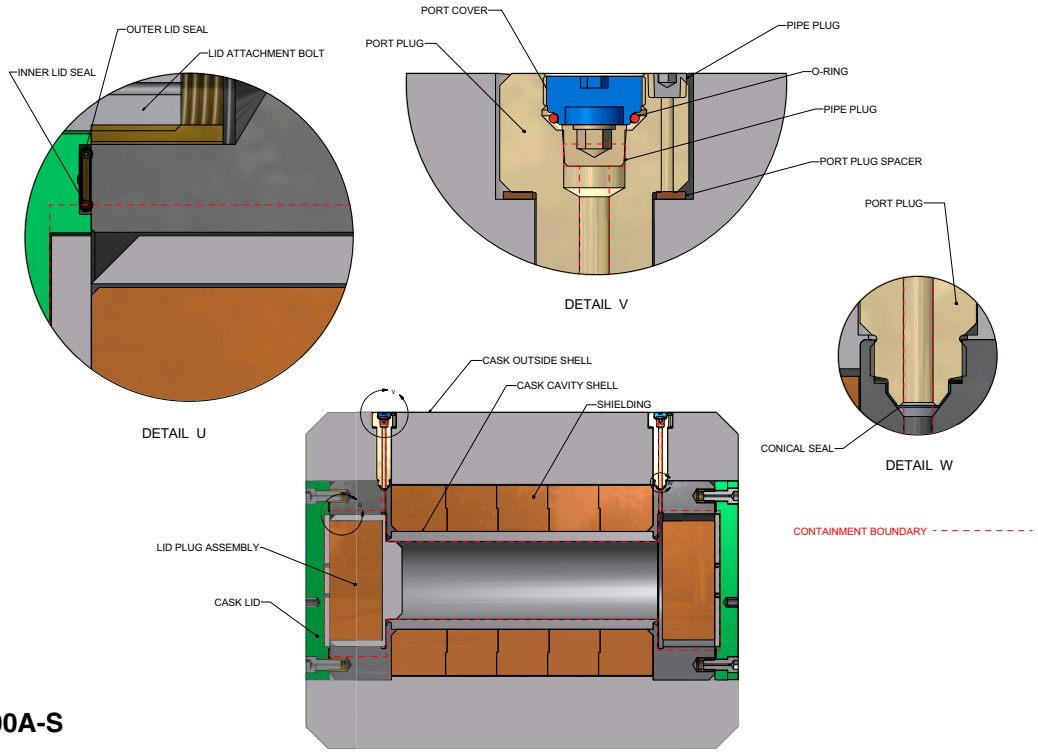
The containment boundary loops along the cask cavity shell walls and port plug walls, across the port opening, between its pipe plug and plug cover, through the cask lid material and across the cask lid seal joint between the two (2) retainer rings (elastomeric seal) or "C" cross-sections (metallic seal). The dashed lines in Figure 4-1 illustrate the containment boundary (located within the cask unit of the transport package).

The cask unit is constructed of 300 series stainless steel (SS300) material. Tungsten alloy or carbon steel material is embedded within the cask body and cask lid plug, to enhance the assembled cask shielding capability. Shielding material options are variable within the AOS Transport Packaging System models. There are two (2) penetrations into the cavity region of the cask – the cask drain port and cask vent port. These ports are comprised of a lower seal, a threaded pipe plug, a silicone material O-Ring, and a port cap, as discussed in Section 4.1.2.

The cask lid seals use either a pair of elastomeric O-Rings captured within one (1) or two (2) SS300 series flat rings, or a metallic double "C" cross-section arrangement, as discussed in Section 4.1.3. Figure 4-1 illustrates the general arrangement of these systems. The cask lid seals used on the AOS Transport Packaging System models are included in Appendix 4.5.1.



Model AOS-100A



Model AOS-100A-S

Figure 4-1. Containment Boundary (Cask Lid Metallic Seal Shown)

Note: *In Figure 4-1, the Model AOS-100A containment boundary illustration is a typical representation of the Model AOS-025A, AOS-050A, and AOS-100B containment boundaries.*

To protect the cask lid/cask lid seal joint, which is part of the containment boundary, during transport, the lid(s) is (are) recessed within the wall of the cask external body. The analytical results, presented throughout this SAR, indicate that the containment boundary (including the cask lid/cask lid seal joint) does not suffer any deformation that can impair its ability to contain the radioactive material content, as detailed in Chapter 2, "Structural Evaluation." These results were validated by a series of Free-Drop tests performed on the AOS-165A prototype packaging. The Free-Drop test results are presented in Appendix 2.12.6, "Impact (Free-Drop) Test Report."

The materials of construction used on the AOS containment boundary meet ASME Code **[4.5]** requirements, except for the cask lid seal materials. All AOS Transport Packaging System materials are listed in the applicable certification drawings, and documented in Section 2.3, "Fabrication and Examination."

A structural weld closes the containment boundary encasing the shielding material cylinders within the cask cavity shell and cask outer shell. The Model AOS-025, AOS-050, and AOS-100 transport packages use an ASME Code corner weld (Type C) joint design for this purpose. Figure 4-2 provides a typical illustration of a corner weld joint on the cask cavity shell.

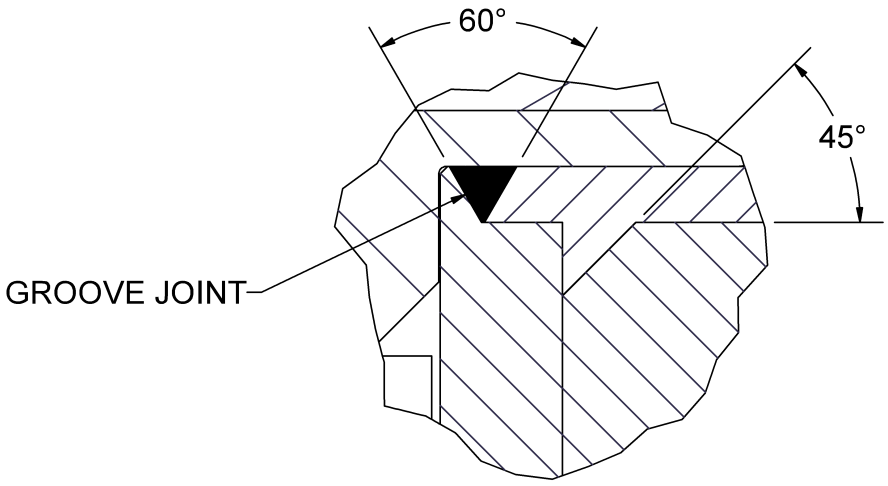


Figure 4-2. Typical Corner Cask Cavity Shell Weld Joint Configuration – All Models

4.1.2 Containment Penetrations (Port Plugs)

The AOS transport packages have two (2) containment penetrations:

- Two (2) penetration ports – the cask drain port and cask vent port. These ports consist of three (3) diametrical steps studded with a threaded end at the smaller diameter. Each of these port plugs connect to the cask cavity shell.

  In addition, there is one (1) penetration into the cask lid seal region, on top of the cask lid.
- One (1) penetration – leak testing port. The cask lid has a port that intersects the channel in the upper surface of the cask lid seal groove, which is provided to detect Helium in the gas stream.

For illustration purposes, Figure 4-3 shows the port plug for the Model AOS-100. A socket head pipe plug (which is located within the containment boundary), followed by a cap, close each penetration. An elastomeric O-Ring (Parker O-Ring Division, S1224-70 compound), attached to the cap, provides a redundant seal to these penetrations. In addition, there is a conduit that is used to verify the integrity of the port plug joint between the port plug and the cask body shells, which is covered by a threaded pipe plug.

Two components within the port assembly close the cask cavity chamber – (1) 3/8-18NPT pipe plug, which provides the primary containment for the drain and vent passages; and (2) 37° conical seal, which isolates the cask cavity from the shield material chamber. Both components have a secondary component. The pipe plug's secondary component is the port cover/O-Ring component. The 37° conical seal's secondary component is the 1/8-27NPT pipe plug. In addition to this isolation function, this pipe plug opening is used for leak testing verification of the 37° conical seal during the annual inspection.

The seal replacement schedule is as follows:

- **Metallic Seal** – Single use only.
- **Elastomeric Seal** – Once every twelve uses or every twelve (12) months, whichever comes first, or if damaged.
- **37° Conical Seal** – Only when damaged. This seal is expected to last a long time; however, it must be monitored during the periodic inspection. Replacement of this seal entails machining of the weld that secures the port plug in place, as well as removal of the port plug and its re-installation and testing, per original requirements. It is important to note that the port plug design was dropped three (3) times, without failure, during the 165 prototype's Drop Test. Therefore, it can be expected that Normal conditions of transport will have minimum impact on this seal.

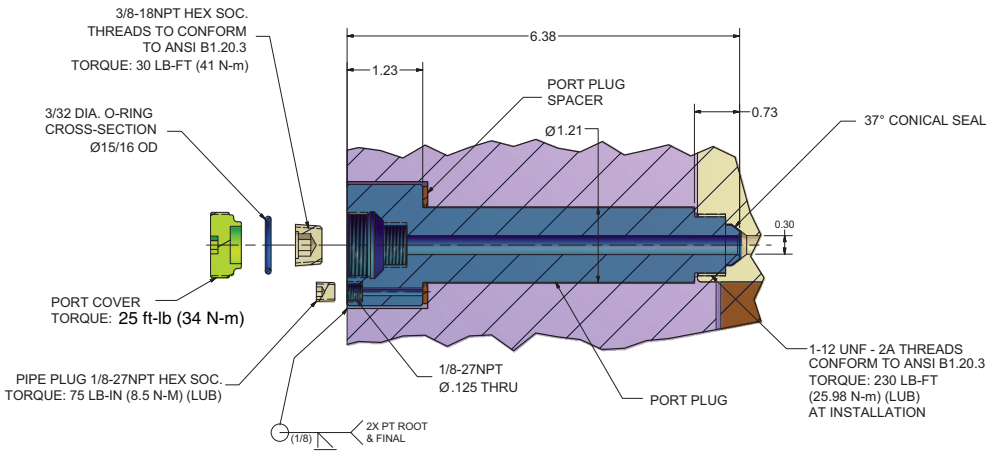


Figure 4-3. Typical Port Plug Configuration

Note: *All dimensions are in inches for the Model AOS-100.*

4.1.3 Cask Lid Seal

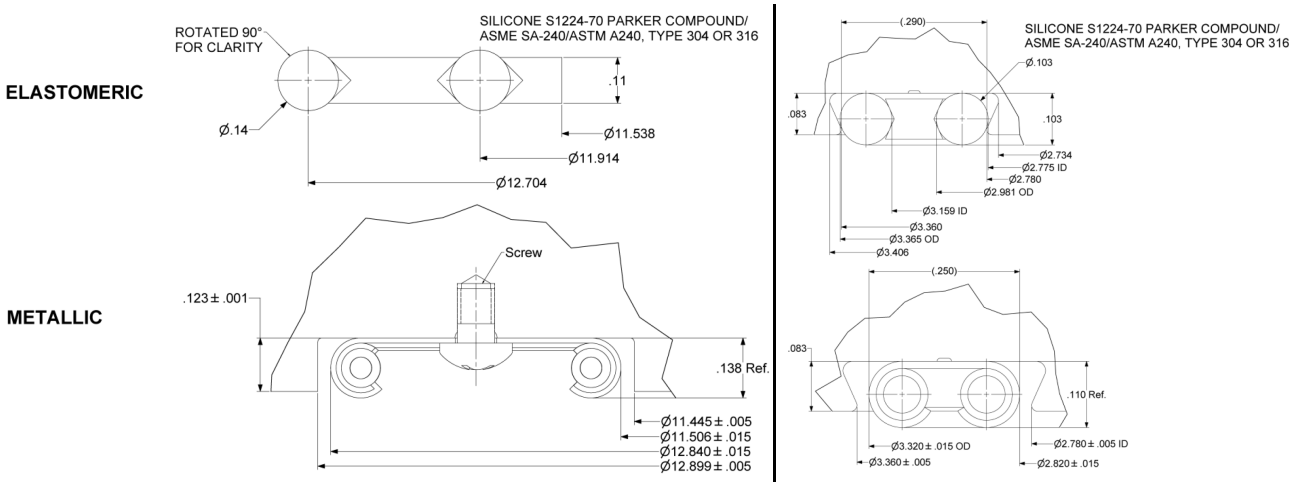
The AOS Transport Packaging System provides two (2) cask lid seal designs for the Model AOS-025A and AOS-050A, and all variations of the Model AOS-100:

- Pair of elastomeric O-Rings captured within either one (1) or two (2) flat metal retainer rings to form a unit, –or–
- Helicoflex metallic (silver, nickel-chromium alloy, and stainless steel) cask lid seal joint design, which includes a seal between the cask lid and cask cavity body

The Model AOS-025A and AOS-050A's cask lid metallic seals are of the same standard configuration as the other models. However, their elastomeric seal consists of two (2) O-Rings separated by a metal ring, which is captured within the dove-tailed groove that is machined onto the cask lid bottom surface.

The sealing principle of these seal options is based upon the deformation of the elastomeric O-Rings or, in the case of the metallic seal, of the jacket of greater ductility than the flange materials. This occurs between the sealing faces of the lid/cask body and O-Rings, for the elastomeric seal; and the elastic core comprised of a close-wound helical spring for the metallic seal. The spring has a specific compression resistance that prevents the seal from being crushed. During compression, the resulting specific pressure forces the jacket to yield and fill the flange surface imperfections, while ensuring positive contact with the flange sealing faces. Each helical spring coil functions independently, and allows the seal to conform to irregularities on the flange surface. The spring's compression resistance maintains the contact between the seal surface and the two (2) sealing surfaces.

Figure 4-4 illustrates the cask lid elastomeric and metallic seals. Appendix 4.5.1 contains manufacturer drawings of the AOS Transport Packaging System cask lid seals, by model.



Cask Lid Seals, Typical
(Dimensions shown are those of the Model AOS-100A)

Cask Lid Seals, Models AOS-025A and AOS-050A
(Dimensions shown are those of the Model AOS-025A)

Figure 4-4. Cask Lid Elastomeric and Metallic Seals

Notes: *The compression resistance of the elastomeric O-Ring or metallic double "C" cross-section's spring maintains the contact between the seal surface and surfaces being sealed.*

The dimensions (in inches) are those of the Model AOS-025A and AOS-100A transport packages.

The Model AOS-100's cask lid elastomeric seal, or the cask lid metallic seal for all models, is attached to the cask lid, inside its groove, by four (4) seal attachment screws. The screws are sized and installed in such a way as to prevent the screws from interfering with the deformation of the elastomeric O-Rings or metallic double "C" cross-sections when the cask lid attachment bolts are being tightened. The Model AOS-025 and AOS-050's cask lid elastomeric seal is captured within the seal groove by dove-tail profile, on the groove's side wall.

Figure 4-5 illustrates how the cask lid metallic seal is attached to the cask lid by four (4) small seal attachment screws. A callout for the hole used for leak testing is included in Figure 4-5, to differentiate it from the screws in the photograph.

Figure 4-5. Cask Lid Showing the Cask Lid Metallic Seal Installed – Attachment by way of Four (4) Screws, and Leak-Testing Hole

4.1.4 Closure

A set of cask lid attachment bolts, ASME SB-637, UNS N07718, attaches the cask lid to the cask lidmetallic seal (all models), or to the cask lid elastomeric seal (Model AOS-100, all variations). For Models AOS-025 and AOS-050, the cask lid elastomeric seal is captured within the dove-tailed groove that is machined onto the cask lid bottom surface. The cask lid bolted joint is recessed within the cask body, to protect the joint from transportation loads. The cask lid attachment bolt stress analysis followed the methodology and acceptance criteria specified in *NUREG/CR-6007* (Reference **[4.6]**), and a Fortran program (Appendix 4.5.2) was coded to facilitate the required calculations. The input information required by the program is listed in Table 4-1. The program's output (results) are summarized in Table 4-2. The actual input and output files used in conjunction with the program are provided in Appendix 4.5.3.

A bolting analysis is performed for Normal and Hypothetical Accident conditions of transport. Ambient conditions of 38°C (100°F) and -40°C (-40°F) are considered. The cask lid and cask lid attachment bolt head are protected in the cask lid design. Cask loadings for pressure, temperature, impact, and vibration are considered in this evaluation. Design conditions for minimum gasket loads and bolt preload are also considered. The Hypothetical Accident conditions of transport ambient temperature of 800°C (1,475°F) is a combination of fire and cool-down transient conditions, following a 30-ft. drop accident event. There are no impact accelerations associated with cool-down, and the evaluation results show that bolting loads are not significant.

Temperatures within the cask lid, cask lid attachment bolts, and cask are used to perform the evaluation, at the locations indicated in Figure 4-6.

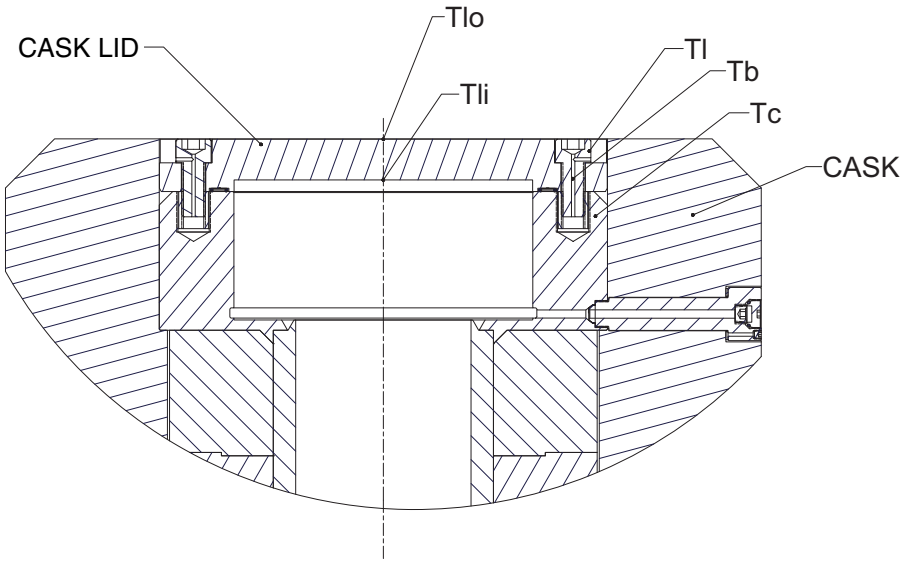


Figure 4-6. Cask Lid, Cask Lid Attachment Bolt, and Cask Temperature Evaluation Nodes

Note: *In Figure 4-6, the cask lid plug is removed for clarity.*

where:

Tb	=	Temperature of cask lid attachment bolt, node 4995
Tc	=	Temperature of cask wall, node 4995
Tl	=	Temperature of cask lid, node 3557
Tlo	=	Temperature of outside surface of cask lid, node 3309
Tli	=	Temperature of inside surface of cask lid, node 3233

Note: *All temperature changes are measured from the stress-free temperature (70°F).*

Normal Conditions of Transport, Maximum Stress Analysis

The following stress limits must be met, per *NUREG/CR-6007* (Reference **[4.6]**):

- Tension
  - Average stress < S_m (Allowable stress)
- Shear
  - Average stress < 0.6 S_m (Allowable stress)
- Tension plus shear
  - Stress ratio = Computed average stress/allowable average stress
  - Rt = Stress ratio for average tensile stress
  - Rs = Stress ratio for average shear stress
  - $Rt^2 + Rs^2 \leq 1.0$
- Tension plus shear plus bending plus residual torsion
  - For bolts having minimum tensile strength (S_u) greater than 100 ksi
  - Maximum stress intensity < 1.35 S_m

where:

S_m = Basic allowable stress limit for the bolt material,
equal to 2/3 of S_y at the room temperature –or–
2/3 of S_y at the operating temperature, whichever is less

S_y = Minimum yield stress or strength of the bolt material

Normal Conditions of Transport, Fatigue Stress Analysis

The following stress limits must be met, per *NUREG/CR-6007* (Reference **[4.6]**):

- Maximum cumulative usage factor (U) due to alternating stress intensity < 1.0
- For bolts with minimum yield strength greater than 100 ksi
  - Use ASME Code, Section III (Reference **[4.5]**), Appendix I, fatigue curves I-9-4

Hypothetical Accident Conditions of Transport, Maximum Stress Analysis

The following stress limits must be met, per *NUREG/CR-6007* (Reference **[4.6]**):

- Tension
  - Average stress < The smaller of 0.7 S_u or S_y at temperature (Allowable stress)
- Shear
  - Average stress < The smaller of 0.42 S_u or 0.6 S_y at temperature (Allowable stress)
- Tension plus shear
  - Stress ratio = Computed average stress/allowable average stress
  - Rt = Stress ratio for average tensile stress
  - Rs = Stress ratio for average shear stress
  - $Rt^2 + Rs^2 \leq 1.0$

where:

S_u = Minimum ultimate stress or strength of the bolt material

Table 4-1. Cask Lid Attachment Bolt Features and Properties Used for Fortran Program Input – All Models[a]

Item	Model and Ambient Temperatures, by Condition[b, c]					
	AOS-025		AOS-050		AOS-100	
	38°C (100°F)	-40°C (-40°F)	38°C (100°F)	-40°C (-40°F)	38°C (100°F)	-40°C (-40°F)
Geometry Definitions						
Seal Type (Cask Lid)[d]	Metallic	Metallic	Metallic	Metallic	Metallic	Metallic
Quantity of Bolts	8	8	10	10	14	14
Cask Lid Diameter at Bolt Line (in.)	3.9	3.9	7.414	7.414	14.064	14.064
Arc Length per Bolt (in.)	1.53	1.53	2.33	2.33	3.16	3.16
Cask Lid Diameter at Gasket (in.)	3.07	3.07	6.09	6.09	12.172	12.172
Bolt Diameter (in.)	0.375	0.375	0.5	0.5	0.875	0.875
Cask Lid Diameter – Inside (in.)	2.63	2.63	5.53	5.53	11.04	11.04
Cask Lid Diameter – Outside (in.)	4.65	4.65	8.90	8.90	16.59	16.59
Cask Lid Thickness (in.)	0.37	0.37	0.75	0.75	1.51	1.51
Cask Lid Flange Thickness (in.)	0.48	0.48	0.97	0.97	1.94	1.94
Cask Wall Thickness (in.)	1.03	1.03	1.705	1.705	2.805	2.805
Bolt Length (in.)	0.15	0.15	0.41	0.41	1.06	1.06
Bolt Momentum of Inertia (in^4)	0.001	0.001	0.003	0.003	0.02	0.02

Table 4-1. Cask Lid Attachment Bolt Features and Properties Used for Fortran Program Input – All Models[a] (Continued)

Item	Model and Ambient Temperatures, by Condition[b, c]					
	AOS-025		AOS-050		AOS-100	
	38°C (100°F)	-40°C (-40°F)	38°C (100°F)	-40°C (-40°F)	38°C (100°F)	-40°C (-40°F)
Material Properties (Provided at the component temperature resulting from the specified Thermal Condition)						
Young Modulus – Cask Lid (psi)	27.3E+06	28.3E+06	27.1E+06	28.3E+06	27.1E+06	28.3E+06
Young Modulus – Flange (psi)	27.3E+06	28.3E+06	27.1E+06	28.3E+06	27.1E+06	28.3E+06
Young Modulus – Cask (psi)	27.3E+06	28.3E+06	27.1E+06	28.3E+06	27.1E+06	28.3E+06
Young Modulus – Bolt (psi)	28.0E+06	29.1E+06	27.9E+06	28.9E+06	27.9E+06	28.9E+06
Poisson's Ratio – Cask Lid	0.3	0.3	0.3	0.3	0.3	0.3
Poisson's Ratio – Cask	0.3	0.3	0.3	0.3	0.3	0.3
Cask Lid – CTE, in/in/°F	9.0E-06	8.6E-06	9.0E-06	8.6E-06	9.1E-06	8.6E-06
Bolt – CTE, in/in/°F	7.2E-06	7.0E-06	7.3E-06	7.0E-06	7.3E-06	7.0E-06
Cask Wall – CTE, in/in/°F	9.0E-06	8.6E-06	9.0E-06	8.6E-06	9.1E-06	8.6E-06
Flange Coefficient Friction[e]	0.9	0.9	0.9	0.9	0.9	0.9
S_m (ksi)	95	100	94	100	94	100
S_y (ksi)	142	150	141	150	141	150
S_u (ksi)	175	185	174	185	174	185
Code Evaluation Options (Select 1 or 2)[f]	1/2	1/2	1/2	1/2	1/2	1/2

Table 4-1. Cask Lid Attachment Bolt Features and Properties Used for Fortran Program Input – All Models[a] (Continued)

Item	Model and Ambient Temperatures, by Condition[b, c]					
	AOS-025		AOS-050		AOS-100	
	38°C (100°F)	-40°C (-40°F)	38°C (100°F)	-40°C (-40°F)	38°C (100°F)	-40°C (-40°F)
Mechanical Loads						
Inside Pressure at Cask Lid (psia)	30	30	60	60	280	280
Outside Pressure at Cask Lid (psia)	15	15	15	15	15	15
Inside Pressure at Wall (psia)	30	30	60	60	280	280
Outside Pressure at Cask Wall (psia)	15	15	15	15	15	15
Temperature Change across Cask Lid	103°C (185°F)	-19°C (-34°F)	120°C (216°F)	8°C (15°F)	124°C (223°F)	9°C (15°F)
Temperature Change across Bolt	103°C (185°F)	-19°C (-34°F)	120°C (216°F)	8°C (15°F)	124°C (223°F)	9°C (15°F)
Temperature Change across Cask Wall	103°C (185°F)	-19°C (-34°F)	120°C (216°F)	8°C (15°F)	124°C (223°F)	9°C (15°F)
Temperature Change at outside of Cask Lid	103°C (185°F)	-19°C (-34°F)	120°C (216°F)	8°C (15°F)	124°C (224°F)	9°C (16°F)
Temperature Change at inside of Cask Lid	103°C (185°F)	-19°C (-34°F)	120°C (216°F)	9°C (16°F)	124°C (224°F)	9°C (16°F)
Weight of Cask Contents + (Plug Weight) (lbs.)	10 + 4 = 14	10 + 4 = 14	60 + 35 = 95	60 + 35 = 95	500 + 278 = 778	500 + 278 = 778
Weight of Cask Lid (lbs.)	2	2	12	12	99	99

Table 4-1. Cask Lid Attachment Bolt Features and Properties Used for Fortran Program Input – All Models[a] (Continued)

Item	Model and Ambient Temperatures, by Condition[b, c]					
	AOS-025		AOS-050		AOS-100	
	38°C (100°F)	-40°C (-40°F)	38°C (100°F)	-40°C (-40°F)	38°C (100°F)	-40°C (-40°F)
Mechanical Loads (Continued)						
Head-On Drop						
Drop Angle of Impact (Degrees)	90	90	90	90	90	90
Impact Acceleration (g)[g]	883	1,237	314	439	156	218
Side Drop						
Drop Angle of Impact (Degrees)	0	0	0	0	0	0
Impact Acceleration (g)[g]	1,286	1,798	335	469	171	240
Cg/Corner Drop						
Drop Angle of Impact (Degrees)	45	45	45	45	45	45
Impact Acceleration (g)[g]	799	1,125	176	247	88	124
Dynamic Load Factor	1.15	1.15	1.15	1.15	1.15	1.15
Puncture Load	0	0	0	0	0	0
Puncture Angle of Impact (Degrees)	0	0	0	0	0	0
Axial Vibration Acceleration (g)[h]	10	10	10	10	10	10
Transverse Vibration Acceleration (g)	5	5	5	5	5	5
Vibration Transmissibility	1.0	1.0	1.0	1.0	1.0	1.0
Preload Torque (ft-lb)[i]	35	35	62.5	62.5	500	500
Nut Factor for Preload Torque	0.15	0.15	0.15	0.15	0.15	0.15
Gasket Seating Width (in.)	1.0	1.0	1.0	1.0	1.0	1.0
Gasket Seating Stress (psi)	3,000	3,000	3,000	3,000	3,000	3,000
Gasket Factor[j]	9.53	9.53	3.18	3.18	0.54	0.54

Table 4-1. Cask Lid Attachment Bolt Features and Properties Used for Fortran Program Input – All Models[a] (Continued)

Item	Model and Ambient Temperatures, by Condition[b, c]					
	AOS-025		AOS-050		AOS-100	
	38°C (100°F)	-40°C (-40°F)	38°C (100°F)	-40°C (-40°F)	38°C (100°F)	-40°C (-40°F)
Geometry Loads						
Fatigue Stress for Normal Operation (ksi)	142	150	141	150	141	150
Fatigue Stress for Vibration (ksi)	13	13	13	13	13	13
Number of Threads per Inch	16	16	13	13	9	9

a. The actual files used as input to the Fortran program are provided in Appendix 4.5.3.1.

b. The conditions are defined in Table 3-1, "Transport Package Thermal Environment Conditions – All Models."

c. Temperature changes are measured from the stress-free temperature of 70°F.

d. Garlock Helicoflex drawing numbers H-309854 (Model AOS-025), H-309852 (Model AOS-050), and H309850 (Model AOS-100). Only the cask lid metallic seal was considered in this analysis, because it requires a higher gasket factor than the cask lid elastomeric seal.

e. Used in bolt flange friction force computation.

f. Code evaluation options are as follows – 1 = Normal, 2 = Hypothetical Accident.

g. Accelerations are obtained from the impact forces defined in the drop analysis results provided in Paragraph 2.7.1.5.2.1, "Impact Load Tables."

h. Normal conditions of transport accelerations, g, are:

Axial 10

Lateral 5

i. Recommended bolt torque:

7/8"-9 500 ft-lb

1/2"-13 62.5 ft-lb

3/8"-16 35 ft-lb

j. Helicoflex spring seal (cask lid metallic seal), per Helicoflex calculations, for gasket factor, m:

Model AOS-025 cask $m = Y1 / (2 * \Delta P) = 286 / (2 * (30 - 15)) = 9.53$

Model AOS-050 cask $m = Y1 / (2 * \Delta P) = 286 / (2 * (60 - 15)) = 3.18$

Model AOS-100 cask $m = Y1 / (2 * \Delta P) = 286 / (2 * (280 - 15)) = 0.54$

where:

$Y1$ = *Linear load on the seal, to maintain sealing in service at low pressure*

ΔP = *Pressure inside the cask cavity*

Table 4-2. Cask Lid Attachment Bolt Fortran Program Results Summary – All Models[a, b]

Item	Model and Ambient Temperatures, by Condition[c]					
	AOS-025		AOS-050		AOS-100	
	38°C (100°F)	-40°C (-40°F)	38°C (100°F)	-40°C (-40°F)	38°C (100°F)	-40°C (-40°F)
Bolt size (in.)	3/8		1/2		7/8	
Number of threads per in.	16		13		9	
Number of Bolts	8		10		14	
Torque, ft-lb	35		62.5		500	
Normal Conditions of Transport						
Axial Stress / S_m	0.09	0.08	0.18	0.14	0.41	0.36
Shear Stress / 0.6 S_m	0.30	0.29	0.22	0.21	0.30	0.28
$Rt^2 + Rs^2$	0.10	0.09	0.08	0.06	0.26	0.21
Se / 1.35 S_m	0.55	0.52	0.47	0.42	0.90	0.82
Accumulated Fatigue Usage	0.10	0.09	0.24	0.19	0.66	0.60
Hypothetical Accident Conditions of Transport						
Head-On Drop						
Axial Stress / 0.7 S_u	0.68	0.87	0.71	0.86	0.81	0.92
Shear Stress / 0.42 S_u	0.23	0.22	0.17	0.16	0.23	0.22
$Rt^2 + Rs^2$	0.52	0.80	0.53	0.77	0.71	0.89
Side Drop						
Axial Stress / 0.7 S_u	0.07	0.06	0.13	0.11	0.32	0.27
Shear Stress / 0.42 S_u	0.23	0.22	0.17	0.16	0.23	0.22
$Rt^2 + Rs^2$	0.06	0.05	0.05	0.04	0.15	0.12
Cg/Corner Drop						
Axial Stress / 0.7 S_u	0.46	0.58	0.36	0.41	0.51	0.53
Shear Stress / 0.42 S_u	0.23	0.22	0.17	0.16	0.23	0.22
$Rt^2 + Rs^2$	0.27	0.38	0.16	0.19	0.32	0.33

a. The Fortran program used to analyze the cask lid attachment bolts, in accordance with NUREG/CR-6007 (Reference **[4.6]***) is provided in Appendix 4.5.2.*

b. The actual files generated as output from the Fortran program are provided in Appendix 4.5.3.

c. The conditions are defined in Table 3-1, "Transport Package Thermal Environment Conditions – All Models."

4.1.5 Keensert Device Evaluation

This subsection documents the evaluation of the Keensert devices used in the cask lid component, for each AOS Transport Packaging System model. The methodology used in the evaluation was taken from References **[4.7]** and **[4.8]**. The insert material is Type 303 or 303SE.

The critical areas of stress to the mating screw threads are as follows:

a. Effective cross-sectional area;
b. Shear area of the external thread; and
c. Shear area of the internal thread.

If failure should occur, it is preferable for the screw to break, rather than to have the external or internal thread strip. To prevent stripping of the external thread, the length of engagement should be not less than:

$$L_e = 2 * A_t / \{3.1416 * K_n max * [1/2 + 0.57735 * n * (E_s min - K_n max)]\}$$

The tensile area, A_t, is given by:

- For steels of up to 100,000 psi ultimate tensile strength:

$$A_t = 0.7854 * (D - 0.9743 / n)^2$$

- For steels of more than 100,000 psi ultimate tensile strength:

$$A_t = 3.1416 * (E_s min / 2 - 0.16238 / n)^2$$

If the internal thread is made of material of a lower strength than the external thread, it is necessary to determine whether stripping of the internal thread occurs before the screw breaks. The relative strength of the external and internal threads is represented as the factor J, and is defined as:

$$J = A_s * S_u ext / (A_n * S_u int)$$

where:

$$A_s = 3.1416 * n * L_e * K_n max * [1 / (2 * n) + 0.57735 * (E_s min - K_n max)]$$

$$A_n = 3.1416 * n * L_e * D_s min * [1 / (2 * n) + 0.57735 * (D_s min - E_n max)]$$

If J is less than or equal to 1, the length of engagement, L_e, is adequate to prevent stripping of the internal thread. If J is greater than 1, the required length of engagement, Q, that is needed to prevent stripping of the internal thread is:

$$Q = J * L_e$$

To compute the pull-out strength in any parent material, use the following formula:

$$F_{po} = SEA * S_{upm}$$

The parameters used above are defined as:

A_n	=	Shear area of the internal thread
A_s	=	Shear area of the external thread
A_t	=	Tensile stress area of the screw thread
D	=	Basic major diameter of the thread
$D_s$min	=	Minimum major diameter of the external thread
$E_n$max	=	Maximum pitch diameter of the internal thread
$E_s$min	=	Minimum pitch diameter of the external thread
F_{po}	=	Pull-out strength
J	=	Relative strength of the external-to-internal thread
$K_n$max	=	Maximum minor diameter of the internal thread
L_e	=	Minimum engagement length to prevent stripping of the external thread
n	=	Number of threads, per inch
Q	=	Required length of engagement to prevent stripping of the internal thread
SEA	=	Shear engagement area
$S_u$ext	=	Tensile strength of the external thread material
$S_u$int	=	Tensile strength of the internal thread material
S_{upm}	=	Ultimate shear strength of the parent material

4.1.5.1 Keensert Evaluation – Model AOS-025

Table 4-3. Keensert Evaluation – Model AOS-025

Parameter	3/8-in. Φ UNC
Number of threads, per inch	16
External thread class	3A
Internal thread class	3B
D (in.)	0.3750
$D_s$min (in.)	0.3656
$E_n$max (in.)	0.3387
$E_s$min (in.)	0.3311
$K_n$max (in.)	0.3182
SEA (in^2)	0.4975
$S_u$ext (ksi)	185.0
$S_u$int (ksi)	90.0
S_{upm} (ksi)	40.6

4.1.5.1.1 Internal Thread Check – Model AOS-025

L_e = (2) (0.0759) / {(3.1416) (0.3182) [1/2 + (0.57735) (16) (0.3311 - 0.3182)]}

= 0.245 in.

Where external thread $S_u$ext > 100 ksi:

A_t = (3.1416) (0.3311 / 2 - 0.16238 / 16)^2 = 0.0759 in^2

Relative strength check:

J = (0.152) (185) / (0.211) (90.0)

= 1.481

where:

A_s = (3.1416) (16) (0.245) (0.3182) [1 / (2 (16)) + (0.57735) (0.3311 - 0.3182)]

= 0.152 in^2

A_n = (3.1416) (16) (0.245) (0.3656) [1 / (2 (16)) + (0.57735) (0.3656 - 0.3387)]

= 0.211 in^2

J is greater than 1.0; therefore, the internal thread may strip.

The minimum internal thread engagement is:

Q = (1.481) (0.245) = 0.363 in. (required minimum engagement)

The Keensert 3/8-inch bolt is catalog number KNH616J. The length of the insert is 0.50 inches. Therefore, the thread design is acceptable.

4.1.5.1.2 Pull-Out Strength – Model AOS-025

The 3/8-inch bolt's insert pull-out strength is:

F_{po} = SEA * S_{upm}

= 0.4975 * 40.6 = 20.20 k

The bolt tensile strength is:

F_b = S_u * A_t

= 185 * 0.0759 = 14.04 k < 20.20 k

where:

S_u = Ultimate strength of the bolt

A_t = Tensile stress area of the bolt

The joint is acceptable.

4.1.5.2 Keensert Evaluation – Model AOS-050

Table 4-4. Keensert Evaluation – Model AOS-050

Parameter	1/2-in. Φ UNC
Number of threads, per inch	13
External thread class	3A
Internal thread class	3B
D (in.)	0.5000
$D_s$min (in.)	0.4891
$E_n$max (in.)	0.4548
$E_s$min (in.)	0.4463
$K_n$max (in.)	0.4284
SEA (in^2)	0.8884
$S_u$ext (ksi)	185.0
$S_u$int (ksi)	90.0
S_{upm} (ksi)	40.6

4.1.5.2.1 Internal Thread Check – Model AOS-050

L_e = (2) (0.139) / {(3.1416) (0.4284) [1 / 2 + (0.57735) (13) (0.4463 - 0.4284)]}

= 0.326 in.

Where external thread $S_u$ext > 100 ksi:

A_t = (3.1416) (0.4463 / 2 - 0.16238 / 13)^2 = 0.139 in^2

Relative strength check:

J = (0.278) (185) / (0.379) (90.0)

= 1.508

where:

A_s = (3.1416) (13) (0.326) (0.4284) [1 / (2 (13)) + (0.57735) (0.4463 - 0.4284)]

= 0.278 in^2

A_n = (3.1416) (13) (0.326) (0.4891) [1 / (2 (13)) + (0.57735) (0.4891 - 0.4548)]

= 0.379 in^2

J is greater than 1.0; therefore, the internal thread may strip.

The minimum internal thread engagement is:

Q = (1.508) (0.326) = 0.492 in. (required minimum engagement)

The Keensert 1/2-inch bolt is catalog number KNH813J. The length of the insert is 0.66 inches. Therefore, the thread design is acceptable.

4.1.5.2.2 Pull-Out Strength – Model AOS-050

The 1/2-inch bolt's insert pull-out strength is:

F_{po} = SEA * S_{upm}

= 0.8884 * 40.6 = 36.07 k

The bolt tensile strength is:

F_b = S_u * A_t

= 185 * 0.139 = 25.72 k < 36.07 k

where:

S_u = Ultimate strength of the bolt

A_t = Tensile stress area of the bolt

The joint is acceptable.

4.1.5.3 Keensert Evaluation – Model AOS-100

Table 4-5. Keensert Evaluation – Model AOS-100

Parameter	7/8-in. Φ UNC
Number of threads, per inch	9
External thread class	3A
Internal thread class	3B
D (in.)	0.8750
$D_s$min (in.)	0.8611
$E_n$max (in.)	0.8089
$E_s$min (in.)	0.7981
$K_n$max (in.)	0.7681
SEA (in^2)	3.137
$S_u$ext (ksi)	185.0
$S_u$int (ksi)	90.0
S_{upm} (ksi)	40.6

4.1.5.3.1 Internal Thread Check – Model AOS-100

L_e = (2) (0.4561) / {(3.1416) (0.7681) [1 / 2 + (0.57735) (9) (0.7981 - 0.7681)]}

= 0.576 in.

Where external thread $S_u$ext > 100 ksi:

A_t = (3.1416) (0.7981 / 2 - 0.16238 / 9)^2 = 0.4561 in^2

Relative strength check:

J = (0.912) (185) / (1.202) (90.0)

= 1.560

where:

A_s = (3.1416) (9) (0.576) (0.7681) [1 / (2 (9)) + (0.57735) (0.7981 - 0.7681)]

= 0.912 in^2

A_n = (3.1416) (9) (0.576) (0.8611) [1 / (2 (9)) + (0.57735) (0.8611 - 0.8089)]

= 1.202 in^2

J is greater than 1.0; therefore, internal thread may strip.

The minimum internal thread engagement is:

Q = (1.560) (0.576) = 0.899 in. (required minimum engagement)

The Keensert 7/8-inch bolt is catalog number KNH1409J. The length of the insert is 1.25 inches. Therefore, the thread design is acceptable.

4.1.5.3.2 Pull-Out Strength – Model AOS-100

The 7/8-inch bolt's insert pull-out strength is:

$$F_{po} = SEA * S_{upm}$$

$$= 3.137 * 40.6 = 127.36 \text{ k}$$

The bolt tensile strength is:

$$F_b = S_u * A_t$$

$$= 185 * 0.4561 = 84.38 \text{ k} < 127.36 \text{ k}$$

where:

S_u = Ultimate strength of the bolt

A_t = Tensile stress area of the bolt

The joint is acceptable.

4.2 CONTAINMENT UNDER NORMAL CONDITIONS OF TRANSPORT

This section presents the evaluation of the AOS containment system under Normal Conditions of Transport for the chemical and physical forms of the approved contents, documented in Subsection 1.2.2, "Contents." and evaluated in Subsection 3.3.2, "Maximum Normal Operating Pressure."

4.2.1 Containment of Radioactive Material

When the radioactive contents are encapsulated in *Special Form* sources, containment under Normal Conditions of Transport is provided by the sealed source. For *Normal Form* material, containment is provided by the cask's containment system. The ability of the cask's containment system to withstand Normal Conditions of Transport is presented below.

The AOS Transport Packaging System containment is designed so that no release, loss, or dispersal of radioactive materials can occur under all conditions of transport, nor will there be any significant increase in external radiation or reduction in package effectiveness. This conclusion is supported by the analyses and various component qualification tests presented throughout this SAR.

4.2.2 Pressurization of Containment Boundary

The AOS transport packages have been designed to withstand pressures and temperatures in excess of those encountered during Normal Conditions of Transport. The maximum Normal Conditions of Transport pressures encountered are well within the Design Pressure of each transport package, documented in Subsection 3.3.2, "Maximum Normal Operating Pressure."

The only mechanism for pressurization of the cask cavity is that due to temperature change. There are no other mechanisms of gas generation from the approved contents, or from interaction with the environment in the cask's cavity. None of the approved contents undergo alpha decay in any appreciable amount, nor is there helium generation from boron captures, because there are no neutron emitters nor boron in the system.

The structural evaluation provided in Subsection 2.6.11, "Structural Evaluation Results Summary and Minimum Margins of Safety under Normal Conditions of Transport," shows low stress values throughout the cask structure, especially in the cask lid seal area, under Normal Conditions of Transport. In addition, the maximum temperatures shown in Table 3-3, "Maximum Temperature Summary, Normal Conditions of Transport – All Models," are lower than the corresponding limits of the containment boundary materials; therefore, they do not pose a threat to containment integrity.

Table 4-6. Maximum Cask Cavity Pressure Due to Normal Conditions of Transport – All Models

Model	Temperature (T)		Pressure (P)[a]			Design Pressure[b]	
	°C	°F	kPa	psia		kPa	psia
AOS-025A	125	257	135	20	<	207	30
AOS-050A	147	296	142	21	<	414	60
AOS-100A AOS-100A-S	155	312	145	21	<	1,930	280
AOS-100B	156	312	145	21	<	1,930	280

a. Pressure calculation is based upon the ideal gas law:

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2} \Rightarrow \frac{P_1}{T_1} = \frac{P_2}{T_2}$$

Initial Condition

$P_1 = 14.7$ psia

$T_1 = 78°F$

Final Condition

$P_2 = ?$

$T_2 = 257°F$

$$P_2 = \frac{(257 + 460)}{(78 + 460)} * 14.7 = 19.59 \text{ psia}$$

*b. **Model AOS-100 transport package** – Pressure value is based upon projected operating conditions.*

Table 4-7. Maximum Cask Cavity Pressure Due to Fire Condition – All Models

Model	Temperature[a]		Pressure[b]			Design Pressure[c]	
	°C	°F	kPa	psia		kPa	psia
AOS-025A	136	277	139	20	<	207	30
AOS-050A	259	499	181	26	<	414	60
AOS-100A AOS-100A-S	246	476	177	26	<	1,930	280
AOS-100B	241	467	175	25	<	1,930	280

a. Temperature listed is the maximum value obtained throughout the Fire event.

b. Pressure calculation is based upon the ideal gas law illustrated in Table 4-6, footnote a.

*c. **Model AOS-100 transport package** – Pressure value is based upon projected operating conditions.*

4.2.3 Containment Criterion

The AOS Transport Packaging System containments are designed, and verified by Leak test, to meet the "leak-tight" criteria established in Reference **[4.4]**, for the transportation of activated material in *Normal form*.

4.3 CONTAINMENT UNDER HYPOTHETICAL ACCIDENT CONDITIONS

When the radioactive contents are encapsulated in *Special Form* sources, containment under Hypothetical Accident Conditions of Transport is provided by the sealed source. For *Normal Form* material, containment is provided by the cask's containment system. The ability of the cask's containment system to withstand Hypothetical Accident Conditions of Transport is presented below.

This section presents the evaluations performed on the AOS Transport Package containment system under Hypothetical Accident Conditions of Transport and documents that the Package design meets the containment requirements of *10 CFR 71.51(a)(2)* **[4.1]** under Hypothetical Accident Conditions of Transport, specifically, the structural performance of the containment system, including the cask lid seal, cask lid attachment bolts, cask cavity shell, and penetrations. These results are documented in Subsection 2.7.8, "Summary of Damages." Temperature distributions under these conditions are listed in Table 3-4, "Maximum Temperature Summary, Hypothetical Accident Conditions of Transport (Condition 3) – All Models."

Under Hypothetical Accident Conditions of Transport, the pressure within the AOS Transport Packaging System models' cask cavity is well below the design pressures listed in Table 4-7. Temperatures at the cask lid elastomeric or metallic seal and port cover seal are also below the temperature criteria for the applicable seal material listed in Table 3-4, "Maximum Temperature Summary, Hypothetical Accident Conditions of Transport (Condition 3) – All Models."

Table 4-7 summarizes the maximum temperatures obtained during the Fire Transient evaluation, for each transport package model. The analytical evaluations under Hypothetical Accident Conditions of Transport, presented in Chapter 2, "Structural Evaluation," show that the stresses throughout the cask structure are below the material's failure criteria. This is also demonstrated by the results of the AOS-165A prototype Free-Drop test, presented in Appendix 2.12.6, "Impact (Free-Drop) Test Report." During the test, the cask structure did not suffer any measurable deformation on its entire surface and the cask leak tightness was maintained, despite the fact that the cask was dropped three (3) times.

4.3.1 Containment of Radioactive Material

The results of the structural and thermal analyses presented in Chapter 2, "Structural Evaluation," and Chapter 3, "Thermal Evaluation," respectively, and the Free-Drop test results presented in Appendix 2.12.6.2, "Free-Drop Test Activity Record – Pre- and Post-Leak Test," verify that the AOS transport packages are capable of withstanding the Hypothetical Accident Conditions of Transport that meet the containment criteria specified in Reference **[4.4]**.

4.3.2 Containment Criterion

The AOS Transport Packaging System containments are designed, and verified by Leak test, to meet the "leak-tight" criteria established in Reference **[4.4]**, for the transportation of activated material in *Normal Form*.

4.3.3 Fission Gas Products

Not applicable. The authorized content of the AOS Transport Packaging System does not include any fission product gases, nor materials that can produce them, during transport.

4.4 LEAKAGE RATE TESTS FOR TYPE B PACKAGES

Pre-shipment and periodic Leakage tests, meeting the requirements of Reference **[4.4]**, are used to demonstrate that the AOS transport packages meet the containment requirements of *10 CFR 71.51* **[4.1]** are delineated in Subsection 8.2.2, "Leakage Tests [8.4]."

4.5 APPENDIX

This appendix includes a lists of references, applicable pages from referenced documents, supporting information and analysis, test results, and other supplemental information:

- Garlock Helicoflex Cask Lid Metallic Seal and AOS Cask Lid Elastomeric Seal Drawings
- Fortran Program Used to Analyze Cask Lid Attachment Bolts (Reference [4.6])
- Cask Lid Attachment Bolt Fortran Program Input/Output Files

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4.5.1 Garlock Helicoflex Cask Lid Metallic Seal and AOS Cask Lid Elastomeric Seal Drawings

Note: *As used throughout this SAR, "Garlock Helicoflex" and/or "Helicoflex" are also referred to as "Technetics Group – Columbia".*

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Garlock Helicoflex Drawing No. H-309854, Rev. 0

Model AOS-025 Cask Lid Metallic Seal

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Proprietary Information withheld from public disclosure per 10 CFR 2.390(a)(4).

Garlock Helicoflex Drawing No. H-309852, Rev. 0

Model AOS-050 Cask Lid Metallic Seal

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Proprietary Information withheld from public disclosure per 10 CFR 2.390(a)(4).

Garlock Helicoflex Drawing No. H-309850, Rev. 0

Model AOS-100 Cask Lid Metallic Seal

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Proprietary Information withheld from public disclosure per 10 CFR 2.390(a)(4).

AOS Drawing No. 183C8478Goo2, Rev. A

Model AOS-025A Lid Seal, Elastomeric

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Proprietary Information withheld from public disclosure per 10 CFR 2.390(a)(4).

AOS Drawing No. 183C8470Goo2, Rev. D

Model AOS-050A Lid Seal, Elastomeric

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Proprietary Information withheld from public disclosure per 10 CFR 2.390(a)(4).

AOS Drawing No. 183C8460Goo2, Rev. B

Models AOS-100A / AOS-100B / AOS-100A-S Lid Seal, Elastomeric

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Proprietary Information withheld from public disclosure per 10 CFR 2.390(a)(4).

4.5.2 Fortran Program Used to Analyze Cask Lid Attachment Bolts (Reference [4.6])

Note: *The actual files used as input to, and output from, the Fortran program are provided in Appendix 4.5.3.*

```
 PROGRAM MAIN
C
C     ANALYSIS OF LID ATTACHMENT BOLTS BY NUREG/CR-6007
C
C
C
C          ********* DEFINITION OF VARIABLES *********
C
C     AB       - COEFFICIENT OF THERMAL EXPANSION FOR BOLT
C     AC       - COEFFICIENT OF THERMAL EXPANSION FOR CASK WALL
C     ACCI     - IMPACT ACCELERATION DUE TO CG/CORNER DROP
C     AL       - COEFFICIENT OF THERMAL EXPANSION FOR LID
C     AVA      - AXIAL VIBRATION ACCELERATION
C     AVT      - TRANSVERSE VIBRATION ACCELERATION
C     ACCI     - IMPACT ACCELERATION DUE TO CG/CORNER DROP
C     BCF      - BOLT CLAMPING FORCE
C     BD       - BOLT DISPLACEMENT
C     BL       - BOLT LENGTH - BETWEEN TOP AND BOTTOM SURFACES OF LID
                 AT BOLT CIRCLE
C     BXA      - BOLT X-SECTION AREA
C     CET      - CODE EVALUATION TYPE: 1-NORMAL, 2-ACCIDENT
C     DB       - NOMINAL BOLT DIAMETER
C     DLB      - LID DIAMETER AT BOLT CIRCLE
C     DLI      - LID DIAMETER AT INNER EDGE
C     DLO      - LID DIAMETER AT OUTER EDGE
C     DPNB     - DOUBLE PRECISION VALUE OF NB
C     DYLF     - DYNAMIC LOAD FACTOR (1.0-1.5)
C     DLG      - LID DIAMETER AT GASSKET
C     EB       - YOUNG'S MODULUS FOR BOLT
C     EC       - YOUNG'S MODULUS FOR CASK
C     EL       - YOUNG'S MODULUS FOR LID
C     ELF      - YOUNG'S MODULUS FOR LID FLANGE
C     FA_i     - BOLT TENSILE FORCE
C     FCF      - FLANGE COEFICIENT OF FRICTION
C     FF_i     - LID EDGE FORCE
C     FS_i     - BOLT SHEAR FORCE
C     FSO      - FATIGUE STRESS FOR OPERATING CONDITIONS
C     FSV      - FATIGUE STRESS FOR VIBRATIONS
C     GB       - GASKET SEATING WIDTH  (ASME BPV CODE, SECT III, APP E)
C     GM       - GASKET FACTOR         (ASME BPV CODE, SECT III, APP E)
C     GY       - GASKET SEATING STRESS (ASME BPV CODE, SECT III, APP E)
C     MF_i     - LID EDGE MOMENT
C     NB       - NUMBER OF BOLTS
C     NTI      - NUMBER OF BOLT THREADS / IN
C     PCI      - INSIDE PRESSURE AT CASK WALL
C     PCO      - OUTSIDE PRESSURE AT CASK WALL
C     PLI      - INSIDE PRESSURE AT LID
C     PLO      - OUTSIDE PRESSURE AT LID
```

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C     PUNC    - PUNCTURE LOAD
C     Q       - PRELOAD TORQUE
C     QK      - NUT FACTOR FOR PRELOAD TORQUE
C     SM      - Sm STRESS
C     SY      - Sy STRESS
C     Su      - Su STRESS
C     TC      - THICKNESS OF CASK WALL
C     TEMPB   - TEMPERATURE CHANGE ACROSS BOLT
C     TEMPC   - TEMPERATURE CHANGE ACROSS CASK WALL
C     TEMPL   - TEMPERATURE CHANGE ACROSS LID
C     TEMPLI  - TEMPERATURE AT INSIDE OF LID
C     TEMPLO  - TEMPERATURE AT OUTSIDE OF LID
C     TL      - THICKNESS OF LID
C     TLF     - THICKNESS OF LID FLANGE
C     TM_i    - BOLT TORSIONAL MOMENT
C     VTR     - VIBRATION TRANSMISSIBILITY FACTOR BETWWEN SUPPORT & CASK
C     WC      - WEIGHT OF CASK CONTENTS
C     WCK     - TOTAL WEIGHT OF CASK
C     WL      - WEIGHT OF CASK LID
C     XIB     - BOLTS AREA MOMENT OF INERTIA / CIRCUMFERENCE OF BOLT CIRCLE
C     XI_DROP - ANGLE OF IMPACT (DEGREES) FOR DROP
C     XI_PUNC - ANGLE OF IMPACT (DEGREES) FOR PUNCTURE
C     XNUC    - POISSON'S RATIO FOR CASK
C     XNUL    - POISSON'S RATION FOR LID
C
C
      IMPLICIT REAL*8(A-H,O-Z)
      CHARACTER*80 TITLE
C
C
C     OPEN INPUT/OUTPUT FILES
C
      OPEN(5,FILE='CASKBOLT.DAT')
      OPEN(6,FILE='CASKBOLT.OUT')
      OPEN(1,FILE='TEMP.DAT')
C
C
C     READ & ECHO DATA
C
      READ(5,'(A)') TITLE
      WRITE(6,'(/,A,//)') TITLE
      WRITE(6,'(//,44H *************** INPUT DATA ***************)')
C
      CALL DATA(DPNB)
      NB=INT(DPNB)
      CALL DATA(DLB )
      CALL DATA(DLG )
      CALL DATA(DB  )
      CALL DATA(DLI )
      CALL DATA(DLO )
      CALL DATA(TL  )
      CALL DATA(TLF )
      CALL DATA(TC  )
      CALL DATA(BL  )
```

```
      CALL DATA(XIB )
C
      WRITE(6,'(1H )')
      WRITE(6,10) NB,DLB,DLG,DB,DLI,DLO,TL,TLF,TC,BL,XIB
   10 FORMAT(43H NUMBER OF BOLTS ......................(NB),I12  ,/,
     .       43H LID DIAMETER AT BOLT CIRCLE .........(DLB),E12.5,/,
     .       43H LID DIAMETER AT GASKET  .............(DLG),E12.5,/,
     .       43H NOMINAL BOLT DIAMETER ...............(DB),E12.5,/,
     .       43H LID DIAMETER AT INNER EDGE ..........(DLI),E12.5,/,
     .       43H LID DIAMETER AT OUTER EDGE ..........(DLO),E12.5,/,
     .       43H THICKNESS OF LID ....................(TL),E12.5,/,
     .       43H THICKNESS OF LID FLANGE .............(TLF),E12.5,/,
     .       43H THICKNESS OF CASK WALL ..............(TC),E12.5,/,
     .       43H BOLT LENGTH .........................(BL),E12.5,/,
     .       43H BOLT MOMENT OF INERTIA / CIR ........(XIB),E12.5   )
C
      CALL DATA(EL  )
      CALL DATA(ELF )
      CALL DATA(EC  )
      CALL DATA(EB  )
      CALL DATA(XNUL)
      CALL DATA(XNUC)
      CALL DATA(AL  )
      CALL DATA(AB  )
      CALL DATA(AC  )
      CALL DATA(FCF )
C
      WRITE(6,'(1H )')
      WRITE(6,20) EL,ELF,EC,EB,XNUL,XNUC,AL,AB,AC,FCF
   20 FORMAT(43H YOUNG'S MODULUS FOR LID ..............(EL),E12.5,/,
     .       43H YOUNG'S MODULUS FOR LID FLANGE ......(ELF),E12.5,/,
     .       43H YOUNG'S MODULUS FOR CASK ............(EC),E12.5,/,
     .       43H YOUNG'S MODULUS FOR BOLT ............(EB),E12.5,/,
     .       43H POISSON'S RATIO FOR LID .............(XNUL),E12.5,/,
     .       43H POISSON'S RATIO FOR CASK ............(XNUC),E12.5,/,
     .       43H LID THERMAL EXPANSION COEFF ..........(AL),E12.5,/,
     .       43H BOLT THERMAL EXPANSION COEFF .........(AB),E12.5,/,
     .       43H WALL THERMAL EXPANSION COEFF .........(AC),E12.5,/,
     .       43H FLANGE COEFFICIENT OF FRICTION ......(FCF),E12.5   )
C
      CALL DATA(PLI)
      CALL DATA(PLO)
      CALL DATA(PCI)
      CALL DATA(PCO)
C
      WRITE(6,'(1H )')
      WRITE(6,40) PLI,PLO,PCI,PCO
   40 FORMAT(43H INSIDE PRESSURE AT LID ..............(PLI),E12.5,/,
     .       43H OUTSIDE PRESSURE AT LID ..............(PLO),E12.5,/,
     .       43H INSIDE PRESSURE AT CASK WALL .........(PCI),E12.5,/,
     .       43H OUTSIDE PRESSURE AT CASK WALL .......(PCO),E12.5   )
C
      CALL DATA(TEMPL )
      CALL DATA(TEMPB )
```

```
      CALL DATA(TEMPC )
      CALL DATA(TEMPLO)
      CALL DATA(TEMPLI)
C
      WRITE(6,'(1H )')
      WRITE(6,50) TEMPL,TEMPB,TEMPC,TEMPLO,TEMPLI
   50 FORMAT(43H TEMPERATURE CHG ACROSS LID ........(TEMPL),E12.5,/,
     .       43H TEMPERATURE CHG ACROSS BOLT .......(TEMPB),E12.5,/,
     .       43H TEMPERATURE CHG ACROSS WALL .......(TEMPC),E12.5,/,
     .       43H TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO),E12.5,/,
     .       43H TEMPERATURE AT INSIDE OF LID .....(TEMPLI),E12.5   )
C
      CALL DATA(WC     )
      CALL DATA(WL     )
      CALL DATA(XI_DROP)
      CALL DATA(ACCI   )
      CALL DATA(DYLF   )
C
      WRITE(6,'(1H )')
      WRITE(6,60) WC,WL,XI_DROP,ACCI,DYLF
   60 FORMAT(43H WEIGHT OF CASK CONTENTS ..............(WC),E12.5,/,
     .       43H WEIGHT OF CASK LID ...................(WL),E12.5,/,
     .       43H DROP ANGLE OF IMPACT, deg .......(XI_DROP),E12.5,/,
     .       43H CG/CORNER IMPACT ACCEL, g ..........(ACCI),E12.5,/,
     .       43H DYNAMIC LOAD FACTOR ................(DYLF),E12.5   )
C
      CALL DATA(PUNC   )
      CALL DATA(XI_PUNC)
C
      WRITE(6,'(1H )')
      WRITE(6,70) PUNC,XI_PUNC
   70 FORMAT(43H PUNCTURE LOAD ......................(PUNC),E12.5,/,
     .       43H PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC),E12.5   )
C
      CALL DATA(AVA)
      CALL DATA(AVT)
      CALL DATA(VTR)
C
      WRITE(6,'(1H )')
      WRITE(6,80) AVA,AVT,VTR
   80 FORMAT(43H AXIAL VIBRATION ACCELERATION ........(AVA),E12.5,/,
     .       43H TRANSVERSE VIBRATION ACCELERATION ...(AVT),E12.5,/,
     .       43H VIBRATION TRANSMISSIBILITY FACTOR ...(VTR),E12.5   )
C
      CALL DATA(Q )
      CALL DATA(QK)
      CALL DATA(GB)
      CALL DATA(GY)
      CALL DATA(GM)
C
      WRITE(6,'(1H )')
      WRITE(6,90) Q,QK,GB,GY,GM
   90 FORMAT(43H PRELOAD TORQUE .......................(Q),E12.5,/,
     .       43H NUT FACTOR FOR PRELOAD TORQUE ........(QK),E12.5,/,
```

```
     .       43H GASKET SEATING WIDTH .................(GB),E12.5,/,
     .       43H GASKET SEATING STRESS ................(GY),E12.5,/,
     .       43H GASKET FACTOR ........................(GM),E12.5   )
C
      CALL DATA(SM )
      CALL DATA(SY )
      CALL DATA(SU )
      CALL DATA(CET)
      ICET=INT(CET)
C
      WRITE(6,'(1H )')
      WRITE(6,93) SM,SY,SU,ICET
   93 FORMAT(43H Sm STRESS ............................(SM),E12.5,/,
     .       43H Sy STRESS ............................(SY),E12.5,/,
     .       43H Su STRESS ............................(SU),E12.5,/,
     .       43H CODE EVALUATION TYPE.................(CET),I12     )
C
      CALL DATA(FSO)
      CALL DATA(FSV)
      CALL DATA(XTI)
      NTI=INT(XTI)
C
      WRITE(6,'(1H )')
      WRITE(6,92) FSO,FSV,NTI
   92 FORMAT(43H OPERATING FATGIGUE STRESS (ksi) .....(FSO),E12.5,/,
     .       43H VIBRATION FATIGUE STRESS (ksi) ......(FSV),E12.5,/,
     .       43H NUMBER OF BOLT THREADS / INCH .......(NTI),I12     )
      N=0
C
  100 CONTINUE
      IF(N.NE.0) THEN
      WRITE(*,110) N
  110 FORMAT(///,' ERROR IN INPUT DATA LINE',I3,//)
      STOP
      ENDIF
C
C
C     FORCES & MOMENT DUE TO PRESSURE (TABLE 4.3)
C
      PIE  = 3.141592654
      FA_1 = PIE*DLG**2*(PLI-PLO)/(4*DPNB)
      FS_1 = PIE*EL*TL*(PCI-PCO)*DLB**2/(2*DPNB*EC*TC*(1.0-XNUL))
      FF_1 = DLB*(PLI-PLO)/4.0
      FM_1 = (PLI-PLO)*DLB**2/32.0
C
      WRITE(6,'(/////,41H ******** BOLT LOADS & STRESSES *********)')
      WRITE(6,'(//)')
      WRITE(6,'(43H BOLT FORCES DUE TO PRESSURE, TABLE 4.3    )')
      WRITE(6,120)
  120 FORMAT(52H ------------------------------------------------)
      WRITE(6,'(37H AXIAL LOAD DUE TO PRESSURE.........,E15.5)') FA_1
      WRITE(6,'(37H SHEAR LOAD DUE TO PRESSURE.........,E15.5)') FS_1
      WRITE(6,'(37H EDGE LOAD DUE TO PRESSURE..........,E15.5)') FF_1
      WRITE(6,'(37H EDGE MOMENT DUE TO PRESSURE........,E15.5)') FM_1
```

```
C
C
C     FORCES & MOMENT DUE TO TEMPERATURE (TABLE 4.4)
C
      FA_2 = 0.25*PIE*DB**2*EB*(AL*TEMPL-AB*TEMPB)
      FS_2 = PIE*EL*TL*DLB*(AL*TEMPL-AC*TEMPC)/(DPNB*(1.0-XNUL))
      FF_2 = 0.0
      FM_2 = EL*AL*TL**2*(TEMPLO-TEMPLI)/(12.0*(1.0-XNUL))
C
      WRITE(6,'(//)')
      WRITE(6,'(43H BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4 )')
      WRITE(6,120)
      WRITE(6,'(37H AXIAL LOAD DUE TO TEMPERATURE.......,E15.5)') FA_2
      WRITE(6,'(37H SHEAR LOAD DUE TO TEMPERATURE.......,E15.5)') FS_2
      WRITE(6,'(37H EDGE LOAD DUE TO TEMPERATURE........,E15.5)') FF_2
      WRITE(6,'(37H EDGE MOMENT DUE TEMPERATURE.........,E15.5)') FM_2
C
C
C     FORCES & MOMENT DUE TO CG/CORNER IMPACT (TABLE 4.5)
C
      XI   = XI_DROP*PIE/180.0
      FA_3 = 1.34*DSIN(XI)*DYLF*ACCI*(WL+WC)/DPNB
      FS_3 = DCOS(XI)*ACCI*WL/DPNB
      FF_3 = 1.34*DSIN(XI)*DYLF*ACCI*(WL+WC)/(PIE*DLB)
      FM_3 = 1.34*DSIN(XI)*DYLF*ACCI*(WL+WC)/(8.0*PIE)
C
      WRITE(6,'(//)')
      WRITE(6,'(43H BOLT FORCES DUE TO IMPACT, TABLE 4.5      )')
      WRITE(6,120)
      WRITE(6,'(37H AXIAL LOAD DUE TO IMPACT............,E15.5)') FA_3
      WRITE(6,'(37H SHEAR LOAD DUE TO IMPACT............,E15.5)') FS_3
      WRITE(6,'(37H EDGE LOAD DUE TO IMPACT.............,E15.5)') FF_3
      WRITE(6,'(37H EDGE MOMENT DUE IMPACT..............,E15.5)') FM_3
C
C
C     FORCES & MOMENT DUE TO PUNCTURE LOAD (TABLE 4.7)
C
      XI   = XI_PUNC*PIE/180.0
      FA_4 =-DSIN(XI)*PUNC/DPNB
      FS_4 = DCOS(XI)*PUNC/DPNB
      FF_4 =-DSIN(XI)*PUNC/(PIE*DLB)
      FM_4 =-DSIN(XI)*PUNC/(4.0*PIE)
C
      WRITE(6,'(//)')
      WRITE(6,'(43H BOLT FORCES DUE TO PUNCTURE, TABLE 4.7    )')
      WRITE(6,120)
      WRITE(6,'(37H AXIAL LOAD DUE TO PUNCTURE..........,E15.5)') FA_4
      WRITE(6,'(37H SHEAR LOAD DUE TO PUNCTURE..........,E15.5)') FS_4
      WRITE(6,'(37H EDGE LOAD DUE TO PUNCTURE...........,E15.5)') FF_4
      WRITE(6,'(37H EDGE MOMENT DUE PUNCTURE............,E15.5)') FM_4
C
C
C     FORCES & MOMENT DUE TO VIBRATION LOAD (TABLE 4.8)
C
```

```
      FA_5 = VTR*AVA*WL/DPNB
      FS_5 = VTR*AVT*WL/DPNB
      FF_5 = VTR*AVA*WL/(PIE*DLB)
      FM_5 = VTR*AVA*WL/(8.0*PIE)
C
      WRITE(6,'(//)')
      WRITE(6,'(43H BOLT FORCES DUE TO VIBRATION, TABLE 4.8   )')
      WRITE(6,120)
      WRITE(6,'(37H AXIAL LOAD DUE TO VIBRATION.........,E15.5)') FA_5
      WRITE(6,'(37H SHEAR LOAD DUE TO VIBRATION.........,E15.5)') FS_5
      WRITE(6,'(37H EDGE LOAD DUE TO VIBRATION..........,E15.5)') FF_5
      WRITE(6,'(37H EDGE MOMENT DUE VIBRATION...........,E15.5)') FM_5
C
C
C     FORCES & TORQUES DUE TO PRELOAD TORQING (TABLES 4.1 & 4.2)
C
      FA_6 = Q/(QK*DB)
      TM_6 = 0.5*Q
      FA_7 = PIE*DLG*GB*GY/DPNB
      TM_7 = 0.5*PIE*QK*DB*DLG*GB*GY/DPNB
      FA_8 = 2.0*PIE*DLG*GB*GM*(PLI-PLO)/DPNB
C
      WRITE(6,'(//)')
      WRITE(6,'(43H BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2)')
      WRITE(6,120)
      WRITE(6,'(37H AXIAL LOAD DUE TO PRELOAD...........,E15.5)') FA_6
      WRITE(6,'(37H AXIAL LOAD DUE TO GASKET SEATING....,E15.5)') FA_7
      WRITE(6,'(37H AXIAL LOAD DUE TO GASKET OPERATION..,E15.5)') FA_8
      WRITE(6,'(37H TORQUE DUE TO PRELOAD..............,E15.5)') TM_6
      WRITE(6,'(37H TORQUE DUE TO GASKET ..............,E15.5)') TM_7
C
C
C     TENSILE BOLT FORCE (TABLE 4.9)
C
      FA    = FA_1 + FA_2 + FA_3 + FA_4 + FA_5 + FA_6 + FA_8
      FA_PT = FA_2 + FA_6
      FA_AL = FA_1 + FA_3 + FA_4 + FA_5 + FA_8
C
      WRITE(6,'(//)')
      WRITE(6,'(43H TOTAL NON-PRYING BOLT FORCES, TABLE 4.9   )')
      WRITE(6,120)
      WRITE(6,'(37H TOTAL NON-PRYING AXIAL LOAD.........,E15.5)') FA
      WRITE(6,'(37H TEMP & PRELOAD NON-PRYING AXIAL LD..,E15.5)') FA_PT
      WRITE(6,'(37H AXIAL LOAD LESS TEMP & PRELOAD......,E15.5)') FA_AL
C
      IF(FA_PT .GE. FA_AL) THEN
      FA_C  = FA_PT
      ELSE
      FA_C  = FA_AL
      ENDIF
      IF(FA_C .LT. 0.0) FA_C=0.0
C
      FF_C = FF_1 + FF_2 + FF_3 + FF_4 + FF_5
      FM_C = FM_1 + FM_2 + FM_3 + FM_4 + FM_5
```

```
C
      WRITE(6,'(37H TOTAL EDGE LOAD.....................,E15.5)') FF_C
      WRITE(6,'(37H TOTAL EDGE MOMENT...................,E15.5)') FM_C
C
C
C     PRYING TENSILE BOLT FORCE (TABLES 2.1 & 2.2)
C
      C1 = 1.0
      C2 = (  8.0/(3.0*(DLO-DLB)**2) )
     .    *(  EL*TL**3/(1.0-XNUL) + (DLO-DLI)*ELF*TLF**3/DLB )
     .    *(  BL/( DPNB*DB**2*EB ) )
C
      S = DPNB/(PIE*DLB)
      P = S*FA_PT
C
      B = P
      IF(FF_C .GT. P)  B = FF_C
C
C
      FAP_C = (PIE*DLB/DPNB)
     .  *( 2.0*FM_C/(DLO-DLB) - C1*(B - FF_C) - C2*(B - P) )
     .  /(C1 + C2)
C
      XKB = (DPNB/BL)*(EB/DLB)*(DB**4/64.0)
      XKI = EL*TL**3/
     . ( 3.0*DLB*( (1.0-XNUL**2) + (1.0-XNUL)**2*(DLB/DLO)**2 ) )
C
      BMB = (PIE*DLB/DPNB)*(XKB/(XKB+XKI))*FM_C
C
      WRITE(6,'(//)')
      WRITE(6,'(43H PRYING ACTION FORCES, TABLE 2.1 & 2.2     )')
      WRITE(6,120)
      WRITE(6,'(37H AXIAL LOAD DUE TO PRYING............,E15.5)') FAP_C
      WRITE(6,'(37H BENDING MOMENT DUE TO PRYING........,E15.5)') BMB
C
C
C     TOTAL BOLT LOADS
C
C     FAT - TOTAL BOLT AXIAL LOAD
C     FST - TOTAL BOLT SHEAR LOAD
C     BMT - TOTAL BOLT BENDING MOMENT
C     BTT - TOTAL BOLT TORSIONAL MOMENT
C
      FAT = FA_C + FAP_C
      FST = FS_1 + FS_2 + FS_3 + FS_4 + FS_5
      BMT = FM_C + BMB
      BTT = TM_6
C
      WRITE(6,'(//)')
      WRITE(6,'(43H TOTAL BOLT FORCES                         )')
      WRITE(6,120)
      WRITE(6,'(37H TOTAL BOLT AXIAL LOAD...............,E15.5)') FAT
      WRITE(6,'(37H TOTAL BOLT SHEAR LOAD...............,E15.5)') FST
```

```
      WRITE(6,'(37H TOTAL BOLT BENDING MOMENT.....,E15.5)') BMT
      WRITE(6,'(37H TOTAL BOLT TORSIONAL MOMENT.....,E15.5)') BTT
C
C
C     BOLT STRESSES
C
      DBA=DB-0.9743/DBLE(NTI)
      BXA=PIE*(DBA/2)**2
      XI=PIE*DBA**3/32
      XJ=PIE*DBA**3/16
      SIG_A0=FAT/BXA
      SIG_A1=SIG_A0+BMT/XI
      SIG_A2=SIG_A0-BMT/XI
      SIG_A=SIG_A1
      IF(SIG_A2 .GT. SIG_A) SIG_A=SIG_A2
C********
C      SIG_S =DABS(FST/BXA)+DABS(BTT/XJ)
C      SIG_S0=DABS(FST/BXA)+DABS(BTT/XJ)/2

      SIG_S =DABS(BTT/XJ)
      SIG_S0=DABS(BTT/XJ)/2
C
      WRITE(6,'(//)')
      WRITE(6,'(43H TOTAL BOLT STRESSES                    )')
      WRITE(6,120)
      WRITE(6,'(37H TOTAL BOLT DIRECT STRESS (+MC/I) ...,E15.5)') SIG_A1
      WRITE(6,'(37H TOTAL BOLT DIRECT STRESS (-MC/I) ...,E15.5)') SIG_A2
      WRITE(6,'(37H AVE BOLT DIRECT STRESS .....,E15.5)') SIG_A0
      WRITE(6,'(37H TOTAL BOLT SHEAR STRESS .....,E15.5)') SIG_S
      WRITE(6,'(37H AVE BOLT SHEAR STRESS .....,E15.5)') SIG_S0
C
C
C     CODE STRESS EVALUATION FOR NORMAL CONDITION (TABLE 6.1)
C
      IF(CET.EQ.1) THEN
      SM=1000.0*SM
      RT=SIG_A0/SM
      RS=SIG_S0/(0.6*SM)
      RC=RT**2 + RS**2
      RB=SIG_A/(1.5*SM)
      SE=DSQRT(SIG_A**2+4.0*SIG_S**2)
      RV=SE/(1.35*SM)
C
      WRITE(6,'(//)')
      WRITE(6,'(43H CODE EVALUATION FOR NORMAL COND, TABLE 6.1)')
      WRITE(6,120)
      WRITE(6,'(37H Rt (AXIAL_STRESS/Sm) .....,E15.5)') RT
      WRITE(6,'(37H Rs (SHEAR_STRESS/0.6Sm) .....,E15.5)') RS
      WRITE(6,'(37H Rtý+Rsý .....,E15.5)') RC
      WRITE(6,'(37H VON MISES EQUIVALENT STRESS (Se) ...,E15.5)') SE
      WRITE(6,'(37H Se/1.35Sm .....,E15.5)') RV
      ENDIF
C
C
```

```
C     CODE STRESS EVALUATION FOR ACCIDENT CONDITION (TABLE 6.3)
C
      IF(CET.EQ.2) THEN
      SU1=700.0*SU
      SY1=1000.0*SY
      SA=SU1
      IF(SA.GT.SY1) SA=SY1
      SU1=420*SU
      SY1=600*SY
      TA=SU1
      IF(TA.GT.SY1) TA=SY1
      RT=SIG_A0/SA
      RS=SIG_S0/TA
      RC=RT**2 + RS**2
C
      WRITE(6,'(//)')
      WRITE(6,'(43H CODE EVALUAT. FOR ACCIDENT COND, TABLE 6.3)')
      WRITE(6,120)
      WRITE(6,'(37H ALLOWABLE TENSILE STRESS (Sa) ......,E15.5)') SA
      WRITE(6,'(37H ALLOWABLE SHEAR STRESS (Ta) .........,E15.5)') TA
      WRITE(6,'(37H Rt (AVE AXIAL STRESS/Sa) ............,E15.5)') RT
      WRITE(6,'(37H Rs (AVE SHEAR_STRESS/Ta) ............,E15.5)') RS
      WRITE(6,'(37H Rtý+Rsý ............................,E15.5)') RC
      ENDIF
C
C
C     BOLT CLAMPING FORCE =   FA_AL (APPLIED LOADS LESS TEMP LOAD & PRE LOAD)
C                           + FAP_C (LOAD DUE TO PRYING ACTION)
C                           - FA_PT (PRE LOAD & TEMP LOAD)
C
      BCF = DABS(FA_AL) + DABS(FAP_C) - DABS(FA_PT)
      BD  = BCF*BL/(BXA*EB)
      BDA = 0.003
      FF  = FCF*BCF
C
      WRITE(6,'(//)')
      WRITE(6,'(43H FLANGE SEPARATION EVALUATION              )')
      WRITE(6,120)
      WRITE(6,'(37H BOLT CLAMPING FORCE ................,E15.5)') BCF
      WRITE(6,'(37H DISPLACEMENT ACROSS BOLT ............,E15.5)') BD
      WRITE(6,'(37H ALLOWABLE FLANGE SEPARATION .........,E15.5)') BDA
      WRITE(6,'(37H FLANGE FRICTION FORCE ...............,E15.5)') FF
      WRITE(6,'(37H TOTAL BOLT SHEAR FORCE ..............,E15.5)') FST
C
C
C     FATIGUE ANALYSIS
C
      IF(CET.EQ.1) THEN
      IF(FSO.GT.0.0 .OR. FSV.GT.0.0) THEN
      R1 = SIG_A/(1000.0*FSO)
      R2 = (FA_5/BXA)/(1000.0*FSV)
      R3 = R1+R2
```

```
C
      WRITE(6,'(//)')
      WRITE(6,'(43H FATIGUE EVALUATION                         )')
      WRITE(6,120)
      WRITE(6,'(37H USEAGE FOR NORMAL OPERATION .........,E15.5)') R1
      WRITE(6,'(37H USEAGE FOR VIBRATION  ...............,E15.5)') R2
      WRITE(6,'(37H ACCUMULATIVE FATIGUE USEAGE .........,E15.5)') R3
      ENDIF
      ENDIF
C
C
      END
      SUBROUTINE DATA(X)
C
C     READ NEXT DATA ITEM ON INPUT FILE
C
      REAL*8 X
      CHARACTER*80 BUFFER
C
  100 CONTINUE
      READ(5,'(A)',ERR=200,END=200) BUFFER
      IF(BUFFER(1:1).EQ.'*') GOTO 100
      BUFFER(1:43)=CHAR(32)
      REWIND 1
      WRITE(1,'(A)') BUFFER
      REWIND 1
      READ(1,*,ERR=100,END=200) X
      RETURN
  200 CONTINUE
      WRITE(6,210)
      STOP
  210 FORMAT(//' ERROR READING INPUT DATA FILE')
C
      RETURN
      END
```

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4.5.3 Cask Lid Attachment Bolt Fortran Program Input/Output Files

Note: *The Fortran program used in conjunction with these input and output files, is provided in Appendix 4.5.2.*

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4.5.3.1 Cask Lid Attachment Bolt Fortran Program Input Files

This appendix provides the following input files, that are used to build the content in Table 4-1:

- Cask Lid Attachment Bolt Fortran Program Input Files – Model AOS-025
- Cask Lid Attachment Bolt Fortran Program Input Files – Model AOS-050
- Cask Lid Attachment Bolt Fortran Program Input Files – Model AOS-100

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4.5.3.1.1 Cask Lid Attachment Bolt Fortran Program Input Files – Model AOS-025

This appendix provides the following input files, that are used to build the content in Table 4-1:

- Input, Normal Conditions of Transport, 30-Ft. Drop, 38°C (100°F) Ambient – Model AOS-025
- Input, Normal Conditions of Transport, 30-Ft. Drop, -40°C (-40°F) Ambient – Model AOS-025
- Input, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, 38°C (100°F) Ambient – Model AOS-025
- Input, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, -40°C (-40°F) Ambient – Model AOS-025
- Input, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, 38°C (100°F) Ambient – Model AOS-025
- Input, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, -40°C (-40°F) Ambient – Model AOS-025
- Input, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, 38°C (100°F) Ambient – Model AOS-025
- Input, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, -40°C (-40°F) Ambient – Model AOS-025

4.5.3.1.1.1 Input, Normal Conditions of Transport, 30-Ft. Drop, 38°C (100°F) Ambient – Model AOS-025

```
 NORMAL CONDITION - AXIAL=10g,LATERAL=5g, AOS-025, 100F AMBIENT
*
 NUMBER OF BOLTS .....................(NB)   8
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   3.90
 LID DIAMETER AT GASKET ..............(DLG)   3.07
 NOMINAL BOLT DIAMETER ...............(DB)   .375
 LID DIAMETER AT INNER EDGE ..........(DLI)   2.63
 LID DIAMETER AT OUTER EDGE ..........(DLO)   4.65
 THICKNESS OF LID ....................(TL)   .37
 THICKNESS OF LID FLANGE .............(TLF)   .48
 THICKNESS OF CASK WALL ..............(TC)   1.03
 BOLT LENGTH .........................(BL)   .15
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .001
*
 YOUNG'S MODULUS FOR LID .............(EL)   27.3E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   27.3E6
 YOUNG'S MODULUS FOR CASK ............(EC)   27.3E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   28.0E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   9.0E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.2E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   9.0E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   30.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   30.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   185.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   185.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   185.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   185.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   185.
*
 WEIGHT OF CASK CONTENTS .............(WC)   14.
 WEIGHT OF CASK LID ..................(WL)   2.
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   0.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   0.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .......................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   10.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   5.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE ......................(Q)   420.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .........(QK)    0.15
 GASKET SEATING WIDTH ..................(GB)    1.0
 GASKET SEATING STRESS .................(GY)    3000.0
 GASKET FACTOR .........................(GM)    9.53
*
 Sm (ksi) ..............................(SM)    95.
 Sy (ksi) ..............................(SY)    142.
 Su (ksi) ..............................(SU)    175.0
 CODE EVALUATION TYPE ..................(CET)    1
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)     142.
 FATIGUE STRESS FOR VIBRATION .........(FSV)     13.0
 NUMBER OF BOLT THREADS INCH ..........(NTI)     16
```

4.5.3.1.1.2 Input, Normal Conditions of Transport, 30-Ft. Drop, -40°C (-40°F) Ambient – Model AOS-025

```
 NORMAL CONDITION - AXIAL=10g,LATERAL=5g, AOS-025, -40F AMBIENT
*
 NUMBER OF BOLTS .....................(NB)   8
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   3.90
 LID DIAMETER AT GASKET ..............(DLG)   3.07
 NOMINAL BOLT DIAMETER ...............(DB)   .375
 LID DIAMETER AT INNER EDGE ..........(DLI)   2.63
 LID DIAMETER AT OUTER EDGE ..........(DLO)   4.65
 THICKNESS OF LID ....................(TL)   .37
 THICKNESS OF LID FLANGE .............(TLF)   .48
 THICKNESS OF CASK WALL ..............(TC)   1.03
 BOLT LENGTH .........................(BL)   .15
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .001
*
 YOUNG'S MODULUS FOR LID .............(EL)   28.3E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   28.3E6
 YOUNG'S MODULUS FOR CASK ............(EC)   28.3E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   29.1E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   8.6E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.0E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   8.6E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   30.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   30.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   -34.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   -34.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   -34.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   -34.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   -34.
*
 WEIGHT OF CASK CONTENTS .............(WC)   14.
 WEIGHT OF CASK LID ..................(WL)   2.
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   0.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   0.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .......................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   10.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   5.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE ......................(Q)   420.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .....(QK)   0.15
 GASKET SEATING WIDTH ..............(GB)   1.0
 GASKET SEATING STRESS .............(GY)   3000.0
 GASKET FACTOR .....................(GM)   9.53
*
 Sm (ksi) ..........................(SM)   100.
 Sy (ksi) ..........................(SY)   150.0
 Su (ksi) ..........................(SU)   185.0
 CODE EVALUATION TYPE ..............(CET)   1
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)    150.0
 FATIGUE STRESS FOR VIBRATION .....(FSV)    13.0
 NUMBER OF BOLT THREADS INCH .....(NTI)    16
```

4.5.3.1.1.3 Input, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, 38°C (100°F) Ambient – Model AOS-025

```
 30 FT DROP - HEAD ON, AOS-025, 100F AMBIENT
*
 NUMBER OF BOLTS .....................(NB)   8
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   3.90
 LID DIAMETER AT GASKET ..............(DLG)   3.07
 NOMINAL BOLT DIAMETER ...............(DB)   .375
 LID DIAMETER AT INNER EDGE ..........(DLI)   2.63
 LID DIAMETER AT OUTER EDGE ..........(DLO)   4.65
 THICKNESS OF LID ....................(TL)   .37
 THICKNESS OF LID FLANGE .............(TLF)   .48
 THICKNESS OF CASK WALL ..............(TC)   1.03
 BOLT LENGTH .........................(BL)   .15
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .001
*
 YOUNG'S MODULUS FOR LID .............(EL)   27.3E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   27.3E6
 YOUNG'S MODULUS FOR CASK ............(EC)   27.3E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   28.0E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   9.0E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.2E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   9.0E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   30.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   30.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   185.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   185.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   185.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   185.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   185.
*
 WEIGHT OF CASK CONTENTS .............(WC)   14.
 WEIGHT OF CASK LID ..................(WL)   2.
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   90.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   883.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .....................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   0.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   0.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE .....................(Q)   420.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .........(QK)    0.15
 GASKET SEATING WIDTH ..................(GB)    1.0
 GASKET SEATING STRESS .................(GY)    3000.0
 GASKET FACTOR .........................(GM)    9.53
*
 Sm (ksi) ..............................(SM)    95.
 Sy (ksi) ..............................(SY)    142.
 Su (ksi) ..............................(SU)    175.0
 CODE EVALUATION TYPE ..................(CET)    2
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)     142.
 FATIGUE STRESS FOR VIBRATION .........(FSV)     13.0
 NUMBER OF BOLT THREADS INCH ..........(NTI)     16
```

4.5.3.1.1.4 Input, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, -40°C (-40°F) Ambient – Model AOS-025

```
 30 FT DROP - HEAD ON, AOS-025, -40F AMBIENT
*
 NUMBER OF BOLTS .....................(NB)   8
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   3.90
 LID DIAMETER AT GASKET ..............(DLG)   3.07
 NOMINAL BOLT DIAMETER ...............(DB)   .375
 LID DIAMETER AT INNER EDGE ..........(DLI)   2.63
 LID DIAMETER AT OUTER EDGE ..........(DLO)   4.65
 THICKNESS OF LID ....................(TL)   .37
 THICKNESS OF LID FLANGE .............(TLF)   .48
 THICKNESS OF CASK WALL ..............(TC)   1.03
 BOLT LENGTH .........................(BL)   .15
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .001
*
 YOUNG'S MODULUS FOR LID .............(EL)   28.3E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   28.3E6
 YOUNG'S MODULUS FOR CASK ............(EC)   28.3E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   29.1E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   8.6E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.0E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   8.6E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   30.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   30.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   -34.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   -34.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   -34.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   -34.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   -34.
*
 WEIGHT OF CASK CONTENTS .............(WC)   14.
 WEIGHT OF CASK LID ..................(WL)   2.
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   90.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   1237.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .....................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   0.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   0.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE .....................(Q)   420.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .....(QK)   0.15
 GASKET SEATING WIDTH ..............(GB)   1.0
 GASKET SEATING STRESS .............(GY)   3000.0
 GASKET FACTOR .....................(GM)   9.53
*
 Sm (ksi) ..........................(SM)   100.
 Sy (ksi) ..........................(SY)   150.0
 Su (ksi) ..........................(SU)   185.0
 CODE EVALUATION TYPE ..............(CET)   2
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)    150.0
 FATIGUE STRESS FOR VIBRATION .....(FSV)    13.0
 NUMBER OF BOLT THREADS INCH .....(NTI)    16
```

4.5.3.1.1.5 Input, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, 38°C (100°F) Ambient – Model AOS-025

```
 30 FT DROP - SIDE ORIENTATION, AOS-025, 100F AMBIENT
*
 NUMBER OF BOLTS .....................(NB)   8
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   3.90
 LID DIAMETER AT GASKET ..............(DLG)   3.07
 NOMINAL BOLT DIAMETER ...............(DB)   .375
 LID DIAMETER AT INNER EDGE ..........(DLI)   2.63
 LID DIAMETER AT OUTER EDGE ..........(DLO)   4.65
 THICKNESS OF LID ....................(TL)   .37
 THICKNESS OF LID FLANGE .............(TLF)   .48
 THICKNESS OF CASK WALL ..............(TC)   1.03
 BOLT LENGTH .........................(BL)   .15
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .001
*
 YOUNG'S MODULUS FOR LID .............(EL)   27.3E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   27.3E6
 YOUNG'S MODULUS FOR CASK ............(EC)   27.3E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   28.0E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   9.0E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.2E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   9.0E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   30.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   30.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   185.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   185.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   185.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   185.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   185.
*
 WEIGHT OF CASK CONTENTS .............(WC)   14.
 WEIGHT OF CASK LID ..................(WL)   2.
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   0.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   1286.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .......................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   0.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   0.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE ......................(Q)   420.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .........(QK)    0.15
 GASKET SEATING WIDTH ..................(GB)    1.0
 GASKET SEATING STRESS .................(GY)    3000.0
 GASKET FACTOR .........................(GM)    9.53
*
 Sm (ksi) ..............................(SM)    95.
 Sy (ksi) ..............................(SY)    142.
 Su (ksi) ..............................(SU)    175.0
 CODE EVALUATION TYPE ..................(CET)    2
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)     142.
 FATIGUE STRESS FOR VIBRATION .........(FSV)     13.0
 NUMBER OF BOLT THREADS INCH ..........(NTI)     16
```

4.5.3.1.1.6 Input, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, -40°C (-40°F) Ambient – Model AOS-025

```
 30 FT DROP - SIDE ORIENTATION, AOS-025, -40F AMBIENT
*
 NUMBER OF BOLTS .....................(NB)   8
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   3.90
 LID DIAMETER AT GASKET ..............(DLG)   3.07
 NOMINAL BOLT DIAMETER ...............(DB)   .375
 LID DIAMETER AT INNER EDGE ..........(DLI)   2.63
 LID DIAMETER AT OUTER EDGE ..........(DLO)   4.65
 THICKNESS OF LID ....................(TL)   .37
 THICKNESS OF LID FLANGE .............(TLF)   .48
 THICKNESS OF CASK WALL ..............(TC)   1.03
 BOLT LENGTH .........................(BL)   .15
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .001
*
 YOUNG'S MODULUS FOR LID .............(EL)   28.3E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   28.3E6
 YOUNG'S MODULUS FOR CASK ............(EC)   28.3E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   29.1E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   8.6E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.0E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   8.6E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   30.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   30.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   -34.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   -34.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   -34.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   -34.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   -34.
*
 WEIGHT OF CASK CONTENTS .............(WC)   14.
 WEIGHT OF CASK LID ..................(WL)   2.
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   0.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   1798.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .....................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   0.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   0.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE .....................(Q)   420.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .....(QK)   0.15
 GASKET SEATING WIDTH ..............(GB)   1.0
 GASKET SEATING STRESS .............(GY)   3000.0
 GASKET FACTOR .....................(GM)   9.53
*
 Sm (ksi) ..........................(SM)   100.
 Sy (ksi) ..........................(SY)   150.0
 Su (ksi) ..........................(SU)   185.0
 CODE EVALUATION TYPE ..............(CET)   2
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)    150.0
 FATIGUE STRESS FOR VIBRATION .....(FSV)    13.0
 NUMBER OF BOLT THREADS INCH .....(NTI)    16
```

4.5.3.1.1.7 Input, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, 38°C (100°F) Ambient – Model AOS-025

```
 30FT DROP @ 45 DEG, AOS-025, 100F AMBIENT
*
 NUMBER OF BOLTS .....................(NB)   8
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   3.90
 LID DIAMETER AT GASKET ..............(DLG)   3.07
 NOMINAL BOLT DIAMETER ...............(DB)   .375
 LID DIAMETER AT INNER EDGE ..........(DLI)   2.63
 LID DIAMETER AT OUTER EDGE ..........(DLO)   4.65
 THICKNESS OF LID ....................(TL)   .37
 THICKNESS OF LID FLANGE .............(TLF)   .48
 THICKNESS OF CASK WALL ..............(TC)   1.03
 BOLT LENGTH .........................(BL)   .15
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .001
*
 YOUNG'S MODULUS FOR LID .............(EL)   27.3E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   27.3E6
 YOUNG'S MODULUS FOR CASK ............(EC)   27.3E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   28.0E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   9.0E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.2E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   9.0E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   30.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   30.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   185.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   185.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   185.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   185.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   185.
*
 WEIGHT OF CASK CONTENTS .............(WC)   14.
 WEIGHT OF CASK LID ..................(WL)   2.
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   45.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   799.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .....................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   0.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   0.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE .....................(Q)   420.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .........(QK)    0.15
 GASKET SEATING WIDTH ..................(GB)    1.0
 GASKET SEATING STRESS .................(GY)    3000.0
 GASKET FACTOR .........................(GM)    9.53
*
 Sm (ksi) ..............................(SM)    95.
 Sy (ksi) ..............................(SY)    142.
 Su (ksi) ..............................(SU)    175.0
 CODE EVALUATION TYPE ..................(CET)    2
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)     142.
 FATIGUE STRESS FOR VIBRATION .........(FSV)     13.0
 NUMBER OF BOLT THREADS INCH ..........(NTI)     16
```

4.5.3.1.1.8 Input, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, -40°C (-40°F) Ambient – Model AOS-025

```
 30FT DROP @ 45 DEG, AOS-025, -40F AMBIENT
*
 NUMBER OF BOLTS .....................(NB)   8
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   3.90
 LID DIAMETER AT GASKET ..............(DLG)   3.07
 NOMINAL BOLT DIAMETER ...............(DB)   .375
 LID DIAMETER AT INNER EDGE ..........(DLI)   2.63
 LID DIAMETER AT OUTER EDGE ..........(DLO)   4.65
 THICKNESS OF LID ....................(TL)   .37
 THICKNESS OF LID FLANGE .............(TLF)   .48
 THICKNESS OF CASK WALL ..............(TC)   1.03
 BOLT LENGTH .........................(BL)   .15
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .001
*
 YOUNG'S MODULUS FOR LID .............(EL)   28.3E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   28.3E6
 YOUNG'S MODULUS FOR CASK ............(EC)   28.3E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   29.1E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   8.6E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.0E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   8.6E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   30.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   30.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   -34.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   -34.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   -34.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   -34.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   -34.
*
 WEIGHT OF CASK CONTENTS .............(WC)   14.
 WEIGHT OF CASK LID ..................(WL)   2.
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   45.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   1125.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .....................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   0.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   0.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE .....................(Q)   420.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .........(QK)    0.15
 GASKET SEATING WIDTH ..................(GB)    1.0
 GASKET SEATING STRESS .................(GY)    3000.0
 GASKET FACTOR .........................(GM)    9.53
*
 Sm (ksi) ..............................(SM)    100.
 Sy (ksi) ..............................(SY)    150.0
 Su (ksi) ..............................(SU)    185.0
 CODE EVALUATION TYPE ..................(CET)    2
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)     150.0
 FATIGUE STRESS FOR VIBRATION .........(FSV)     13.0
 NUMBER OF BOLT THREADS INCH ..........(NTI)     16
```

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4.5.3.1.2 Cask Lid Attachment Bolt Fortran Program Input Files – Model AOS-050

This appendix provides the following input files, that are used to build the content in Table 4-1:

- Input, Normal Conditions of Transport, 30-Ft. Drop, 38°C (100°F) Ambient – Model AOS-050
- Input, Normal Conditions of Transport, 30-Ft. Drop, -40°C (-40°F) Ambient – Model AOS-050
- Input, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, 38°C (100°F) Ambient – Model AOS-050
- Input, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, -40°C (-40°F) Ambient – Model AOS-050
- Input, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, 38°C (100°F) Ambient – Model AOS-050
- Input, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, -40°C (-40°F) Ambient – Model AOS-050
- Input, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, 38°C (100°F) Ambient – Model AOS-050
- Input, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, -40°C (-40°F) Ambient – Model AOS-050

4.5.3.1.2.1 Input, Normal Conditions of Transport, 30-Ft. Drop, 38°C (100°F) Ambient – Model AOS-050

```
 30FT DROP @ 45 DEG, AOS-025, -40F AMBIENT
*
 NUMBER OF BOLTS .....................(NB)   8
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   3.90
 LID DIAMETER AT GASKET ..............(DLG)   3.07
 NOMINAL BOLT DIAMETER ...............(DB)   .375
 LID DIAMETER AT INNER EDGE ..........(DLI)   2.63
 LID DIAMETER AT OUTER EDGE ..........(DLO)   4.65
 THICKNESS OF LID ....................(TL)   .37
 THICKNESS OF LID FLANGE .............(TLF)   .48
 THICKNESS OF CASK WALL ..............(TC)   1.03
 BOLT LENGTH .........................(BL)   .15
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .001
*
 YOUNG'S MODULUS FOR LID .............(EL)   28.3E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   28.3E6
 YOUNG'S MODULUS FOR CASK ............(EC)   28.3E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   29.1E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   8.6E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.0E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   8.6E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   30.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   30.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   -34.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   -34.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   -34.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   -34.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   -34.
*
 WEIGHT OF CASK CONTENTS .............(WC)   14.
 WEIGHT OF CASK LID ..................(WL)   2.
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   45.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   1125.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .....................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   0.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   0.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE .....................(Q)   420.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .........(QK)    0.15
 GASKET SEATING WIDTH ..................(GB)    1.0
 GASKET SEATING STRESS .................(GY)    3000.0
 GASKET FACTOR .........................(GM)    9.53
*
 Sm (ksi) ..............................(SM)    100.
 Sy (ksi) ..............................(SY)    150.0
 Su (ksi) ..............................(SU)    185.0
 CODE EVALUATION TYPE ..................(CET)    2
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)     150.0
 FATIGUE STRESS FOR VIBRATION .........(FSV)     13.0
 NUMBER OF BOLT THREADS INCH ..........(NTI)     16
```

4.5.3.1.2.2 Input, Normal Conditions of Transport, 30-Ft. Drop, -40°C (-40°F) Ambient – Model AOS-050

```
 NORMAL CONDITION - AXIAL=10g,LATERAL=5g AOS-050, -40F AMBIENT
*
 NUMBER OF BOLTS .....................(NB)   10
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   7.414
 LID DIAMETER AT GASKET ..............(DLG)   6.09
 NOMINAL BOLT DIAMETER ...............(DB)   .50
 LID DIAMETER AT INNER EDGE ..........(DLI)   5.53
 LID DIAMETER AT OUTER EDGE ..........(DLO)   8.90
 THICKNESS OF LID ....................(TL)   .75
 THICKNESS OF LID FLANGE .............(TLF)   .97
 THICKNESS OF CASK WALL ..............(TC)   1.705
 BOLT LENGTH .........................(BL)   .41
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .003
*
 YOUNG'S MODULUS FOR LID .............(EL)   28.3E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   28.3E6
 YOUNG'S MODULUS FOR CASK ............(EC)   28.3E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   28.9E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   8.6E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.0E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   8.6E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   60.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   60.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   15.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   15.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   15.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   15.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   16.
*
 WEIGHT OF CASK CONTENTS .............(WC)   95.
 WEIGHT OF CASK LID ..................(WL)   14.
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   0.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   0.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .....................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   10.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   5.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE ......................(Q)   750.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .........(QK)    0.15
 GASKET SEATING WIDTH ..................(GB)    1.0
 GASKET SEATING STRESS .................(GY)    3000.0
 GASKET FACTOR .........................(GM)    3.18
*
 Sm (ksi) ..............................(SM)    100.
 Sy (ksi) ..............................(SY)    150.0
 Su (ksi) ..............................(SU)    185.0
 CODE EVALUATION TYPE ..................(CET)   1
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)     150.0
 FATIGUE STRESS FOR VIBRATION .........(FSV)    13.0
 NUMBER OF BOLT THREADS INCH ..........(NTI)    13
```

4.5.3.1.2.3 Input, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, 38°C (100°F) Ambient – Model AOS-050

```
 30-FT DROP HEAD ON AOS-050 CONFIGURATION, 100F AMBIENT
*
 NUMBER OF BOLTS .....................(NB)   10
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   7.414
 LID DIAMETER AT GASKET ..............(DLG)   6.09
 NOMINAL BOLT DIAMETER ...............(DB)   .50
 LID DIAMETER AT INNER EDGE ..........(DLI)   5.53
 LID DIAMETER AT OUTER EDGE ..........(DLO)   8.90
 THICKNESS OF LID ....................(TL)   .75
 THICKNESS OF LID FLANGE .............(TLF)   .97
 THICKNESS OF CASK WALL ..............(TC)   1.705
 BOLT LENGTH .........................(BL)   .41
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .003
*
 YOUNG'S MODULUS FOR LID .............(EL)   27.1E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   27.1E6
 YOUNG'S MODULUS FOR CASK ............(EC)   27.1E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   27.9E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   9.0E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.3E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   9.0E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   60.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   60.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   216.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   216.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   216.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   216.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   216.
*
 WEIGHT OF CASK CONTENTS .............(WC)   95.
 WEIGHT OF CASK LID ..................(WL)   14.
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   90.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   314.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .....................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   0.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   0.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE ......................(Q)   750.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .........(QK)    0.15
 GASKET SEATING WIDTH ..................(GB)    1.0
 GASKET SEATING STRESS .................(GY)    3000.0
 GASKET FACTOR .........................(GM)    3.18
*
 Sm (ksi) ..............................(SM)    94.
 Sy (ksi) ..............................(SY)    141.0
 Su (ksi) ..............................(SU)    174.0
 CODE EVALUATION TYPE ..................(CET)   2
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)     141.0
 FATIGUE STRESS FOR VIBRATION .........(FSV)    13.0
 NUMBER OF BOLT THREADS INCH ..........(NTI)    13
```

4.5.3.1.2.4 Input, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, -40°C (-40°F) Ambient – Model AOS-050

```
 30-FT DROP HEAD ON AOS-050 CONFIGURATION, -40F AMBIENT
*
 NUMBER OF BOLTS .....................(NB)   10
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   7.414
 LID DIAMETER AT GASKET ..............(DLG)   6.09
 NOMINAL BOLT DIAMETER ...............(DB)   .50
 LID DIAMETER AT INNER EDGE ..........(DLI)   5.53
 LID DIAMETER AT OUTER EDGE ..........(DLO)   8.90
 THICKNESS OF LID ....................(TL)   .75
 THICKNESS OF LID FLANGE .............(TLF)   .97
 THICKNESS OF CASK WALL ..............(TC)   1.705
 BOLT LENGTH .........................(BL)   .41
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .003
*
 YOUNG'S MODULUS FOR LID .............(EL)   28.3E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   28.3E6
 YOUNG'S MODULUS FOR CASK ............(EC)   28.3E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   28.9E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   8.6E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.0E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   8.6E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   60.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   60.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   15.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   15.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   15.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   15.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   16.
*
 WEIGHT OF CASK CONTENTS .............(WC)   95.
 WEIGHT OF CASK LID ..................(WL)   14.
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   90.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   439.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .....................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   0.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   0.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE .....................(Q)   750.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .....(QK)   0.15
 GASKET SEATING WIDTH ..............(GB)   1.0
 GASKET SEATING STRESS .............(GY)   3000.0
 GASKET FACTOR .....................(GM)   3.18
*
 Sm (ksi) ..........................(SM)   100.
 Sy (ksi) ..........................(SY)   150.
 Su (ksi) ..........................(SU)   185.0
 CODE EVALUATION TYPE ..............(CET)   2
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)    150.
 FATIGUE STRESS FOR VIBRATION .....(FSV)    13.0
 NUMBER OF BOLT THREADS INCH .....(NTI)    13
```

4.5.3.1.2.5 Input, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, 38°C (100°F) Ambient – Model AOS-050

```
 30-FT DROP SIDE ORIENTATION AOS-050 , 100F AMBIENT
*
 NUMBER OF BOLTS .....................(NB)   10
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   7.414
 LID DIAMETER AT GASKET ..............(DLG)   6.09
 NOMINAL BOLT DIAMETER ...............(DB)   .50
 LID DIAMETER AT INNER EDGE ..........(DLI)   5.53
 LID DIAMETER AT OUTER EDGE ..........(DLO)   8.90
 THICKNESS OF LID ....................(TL)   .75
 THICKNESS OF LID FLANGE .............(TLF)   .97
 THICKNESS OF CASK WALL ..............(TC)   1.705
 BOLT LENGTH .........................(BL)   .41
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .003
*
 YOUNG'S MODULUS FOR LID .............(EL)   27.1E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   27.1E6
 YOUNG'S MODULUS FOR CASK ............(EC)   27.1E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   27.9E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   9.0E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.3E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   9.0E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   60.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   60.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   216.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   216.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   216.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   216.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   216.
*
 WEIGHT OF CASK CONTENTS .............(WC)   95.
 WEIGHT OF CASK LID ..................(WL)   14.
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   0.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   335.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .......................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   0.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   0.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE ......................(Q)   750.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .........(QK)    0.15
 GASKET SEATING WIDTH ..................(GB)    1.0
 GASKET SEATING STRESS .................(GY)    3000.0
 GASKET FACTOR .........................(GM)    3.18
*
 Sm (ksi) ..............................(SM)    94.
 Sy (ksi) ..............................(SY)    141.0
 Su (ksi) ..............................(SU)    174.0
 CODE EVALUATION TYPE ..................(CET)   2
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)     141.0
 FATIGUE STRESS FOR VIBRATION .........(FSV)    13.0
 NUMBER OF BOLT THREADS INCH ..........(NTI)    13
```

4.5.3.1.2.6 Input, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, -40°C (-40°F) Ambient – Model AOS-050

```
 30-FT DROP SIDE ORIENTATION AOS-050, -40F AMBIENT
*
 NUMBER OF BOLTS .....................(NB)   10
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   7.414
 LID DIAMETER AT GASKET ..............(DLG)   6.09
 NOMINAL BOLT DIAMETER ...............(DB)   .50
 LID DIAMETER AT INNER EDGE ..........(DLI)   5.53
 LID DIAMETER AT OUTER EDGE ..........(DLO)   8.90
 THICKNESS OF LID ....................(TL)   .75
 THICKNESS OF LID FLANGE .............(TLF)   .97
 THICKNESS OF CASK WALL ..............(TC)   1.705
 BOLT LENGTH .........................(BL)   .41
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .003
*
 YOUNG'S MODULUS FOR LID .............(EL)   28.3E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   28.3E6
 YOUNG'S MODULUS FOR CASK ............(EC)   28.3E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   28.9E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   8.6E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.0E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   8.6E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   60.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   60.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   15.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   15.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   15.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   15.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   16.
*
 WEIGHT OF CASK CONTENTS .............(WC)   95.
 WEIGHT OF CASK LID ..................(WL)   14.
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   0.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   469.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .......................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   0.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   0.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE ......................(Q)   750.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .........(QK)    0.15
 GASKET SEATING WIDTH ..................(GB)    1.0
 GASKET SEATING STRESS .................(GY)    3000.0
 GASKET FACTOR .........................(GM)    3.18
*
 Sm (ksi) ..............................(SM)    100.
 Sy (ksi) ..............................(SY)    150.
 Su (ksi) ..............................(SU)    185.0
 CODE EVALUATION TYPE ..................(CET)   2
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)     150.
 FATIGUE STRESS FOR VIBRATION .........(FSV)    13.0
 NUMBER OF BOLT THREADS INCH ..........(NTI)    13
```

4.5.3.1.2.7 Input, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, 38°C (100°F) Ambient – Model AOS-050

```
 30-FT @ 45 DEG CORNER AOS-050 CONFIGURATION, 100F AMBIENT
*
 NUMBER OF BOLTS .....................(NB)   10
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   7.414
 LID DIAMETER AT GASKET ..............(DLG)   6.09
 NOMINAL BOLT DIAMETER ...............(DB)   .50
 LID DIAMETER AT INNER EDGE ..........(DLI)   5.53
 LID DIAMETER AT OUTER EDGE ..........(DLO)   8.9
 THICKNESS OF LID ....................(TL)   .75
 THICKNESS OF LID FLANGE .............(TLF)   .97
 THICKNESS OF CASK WALL ..............(TC)   1.705
 BOLT LENGTH .........................(BL)   .41
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .003
*
 YOUNG'S MODULUS FOR LID .............(EL)   27.1E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   27.1E6
 YOUNG'S MODULUS FOR CASK ............(EC)   27.1E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   27.9E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   9.0E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.3E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   9.0E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   60.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   60.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   216.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   216.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   216.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   216.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   216.
*
 WEIGHT OF CASK CONTENTS .............(WC)   95.
 WEIGHT OF CASK LID ..................(WL)   14.
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   45.
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   176.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .......................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   0.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   0.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE ......................(Q)   750.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .........(QK)    0.15
 GASKET SEATING WIDTH ..................(GB)    1.0
 GASKET SEATING STRESS .................(GY)    3000.
 GASKET FACTOR .........................(GM)    3.18
*
 Sm (ksi) ..............................(SM)    94.
 Sy (ksi) ..............................(SY)    141.0
 Su (ksi) ..............................(SU)    174.0
 CODE EVALUATION TYPE ..................(CET)    2
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)     141.0
 FATIGUE STRESS FOR VIBRATION .........(FSV)     13.0
 NUMBER OF BOLT THREADS INCH ..........(NTI)     13
```

4.5.3.1.2.8 Input, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, -40°C (-40°F) Ambient – Model AOS-050

```
 30-FT @ 45 DEG CORNER AOS-050 CONFIGURATION, -40F AMBIENT
*
 NUMBER OF BOLTS .....................(NB)   10
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   7.414
 LID DIAMETER AT GASKET ..............(DLG)   6.09
 NOMINAL BOLT DIAMETER ...............(DB)   .50
 LID DIAMETER AT INNER EDGE ..........(DLI)   5.53
 LID DIAMETER AT OUTER EDGE ..........(DLO)   8.9
 THICKNESS OF LID ....................(TL)   .75
 THICKNESS OF LID FLANGE .............(TLF)   .97
 THICKNESS OF CASK WALL ..............(TC)   1.705
 BOLT LENGTH .........................(BL)   .41
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .003
*
 YOUNG'S MODULUS FOR LID .............(EL)   28.3E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   28.3E6
 YOUNG'S MODULUS FOR CASK ............(EC)   28.3E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   28.9E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   8.6E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.0E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   8.6E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   60.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   60.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   15.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   15.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   15.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   15.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   16.
*
 WEIGHT OF CASK CONTENTS .............(WC)   95.
 WEIGHT OF CASK LID ..................(WL)   14.
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   45.
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   247.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .......................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   0.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   0.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE ......................(Q)   750.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .....(QK)   0.15
 GASKET SEATING WIDTH ..............(GB)   1.0
 GASKET SEATING STRESS .............(GY)   3000.
 GASKET FACTOR .....................(GM)   3.18
*
 Sm (ksi) ..........................(SM)   100.
 Sy (ksi) ..........................(SY)   150.
 Su (ksi) ..........................(SU)   185.0
 CODE EVALUATION TYPE ..............(CET)   2
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)    150.
 FATIGUE STRESS FOR VIBRATION .....(FSV)    13.0
 NUMBER OF BOLT THREADS INCH .....(NTI)    13
```

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4.5.3.1.3 Cask Lid Attachment Bolt Fortran Program Input Files – Model AOS-100

This appendix provides the following input files, that are used to build the content in Table 4-1:

- Input, Normal Conditions of Transport, 30-Ft. Drop, 38°C (100°F) Ambient – Model AOS-100
- Input, Normal Conditions of Transport, 30-Ft. Drop, -40°C (-40°F) Ambient – Model AOS-100
- Input, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, 38°C (100°F) Ambient – Model AOS-100
- Input, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, -40°C (-40°F) Ambient – Model AOS-100
- Input, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, 38°C (100°F) Ambient – Model AOS-100
- Input, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, -40°C (-40°F) Ambient – Model AOS-100
- Input, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, 38°C (100°F) Ambient – Model AOS-100
- Input, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, -40°C (-40°F) Ambient – Model AOS-100

4.5.3.1.3.1 Input, Normal Conditions of Transport, 30-Ft. Drop, 38°C (100°F) Ambient – Model AOS-100

```
 NORMAL CONDITION - AXIAL=10g,LATERAL=5g AOS-100, 100F AMBIENT
*
 NUMBER OF BOLTS .....................(NB)   14
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   14.064
 LID DIAMETER AT GASKET ..............(DLG)   12.172
 NOMINAL BOLT DIAMETER ...............(DB)   .875
 LID DIAMETER AT INNER EDGE ..........(DLI)   11.04
 LID DIAMETER AT OUTER EDGE ..........(DLO)   16.59
 THICKNESS OF LID ....................(TL)   1.51
 THICKNESS OF LID FLANGE .............(TLF)   1.94
 THICKNESS OF CASK WALL ..............(TC)   2.805
 BOLT LENGTH .........................(BL)   1.06
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .029
*
 YOUNG'S MODULUS FOR LID .............(EL)   27.1E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   27.1E6
 YOUNG'S MODULUS FOR CASK ............(EC)   27.1E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   27.9E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   9.1E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.3E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   9.1E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   280.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   280.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   223.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   223.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   223.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   224.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   224.
*
 WEIGHT OF CASK CONTENTS .............(WC)   786.0
 WEIGHT OF CASK LID ..................(WL)   96.0
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   0.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   0.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .......................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   10.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   5.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE ......................(Q)   6000.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .....(QK)   0.15
 GASKET SEATING WIDTH ..............(GB)   1.0
 GASKET SEATING STRESS .............(GY)   3000.0
 GASKET FACTOR .....................(GM)   .54
*
 Sm (ksi) ..........................(SM)   94.
 Sy (ksi) ..........................(SY)   141.
 Su (ksi) ..........................(SU)   174.0
 CODE EVALUATION TYPE ..............(CET)   1
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)    141.
 FATIGUE STRESS FOR VIBRATION .....(FSV)    13.0
 NUMBER OF BOLT THREADS INCH .....(NTI)    9
```

4.5.3.1.3.2 Input, Normal Conditions of Transport, 30-Ft. Drop, -40°C (-40°F) Ambient – Model AOS-100

```
 NORMAL CONDITION - AXIAL=10g,LATERAL=5g AOS-100, -40F Ambient
*
 NUMBER OF BOLTS .....................(NB)   14
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   14.064
 LID DIAMETER AT GASKET ..............(DLG)   12.172
 NOMINAL BOLT DIAMETER ...............(DB)   .875
 LID DIAMETER AT INNER EDGE ..........(DLI)   11.04
 LID DIAMETER AT OUTER EDGE ..........(DLO)   16.59
 THICKNESS OF LID ....................(TL)   1.51
 THICKNESS OF LID FLANGE .............(TLF)   1.94
 THICKNESS OF CASK WALL ..............(TC)   2.805
 BOLT LENGTH .........................(BL)   1.06
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .029
*
 YOUNG'S MODULUS FOR LID .............(EL)   28.3E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   28.3E6
 YOUNG'S MODULUS FOR CASK ............(EC)   28.3E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   28.9E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   8.6E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.0E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   8.6E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   280.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   280.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   15.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   15.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   15.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   16.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   16.
*
 WEIGHT OF CASK CONTENTS .............(WC)   786.0
 WEIGHT OF CASK LID ..................(WL)   96.0
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   0.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   0.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .......................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   10.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   5.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE ......................(Q)   6000.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .....(QK)   0.15
 GASKET SEATING WIDTH ..............(GB)   1.0
 GASKET SEATING STRESS .............(GY)   3000.0
 GASKET FACTOR .....................(GM)   .54
*
 Sm (ksi) ..........................(SM)   100.
 Sy (ksi) ..........................(SY)   150.0
 Su (ksi) ..........................(SU)   185.0
 CODE EVALUATION TYPE ..............(CET)   1
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)    150.0
 FATIGUE STRESS FOR VIBRATION .....(FSV)    13.0
 NUMBER OF BOLT THREADS INCH .....(NTI)    9
```

4.5.3.1.3.3 Input, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, 38°C (100°F) Ambient – Model AOS-100

```
30-FT DROP - Head-on  AOS-100, 100F Ambient
*
 NUMBER OF BOLTS .....................(NB)   14
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   14.064
 LID DIAMETER AT GASKET ..............(DLG)   12.172
 NOMINAL BOLT DIAMETER ...............(DB)   .875
 LID DIAMETER AT INNER EDGE ..........(DLI)   11.04
 LID DIAMETER AT OUTER EDGE ..........(DLO)   16.59
 THICKNESS OF LID ....................(TL)   1.51
 THICKNESS OF LID FLANGE .............(TLF)   1.94
 THICKNESS OF CASK WALL ..............(TC)   2.805
 BOLT LENGTH .........................(BL)   1.06
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .029
*
 YOUNG'S MODULUS FOR LID .............(EL)   27.1E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   27.1E6
 YOUNG'S MODULUS FOR CASK ............(EC)   27.1E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   27.9E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   9.1E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.3E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   9.1E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   280.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   280.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   223.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   223.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   223.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   224.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   224.
*
 WEIGHT OF CASK CONTENTS .............(WC)   786.0
 WEIGHT OF CASK LID ..................(WL)   96.0
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   90.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   156.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .......................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   0.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   0.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE ......................(Q)   6000.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .....(QK)   0.15
 GASKET SEATING WIDTH ..............(GB)   1.0
 GASKET SEATING STRESS .............(GY)   3000.0
 GASKET FACTOR .....................(GM)   .54
*
 Sm (ksi) ..........................(SM)   94.0
 Sy (ksi) ..........................(SY)   141.0
 Su (ksi) ..........................(SU)   174.0
 CODE EVALUATION TYPE ..............(CET)   2
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)    141.0
 FATIGUE STRESS FOR VIBRATION .....(FSV)    13.0
 NUMBER OF BOLT THREADS INCH .....(NTI)    9
```

4.5.3.1.3.4 Input, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, -40°C (-40°F) Ambient – Model AOS-100

```
 30-FT DROP - Head-on  AOS-100, -40F Ambient
*
 NUMBER OF BOLTS .....................(NB)   14
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   14.064
 LID DIAMETER AT GASKET ..............(DLG)   12.172
 NOMINAL BOLT DIAMETER ...............(DB)   .875
 LID DIAMETER AT INNER EDGE ..........(DLI)   11.04
 LID DIAMETER AT OUTER EDGE ..........(DLO)   16.59
 THICKNESS OF LID ....................(TL)   1.51
 THICKNESS OF LID FLANGE .............(TLF)   1.94
 THICKNESS OF CASK WALL ..............(TC)   2.805
 BOLT LENGTH .........................(BL)   1.06
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .029
*
 YOUNG'S MODULUS FOR LID .............(EL)   28.3E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   28.3E6
 YOUNG'S MODULUS FOR CASK ............(EC)   28.3E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   28.9E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   8.6E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.0E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   8.6E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   280.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   280.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   15.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   15.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   15.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   16.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   16.
*
 WEIGHT OF CASK CONTENTS .............(WC)   786.0
 WEIGHT OF CASK LID ..................(WL)   96.0
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   90.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   218.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .......................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   0.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   0.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE ......................(Q)   6000.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .....(QK)   0.15
 GASKET SEATING WIDTH ..............(GB)   1.0
 GASKET SEATING STRESS .............(GY)   3000.0
 GASKET FACTOR .....................(GM)   .54
*
 Sm (ksi) ..........................(SM)   100.
 Sy (ksi) ..........................(SY)   150.0
 Su (ksi) ..........................(SU)   185.0
 CODE EVALUATION TYPE ..............(CET)   2
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)    150.0
 FATIGUE STRESS FOR VIBRATION .....(FSV)    13.0
 NUMBER OF BOLT THREADS INCH .....(NTI)    9
```

4.5.3.1.3.5 Input, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, 38°C (100°F) Ambient – Model AOS-100

```
30-FT DROP - Side  AOS-100, 100F Ambient
*
 NUMBER OF BOLTS .....................(NB)   14
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   14.064
 LID DIAMETER AT GASKET ..............(DLG)   12.172
 NOMINAL BOLT DIAMETER ...............(DB)   .875
 LID DIAMETER AT INNER EDGE ..........(DLI)   11.04
 LID DIAMETER AT OUTER EDGE ..........(DLO)   16.59
 THICKNESS OF LID ....................(TL)   1.51
 THICKNESS OF LID FLANGE .............(TLF)   1.94
 THICKNESS OF CASK WALL ..............(TC)   2.805
 BOLT LENGTH .........................(BL)   1.06
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .029
*
 YOUNG'S MODULUS FOR LID .............(EL)   27.1E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   27.1E6
 YOUNG'S MODULUS FOR CASK ............(EC)   27.1E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   27.9E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   9.1E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.3E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   9.1E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   280.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   280.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   223.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   223.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   223.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   224.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   224.
*
 WEIGHT OF CASK CONTENTS .............(WC)   786.0
 WEIGHT OF CASK LID ..................(WL)   96.0
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   0.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   171.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .......................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   0.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   0.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE ......................(Q)   6000.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .........(QK)    0.15
 GASKET SEATING WIDTH ..................(GB)    1.0
 GASKET SEATING STRESS .................(GY)    3000.0
 GASKET FACTOR .........................(GM)    .54
*
 Sm (ksi) ..............................(SM)    94.
 Sy (ksi) ..............................(SY)    141.
 Su (ksi) ..............................(SU)    174.0
 CODE EVALUATION TYPE ..................(CET)   2
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)     141.
 FATIGUE STRESS FOR VIBRATION .........(FSV)    13.0
 NUMBER OF BOLT THREADS INCH ..........(NTI)    9
```

4.5.3.1.3.6 Input, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, -40°C (-40°F) Ambient – Model AOS-100

```
 30-FT DROP - Side  AOS-100, -40F Ambient
*
 NUMBER OF BOLTS .....................(NB)   14
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   14.064
 LID DIAMETER AT GASKET ..............(DLG)   12.172
 NOMINAL BOLT DIAMETER ...............(DB)   .875
 LID DIAMETER AT INNER EDGE ..........(DLI)   11.04
 LID DIAMETER AT OUTER EDGE ..........(DLO)   16.59
 THICKNESS OF LID ....................(TL)   1.51
 THICKNESS OF LID FLANGE .............(TLF)   1.94
 THICKNESS OF CASK WALL ..............(TC)   2.805
 BOLT LENGTH .........................(BL)   1.06
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .029
*
 YOUNG'S MODULUS FOR LID .............(EL)   28.3E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   28.3E6
 YOUNG'S MODULUS FOR CASK ............(EC)   28.3E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   28.9E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   8.6E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.0E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   8.6E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   280.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   280.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   15.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   15.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   15.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   16.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   16.
*
 WEIGHT OF CASK CONTENTS .............(WC)   786.0
 WEIGHT OF CASK LID ..................(WL)   96.0
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   0.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   240.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .......................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   0.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   0.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE ......................(Q)   6000.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .....(QK)   0.15
 GASKET SEATING WIDTH ..............(GB)   1.0
 GASKET SEATING STRESS .............(GY)   3000.0
 GASKET FACTOR .....................(GM)   .54
*
 Sm (ksi) ..........................(SM)   100.
 Sy (ksi) ..........................(SY)   150.0
 Su (ksi) ..........................(SU)   185.0
 CODE EVALUATION TYPE ..............(CET)   2
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)    150.0
 FATIGUE STRESS FOR VIBRATION .....(FSV)    13.0
 NUMBER OF BOLT THREADS INCH .....(NTI)    9
```

4.5.3.1.3.7 Input, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, 38°C (100°F) Ambient – Model AOS-100

```
 30-FT DROP - @ 45 DEG CORNER AOS-100, 100F AMBIENT
*
 NUMBER OF BOLTS .....................(NB)   14
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   14.064
 LID DIAMETER AT GASKET ..............(DLG)   12.172
 NOMINAL BOLT DIAMETER ...............(DB)   .875
 LID DIAMETER AT INNER EDGE ..........(DLI)   11.04
 LID DIAMETER AT OUTER EDGE ..........(DLO)   16.59
 THICKNESS OF LID ....................(TL)   1.51
 THICKNESS OF LID FLANGE .............(TLF)   1.94
 THICKNESS OF CASK WALL ..............(TC)   2.805
 BOLT LENGTH .........................(BL)   1.06
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .029
*
 YOUNG'S MODULUS FOR LID .............(EL)   27.1E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   27.1E6
 YOUNG'S MODULUS FOR CASK ............(EC)   27.1E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   27.9E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   9.1E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.3E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   9.1E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   280.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   280.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   223.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   223.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   223.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   224.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   224.
*
 WEIGHT OF CASK CONTENTS .............(WC)   786.0
 WEIGHT OF CASK LID ..................(WL)   96.0
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   45.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   88.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .......................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   0.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   0.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE ......................(Q)   6000.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .........(QK)    0.15
 GASKET SEATING WIDTH ..................(GB)    1.0
 GASKET SEATING STRESS .................(GY)    3000.0
 GASKET FACTOR .........................(GM)    .54
*
 Sm (ksi) ..............................(SM)    94.0
 Sy (ksi) ..............................(SY)    141.0
 Su (ksi) ..............................(SU)    174.0
 CODE EVALUATION TYPE ..................(CET)   2
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)     141.0
 FATIGUE STRESS FOR VIBRATION .........(FSV)    13.0
 NUMBER OF BOLT THREADS INCH ..........(NTI)    9
```

4.5.3.1.3.8 Input, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, -40°C (-40°F) Ambient – Model AOS-100

```
 30-FT DROP - @ 45 DEG CORNER AOS-100, -40F AMBIENT
*
 NUMBER OF BOLTS .....................(NB)   14
 LID DIAMETER AT BOLT CIRCLE .........(DLB)   14.064
 LID DIAMETER AT GASKET ..............(DLG)   12.172
 NOMINAL BOLT DIAMETER ...............(DB)   .875
 LID DIAMETER AT INNER EDGE ..........(DLI)   11.04
 LID DIAMETER AT OUTER EDGE ..........(DLO)   16.59
 THICKNESS OF LID ....................(TL)   1.51
 THICKNESS OF LID FLANGE .............(TLF)   1.94
 THICKNESS OF CASK WALL ..............(TC)   2.805
 BOLT LENGTH .........................(BL)   1.06
 BOLT MOMENT OF INERTIA / CIRUMFER....(XIB)   .029
*
 YOUNG'S MODULUS FOR LID .............(EL)   28.3E6
 YOUNG'S MODULUS FOR LID FLANGE .......(EL)   28.3E6
 YOUNG'S MODULUS FOR CASK ............(EC)   28.3E6
 YOUNG'S MODULUS FOR BOLT ............(EB)   28.9E6
 POISSON'S RATIO FOR LID .............(XNUL)   0.3
 POISSON'S RATIO FOR CASK ............(XNUC)   0.3
 LID THERMAL EXPANSION COEFF ..........(AL)   8.6E-6
 BOLT THERMAL EXPANSION COEFF .........(AB)   7.0E-6
 WALL THERMAL EXPANSION COEFF .........(AC)   8.6E-6
 FLANGE COEFFICIENT OF FRICTION ......(FCF)   0.9
*
 INSIDE PRESSURE AT LID ..............(PLI)   280.0
 OUTSIDE PRESSURE AT LID .............(PLO)   15.0
 INSIDE PRESSURE AT CASK WALL ........(PCI)   280.0
 OUTSIDE PRESSURE AT CASK WALL .......(PCO)   15.0
*
 TEMPERATURE CHG ACROSS LID ........(TEMPL)   15.
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB)   15.
 TEMPERATURE CHG ACROSS WALL .......(TEMPC)   15.
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)   16.
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI)   16.
*
 WEIGHT OF CASK CONTENTS .............(WC)   786.0
 WEIGHT OF CASK LID ..................(WL)   96.0
 DROP ANGLE OF IMPACT, deg .......(XI_DROP)   45.0
 CG/CORNER IMPACT ACCEL, g ..........(ACCI)   124.
 DYNAMIC LOAD FACTOR .................(DYLF)   1.15
*
 PUNCTURE LOAD .......................(PUNC)   0.0
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC)   45.0
*
 AXIAL VIBRATION ACCELERATION (g) ....(AVA)   0.0
 TRANSVERSE VIBRATION ACCELER (g). ...(AVT)   0.0
 VIBRATION TRANSMISSIBILITY FACTOR ...(VTR)   1.0
*
 PRELOAD TORQUE ......................(Q)   6000.0
```

```
 NUT FACTOR FOR PRELOAD TORQUE .....(QK)   0.15
 GASKET SEATING WIDTH ..............(GB)   1.0
 GASKET SEATING STRESS .............(GY)   3000.0
 GASKET FACTOR .....................(GM)   .54
*
 Sm (ksi) ..........................(SM)   100.
 Sy (ksi) ..........................(SY)   150.0
 Su (ksi) ..........................(SU)   185.0
 CODE EVALUATION TYPE ..............(CET)   2
*
 FATIGUE STRESS FOR NORMAL OPERATION .(FSO)    150.0
 FATIGUE STRESS FOR VIBRATION .....(FSV)    13.0
 NUMBER OF BOLT THREADS INCH .....(NTI)    9
```

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4.5.3.2 Output Files from Cask Lid Attachment Bolt Fortran Program

This appendix provides the following output files, that are used to build the content in Table 4-2:

- Cask Lid Attachment Bolt Fortran Program Output Files – Model AOS-025
- Cask Lid Attachment Bolt Fortran Program Output Files – Model AOS-050
- Cask Lid Attachment Bolt Fortran Program Output Files – Model AOS-100

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4.5.3.2.1 Cask Lid Attachment Bolt Fortran Program Output Files – Model AOS-025

This appendix provides the following output files, that are used to build the content in Table 4-2:

- Output, Normal Conditions of Transport, 30-Ft. Drop, 38°C (100°F) Ambient – Model AOS-025
- Output, Normal Conditions of Transport, 30-Ft. Drop, -40°C (-40°F) Ambient – Model AOS-025
- Output, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, 38°C (100°F) Ambient – Model AOS-025
- Output, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, -40°C (-40°F) Ambient – Model AOS-025
- Output, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, 38°C (100°F) Ambient – Model AOS-025
- Output, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, -40°C (-40°F) Ambient – Model AOS-025
- Output, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, 38°C (100°F) Ambient – Model AOS-025
- Output, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, -40°C (-40°F) Ambient – Model AOS-025

4.5.3.2.1.1 Output, Normal Conditions of Transport, 30-Ft. Drop, 38°C (100°F) Ambient – Model AOS-025

```
NORMAL CONDITION - AXIAL=10g,LATERAL=5g, AOS-025, 100F AMBIENT



*************** INPUT DATA ***************

NUMBER OF BOLTS .....................(NB)           8
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.39000E+01
LID DIAMETER AT GASKET  .............(DLG) 0.30700E+01
NOMINAL BOLT DIAMETER ...............(DB) 0.37500E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.26300E+01
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.46500E+01
THICKNESS OF LID ....................(TL) 0.37000E+00
THICKNESS OF LID FLANGE .............(TLF) 0.48000E+00
THICKNESS OF CASK WALL ..............(TC) 0.10300E+01
BOLT LENGTH .........................(BL) 0.15000E+00
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.10000E-02

YOUNG'S MODULUS FOR LID .............(EL) 0.27300E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.27300E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.27300E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.28000E+08
POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.90000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.72000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.90000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.30000E+02
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.30000E+02
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL) 0.18500E+03
TEMPERATURE CHG ACROSS BOLT .......(TEMPB) 0.18500E+03
TEMPERATURE CHG ACROSS WALL .......(TEMPC) 0.18500E+03
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO) 0.18500E+03
TEMPERATURE AT INSIDE OF LID .....(TEMPLI) 0.18500E+03

WEIGHT OF CASK CONTENTS .............(WC) 0.14000E+02
WEIGHT OF CASK LID ..................(WL) 0.20000E+01
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.00000E+00
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.00000E+00
DYNAMIC LOAD FACTOR .................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
```

```
AXIAL VIBRATION ACCELERATION ........(AVA) 0.10000E+02
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.50000E+01
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.42000E+03
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.95300E+01

Sm STRESS ............................(SM) 0.95000E+02
Sy STRESS ............................(SY) 0.14200E+03
Su STRESS ............................(SU) 0.17500E+03
CODE EVALUATION TYPE..................(CET)           1

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.14200E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)          16
```

******** BOLT LOADS & STRESSES *********

BOLT FORCES DUE TO PRESSURE, TABLE 4.3

AXIAL LOAD DUE TO PRESSURE.....	0.13879E+02
SHEAR LOAD DUE TO PRESSURE.....	0.22989E+02
EDGE LOAD DUE TO PRESSURE.....	0.14625E+02
EDGE MOMENT DUE TO PRESSURE.....	0.71297E+01

BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4

AXIAL LOAD DUE TO TEMPERATURE.....	0.10298E+04
SHEAR LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE MOMENT DUE TEMPERATURE.....	0.00000E+00

BOLT FORCES DUE TO IMPACT, TABLE 4.5

AXIAL LOAD DUE TO IMPACT.....	0.00000E+00
SHEAR LOAD DUE TO IMPACT.....	0.00000E+00
EDGE LOAD DUE TO IMPACT.....	0.00000E+00
EDGE MOMENT DUE IMPACT.....	0.00000E+00

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.25000E+01
SHEAR LOAD DUE TO VIBRATION.....	0.12500E+01
EDGE LOAD DUE TO VIBRATION.....	0.16324E+01
EDGE MOMENT DUE VIBRATION.....	0.79577E+00

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.74667E+04
AXIAL LOAD DUE TO GASKET SEATING....	0.36168E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.34468E+03
TORQUE DUE TO PRELOAD.....	0.21000E+03
TORQUE DUE TO GASKET	0.10172E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.88575E+04
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.84965E+04
AXIAL LOAD LESS TEMP & PRELOAD.....	0.36106E+03
TOTAL EDGE LOAD.....	0.16257E+02
TOTAL EDGE MOMENT.....	0.79255E+01

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	-0.78148E+04
BENDING MOMENT DUE TO PRYING.....	0.67577E+01

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.68166E+03
TOTAL BOLT SHEAR LOAD.....	0.24239E+02
TOTAL BOLT BENDING MOMENT.....	0.14683E+02
TOTAL BOLT TORSIONAL MOMENT.....	0.21000E+03

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.13623E+05
TOTAL BOLT DIRECT STRESS (-MC/I) ...	0.39707E+04
AVE BOLT DIRECT STRESS	0.87967E+04
TOTAL BOLT SHEAR STRESS	0.34511E+05
AVE BOLT SHEAR STRESS	0.17256E+05

CODE EVALUATION FOR NORMAL COND, TABLE 6.1

Rt (AXIAL_STRESS/Sm)	0.92597E-01
Rs (SHEAR_STRESS/0.6Sm)	0.30273E+00
Rtý+Rsý	0.10022E+00
VON MISES EQUIVALENT STRESS (Se) ...	0.70354E+05
Se/1.35Sm	0.54857E+00

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.32060E+03
DISPLACEMENT ACROSS BOLT	-0.22164E-04
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.28854E+03
TOTAL BOLT SHEAR FORCE	0.24239E+02

FATIGUE EVALUATION

USEAGE FOR NORMAL OPERATION	0.95935E-01
USEAGE FOR VIBRATION	0.24817E-02
ACCUMULATIVE FATIGUE USEAGE	0.98417E-01

4.5.3.2.1.2 Output, Normal Conditions of Transport, 30-Ft. Drop, -40°C (-40°F) Ambient – Model AOS-025

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NORMAL CONDITION - AXIAL=10g,LATERAL=5g, AOS-025, -40F AMBIENT



*************** INPUT DATA ***************

NUMBER OF BOLTS .....................(NB)           8
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.39000E+01
LID DIAMETER AT GASKET  .............(DLG) 0.30700E+01
NOMINAL BOLT DIAMETER ...............(DB) 0.37500E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.26300E+01
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.46500E+01
THICKNESS OF LID ....................(TL) 0.37000E+00
THICKNESS OF LID FLANGE .............(TLF) 0.48000E+00
THICKNESS OF CASK WALL ..............(TC) 0.10300E+01
BOLT LENGTH .........................(BL) 0.15000E+00
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.10000E-02

YOUNG'S MODULUS FOR LID .............(EL) 0.28300E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.28300E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.28300E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.29100E+08
POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.86000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.70000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.86000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.30000E+02
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.30000E+02
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL)-0.34000E+02
TEMPERATURE CHG ACROSS BOLT .......(TEMPB)-0.34000E+02
TEMPERATURE CHG ACROSS WALL .......(TEMPC)-0.34000E+02
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)-0.34000E+02
TEMPERATURE AT INSIDE OF LID .....(TEMPLI)-0.34000E+02

WEIGHT OF CASK CONTENTS .............(WC) 0.14000E+02
WEIGHT OF CASK LID ..................(WL) 0.20000E+01
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.00000E+00
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.00000E+00
DYNAMIC LOAD FACTOR .................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
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AXIAL VIBRATION ACCELERATION ........(AVA) 0.10000E+02
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.50000E+01
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.42000E+03
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.95300E+01

Sm STRESS ............................(SM) 0.10000E+03
Sy STRESS ............................(SY) 0.15000E+03
Su STRESS ............................(SU) 0.18500E+03
CODE EVALUATION TYPE..................(CET)           1

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.15000E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)          16
```

******** BOLT LOADS & STRESSES *********

BOLT FORCES DUE TO PRESSURE, TABLE 4.3

AXIAL LOAD DUE TO PRESSURE.....	0.13879E+02
SHEAR LOAD DUE TO PRESSURE.....	0.22989E+02
EDGE LOAD DUE TO PRESSURE.....	0.14625E+02
EDGE MOMENT DUE TO PRESSURE.....	0.71297E+01

BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4

AXIAL LOAD DUE TO TEMPERATURE.....	-0.17484E+03
SHEAR LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE MOMENT DUE TEMPERATURE.....	0.00000E+00

BOLT FORCES DUE TO IMPACT, TABLE 4.5

AXIAL LOAD DUE TO IMPACT.....	0.00000E+00
SHEAR LOAD DUE TO IMPACT.....	0.00000E+00
EDGE LOAD DUE TO IMPACT.....	0.00000E+00
EDGE MOMENT DUE IMPACT.....	0.00000E+00

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.25000E+01
SHEAR LOAD DUE TO VIBRATION.....	0.12500E+01
EDGE LOAD DUE TO VIBRATION.....	0.16324E+01
EDGE MOMENT DUE VIBRATION.....	0.79577E+00

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.74667E+04
AXIAL LOAD DUE TO GASKET SEATING....	0.36168E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.34468E+03
TORQUE DUE TO PRELOAD.....	0.21000E+03
TORQUE DUE TO GASKET	0.10172E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.76529E+04
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.72918E+04
AXIAL LOAD LESS TEMP & PRELOAD.....	0.36106E+03
TOTAL EDGE LOAD.....	0.16257E+02
TOTAL EDGE MOMENT.....	0.79255E+01

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	-0.67006E+04
BENDING MOMENT DUE TO PRYING.....	0.67654E+01

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.59126E+03
TOTAL BOLT SHEAR LOAD.....	0.24239E+02
TOTAL BOLT BENDING MOMENT.....	0.14691E+02
TOTAL BOLT TORSIONAL MOMENT.....	0.21000E+03

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.12459E+05
TOTAL BOLT DIRECT STRESS (-MC/I) ...	0.28017E+04
AVE BOLT DIRECT STRESS	0.76302E+04
TOTAL BOLT SHEAR STRESS	0.34511E+05
AVE BOLT SHEAR STRESS	0.17256E+05

CODE EVALUATION FOR NORMAL COND, TABLE 6.1

Rt (AXIAL_STRESS/Sm)	0.76302E-01
Rs (SHEAR_STRESS/0.6Sm)	0.28759E+00
Rtý+Rsý	0.88532E-01
VON MISES EQUIVALENT STRESS (Se) ...	0.70138E+05
Se/1.35Sm	0.51954E+00

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.23020E+03
DISPLACEMENT ACROSS BOLT	-0.15313E-04
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.20718E+03
TOTAL BOLT SHEAR FORCE	0.24239E+02

FATIGUE EVALUATION

USEAGE FOR NORMAL OPERATION	0.83058E-01
USEAGE FOR VIBRATION	0.24817E-02
ACCUMULATIVE FATIGUE USEAGE	0.85540E-01

4.5.3.2.1.3 Output, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, 38°C (100°F) Ambient – Model AOS-025

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30 FT DROP - HEAD ON, AOS-025, 100F AMBIENT



*************** INPUT DATA ****************

NUMBER OF BOLTS .....................(NB)           8
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.39000E+01
LID DIAMETER AT GASKET  .............(DLG) 0.30700E+01
NOMINAL BOLT DIAMETER ...............(DB) 0.37500E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.26300E+01
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.46500E+01
THICKNESS OF LID ....................(TL) 0.37000E+00
THICKNESS OF LID FLANGE .............(TLF) 0.48000E+00
THICKNESS OF CASK WALL ..............(TC) 0.10300E+01
BOLT LENGTH .........................(BL) 0.15000E+00
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.10000E-02

YOUNG'S MODULUS FOR LID .............(EL) 0.27300E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.27300E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.27300E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.28000E+08
POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.90000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.72000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.90000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.30000E+02
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.30000E+02
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL) 0.18500E+03
TEMPERATURE CHG ACROSS BOLT .......(TEMPB) 0.18500E+03
TEMPERATURE CHG ACROSS WALL .......(TEMPC) 0.18500E+03
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO) 0.18500E+03
TEMPERATURE AT INSIDE OF LID .....(TEMPLI) 0.18500E+03

WEIGHT OF CASK CONTENTS .............(WC) 0.14000E+02
WEIGHT OF CASK LID ..................(WL) 0.20000E+01
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.90000E+02
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.88300E+03
DYNAMIC LOAD FACTOR .................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
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AXIAL VIBRATION ACCELERATION ........(AVA) 0.00000E+00
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.00000E+00
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.42000E+03
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.95300E+01

Sm STRESS ............................(SM) 0.95000E+02
Sy STRESS ............................(SY) 0.14200E+03
Su STRESS ............................(SU) 0.17500E+03
CODE EVALUATION TYPE..................(CET)           2

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.14200E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)          16
```

******** BOLT LOADS & STRESSES *********

BOLT FORCES DUE TO PRESSURE, TABLE 4.3

AXIAL LOAD DUE TO PRESSURE.....	0.13879E+02
SHEAR LOAD DUE TO PRESSURE.....	0.22989E+02
EDGE LOAD DUE TO PRESSURE.....	0.14625E+02
EDGE MOMENT DUE TO PRESSURE.....	0.71297E+01

BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4

AXIAL LOAD DUE TO TEMPERATURE.....	0.10298E+04
SHEAR LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE MOMENT DUE TEMPERATURE.....	0.00000E+00

BOLT FORCES DUE TO IMPACT, TABLE 4.5

AXIAL LOAD DUE TO IMPACT.....	0.27214E+04
SHEAR LOAD DUE TO IMPACT.....	-0.96493E-05
EDGE LOAD DUE TO IMPACT.....	0.17769E+04
EDGE MOMENT DUE IMPACT.....	0.86625E+03

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.00000E+00
SHEAR LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE MOMENT DUE VIBRATION.....	0.00000E+00

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.74667E+04
AXIAL LOAD DUE TO GASKET SEATING....	0.36168E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.34468E+03
TORQUE DUE TO PRELOAD.....	0.21000E+03
TORQUE DUE TO GASKET	0.10172E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.11576E+05
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.84965E+04
AXIAL LOAD LESS TEMP & PRELOAD.....	0.30800E+04
TOTAL EDGE LOAD.....	0.17915E+04
TOTAL EDGE MOMENT.....	0.87338E+03

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	-0.20240E+04
BENDING MOMENT DUE TO PRYING.....	0.74469E+03

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.64725E+04
TOTAL BOLT SHEAR LOAD.....	0.22989E+02
TOTAL BOLT BENDING MOMENT.....	0.16181E+04
TOTAL BOLT TORSIONAL MOMENT.....	0.21000E+03

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.61535E+06
TOTAL BOLT DIRECT STRESS (-MC/I) ...	-0.44830E+06
AVE BOLT DIRECT STRESS	0.83527E+05
TOTAL BOLT SHEAR STRESS	0.34511E+05
AVE BOLT SHEAR STRESS	0.17256E+05

CODE EVALUAT. FOR ACCIDENT COND, TABLE 6.3

ALLOWABLE TENSILE STRESS (Sa)	0.12250E+06
ALLOWABLE SHEAR STRESS (Ta)	0.73500E+05
Rt (AVE AXIAL STRESS/Sa)	0.68185E+00
Rs (AVE SHEAR_STRESS/Ta)	0.23477E+00
Rtý+Rsý	0.52004E+00

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.33925E+04
DISPLACEMENT ACROSS BOLT	-0.23454E-03
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.30533E+04
TOTAL BOLT SHEAR FORCE	0.22989E+02

4.5.3.2.1.4 Output, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, -40°C (-40°F) Ambient – Model AOS-025

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30 FT DROP - HEAD ON, AOS-025, -40F AMBIENT



*************** INPUT DATA ****************

NUMBER OF BOLTS .....................(NB)           8
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.39000E+01
LID DIAMETER AT GASKET  .............(DLG) 0.30700E+01
NOMINAL BOLT DIAMETER ...............(DB) 0.37500E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.26300E+01
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.46500E+01
THICKNESS OF LID ....................(TL) 0.37000E+00
THICKNESS OF LID FLANGE .............(TLF) 0.48000E+00
THICKNESS OF CASK WALL ..............(TC) 0.10300E+01
BOLT LENGTH .........................(BL) 0.15000E+00
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.10000E-02

YOUNG'S MODULUS FOR LID .............(EL) 0.28300E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.28300E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.28300E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.29100E+08
POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.86000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.70000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.86000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.30000E+02
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.30000E+02
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL)-0.34000E+02
TEMPERATURE CHG ACROSS BOLT .......(TEMPB)-0.34000E+02
TEMPERATURE CHG ACROSS WALL .......(TEMPC)-0.34000E+02
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)-0.34000E+02
TEMPERATURE AT INSIDE OF LID .....(TEMPLI)-0.34000E+02

WEIGHT OF CASK CONTENTS .............(WC) 0.14000E+02
WEIGHT OF CASK LID ..................(WL) 0.20000E+01
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.90000E+02
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.12370E+04
DYNAMIC LOAD FACTOR .................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
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AXIAL VIBRATION ACCELERATION ........(AVA) 0.00000E+00
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.00000E+00
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.42000E+03
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.95300E+01

Sm STRESS ............................(SM) 0.10000E+03
Sy STRESS ............................(SY) 0.15000E+03
Su STRESS ............................(SU) 0.18500E+03
CODE EVALUATION TYPE..................(CET)           2

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.15000E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)          16
```

******** BOLT LOADS & STRESSES *********

BOLT FORCES DUE TO PRESSURE, TABLE 4.3

AXIAL LOAD DUE TO PRESSURE.....	0.13879E+02
SHEAR LOAD DUE TO PRESSURE.....	0.22989E+02
EDGE LOAD DUE TO PRESSURE.....	0.14625E+02
EDGE MOMENT DUE TO PRESSURE.....	0.71297E+01

BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4

AXIAL LOAD DUE TO TEMPERATURE.....	-0.17484E+03
SHEAR LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE MOMENT DUE TEMPERATURE.....	0.00000E+00

BOLT FORCES DUE TO IMPACT, TABLE 4.5

AXIAL LOAD DUE TO IMPACT.....	0.38124E+04
SHEAR LOAD DUE TO IMPACT.....	-0.13518E-04
EDGE LOAD DUE TO IMPACT.....	0.24893E+04
EDGE MOMENT DUE IMPACT.....	0.12135E+04

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.00000E+00
SHEAR LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE MOMENT DUE VIBRATION.....	0.00000E+00

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.74667E+04
AXIAL LOAD DUE TO GASKET SEATING....	0.36168E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.34468E+03
TORQUE DUE TO PRELOAD.....	0.21000E+03
TORQUE DUE TO GASKET	0.10172E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.11463E+05
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.72918E+04
AXIAL LOAD LESS TEMP & PRELOAD.....	0.41710E+04
TOTAL EDGE LOAD.....	0.25039E+04
TOTAL EDGE MOMENT.....	0.12207E+04

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	0.14155E+04
BENDING MOMENT DUE TO PRYING.....	0.10420E+04

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.87073E+04
TOTAL BOLT SHEAR LOAD.....	0.22989E+02
TOTAL BOLT BENDING MOMENT.....	0.22627E+04
TOTAL BOLT TORSIONAL MOMENT.....	0.21000E+03

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.85605E+06
TOTAL BOLT DIRECT STRESS (-MC/I) ...	-0.63132E+06
AVE BOLT DIRECT STRESS	0.11237E+06
TOTAL BOLT SHEAR STRESS	0.34511E+05
AVE BOLT SHEAR STRESS	0.17256E+05

CODE EVALUAT. FOR ACCIDENT COND, TABLE 6.3

ALLOWABLE TENSILE STRESS (Sa)	0.12950E+06
ALLOWABLE SHEAR STRESS (Ta)	0.77700E+05
Rt (AVE AXIAL STRESS/Sa)	0.86770E+00
Rs (AVE SHEAR_STRESS/Ta)	0.22208E+00
Rtý+Rsý	0.80223E+00

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.17054E+04
DISPLACEMENT ACROSS BOLT	-0.11344E-03
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.15348E+04
TOTAL BOLT SHEAR FORCE	0.22989E+02

4.5.3.2.1.5 Output, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, 38°C (100°F) Ambient – Model AOS-025

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30 FT DROP - SIDE ORIENTATION, AOS-025, 100F AMBIENT



*************** INPUT DATA ****************

NUMBER OF BOLTS .....................(NB)           8
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.39000E+01
LID DIAMETER AT GASKET  .............(DLG) 0.30700E+01
NOMINAL BOLT DIAMETER ...............(DB) 0.37500E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.26300E+01
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.46500E+01
THICKNESS OF LID ....................(TL) 0.37000E+00
THICKNESS OF LID FLANGE .............(TLF) 0.48000E+00
THICKNESS OF CASK WALL ..............(TC) 0.10300E+01
BOLT LENGTH .........................(BL) 0.15000E+00
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.10000E-02

YOUNG'S MODULUS FOR LID .............(EL) 0.27300E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.27300E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.27300E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.28000E+08
POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.90000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.72000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.90000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.30000E+02
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.30000E+02
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL) 0.18500E+03
TEMPERATURE CHG ACROSS BOLT .......(TEMPB) 0.18500E+03
TEMPERATURE CHG ACROSS WALL .......(TEMPC) 0.18500E+03
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO) 0.18500E+03
TEMPERATURE AT INSIDE OF LID .....(TEMPLI) 0.18500E+03

WEIGHT OF CASK CONTENTS .............(WC) 0.14000E+02
WEIGHT OF CASK LID ..................(WL) 0.20000E+01
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.00000E+00
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.12860E+04
DYNAMIC LOAD FACTOR .................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
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AXIAL VIBRATION ACCELERATION ........(AVA) 0.00000E+00
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.00000E+00
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.42000E+03
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.95300E+01

Sm STRESS ............................(SM) 0.95000E+02
Sy STRESS ............................(SY) 0.14200E+03
Su STRESS ............................(SU) 0.17500E+03
CODE EVALUATION TYPE..................(CET)           2

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.14200E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)          16
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******** BOLT LOADS & STRESSES *********

BOLT FORCES DUE TO PRESSURE, TABLE 4.3

AXIAL LOAD DUE TO PRESSURE.....	0.13879E+02
SHEAR LOAD DUE TO PRESSURE.....	0.22989E+02
EDGE LOAD DUE TO PRESSURE.....	0.14625E+02
EDGE MOMENT DUE TO PRESSURE.....	0.71297E+01

BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4

AXIAL LOAD DUE TO TEMPERATURE.....	0.10298E+04
SHEAR LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE MOMENT DUE TEMPERATURE.....	0.00000E+00

BOLT FORCES DUE TO IMPACT, TABLE 4.5

AXIAL LOAD DUE TO IMPACT.....	0.00000E+00
SHEAR LOAD DUE TO IMPACT.....	0.32150E+03
EDGE LOAD DUE TO IMPACT.....	0.00000E+00
EDGE MOMENT DUE IMPACT.....	0.00000E+00

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.00000E+00
SHEAR LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE MOMENT DUE VIBRATION.....	0.00000E+00

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.74667E+04
AXIAL LOAD DUE TO GASKET SEATING....	0.36168E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.34468E+03
TORQUE DUE TO PRELOAD.....	0.21000E+03
TORQUE DUE TO GASKET	0.10172E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.88550E+04
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.84965E+04
AXIAL LOAD LESS TEMP & PRELOAD.....	0.35856E+03
TOTAL EDGE LOAD.....	0.14625E+02
TOTAL EDGE MOMENT.....	0.71297E+01

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	-0.78201E+04
BENDING MOMENT DUE TO PRYING.....	0.60792E+01

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.67633E+03
TOTAL BOLT SHEAR LOAD.....	0.34449E+03
TOTAL BOLT BENDING MOMENT.....	0.13209E+02
TOTAL BOLT TORSIONAL MOMENT.....	0.21000E+03

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.13069E+05
TOTAL BOLT DIRECT STRESS (-MC/I) ...	0.43866E+04
AVE BOLT DIRECT STRESS	0.87280E+04
TOTAL BOLT SHEAR STRESS	0.34511E+05
AVE BOLT SHEAR STRESS	0.17256E+05

CODE EVALUAT. FOR ACCIDENT COND, TABLE 6.3

ALLOWABLE TENSILE STRESS (Sa)	0.12250E+06
ALLOWABLE SHEAR STRESS (Ta)	0.73500E+05
Rt (AVE AXIAL STRESS/Sa)	0.71249E-01
Rs (AVE SHEAR_STRESS/Ta)	0.23477E+00
Rtý+Rsý	0.60193E-01

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.31777E+03
DISPLACEMENT ACROSS BOLT	-0.21969E-04
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.28600E+03
TOTAL BOLT SHEAR FORCE	0.34449E+03

4.5.3.2.1.6 Output, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, -40°C (-40°F) Ambient – Model AOS-025

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30 FT DROP - SIDE ORIENTATION, AOS-025, -40F AMBIENT



*************** INPUT DATA ****************

NUMBER OF BOLTS .....................(NB)           8
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.39000E+01
LID DIAMETER AT GASKET  .............(DLG) 0.30700E+01
NOMINAL BOLT DIAMETER ...............(DB) 0.37500E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.26300E+01
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.46500E+01
THICKNESS OF LID ....................(TL) 0.37000E+00
THICKNESS OF LID FLANGE .............(TLF) 0.48000E+00
THICKNESS OF CASK WALL ..............(TC) 0.10300E+01
BOLT LENGTH .........................(BL) 0.15000E+00
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.10000E-02

YOUNG'S MODULUS FOR LID .............(EL) 0.28300E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.28300E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.28300E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.29100E+08
POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.86000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.70000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.86000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.30000E+02
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.30000E+02
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL)-0.34000E+02
TEMPERATURE CHG ACROSS BOLT .......(TEMPB)-0.34000E+02
TEMPERATURE CHG ACROSS WALL .......(TEMPC)-0.34000E+02
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)-0.34000E+02
TEMPERATURE AT INSIDE OF LID .....(TEMPLI)-0.34000E+02

WEIGHT OF CASK CONTENTS .............(WC) 0.14000E+02
WEIGHT OF CASK LID ..................(WL) 0.20000E+01
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.00000E+00
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.17980E+04
DYNAMIC LOAD FACTOR .................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
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AXIAL VIBRATION ACCELERATION ........(AVA) 0.00000E+00
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.00000E+00
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.42000E+03
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.95300E+01

Sm STRESS ............................(SM) 0.10000E+03
Sy STRESS ............................(SY) 0.15000E+03
Su STRESS ............................(SU) 0.18500E+03
CODE EVALUATION TYPE..................(CET)           2

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.15000E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)          16
```

******** BOLT LOADS & STRESSES *********

BOLT FORCES DUE TO PRESSURE, TABLE 4.3

AXIAL LOAD DUE TO PRESSURE.....	0.13879E+02
SHEAR LOAD DUE TO PRESSURE.....	0.22989E+02
EDGE LOAD DUE TO PRESSURE.....	0.14625E+02
EDGE MOMENT DUE TO PRESSURE.....	0.71297E+01

BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4

AXIAL LOAD DUE TO TEMPERATURE.....	-0.17484E+03
SHEAR LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE MOMENT DUE TEMPERATURE.....	0.00000E+00

BOLT FORCES DUE TO IMPACT, TABLE 4.5

AXIAL LOAD DUE TO IMPACT.....	0.00000E+00
SHEAR LOAD DUE TO IMPACT.....	0.44950E+03
EDGE LOAD DUE TO IMPACT.....	0.00000E+00
EDGE MOMENT DUE IMPACT.....	0.00000E+00

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.00000E+00
SHEAR LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE MOMENT DUE VIBRATION.....	0.00000E+00

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.74667E+04
AXIAL LOAD DUE TO GASKET SEATING....	0.36168E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.34468E+03
TORQUE DUE TO PRELOAD.....	0.21000E+03
TORQUE DUE TO GASKET	0.10172E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.76504E+04
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.72918E+04
AXIAL LOAD LESS TEMP & PRELOAD.....	0.35856E+03
TOTAL EDGE LOAD.....	0.14625E+02
TOTAL EDGE MOMENT.....	0.71297E+01

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	-0.67059E+04
BENDING MOMENT DUE TO PRYING.....	0.60861E+01

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.58594E+03
TOTAL BOLT SHEAR LOAD.....	0.47249E+03
TOTAL BOLT BENDING MOMENT.....	0.13216E+02
TOTAL BOLT TORSIONAL MOMENT.....	0.21000E+03

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.11905E+05
TOTAL BOLT DIRECT STRESS (-MC/I) ...	0.32178E+04
AVE BOLT DIRECT STRESS	0.75615E+04
TOTAL BOLT SHEAR STRESS	0.34511E+05
AVE BOLT SHEAR STRESS	0.17256E+05

CODE EVALUAT. FOR ACCIDENT COND, TABLE 6.3

ALLOWABLE TENSILE STRESS (Sa)	0.12950E+06
ALLOWABLE SHEAR STRESS (Ta)	0.77700E+05
Rt (AVE AXIAL STRESS/Sa)	0.58390E-01
Rs (AVE SHEAR_STRESS/Ta)	0.22208E+00
Rtý+Rsý	0.52729E-01

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.22738E+03
DISPLACEMENT ACROSS BOLT	-0.15125E-04
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.20464E+03
TOTAL BOLT SHEAR FORCE	0.47249E+03

4.5.3.2.1.7 Output, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, 38°C (100°F) Ambient – Model AOS-025

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30FT DROP @ 45 DEG, AOS-025, 100F AMBIENT



*************** INPUT DATA ****************

NUMBER OF BOLTS .....................(NB)           8
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.39000E+01
LID DIAMETER AT GASKET  .............(DLG) 0.30700E+01
NOMINAL BOLT DIAMETER ...............(DB) 0.37500E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.26300E+01
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.46500E+01
THICKNESS OF LID ....................(TL) 0.37000E+00
THICKNESS OF LID FLANGE .............(TLF) 0.48000E+00
THICKNESS OF CASK WALL ..............(TC) 0.10300E+01
BOLT LENGTH .........................(BL) 0.15000E+00
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.10000E-02

YOUNG'S MODULUS FOR LID .............(EL) 0.27300E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.27300E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.27300E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.28000E+08
POISSON'S RATIO FOR LID ............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.90000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.72000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.90000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.30000E+02
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.30000E+02
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL) 0.18500E+03
TEMPERATURE CHG ACROSS BOLT .......(TEMPB) 0.18500E+03
TEMPERATURE CHG ACROSS WALL .......(TEMPC) 0.18500E+03
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO) 0.18500E+03
TEMPERATURE AT INSIDE OF LID .....(TEMPLI) 0.18500E+03

WEIGHT OF CASK CONTENTS .............(WC) 0.14000E+02
WEIGHT OF CASK LID ..................(WL) 0.20000E+01
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.45000E+02
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.79900E+03
DYNAMIC LOAD FACTOR ................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
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AXIAL VIBRATION ACCELERATION ........(AVA) 0.00000E+00
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.00000E+00
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.42000E+03
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.95300E+01

Sm STRESS ............................(SM) 0.95000E+02
Sy STRESS ............................(SY) 0.14200E+03
Su STRESS ............................(SU) 0.17500E+03
CODE EVALUATION TYPE..................(CET)           2

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.14200E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)          16
```

******** BOLT LOADS & STRESSES *********

BOLT FORCES DUE TO PRESSURE, TABLE 4.3

AXIAL LOAD DUE TO PRESSURE.....	0.13879E+02
SHEAR LOAD DUE TO PRESSURE.....	0.22989E+02
EDGE LOAD DUE TO PRESSURE.....	0.14625E+02
EDGE MOMENT DUE TO PRESSURE.....	0.71297E+01

BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4

AXIAL LOAD DUE TO TEMPERATURE.....	0.10298E+04
SHEAR LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE MOMENT DUE TEMPERATURE.....	0.00000E+00

BOLT FORCES DUE TO IMPACT, TABLE 4.5

AXIAL LOAD DUE TO IMPACT.....	0.17413E+04
SHEAR LOAD DUE TO IMPACT.....	0.14124E+03
EDGE LOAD DUE TO IMPACT.....	0.11369E+04
EDGE MOMENT DUE IMPACT.....	0.55426E+03

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.00000E+00
SHEAR LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE MOMENT DUE VIBRATION.....	0.00000E+00

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.74667E+04
AXIAL LOAD DUE TO GASKET SEATING....	0.36168E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.34468E+03
TORQUE DUE TO PRELOAD.....	0.21000E+03
TORQUE DUE TO GASKET	0.10172E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.10596E+05
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.84965E+04
AXIAL LOAD LESS TEMP & PRELOAD.....	0.20998E+04
TOTAL EDGE LOAD.....	0.11516E+04
TOTAL EDGE MOMENT.....	0.56139E+03

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	-0.41115E+04
BENDING MOMENT DUE TO PRYING.....	0.47867E+03

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.43849E+04
TOTAL BOLT SHEAR LOAD.....	0.16423E+03
TOTAL BOLT BENDING MOMENT.....	0.10401E+04
TOTAL BOLT TORSIONAL MOMENT.....	0.21000E+03

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.39843E+06
TOTAL BOLT DIRECT STRESS (-MC/I) ...	-0.28526E+06
AVE BOLT DIRECT STRESS	0.56587E+05
TOTAL BOLT SHEAR STRESS	0.34511E+05
AVE BOLT SHEAR STRESS	0.17256E+05

CODE EVALUAT. FOR ACCIDENT COND, TABLE 6.3

ALLOWABLE TENSILE STRESS (Sa)	0.12250E+06
ALLOWABLE SHEAR STRESS (Ta)	0.73500E+05
Rt (AVE AXIAL STRESS/Sa)	0.46194E+00
Rs (AVE SHEAR_STRESS/Ta)	0.23477E+00
Rtý+Rsý	0.26850E+00

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.22851E+04
DISPLACEMENT ACROSS BOLT	-0.15798E-03
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.20566E+04
TOTAL BOLT SHEAR FORCE	0.16423E+03

4.5.3.2.1.8 Output, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, -40°C (-40°F) Ambient – Model AOS-025

```
30FT DROP @ 45 DEG, AOS-025, -40F AMBIENT



*************** INPUT DATA ****************

NUMBER OF BOLTS .....................(NB)           8
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.39000E+01
LID DIAMETER AT GASKET  .............(DLG) 0.30700E+01
NOMINAL BOLT DIAMETER ...............(DB) 0.37500E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.26300E+01
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.46500E+01
THICKNESS OF LID ....................(TL) 0.37000E+00
THICKNESS OF LID FLANGE .............(TLF) 0.48000E+00
THICKNESS OF CASK WALL ..............(TC) 0.10300E+01
BOLT LENGTH .........................(BL) 0.15000E+00
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.10000E-02

YOUNG'S MODULUS FOR LID .............(EL) 0.28300E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.28300E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.28300E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.29100E+08
POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.86000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.70000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.86000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.30000E+02
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.30000E+02
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL)-0.34000E+02
TEMPERATURE CHG ACROSS BOLT .......(TEMPB)-0.34000E+02
TEMPERATURE CHG ACROSS WALL .......(TEMPC)-0.34000E+02
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO)-0.34000E+02
TEMPERATURE AT INSIDE OF LID .....(TEMPLI)-0.34000E+02

WEIGHT OF CASK CONTENTS .............(WC) 0.14000E+02
WEIGHT OF CASK LID ..................(WL) 0.20000E+01
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.45000E+02
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.11250E+04
DYNAMIC LOAD FACTOR .................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
```

```
AXIAL VIBRATION ACCELERATION ........(AVA) 0.00000E+00
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.00000E+00
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.42000E+03
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.95300E+01

Sm STRESS ............................(SM) 0.10000E+03
Sy STRESS ............................(SY) 0.15000E+03
Su STRESS ............................(SU) 0.18500E+03
CODE EVALUATION TYPE..................(CET)           2

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.15000E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)          16
```

******** BOLT LOADS & STRESSES *********

BOLT FORCES DUE TO PRESSURE, TABLE 4.3

AXIAL LOAD DUE TO PRESSURE.....	0.13879E+02
SHEAR LOAD DUE TO PRESSURE.....	0.22989E+02
EDGE LOAD DUE TO PRESSURE.....	0.14625E+02
EDGE MOMENT DUE TO PRESSURE.....	0.71297E+01

BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4

AXIAL LOAD DUE TO TEMPERATURE.....	-0.17484E+03
SHEAR LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE MOMENT DUE TEMPERATURE.....	0.00000E+00

BOLT FORCES DUE TO IMPACT, TABLE 4.5

AXIAL LOAD DUE TO IMPACT.....	0.24517E+04
SHEAR LOAD DUE TO IMPACT.....	0.19887E+03
EDGE LOAD DUE TO IMPACT.....	0.16008E+04
EDGE MOMENT DUE IMPACT.....	0.78041E+03

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.00000E+00
SHEAR LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE MOMENT DUE VIBRATION.....	0.00000E+00

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.74667E+04
AXIAL LOAD DUE TO GASKET SEATING....	0.36168E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.34468E+03
TORQUE DUE TO PRELOAD.....	0.21000E+03
TORQUE DUE TO GASKET	0.10172E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.10102E+05
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.72918E+04
AXIAL LOAD LESS TEMP & PRELOAD.....	0.28103E+04
TOTAL EDGE LOAD.....	0.16155E+04
TOTAL EDGE MOMENT.....	0.78754E+03

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	-0.14832E+04
BENDING MOMENT DUE TO PRYING.....	0.67226E+03

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.58087E+04
TOTAL BOLT SHEAR LOAD.....	0.22186E+03
TOTAL BOLT BENDING MOMENT.....	0.14598E+04
TOTAL BOLT TORSIONAL MOMENT.....	0.21000E+03

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.55476E+06
TOTAL BOLT DIRECT STRESS (-MC/I) ...	-0.40484E+06
AVE BOLT DIRECT STRESS	0.74961E+05
TOTAL BOLT SHEAR STRESS	0.34511E+05
AVE BOLT SHEAR STRESS	0.17256E+05

CODE EVALUAT. FOR ACCIDENT COND, TABLE 6.3

ALLOWABLE TENSILE STRESS (Sa)	0.12950E+06
ALLOWABLE SHEAR STRESS (Ta)	0.77700E+05
Rt (AVE AXIAL STRESS/Sa)	0.57885E+00
Rs (AVE SHEAR_STRESS/Ta)	0.22208E+00
Rtý+Rsý	0.38438E+00

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.29984E+04
DISPLACEMENT ACROSS BOLT	-0.19945E-03
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.26986E+04
TOTAL BOLT SHEAR FORCE	0.22186E+03

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4.5.3.2.2 Cask Lid Attachment Bolt Fortran Program Output Files – Model AOS-050

This appendix provides the following output files, that are used to build the content in Table 4-2:

- Output, Normal Conditions of Transport, 30-Ft. Drop, 38°C (100°F) Ambient – Model AOS-050
- Output, Normal Conditions of Transport, 30-Ft. Drop, -40°C (-40°F) Ambient – Model AOS-050
- Output, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, 38°C (100°F) Ambient – Model AOS-050
- Output, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, -40°C (-40°F) Ambient – Model AOS-050
- Output, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, 38°C (100°F) Ambient – Model AOS-050
- Output, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, -40°C (-40°F) Ambient – Model AOS-050
- Output, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, 38°C (100°F) Ambient – Model AOS-050
- Output, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, -40°C (-40°F) Ambient – Model AOS-050

4.5.3.2.2.1 Output, Normal Conditions of Transport, 30-Ft. Drop, 38°C (100°F) Ambient – Model AOS-050

```
NORMAL CONDITION - AXIAL=10g,LATERAL=5g AOS-050 ,100F AMBIENT



*************** INPUT DATA ****************

NUMBER OF BOLTS .....................(NB)          10
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.74140E+01
LID DIAMETER AT GASKET  .............(DLG) 0.60900E+01
NOMINAL BOLT DIAMETER ...............(DB) 0.50000E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.55300E+01
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.89000E+01
THICKNESS OF LID ....................(TL) 0.75000E+00
THICKNESS OF LID FLANGE .............(TLF) 0.97000E+00
THICKNESS OF CASK WALL ..............(TC) 0.17050E+01
BOLT LENGTH .........................(BL) 0.41000E+00
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.30000E-02

YOUNG'S MODULUS FOR LID .............(EL) 0.27100E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.27100E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.27100E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.27900E+08
POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.90000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.73000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.90000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.60000E+02
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.60000E+02
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL) 0.21600E+03
TEMPERATURE CHG ACROSS BOLT .......(TEMPB) 0.21600E+03
TEMPERATURE CHG ACROSS WALL .......(TEMPC) 0.21600E+03
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO) 0.21600E+03
TEMPERATURE AT INSIDE OF LID .....(TEMPLI) 0.21600E+03

WEIGHT OF CASK CONTENTS .............(WC) 0.95000E+02
WEIGHT OF CASK LID ..................(WL) 0.14000E+02
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.00000E+00
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.00000E+00
DYNAMIC LOAD FACTOR .................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
```

```
AXIAL VIBRATION ACCELERATION ........(AVA) 0.10000E+02
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.50000E+01
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.75000E+03
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.31800E+01

Sm STRESS ............................(SM) 0.94000E+02
Sy STRESS ............................(SY) 0.14100E+03
Su STRESS ............................(SU) 0.17400E+03
CODE EVALUATION TYPE..................(CET)           1

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.14100E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)          13
```

******** BOLT LOADS & STRESSES *********

BOLT FORCES DUE TO PRESSURE, TABLE 4.3

AXIAL LOAD DUE TO PRESSURE.....	0.13108E+03
SHEAR LOAD DUE TO PRESSURE.....	0.24416E+03
EDGE LOAD DUE TO PRESSURE.....	0.83407E+02
EDGE MOMENT DUE TO PRESSURE.....	0.77298E+02

BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4

AXIAL LOAD DUE TO TEMPERATURE.....	0.20116E+04
SHEAR LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE MOMENT DUE TEMPERATURE.....	0.00000E+00

BOLT FORCES DUE TO IMPACT, TABLE 4.5

AXIAL LOAD DUE TO IMPACT.....	0.00000E+00
SHEAR LOAD DUE TO IMPACT.....	0.00000E+00
EDGE LOAD DUE TO IMPACT.....	0.00000E+00
EDGE MOMENT DUE IMPACT.....	0.00000E+00

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.14000E+02
SHEAR LOAD DUE TO VIBRATION.....	0.70000E+01
EDGE LOAD DUE TO VIBRATION.....	0.60107E+01
EDGE MOMENT DUE VIBRATION.....	0.55704E+01

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.10000E+05
AXIAL LOAD DUE TO GASKET SEATING....	0.57397E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.54757E+03
TORQUE DUE TO PRELOAD.....	0.37500E+03
TORQUE DUE TO GASKET	0.21524E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.12704E+05
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.12012E+05
AXIAL LOAD LESS TEMP & PRELOAD.....	0.69265E+03
TOTAL EDGE LOAD.....	0.89418E+02
TOTAL EDGE MOMENT.....	0.82868E+02

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	-0.96539E+04
BENDING MOMENT DUE TO PRYING.....	0.34543E+02

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.23577E+04
TOTAL BOLT SHEAR LOAD.....	0.25116E+03
TOTAL BOLT BENDING MOMENT.....	0.11741E+03
TOTAL BOLT TORSIONAL MOMENT.....	0.37500E+03

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.32189E+05
TOTAL BOLT DIRECT STRESS (-MC/I) ...	0.10424E+04
AVE BOLT DIRECT STRESS	0.16616E+05
TOTAL BOLT SHEAR STRESS	0.24870E+05
AVE BOLT SHEAR STRESS	0.12435E+05

CODE EVALUATION FOR NORMAL COND, TABLE 6.1

Rt (AXIAL_STRESS/Sm)	0.17676E+00
Rs (SHEAR_STRESS/0.6Sm)	0.22048E+00
Rtý+Rsý	0.79854E-01
VON MISES EQUIVALENT STRESS (Se) ...	0.59246E+05
Se/1.35Sm	0.46687E+00

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.16651E+04
DISPLACEMENT ACROSS BOLT	-0.17244E-03
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.14986E+04
TOTAL BOLT SHEAR FORCE	0.25116E+03

FATIGUE EVALUATION

USEAGE FOR NORMAL OPERATION	0.22829E+00
USEAGE FOR VIBRATION	0.75894E-02
ACCUMULATIVE FATIGUE USEAGE	0.23588E+00

4.5.3.2.2.2 Output, Normal Conditions of Transport, 30-Ft. Drop, -40°C (-40°F) Ambient – Model AOS-050

```
NORMAL CONDITION - AXIAL=10g,LATERAL=5g AOS-050, -40F AMBIENT



*************** INPUT DATA ***************

NUMBER OF BOLTS .....................(NB)          10
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.74140E+01
LID DIAMETER AT GASKET  .............(DLG) 0.60900E+01
NOMINAL BOLT DIAMETER ...............(DB) 0.50000E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.55300E+01
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.89000E+01
THICKNESS OF LID ....................(TL) 0.75000E+00
THICKNESS OF LID FLANGE .............(TLF) 0.97000E+00
THICKNESS OF CASK WALL ..............(TC) 0.17050E+01
BOLT LENGTH .........................(BL) 0.41000E+00
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.30000E-02

YOUNG'S MODULUS FOR LID .............(EL) 0.28300E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.28300E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.28300E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.28900E+08
POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.86000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.70000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.86000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.60000E+02
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.60000E+02
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL) 0.15000E+02
TEMPERATURE CHG ACROSS BOLT .......(TEMPB) 0.15000E+02
TEMPERATURE CHG ACROSS WALL .......(TEMPC) 0.15000E+02
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO) 0.15000E+02
TEMPERATURE AT INSIDE OF LID .....(TEMPLI) 0.16000E+02

WEIGHT OF CASK CONTENTS .............(WC) 0.95000E+02
WEIGHT OF CASK LID ..................(WL) 0.14000E+02
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.00000E+00
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.00000E+00
DYNAMIC LOAD FACTOR .................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
```

```
AXIAL VIBRATION ACCELERATION ........(AVA) 0.10000E+02
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.50000E+01
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.75000E+03
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.31800E+01

Sm STRESS ............................(SM) 0.10000E+03
Sy STRESS ............................(SY) 0.15000E+03
Su STRESS ............................(SU) 0.18500E+03
CODE EVALUATION TYPE..................(CET)           1

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.15000E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)          13
```

```
******** BOLT LOADS & STRESSES *********
```

```
BOLT FORCES DUE TO PRESSURE, TABLE 4.3
--------------------------------------------------
AXIAL LOAD DUE TO PRESSURE.........    0.13108E+03
SHEAR LOAD DUE TO PRESSURE.........    0.24416E+03
EDGE LOAD DUE TO PRESSURE..........    0.83407E+02
EDGE MOMENT DUE TO PRESSURE........    0.77298E+02
```

```
BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4
--------------------------------------------------
AXIAL LOAD DUE TO TEMPERATURE......    0.13619E+03
SHEAR LOAD DUE TO TEMPERATURE......    0.00000E+00
EDGE LOAD DUE TO TEMPERATURE.......    0.00000E+00
EDGE MOMENT DUE TEMPERATURE........   -0.16298E+02
```

```
BOLT FORCES DUE TO IMPACT, TABLE 4.5
--------------------------------------------------
AXIAL LOAD DUE TO IMPACT...........    0.00000E+00
SHEAR LOAD DUE TO IMPACT...........    0.00000E+00
EDGE LOAD DUE TO IMPACT............    0.00000E+00
EDGE MOMENT DUE IMPACT.............    0.00000E+00
```

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.14000E+02
SHEAR LOAD DUE TO VIBRATION.....	0.70000E+01
EDGE LOAD DUE TO VIBRATION.....	0.60107E+01
EDGE MOMENT DUE VIBRATION.....	0.55704E+01

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.10000E+05
AXIAL LOAD DUE TO GASKET SEATING....	0.57397E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.54757E+03
TORQUE DUE TO PRELOAD.....	0.37500E+03
TORQUE DUE TO GASKET	0.21524E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.10829E+05
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.10136E+05
AXIAL LOAD LESS TEMP & PRELOAD.....	0.69265E+03
TOTAL EDGE LOAD.....	0.89418E+02
TOTAL EDGE MOMENT.....	0.66571E+02

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	-0.81174E+04
BENDING MOMENT DUE TO PRYING.....	0.27565E+02

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.20188E+04
TOTAL BOLT SHEAR LOAD.....	0.25116E+03
TOTAL BOLT BENDING MOMENT.....	0.94136E+02
TOTAL BOLT TORSIONAL MOMENT.....	0.37500E+03

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.26713E+05
TOTAL BOLT DIRECT STRESS (-MC/I) ...	0.17412E+04
AVE BOLT DIRECT STRESS	0.14227E+05
TOTAL BOLT SHEAR STRESS	0.24870E+05
AVE BOLT SHEAR STRESS	0.12435E+05

CODE EVALUATION FOR NORMAL COND, TABLE 6.1

Rt (AXIAL_STRESS/Sm)	0.14227E+00
Rs (SHEAR_STRESS/0.6Sm)	0.20725E+00
Rtý+Rsý	0.63193E-01
VON MISES EQUIVALENT STRESS (Se) ...	0.56459E+05
Se/1.35Sm	0.41821E+00

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.13262E+04
DISPLACEMENT ACROSS BOLT	-0.13259E-03
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.11936E+04
TOTAL BOLT SHEAR FORCE	0.25116E+03

FATIGUE EVALUATION

USEAGE FOR NORMAL OPERATION	0.17809E+00
USEAGE FOR VIBRATION	0.75894E-02
ACCUMULATIVE FATIGUE USEAGE	0.18568E+00

4.5.3.2.2.3 Output, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, 38°C (100°F) Ambient – Model AOS-050

```
30-FT DROP HEAD ON AOS-050 CONFIGURATION, 100F AMBIENT



*************** INPUT DATA ****************

NUMBER OF BOLTS .....................(NB)          10
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.74140E+01
LID DIAMETER AT GASKET  .............(DLG) 0.60900E+01
NOMINAL BOLT DIAMETER ...............(DB) 0.50000E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.55300E+01
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.89000E+01
THICKNESS OF LID ....................(TL) 0.75000E+00
THICKNESS OF LID FLANGE .............(TLF) 0.97000E+00
THICKNESS OF CASK WALL ..............(TC) 0.17050E+01
BOLT LENGTH .........................(BL) 0.41000E+00
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.30000E-02

YOUNG'S MODULUS FOR LID .............(EL) 0.27100E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.27100E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.27100E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.27900E+08
POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.90000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.73000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.90000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.60000E+02
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.60000E+02
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL) 0.21600E+03
TEMPERATURE CHG ACROSS BOLT .......(TEMPB) 0.21600E+03
TEMPERATURE CHG ACROSS WALL .......(TEMPC) 0.21600E+03
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO) 0.21600E+03
TEMPERATURE AT INSIDE OF LID .....(TEMPLI) 0.21600E+03

WEIGHT OF CASK CONTENTS .............(WC) 0.95000E+02
WEIGHT OF CASK LID ..................(WL) 0.14000E+02
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.90000E+02
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.31400E+03
DYNAMIC LOAD FACTOR ................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
```

```
AXIAL VIBRATION ACCELERATION ........(AVA) 0.00000E+00
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.00000E+00
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.75000E+03
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.31800E+01

Sm STRESS ............................(SM) 0.94000E+02
Sy STRESS ............................(SY) 0.14100E+03
Su STRESS ............................(SU) 0.17400E+03
CODE EVALUATION TYPE..................(CET)           2

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.14100E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)          13
```

```
******** BOLT LOADS & STRESSES *********
```

```
BOLT FORCES DUE TO PRESSURE, TABLE 4.3
--------------------------------------------------
AXIAL LOAD DUE TO PRESSURE.........    0.13108E+03
SHEAR LOAD DUE TO PRESSURE.........    0.24416E+03
EDGE LOAD DUE TO PRESSURE..........    0.83407E+02
EDGE MOMENT DUE TO PRESSURE........    0.77298E+02
```

```
BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4
--------------------------------------------------
AXIAL LOAD DUE TO TEMPERATURE.......    0.20116E+04
SHEAR LOAD DUE TO TEMPERATURE.......    0.00000E+00
EDGE LOAD DUE TO TEMPERATURE........    0.00000E+00
EDGE MOMENT DUE TEMPERATURE.........    0.00000E+00
```

```
BOLT FORCES DUE TO IMPACT, TABLE 4.5
--------------------------------------------------
AXIAL LOAD DUE TO IMPACT............    0.52742E+04
SHEAR LOAD DUE TO IMPACT............   -0.19216E-04
EDGE LOAD DUE TO IMPACT.............    0.22644E+04
EDGE MOMENT DUE IMPACT..............    0.20985E+04
```

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.00000E+00
SHEAR LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE MOMENT DUE VIBRATION.....	0.00000E+00

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.10000E+05
AXIAL LOAD DUE TO GASKET SEATING....	0.57397E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.54757E+03
TORQUE DUE TO PRELOAD.....	0.37500E+03
TORQUE DUE TO GASKET	0.21524E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.17964E+05
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.12012E+05
AXIAL LOAD LESS TEMP & PRELOAD.....	0.59529E+04
TOTAL EDGE LOAD.....	0.23478E+04
TOTAL EDGE MOMENT.....	0.21758E+04

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	0.23234E+03
BENDING MOMENT DUE TO PRYING.....	0.90699E+03

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.12244E+05
TOTAL BOLT SHEAR LOAD.....	0.24416E+03
TOTAL BOLT BENDING MOMENT.....	0.30828E+04
TOTAL BOLT TORSIONAL MOMENT.....	0.37500E+03

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.49519E+06
TOTAL BOLT DIRECT STRESS (-MC/I) ...	-0.32261E+06
AVE BOLT DIRECT STRESS	0.86286E+05
TOTAL BOLT SHEAR STRESS	0.24870E+05
AVE BOLT SHEAR STRESS	0.12435E+05

CODE EVALUAT. FOR ACCIDENT COND, TABLE 6.3

ALLOWABLE TENSILE STRESS (Sa)	0.12180E+06
ALLOWABLE SHEAR STRESS (Ta)	0.73080E+05
Rt (AVE AXIAL STRESS/Sa)	0.70843E+00
Rs (AVE SHEAR_STRESS/Ta)	0.17015E+00
Rtý+Rsý	0.53082E+00

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.58264E+04
DISPLACEMENT ACROSS BOLT	-0.60339E-03
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.52437E+04
TOTAL BOLT SHEAR FORCE	0.24416E+03

4.5.3.2.2.4 Output, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, -40°C (-40°F) Ambient – Model AOS-050

```
30-FT DROP HEAD ON AOS-050 CONFIGURATION, -40F AMBIENT



*************** INPUT DATA ****************

NUMBER OF BOLTS .....................(NB)          10
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.74140E+01
LID DIAMETER AT GASKET  .............(DLG) 0.60900E+01
NOMINAL BOLT DIAMETER ...............(DB) 0.50000E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.55300E+01
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.89000E+01
THICKNESS OF LID ....................(TL) 0.75000E+00
THICKNESS OF LID FLANGE .............(TLF) 0.97000E+00
THICKNESS OF CASK WALL ..............(TC) 0.17050E+01
BOLT LENGTH .........................(BL) 0.41000E+00
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.30000E-02

YOUNG'S MODULUS FOR LID .............(EL) 0.28300E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.28300E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.28300E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.28900E+08
POISSON'S RATIO FOR LID ............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.86000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.70000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.86000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.60000E+02
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.60000E+02
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL) 0.15000E+02
TEMPERATURE CHG ACROSS BOLT .......(TEMPB) 0.15000E+02
TEMPERATURE CHG ACROSS WALL .......(TEMPC) 0.15000E+02
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO) 0.15000E+02
TEMPERATURE AT INSIDE OF LID .....(TEMPLI) 0.16000E+02

WEIGHT OF CASK CONTENTS .............(WC) 0.95000E+02
WEIGHT OF CASK LID ..................(WL) 0.14000E+02
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.90000E+02
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.43900E+03
DYNAMIC LOAD FACTOR ................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
```

```
AXIAL VIBRATION ACCELERATION ........(AVA) 0.00000E+00
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.00000E+00
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.75000E+03
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.31800E+01

Sm STRESS ............................(SM) 0.10000E+03
Sy STRESS ............................(SY) 0.15000E+03
Su STRESS ............................(SU) 0.18500E+03
CODE EVALUATION TYPE..................(CET)           2

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.15000E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)          13



******** BOLT LOADS & STRESSES *********


BOLT FORCES DUE TO PRESSURE, TABLE 4.3
-------------------------------------------------
AXIAL LOAD DUE TO PRESSURE.........    0.13108E+03
SHEAR LOAD DUE TO PRESSURE.........    0.24416E+03
EDGE LOAD DUE TO PRESSURE..........    0.83407E+02
EDGE MOMENT DUE TO PRESSURE........    0.77298E+02


BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4
-------------------------------------------------
AXIAL LOAD DUE TO TEMPERATURE.......    0.13619E+03
SHEAR LOAD DUE TO TEMPERATURE.......    0.00000E+00
EDGE LOAD DUE TO TEMPERATURE........    0.00000E+00
EDGE MOMENT DUE TEMPERATURE.........   -0.16298E+02


BOLT FORCES DUE TO IMPACT, TABLE 4.5
-------------------------------------------------
AXIAL LOAD DUE TO IMPACT............    0.73738E+04
SHEAR LOAD DUE TO IMPACT............   -0.26865E-04
EDGE LOAD DUE TO IMPACT.............    0.31659E+04
EDGE MOMENT DUE IMPACT..............    0.29340E+04
```

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.00000E+00
SHEAR LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE MOMENT DUE VIBRATION.....	0.00000E+00

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.10000E+05
AXIAL LOAD DUE TO GASKET SEATING....	0.57397E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.54757E+03
TORQUE DUE TO PRELOAD.....	0.37500E+03
TORQUE DUE TO GASKET	0.21524E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.18189E+05
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.10136E+05
AXIAL LOAD LESS TEMP & PRELOAD.....	0.80525E+04
TOTAL EDGE LOAD.....	0.32493E+04
TOTAL EDGE MOMENT.....	0.29950E+04

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	0.56965E+04
BENDING MOMENT DUE TO PRYING.....	0.12401E+04

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.15833E+05
TOTAL BOLT SHEAR LOAD.....	0.24416E+03
TOTAL BOLT BENDING MOMENT.....	0.42351E+04
TOTAL BOLT TORSIONAL MOMENT.....	0.37500E+03

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.67331E+06
TOTAL BOLT DIRECT STRESS (-MC/I) ...	-0.45016E+06
AVE BOLT DIRECT STRESS	0.11158E+06
TOTAL BOLT SHEAR STRESS	0.24870E+05
AVE BOLT SHEAR STRESS	0.12435E+05

CODE EVALUAT. FOR ACCIDENT COND, TABLE 6.3

ALLOWABLE TENSILE STRESS (Sa)	0.12950E+06
ALLOWABLE SHEAR STRESS (Ta)	0.77700E+05
Rt (AVE AXIAL STRESS/Sa)	0.86160E+00
Rs (AVE SHEAR_STRESS/Ta)	0.16004E+00
Rtý+Rsý	0.76797E+00

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	0.36128E+04
DISPLACEMENT ACROSS BOLT	0.36120E-03
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	0.32515E+04
TOTAL BOLT SHEAR FORCE	0.24416E+03

4.5.3.2.2.5 Output, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, 38°C (100°F) Ambient – Model AOS-050

```
30-FT DROP SIDE ORIENTATION AOS-050 , 100F AMBIENT



*************** INPUT DATA ****************

NUMBER OF BOLTS .....................(NB)          10
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.74140E+01
LID DIAMETER AT GASKET  .............(DLG) 0.60900E+01
NOMINAL BOLT DIAMETER ...............(DB) 0.50000E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.55300E+01
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.89000E+01
THICKNESS OF LID ....................(TL) 0.75000E+00
THICKNESS OF LID FLANGE .............(TLF) 0.97000E+00
THICKNESS OF CASK WALL ..............(TC) 0.17050E+01
BOLT LENGTH .........................(BL) 0.41000E+00
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.30000E-02

YOUNG'S MODULUS FOR LID .............(EL) 0.27100E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.27100E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.27100E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.27900E+08
POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.90000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.73000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.90000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.60000E+02
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.60000E+02
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL) 0.21600E+03
TEMPERATURE CHG ACROSS BOLT .......(TEMPB) 0.21600E+03
TEMPERATURE CHG ACROSS WALL .......(TEMPC) 0.21600E+03
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO) 0.21600E+03
TEMPERATURE AT INSIDE OF LID .....(TEMPLI) 0.21600E+03

WEIGHT OF CASK CONTENTS .............(WC) 0.95000E+02
WEIGHT OF CASK LID ..................(WL) 0.14000E+02
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.00000E+00
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.33500E+03
DYNAMIC LOAD FACTOR ................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
```

```
AXIAL VIBRATION ACCELERATION ........(AVA) 0.00000E+00
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.00000E+00
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.75000E+03
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.31800E+01

Sm STRESS ............................(SM) 0.94000E+02
Sy STRESS ............................(SY) 0.14100E+03
Su STRESS ............................(SU) 0.17400E+03
CODE EVALUATION TYPE..................(CET)           2

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.14100E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)          13
```

```
******** BOLT LOADS & STRESSES *********
```

```
BOLT FORCES DUE TO PRESSURE, TABLE 4.3
--------------------------------------------------
AXIAL LOAD DUE TO PRESSURE.........    0.13108E+03
SHEAR LOAD DUE TO PRESSURE.........    0.24416E+03
EDGE LOAD DUE TO PRESSURE..........    0.83407E+02
EDGE MOMENT DUE TO PRESSURE........    0.77298E+02
```

```
BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4
--------------------------------------------------
AXIAL LOAD DUE TO TEMPERATURE.......    0.20116E+04
SHEAR LOAD DUE TO TEMPERATURE.......    0.00000E+00
EDGE LOAD DUE TO TEMPERATURE........    0.00000E+00
EDGE MOMENT DUE TEMPERATURE.........    0.00000E+00
```

```
BOLT FORCES DUE TO IMPACT, TABLE 4.5
--------------------------------------------------
AXIAL LOAD DUE TO IMPACT............    0.00000E+00
SHEAR LOAD DUE TO IMPACT............    0.46900E+03
EDGE LOAD DUE TO IMPACT.............    0.00000E+00
EDGE MOMENT DUE IMPACT..............    0.00000E+00
```

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.00000E+00
SHEAR LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE MOMENT DUE VIBRATION.....	0.00000E+00

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.10000E+05
AXIAL LOAD DUE TO GASKET SEATING....	0.57397E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.54757E+03
TORQUE DUE TO PRELOAD.....	0.37500E+03
TORQUE DUE TO GASKET	0.21524E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.12690E+05
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.12012E+05
AXIAL LOAD LESS TEMP & PRELOAD.....	0.67865E+03
TOTAL EDGE LOAD.....	0.83407E+02
TOTAL EDGE MOMENT.....	0.77298E+02

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	-0.96802E+04
BENDING MOMENT DUE TO PRYING.....	0.32221E+02

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.23314E+04
TOTAL BOLT SHEAR LOAD.....	0.71316E+03
TOTAL BOLT BENDING MOMENT.....	0.10952E+03
TOTAL BOLT TORSIONAL MOMENT.....	0.37500E+03

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.30957E+05
TOTAL BOLT DIRECT STRESS (-MC/I) ...	0.19038E+04
AVE BOLT DIRECT STRESS	0.16430E+05
TOTAL BOLT SHEAR STRESS	0.24870E+05
AVE BOLT SHEAR STRESS	0.12435E+05

CODE EVALUAT. FOR ACCIDENT COND, TABLE 6.3

ALLOWABLE TENSILE STRESS (Sa)	0.12180E+06
ALLOWABLE SHEAR STRESS (Ta)	0.73080E+05
Rt (AVE AXIAL STRESS/Sa)	0.13489E+00
Rs (AVE SHEAR_STRESS/Ta)	0.17015E+00
Rtý+Rsý	0.47149E-01

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.16528E+04
DISPLACEMENT ACROSS BOLT	-0.17116E-03
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.14875E+04
TOTAL BOLT SHEAR FORCE	0.71316E+03

4.5.3.2.2.6 Output, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, -40°C (-40°F) Ambient – Model AOS-050

```
30-FT DROP SIDE ORIENTATION AOS-050, -40F AMBIENT



*************** INPUT DATA ****************

NUMBER OF BOLTS .....................(NB)          10
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.74140E+01
LID DIAMETER AT GASKET  .............(DLG) 0.60900E+01
NOMINAL BOLT DIAMETER ...............(DB) 0.50000E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.55300E+01
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.89000E+01
THICKNESS OF LID ....................(TL) 0.75000E+00
THICKNESS OF LID FLANGE .............(TLF) 0.97000E+00
THICKNESS OF CASK WALL ..............(TC) 0.17050E+01
BOLT LENGTH .........................(BL) 0.41000E+00
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.30000E-02

YOUNG'S MODULUS FOR LID .............(EL) 0.28300E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.28300E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.28300E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.28900E+08
POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.86000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.70000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.86000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.60000E+02
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.60000E+02
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL) 0.15000E+02
TEMPERATURE CHG ACROSS BOLT .......(TEMPB) 0.15000E+02
TEMPERATURE CHG ACROSS WALL .......(TEMPC) 0.15000E+02
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO) 0.15000E+02
TEMPERATURE AT INSIDE OF LID .....(TEMPLI) 0.16000E+02

WEIGHT OF CASK CONTENTS .............(WC) 0.95000E+02
WEIGHT OF CASK LID ..................(WL) 0.14000E+02
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.00000E+00
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.46900E+03
DYNAMIC LOAD FACTOR ................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
```

```
AXIAL VIBRATION ACCELERATION ........(AVA) 0.00000E+00
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.00000E+00
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.75000E+03
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.31800E+01

Sm STRESS ............................(SM) 0.10000E+03
Sy STRESS ............................(SY) 0.15000E+03
Su STRESS ............................(SU) 0.18500E+03
CODE EVALUATION TYPE..................(CET)           2

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.15000E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)          13
```

```
******** BOLT LOADS & STRESSES *********
```

```
BOLT FORCES DUE TO PRESSURE, TABLE 4.3
-------------------------------------------------
AXIAL LOAD DUE TO PRESSURE.........    0.13108E+03
SHEAR LOAD DUE TO PRESSURE.........    0.24416E+03
EDGE LOAD DUE TO PRESSURE..........    0.83407E+02
EDGE MOMENT DUE TO PRESSURE........    0.77298E+02
```

```
BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4
-------------------------------------------------
AXIAL LOAD DUE TO TEMPERATURE......    0.13619E+03
SHEAR LOAD DUE TO TEMPERATURE......    0.00000E+00
EDGE LOAD DUE TO TEMPERATURE.......    0.00000E+00
EDGE MOMENT DUE TEMPERATURE........   -0.16298E+02
```

```
BOLT FORCES DUE TO IMPACT, TABLE 4.5
-------------------------------------------------
AXIAL LOAD DUE TO IMPACT...........    0.00000E+00
SHEAR LOAD DUE TO IMPACT...........    0.65660E+03
EDGE LOAD DUE TO IMPACT............    0.00000E+00
EDGE MOMENT DUE IMPACT.............    0.00000E+00
```

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.00000E+00
SHEAR LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE MOMENT DUE VIBRATION.....	0.00000E+00

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.10000E+05
AXIAL LOAD DUE TO GASKET SEATING....	0.57397E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.54757E+03
TORQUE DUE TO PRELOAD.....	0.37500E+03
TORQUE DUE TO GASKET	0.21524E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.10815E+05
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.10136E+05
AXIAL LOAD LESS TEMP & PRELOAD.....	0.67865E+03
TOTAL EDGE LOAD.....	0.83407E+02
TOTAL EDGE MOMENT.....	0.61000E+02

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	-0.81436E+04
BENDING MOMENT DUE TO PRYING.....	0.25259E+02

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.19925E+04
TOTAL BOLT SHEAR LOAD.....	0.90076E+03
TOTAL BOLT BENDING MOMENT.....	0.86259E+02
TOTAL BOLT TORSIONAL MOMENT.....	0.37500E+03

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.25483E+05
TOTAL BOLT DIRECT STRESS (-MC/I) ...	0.26009E+04
AVE BOLT DIRECT STRESS	0.14042E+05
TOTAL BOLT SHEAR STRESS	0.24870E+05
AVE BOLT SHEAR STRESS	0.12435E+05

CODE EVALUAT. FOR ACCIDENT COND, TABLE 6.3

ALLOWABLE TENSILE STRESS (Sa)	0.12950E+06
ALLOWABLE SHEAR STRESS (Ta)	0.77700E+05
Rt (AVE AXIAL STRESS/Sa)	0.10843E+00
Rs (AVE SHEAR_STRESS/Ta)	0.16004E+00
Rtý+Rsý	0.37369E-01

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.13139E+04
DISPLACEMENT ACROSS BOLT	-0.13136E-03
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.11825E+04
TOTAL BOLT SHEAR FORCE	0.90076E+03

4.5.3.2.2.7 Output, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, 38°C (100°F) Ambient – Model AOS-050

```
30-FT @ 45 DEG CORNER AOS-050 CONFIGURATION, 100F AMBIENT



*************** INPUT DATA ****************

NUMBER OF BOLTS .....................(NB)          10
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.74140E+01
LID DIAMETER AT GASKET  .............(DLG) 0.60900E+01
NOMINAL BOLT DIAMETER ...............(DB) 0.50000E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.55300E+01
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.89000E+01
THICKNESS OF LID ....................(TL) 0.75000E+00
THICKNESS OF LID FLANGE .............(TLF) 0.97000E+00
THICKNESS OF CASK WALL ..............(TC) 0.17050E+01
BOLT LENGTH .........................(BL) 0.41000E+00
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.30000E-02

YOUNG'S MODULUS FOR LID .............(EL) 0.27100E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.27100E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.27100E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.27900E+08
POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.90000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.73000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.90000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.60000E+02
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.60000E+02
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL) 0.21600E+03
TEMPERATURE CHG ACROSS BOLT .......(TEMPB) 0.21600E+03
TEMPERATURE CHG ACROSS WALL .......(TEMPC) 0.21600E+03
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO) 0.21600E+03
TEMPERATURE AT INSIDE OF LID .....(TEMPLI) 0.21600E+03

WEIGHT OF CASK CONTENTS .............(WC) 0.95000E+02
WEIGHT OF CASK LID ..................(WL) 0.14000E+02
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.45000E+02
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.17600E+03
DYNAMIC LOAD FACTOR .................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
```

```
AXIAL VIBRATION ACCELERATION ........(AVA) 0.00000E+00
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.00000E+00
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.75000E+03
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.31800E+01

Sm STRESS ............................(SM) 0.94000E+02
Sy STRESS ............................(SY) 0.14100E+03
Su STRESS ............................(SU) 0.17400E+03
CODE EVALUATION TYPE..................(CET)           2

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.14100E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)          13
```

******** BOLT LOADS & STRESSES *********

BOLT FORCES DUE TO PRESSURE, TABLE 4.3

AXIAL LOAD DUE TO PRESSURE.....	0.13108E+03
SHEAR LOAD DUE TO PRESSURE.....	0.24416E+03
EDGE LOAD DUE TO PRESSURE.....	0.83407E+02
EDGE MOMENT DUE TO PRESSURE.....	0.77298E+02

BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4

AXIAL LOAD DUE TO TEMPERATURE.....	0.20116E+04
SHEAR LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE MOMENT DUE TEMPERATURE.....	0.00000E+00

BOLT FORCES DUE TO IMPACT, TABLE 4.5

AXIAL LOAD DUE TO IMPACT.....	0.20904E+04
SHEAR LOAD DUE TO IMPACT.....	0.17423E+03
EDGE LOAD DUE TO IMPACT.....	0.89748E+03
EDGE MOMENT DUE IMPACT.....	0.83174E+03

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.00000E+00
SHEAR LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE MOMENT DUE VIBRATION.....	0.00000E+00

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.10000E+05
AXIAL LOAD DUE TO GASKET SEATING....	0.57397E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.54757E+03
TORQUE DUE TO PRELOAD.....	0.37500E+03
TORQUE DUE TO GASKET	0.21524E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.14781E+05
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.12012E+05
AXIAL LOAD LESS TEMP & PRELOAD.....	0.27690E+04
TOTAL EDGE LOAD.....	0.98089E+03
TOTAL EDGE MOMENT.....	0.90904E+03

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	-0.57514E+04
BENDING MOMENT DUE TO PRYING.....	0.37893E+03

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.62601E+04
TOTAL BOLT SHEAR LOAD.....	0.41839E+03
TOTAL BOLT BENDING MOMENT.....	0.12880E+04
TOTAL BOLT TORSIONAL MOMENT.....	0.37500E+03

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.21495E+06
TOTAL BOLT DIRECT STRESS (-MC/I) ...	-0.12672E+06
AVE BOLT DIRECT STRESS	0.44117E+05
TOTAL BOLT SHEAR STRESS	0.24870E+05
AVE BOLT SHEAR STRESS	0.12435E+05

CODE EVALUAT. FOR ACCIDENT COND, TABLE 6.3

ALLOWABLE TENSILE STRESS (Sa)	0.12180E+06
ALLOWABLE SHEAR STRESS (Ta)	0.73080E+05
Rt (AVE AXIAL STRESS/Sa)	0.36221E+00
Rs (AVE SHEAR_STRESS/Ta)	0.17015E+00
Rtý+Rsý	0.16015E+00

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.34911E+04
DISPLACEMENT ACROSS BOLT	-0.36155E-03
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.31420E+04
TOTAL BOLT SHEAR FORCE	0.41839E+03

4.5.3.2.2.8 Output, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, -40°C (-40°F) Ambient – Model AOS-050

```
30-FT @ 45 DEG CORNER AOS-050 CONFIGURATION, -40F AMBIENT



*************** INPUT DATA ****************

NUMBER OF BOLTS .....................(NB)          10
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.74140E+01
LID DIAMETER AT GASKET  .............(DLG) 0.60900E+01
NOMINAL BOLT DIAMETER ...............(DB) 0.50000E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.55300E+01
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.89000E+01
THICKNESS OF LID ....................(TL) 0.75000E+00
THICKNESS OF LID FLANGE .............(TLF) 0.97000E+00
THICKNESS OF CASK WALL ..............(TC) 0.17050E+01
BOLT LENGTH .........................(BL) 0.41000E+00
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.30000E-02

YOUNG'S MODULUS FOR LID .............(EL) 0.28300E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.28300E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.28300E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.28900E+08
POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.86000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.70000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.86000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.60000E+02
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.60000E+02
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL) 0.15000E+02
TEMPERATURE CHG ACROSS BOLT .......(TEMPB) 0.15000E+02
TEMPERATURE CHG ACROSS WALL .......(TEMPC) 0.15000E+02
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO) 0.15000E+02
TEMPERATURE AT INSIDE OF LID .....(TEMPLI) 0.16000E+02

WEIGHT OF CASK CONTENTS .............(WC) 0.95000E+02
WEIGHT OF CASK LID ..................(WL) 0.14000E+02
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.45000E+02
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.24700E+03
DYNAMIC LOAD FACTOR .................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
```

```
AXIAL VIBRATION ACCELERATION ........(AVA) 0.00000E+00
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.00000E+00
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.75000E+03
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.31800E+01

Sm STRESS ............................(SM) 0.10000E+03
Sy STRESS ............................(SY) 0.15000E+03
Su STRESS ............................(SU) 0.18500E+03
CODE EVALUATION TYPE..................(CET)           2

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.15000E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)          13
```

******** BOLT LOADS & STRESSES *********

BOLT FORCES DUE TO PRESSURE, TABLE 4.3

AXIAL LOAD DUE TO PRESSURE.....	0.13108E+03
SHEAR LOAD DUE TO PRESSURE.....	0.24416E+03
EDGE LOAD DUE TO PRESSURE.....	0.83407E+02
EDGE MOMENT DUE TO PRESSURE.....	0.77298E+02

BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4

AXIAL LOAD DUE TO TEMPERATURE.....	0.13619E+03
SHEAR LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE MOMENT DUE TEMPERATURE.....	-0.16298E+02

BOLT FORCES DUE TO IMPACT, TABLE 4.5

AXIAL LOAD DUE TO IMPACT.....	0.29337E+04
SHEAR LOAD DUE TO IMPACT.....	0.24452E+03
EDGE LOAD DUE TO IMPACT.....	0.12595E+04
EDGE MOMENT DUE IMPACT.....	0.11673E+04

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.00000E+00
SHEAR LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE MOMENT DUE VIBRATION.....	0.00000E+00

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.10000E+05
AXIAL LOAD DUE TO GASKET SEATING....	0.57397E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.54757E+03
TORQUE DUE TO PRELOAD.....	0.37500E+03
TORQUE DUE TO GASKET	0.21524E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.13749E+05
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.10136E+05
AXIAL LOAD LESS TEMP & PRELOAD.....	0.36123E+04
TOTAL EDGE LOAD.....	0.13429E+04
TOTAL EDGE MOMENT.....	0.12283E+04

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	-0.26374E+04
BENDING MOMENT DUE TO PRYING.....	0.50860E+03

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.74988E+04
TOTAL BOLT SHEAR LOAD.....	0.48868E+03
TOTAL BOLT BENDING MOMENT.....	0.17369E+04
TOTAL BOLT TORSIONAL MOMENT.....	0.37500E+03

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.28322E+06
TOTAL BOLT DIRECT STRESS (-MC/I) ...	-0.17753E+06
AVE BOLT DIRECT STRESS	0.52846E+05
TOTAL BOLT SHEAR STRESS	0.24870E+05
AVE BOLT SHEAR STRESS	0.12435E+05

CODE EVALUAT. FOR ACCIDENT COND, TABLE 6.3

ALLOWABLE TENSILE STRESS (Sa)	0.12950E+06
ALLOWABLE SHEAR STRESS (Ta)	0.77700E+05
Rt (AVE AXIAL STRESS/Sa)	0.40808E+00
Rs (AVE SHEAR_STRESS/Ta)	0.16004E+00
Rtý+Rsý	0.19214E+00

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.38865E+04
DISPLACEMENT ACROSS BOLT	-0.38857E-03
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.34978E+04
TOTAL BOLT SHEAR FORCE	0.48868E+03

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4.5.3.2.3 Cask Lid Attachment Bolt Fortran Program Output Files – Model AOS-100

This appendix provides the following output files, that are used to build the content in Table 4-2:

- Output, Normal Conditions of Transport, 30-Ft. Drop, 38°C (100°F) Ambient – Model AOS-100
- Output, Normal Conditions of Transport, 30-Ft. Drop, -40°C (-40°F) Ambient – Model AOS-100
- Output, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, 38°C (100°F) Ambient – Model AOS-100
- Output, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, -40°C (-40°F) Ambient – Model AOS-100
- Output, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, 38°C (100°F) Ambient – Model AOS-100
- Output, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, -40°C (-40°F) Ambient – Model AOS-100
- Output, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, 38°C (100°F) Ambient – Model AOS-100
- Output, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, -40°C (-40°F) Ambient – Model AOS-100

4.5.3.2.3.1 Output, Normal Conditions of Transport, 30-Ft. Drop, 38°C (100°F) Ambient – Model AOS-100

```
NORMAL CONDITION - AXIAL=10g,LATERAL=5g AOS-100, 100F AMBIENT



*************** INPUT DATA ***************

NUMBER OF BOLTS .....................(NB)          14
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.14064E+02
LID DIAMETER AT GASKET  .............(DLG) 0.12172E+02
NOMINAL BOLT DIAMETER ...............(DB) 0.87500E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.11040E+02
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.16590E+02
THICKNESS OF LID ....................(TL) 0.15100E+01
THICKNESS OF LID FLANGE .............(TLF) 0.19400E+01
THICKNESS OF CASK WALL ..............(TC) 0.28050E+01
BOLT LENGTH .........................(BL) 0.10600E+01
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.29000E-01

YOUNG'S MODULUS FOR LID .............(EL) 0.27100E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.27100E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.27100E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.27900E+08
POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.91000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.73000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.91000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.28000E+03
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.28000E+03
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL) 0.22300E+03
TEMPERATURE CHG ACROSS BOLT .......(TEMPB) 0.22300E+03
TEMPERATURE CHG ACROSS WALL .......(TEMPC) 0.22300E+03
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO) 0.22400E+03
TEMPERATURE AT INSIDE OF LID .....(TEMPLI) 0.22400E+03

WEIGHT OF CASK CONTENTS .............(WC) 0.78600E+03
WEIGHT OF CASK LID ..................(WL) 0.96000E+02
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.00000E+00
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.00000E+00
DYNAMIC LOAD FACTOR ................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
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```
AXIAL VIBRATION ACCELERATION ........(AVA) 0.10000E+02
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.50000E+01
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.60000E+04
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.54000E+00

Sm STRESS ............................(SM) 0.94000E+02
Sy STRESS ............................(SY) 0.14100E+03
Su STRESS ............................(SU) 0.17400E+03
CODE EVALUATION TYPE..................(CET)           1

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.14100E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)           9
```

******** BOLT LOADS & STRESSES *********

BOLT FORCES DUE TO PRESSURE, TABLE 4.3

AXIAL LOAD DUE TO PRESSURE.....	0.22026E+04
SHEAR LOAD DUE TO PRESSURE.....	0.45227E+04
EDGE LOAD DUE TO PRESSURE.....	0.93174E+03
EDGE MOMENT DUE TO PRESSURE.....	0.16380E+04

BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4

AXIAL LOAD DUE TO TEMPERATURE.....	0.67342E+04
SHEAR LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE MOMENT DUE TEMPERATURE.....	0.00000E+00

BOLT FORCES DUE TO IMPACT, TABLE 4.5

AXIAL LOAD DUE TO IMPACT.....	0.00000E+00
SHEAR LOAD DUE TO IMPACT.....	0.00000E+00
EDGE LOAD DUE TO IMPACT.....	0.00000E+00
EDGE MOMENT DUE IMPACT.....	0.00000E+00

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.68571E+02
SHEAR LOAD DUE TO VIBRATION.....	0.34286E+02
EDGE LOAD DUE TO VIBRATION.....	0.21728E+02
EDGE MOMENT DUE VIBRATION.....	0.38197E+02

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.45714E+05
AXIAL LOAD DUE TO GASKET SEATING....	0.81942E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.78172E+03
TORQUE DUE TO PRELOAD.....	0.30000E+04
TORQUE DUE TO GASKET	0.53774E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.55501E+05
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.52449E+05
AXIAL LOAD LESS TEMP & PRELOAD.....	0.30529E+04
TOTAL EDGE LOAD.....	0.95347E+03
TOTAL EDGE MOMENT.....	0.16762E+04

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	-0.34461E+05
BENDING MOMENT DUE TO PRYING.....	0.63726E+03

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.17988E+05
TOTAL BOLT SHEAR LOAD.....	0.45570E+04
TOTAL BOLT BENDING MOMENT.....	0.23135E+04
TOTAL BOLT TORSIONAL MOMENT.....	0.30000E+04

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.91234E+05
TOTAL BOLT DIRECT STRESS (-MC/I) ...	-0.13320E+05
AVE BOLT DIRECT STRESS	0.38957E+05
TOTAL BOLT SHEAR STRESS	0.33895E+05
AVE BOLT SHEAR STRESS	0.16948E+05

CODE EVALUATION FOR NORMAL COND, TABLE 6.1

Rt (AXIAL_STRESS/Sm)	0.41444E+00
Rs (SHEAR_STRESS/0.6Sm)	0.30049E+00
Rtý+Rsý	0.26205E+00
VON MISES EQUIVALENT STRESS (Se) ...	0.11366E+06
Se/1.35Sm	0.89569E+00

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.14935E+05
DISPLACEMENT ACROSS BOLT	-0.12289E-02
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.13442E+05
TOTAL BOLT SHEAR FORCE	0.45570E+04

FATIGUE EVALUATION

USEAGE FOR NORMAL OPERATION	0.64705E+00
USEAGE FOR VIBRATION	0.11424E-01
ACCUMULATIVE FATIGUE USEAGE	0.65847E+00

4.5.3.2.3.2 Output, Normal Conditions of Transport, 30-Ft. Drop, -40°C (-40°F) Ambient – Model AOS-100

```
NORMAL CONDITION - AXIAL=10g,LATERAL=5g AOS-100, -40F Ambient



*************** INPUT DATA ****************

NUMBER OF BOLTS .....................(NB)          14
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.14064E+02
LID DIAMETER AT GASKET  .............(DLG) 0.12172E+02
NOMINAL BOLT DIAMETER ...............(DB) 0.87500E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.11040E+02
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.16590E+02
THICKNESS OF LID ....................(TL) 0.15100E+01
THICKNESS OF LID FLANGE .............(TLF) 0.19400E+01
THICKNESS OF CASK WALL ..............(TC) 0.28050E+01
BOLT LENGTH .........................(BL) 0.10600E+01
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.29000E-01

YOUNG'S MODULUS FOR LID .............(EL) 0.28300E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.28300E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.28300E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.28900E+08
POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.86000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.70000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.86000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.28000E+03
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.28000E+03
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL) 0.15000E+02
TEMPERATURE CHG ACROSS BOLT .......(TEMPB) 0.15000E+02
TEMPERATURE CHG ACROSS WALL .......(TEMPC) 0.15000E+02
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO) 0.16000E+02
TEMPERATURE AT INSIDE OF LID .....(TEMPLI) 0.16000E+02

WEIGHT OF CASK CONTENTS .............(WC) 0.78600E+03
WEIGHT OF CASK LID ..................(WL) 0.96000E+02
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.00000E+00
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.00000E+00
DYNAMIC LOAD FACTOR .................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
```

```
AXIAL VIBRATION ACCELERATION ........(AVA) 0.10000E+02
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.50000E+01
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.60000E+04
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.54000E+00

Sm STRESS ............................(SM) 0.10000E+03
Sy STRESS ............................(SY) 0.15000E+03
Su STRESS ............................(SU) 0.18500E+03
CODE EVALUATION TYPE..................(CET)           1

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.15000E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)           9
```

```
******** BOLT LOADS & STRESSES *********
```

```
BOLT FORCES DUE TO PRESSURE, TABLE 4.3
--------------------------------------------------
AXIAL LOAD DUE TO PRESSURE.........    0.22026E+04
SHEAR LOAD DUE TO PRESSURE.........    0.45227E+04
EDGE LOAD DUE TO PRESSURE..........    0.93174E+03
EDGE MOMENT DUE TO PRESSURE........    0.16380E+04
```

```
BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4
--------------------------------------------------
AXIAL LOAD DUE TO TEMPERATURE.......    0.41708E+03
SHEAR LOAD DUE TO TEMPERATURE.......    0.00000E+00
EDGE LOAD DUE TO TEMPERATURE........    0.00000E+00
EDGE MOMENT DUE TEMPERATURE.........    0.00000E+00
```

```
BOLT FORCES DUE TO IMPACT, TABLE 4.5
--------------------------------------------------
AXIAL LOAD DUE TO IMPACT............    0.00000E+00
SHEAR LOAD DUE TO IMPACT............    0.00000E+00
EDGE LOAD DUE TO IMPACT.............    0.00000E+00
EDGE MOMENT DUE IMPACT..............    0.00000E+00
```

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.68571E+02
SHEAR LOAD DUE TO VIBRATION.....	0.34286E+02
EDGE LOAD DUE TO VIBRATION.....	0.21728E+02
EDGE MOMENT DUE VIBRATION.....	0.38197E+02

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.45714E+05
AXIAL LOAD DUE TO GASKET SEATING....	0.81942E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.78172E+03
TORQUE DUE TO PRELOAD.....	0.30000E+04
TORQUE DUE TO GASKET	0.53774E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.49184E+05
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.46131E+05
AXIAL LOAD LESS TEMP & PRELOAD.....	0.30529E+04
TOTAL EDGE LOAD.....	0.95347E+03
TOTAL EDGE MOMENT.....	0.16762E+04

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	-0.29592E+05
BENDING MOMENT DUE TO PRYING.....	0.63273E+03

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.16539E+05
TOTAL BOLT SHEAR LOAD.....	0.45570E+04
TOTAL BOLT BENDING MOMENT.....	0.23089E+04
TOTAL BOLT TORSIONAL MOMENT.....	0.30000E+04

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.87994E+05
TOTAL BOLT DIRECT STRESS (-MC/I) ...	-0.16355E+05
AVE BOLT DIRECT STRESS	0.35819E+05
TOTAL BOLT SHEAR STRESS	0.33895E+05
AVE BOLT SHEAR STRESS	0.16948E+05

CODE EVALUATION FOR NORMAL COND, TABLE 6.1

Rt (AXIAL_STRESS/Sm)	0.35819E+00
Rs (SHEAR_STRESS/0.6Sm)	0.28246E+00
Rtý+Rsý	0.20809E+00
VON MISES EQUIVALENT STRESS (Se) ...	0.11108E+06
Se/1.35Sm	0.82281E+00

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.13486E+05
DISPLACEMENT ACROSS BOLT	-0.10713E-02
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.12138E+05
TOTAL BOLT SHEAR FORCE	0.45570E+04

FATIGUE EVALUATION

USEAGE FOR NORMAL OPERATION	0.58663E+00
USEAGE FOR VIBRATION	0.11424E-01
ACCUMULATIVE FATIGUE USEAGE	0.59805E+00

4.5.3.2.3.3 Output, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, 38°C (100°F) Ambient – Model AOS-100

```
30-FT DROP - Head-on  AOS-100, 100F Ambient



 *************** INPUT DATA ****************

 NUMBER OF BOLTS .....................(NB)          14
 LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.14064E+02
 LID DIAMETER AT GASKET  .............(DLG) 0.12172E+02
 NOMINAL BOLT DIAMETER ...............(DB) 0.87500E+00
 LID DIAMETER AT INNER EDGE ..........(DLI) 0.11040E+02
 LID DIAMETER AT OUTER EDGE ..........(DLO) 0.16590E+02
 THICKNESS OF LID ....................(TL) 0.15100E+01
 THICKNESS OF LID FLANGE .............(TLF) 0.19400E+01
 THICKNESS OF CASK WALL ..............(TC) 0.28050E+01
 BOLT LENGTH .........................(BL) 0.10600E+01
 BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.29000E-01

 YOUNG'S MODULUS FOR LID .............(EL) 0.27100E+08
 YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.27100E+08
 YOUNG'S MODULUS FOR CASK ............(EC) 0.27100E+08
 YOUNG'S MODULUS FOR BOLT ............(EB) 0.27900E+08
 POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
 POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
 LID THERMAL EXPANSION COEFF ..........(AL) 0.91000E-05
 BOLT THERMAL EXPANSION COEFF .........(AB) 0.73000E-05
 WALL THERMAL EXPANSION COEFF .........(AC) 0.91000E-05
 FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

 INSIDE PRESSURE AT LID ..............(PLI) 0.28000E+03
 OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
 INSIDE PRESSURE AT CASK WALL ........(PCI) 0.28000E+03
 OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

 TEMPERATURE CHG ACROSS LID ........(TEMPL) 0.22300E+03
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB) 0.22300E+03
 TEMPERATURE CHG ACROSS WALL .......(TEMPC) 0.22300E+03
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO) 0.22400E+03
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI) 0.22400E+03

 WEIGHT OF CASK CONTENTS .............(WC) 0.78600E+03
 WEIGHT OF CASK LID ..................(WL) 0.96000E+02
 DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.90000E+02
 CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.15600E+03
 DYNAMIC LOAD FACTOR ................(DYLF) 0.11500E+01

 PUNCTURE LOAD .....................(PUNC) 0.00000E+00
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
```

```
AXIAL VIBRATION ACCELERATION ........(AVA) 0.00000E+00
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.00000E+00
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.60000E+04
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.54000E+00

Sm STRESS ............................(SM) 0.94000E+02
Sy STRESS ............................(SY) 0.14100E+03
Su STRESS ............................(SU) 0.17400E+03
CODE EVALUATION TYPE..................(CET)           2

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.14100E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)           9
```

******** BOLT LOADS & STRESSES *********

BOLT FORCES DUE TO PRESSURE, TABLE 4.3

AXIAL LOAD DUE TO PRESSURE.....	0.22026E+04
SHEAR LOAD DUE TO PRESSURE.....	0.45227E+04
EDGE LOAD DUE TO PRESSURE.....	0.93174E+03
EDGE MOMENT DUE TO PRESSURE.....	0.16380E+04

BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4

AXIAL LOAD DUE TO TEMPERATURE.....	0.67342E+04
SHEAR LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE LOAD DUE TO TEMPERATURE.....	0.00000E+00
EDGE MOMENT DUE TEMPERATURE.....	0.00000E+00

BOLT FORCES DUE TO IMPACT, TABLE 4.5

AXIAL LOAD DUE TO IMPACT.....	0.15145E+05
SHEAR LOAD DUE TO IMPACT.....	-0.46759E-04
EDGE LOAD DUE TO IMPACT.....	0.47988E+04
EDGE MOMENT DUE IMPACT.....	0.84364E+04

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.00000E+00
SHEAR LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE MOMENT DUE VIBRATION.....	0.00000E+00

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.45714E+05
AXIAL LOAD DUE TO GASKET SEATING....	0.81942E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.78172E+03
TORQUE DUE TO PRELOAD.....	0.30000E+04
TORQUE DUE TO GASKET	0.53774E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.70578E+05
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.52449E+05
AXIAL LOAD LESS TEMP & PRELOAD.....	0.18129E+05
TOTAL EDGE LOAD.....	0.57306E+04
TOTAL EDGE MOMENT.....	0.10074E+05

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	-0.69982E+04
BENDING MOMENT DUE TO PRYING.....	0.38301E+04

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.45450E+05
TOTAL BOLT SHEAR LOAD.....	0.45227E+04
TOTAL BOLT BENDING MOMENT.....	0.13904E+05
TOTAL BOLT TORSIONAL MOMENT.....	0.30000E+04

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.41263E+06
TOTAL BOLT DIRECT STRESS (-MC/I) ...	-0.21576E+06
AVE BOLT DIRECT STRESS	0.98434E+05
TOTAL BOLT SHEAR STRESS	0.33895E+05
AVE BOLT SHEAR STRESS	0.16948E+05

CODE EVALUAT. FOR ACCIDENT COND, TABLE 6.3

ALLOWABLE TENSILE STRESS (Sa)	0.12180E+06
ALLOWABLE SHEAR STRESS (Ta)	0.73080E+05
Rt (AVE AXIAL STRESS/Sa)	0.80816E+00
Rs (AVE SHEAR_STRESS/Ta)	0.23191E+00
Rtý+Rsý	0.70691E+00

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.27321E+05
DISPLACEMENT ACROSS BOLT	-0.22481E-02
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.24589E+05
TOTAL BOLT SHEAR FORCE	0.45227E+04

4.5.3.2.3.4 Output, Hypothetical Accident Conditions of Transport, 30-Ft. Head-On Drop, -40°C (-40°F) Ambient – Model AOS-100

```
30-FT DROP - Head-on  AOS-100, -40F Ambient



*************** INPUT DATA ****************

NUMBER OF BOLTS .....................(NB)          14
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.14064E+02
LID DIAMETER AT GASKET  .............(DLG) 0.12172E+02
NOMINAL BOLT DIAMETER ...............(DB) 0.87500E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.11040E+02
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.16590E+02
THICKNESS OF LID ....................(TL) 0.15100E+01
THICKNESS OF LID FLANGE .............(TLF) 0.19400E+01
THICKNESS OF CASK WALL ..............(TC) 0.28050E+01
BOLT LENGTH .........................(BL) 0.10600E+01
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.29000E-01

YOUNG'S MODULUS FOR LID .............(EL) 0.28300E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.28300E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.28300E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.28900E+08
POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.86000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.70000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.86000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.28000E+03
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.28000E+03
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL) 0.15000E+02
TEMPERATURE CHG ACROSS BOLT .......(TEMPB) 0.15000E+02
TEMPERATURE CHG ACROSS WALL .......(TEMPC) 0.15000E+02
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO) 0.16000E+02
TEMPERATURE AT INSIDE OF LID .....(TEMPLI) 0.16000E+02

WEIGHT OF CASK CONTENTS .............(WC) 0.78600E+03
WEIGHT OF CASK LID ..................(WL) 0.96000E+02
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.90000E+02
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.21800E+03
DYNAMIC LOAD FACTOR .................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
```

```
AXIAL VIBRATION ACCELERATION ........(AVA) 0.00000E+00
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.00000E+00
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.60000E+04
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.54000E+00

Sm STRESS ............................(SM) 0.10000E+03
Sy STRESS ............................(SY) 0.15000E+03
Su STRESS ............................(SU) 0.18500E+03
CODE EVALUATION TYPE..................(CET)           2

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.15000E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)           9
```

```
******** BOLT LOADS & STRESSES *********
```

```
BOLT FORCES DUE TO PRESSURE, TABLE 4.3
--------------------------------------------------
AXIAL LOAD DUE TO PRESSURE.........    0.22026E+04
SHEAR LOAD DUE TO PRESSURE.........    0.45227E+04
EDGE LOAD DUE TO PRESSURE..........    0.93174E+03
EDGE MOMENT DUE TO PRESSURE........    0.16380E+04
```

```
BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4
--------------------------------------------------
AXIAL LOAD DUE TO TEMPERATURE.......    0.41708E+03
SHEAR LOAD DUE TO TEMPERATURE.......    0.00000E+00
EDGE LOAD DUE TO TEMPERATURE........    0.00000E+00
EDGE MOMENT DUE TEMPERATURE.........    0.00000E+00
```

```
BOLT FORCES DUE TO IMPACT, TABLE 4.5
--------------------------------------------------
AXIAL LOAD DUE TO IMPACT............    0.21164E+05
SHEAR LOAD DUE TO IMPACT............   -0.65342E-04
EDGE LOAD DUE TO IMPACT.............    0.67061E+04
EDGE MOMENT DUE IMPACT..............    0.11789E+05
```

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.00000E+00
SHEAR LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE MOMENT DUE VIBRATION.....	0.00000E+00

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.45714E+05
AXIAL LOAD DUE TO GASKET SEATING....	0.81942E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.78172E+03
TORQUE DUE TO PRELOAD.....	0.30000E+04
TORQUE DUE TO GASKET	0.53774E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.70280E+05
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.46131E+05
AXIAL LOAD LESS TEMP & PRELOAD.....	0.24148E+05
TOTAL EDGE LOAD.....	0.76378E+04
TOTAL EDGE MOMENT.....	0.13427E+05

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	0.87598E+04
BENDING MOMENT DUE TO PRYING.....	0.50685E+04

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.54891E+05
TOTAL BOLT SHEAR LOAD.....	0.45227E+04
TOTAL BOLT BENDING MOMENT.....	0.18496E+05
TOTAL BOLT TORSIONAL MOMENT.....	0.30000E+04

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.53683E+06
TOTAL BOLT DIRECT STRESS (-MC/I) ...	-0.29907E+06
AVE BOLT DIRECT STRESS	0.11888E+06
TOTAL BOLT SHEAR STRESS	0.33895E+05
AVE BOLT SHEAR STRESS	0.16948E+05

CODE EVALUAT. FOR ACCIDENT COND, TABLE 6.3

ALLOWABLE TENSILE STRESS (Sa)	0.12950E+06
ALLOWABLE SHEAR STRESS (Ta)	0.77700E+05
Rt (AVE AXIAL STRESS/Sa)	0.91800E+00
Rs (AVE SHEAR_STRESS/Ta)	0.21812E+00
Rtý+Rsý	0.89030E+00

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.13223E+05
DISPLACEMENT ACROSS BOLT	-0.10504E-02
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.11901E+05
TOTAL BOLT SHEAR FORCE	0.45227E+04

4.5.3.2.3.5 Output, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, 38°C (100°F) Ambient – Model AOS-100

```
30-FT DROP - Side  AOS-100, 100F Ambient



 *************** INPUT DATA ****************

 NUMBER OF BOLTS .....................(NB)          14
 LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.14064E+02
 LID DIAMETER AT GASKET  .............(DLG) 0.12172E+02
 NOMINAL BOLT DIAMETER ...............(DB) 0.87500E+00
 LID DIAMETER AT INNER EDGE ..........(DLI) 0.11040E+02
 LID DIAMETER AT OUTER EDGE ..........(DLO) 0.16590E+02
 THICKNESS OF LID ....................(TL) 0.15100E+01
 THICKNESS OF LID FLANGE .............(TLF) 0.19400E+01
 THICKNESS OF CASK WALL ..............(TC) 0.28050E+01
 BOLT LENGTH .........................(BL) 0.10600E+01
 BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.29000E-01

 YOUNG'S MODULUS FOR LID .............(EL) 0.27100E+08
 YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.27100E+08
 YOUNG'S MODULUS FOR CASK ............(EC) 0.27100E+08
 YOUNG'S MODULUS FOR BOLT ............(EB) 0.27900E+08
 POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
 POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
 LID THERMAL EXPANSION COEFF ..........(AL) 0.91000E-05
 BOLT THERMAL EXPANSION COEFF .........(AB) 0.73000E-05
 WALL THERMAL EXPANSION COEFF .........(AC) 0.91000E-05
 FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

 INSIDE PRESSURE AT LID ..............(PLI) 0.28000E+03
 OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
 INSIDE PRESSURE AT CASK WALL ........(PCI) 0.28000E+03
 OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

 TEMPERATURE CHG ACROSS LID ........(TEMPL) 0.22300E+03
 TEMPERATURE CHG ACROSS BOLT .......(TEMPB) 0.22300E+03
 TEMPERATURE CHG ACROSS WALL .......(TEMPC) 0.22300E+03
 TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO) 0.22400E+03
 TEMPERATURE AT INSIDE OF LID .....(TEMPLI) 0.22400E+03

 WEIGHT OF CASK CONTENTS .............(WC) 0.78600E+03
 WEIGHT OF CASK LID ..................(WL) 0.96000E+02
 DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.00000E+00
 CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.17100E+03
 DYNAMIC LOAD FACTOR ................(DYLF) 0.11500E+01

 PUNCTURE LOAD .....................(PUNC) 0.00000E+00
 PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
```

```
AXIAL VIBRATION ACCELERATION ........(AVA) 0.00000E+00
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.00000E+00
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.60000E+04
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.54000E+00

Sm STRESS ............................(SM) 0.94000E+02
Sy STRESS ............................(SY) 0.14100E+03
Su STRESS ............................(SU) 0.17400E+03
CODE EVALUATION TYPE..................(CET)           2

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.14100E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)           9



******** BOLT LOADS & STRESSES *********


BOLT FORCES DUE TO PRESSURE, TABLE 4.3
-------------------------------------------------
AXIAL LOAD DUE TO PRESSURE.........    0.22026E+04
SHEAR LOAD DUE TO PRESSURE.........    0.45227E+04
EDGE LOAD DUE TO PRESSURE..........    0.93174E+03
EDGE MOMENT DUE TO PRESSURE........    0.16380E+04


BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4
-------------------------------------------------
AXIAL LOAD DUE TO TEMPERATURE.......    0.67342E+04
SHEAR LOAD DUE TO TEMPERATURE.......    0.00000E+00
EDGE LOAD DUE TO TEMPERATURE........    0.00000E+00
EDGE MOMENT DUE TEMPERATURE.........    0.00000E+00


BOLT FORCES DUE TO IMPACT, TABLE 4.5
-------------------------------------------------
AXIAL LOAD DUE TO IMPACT............    0.00000E+00
SHEAR LOAD DUE TO IMPACT............    0.11726E+04
EDGE LOAD DUE TO IMPACT.............    0.00000E+00
EDGE MOMENT DUE IMPACT..............    0.00000E+00
```

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.00000E+00
SHEAR LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE MOMENT DUE VIBRATION.....	0.00000E+00

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.45714E+05
AXIAL LOAD DUE TO GASKET SEATING....	0.81942E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.78172E+03
TORQUE DUE TO PRELOAD.....	0.30000E+04
TORQUE DUE TO GASKET	0.53774E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.55433E+05
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.52449E+05
AXIAL LOAD LESS TEMP & PRELOAD.....	0.29843E+04
TOTAL EDGE LOAD.....	0.93174E+03
TOTAL EDGE MOMENT.....	0.16380E+04

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	-0.34586E+05
BENDING MOMENT DUE TO PRYING.....	0.62274E+03

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.17863E+05
TOTAL BOLT SHEAR LOAD.....	0.56953E+04
TOTAL BOLT BENDING MOMENT.....	0.22607E+04
TOTAL BOLT TORSIONAL MOMENT.....	0.30000E+04

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.89772E+05
TOTAL BOLT DIRECT STRESS (-MC/I) ...	-0.12399E+05
AVE BOLT DIRECT STRESS	0.38687E+05
TOTAL BOLT SHEAR STRESS	0.33895E+05
AVE BOLT SHEAR STRESS	0.16948E+05

CODE EVALUAT. FOR ACCIDENT COND, TABLE 6.3

ALLOWABLE TENSILE STRESS (Sa)	0.12180E+06
ALLOWABLE SHEAR STRESS (Ta)	0.73080E+05
Rt (AVE AXIAL STRESS/Sa)	0.31763E+00
Rs (AVE SHEAR_STRESS/Ta)	0.23191E+00
Rtý+Rsý	0.15467E+00

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.14879E+05
DISPLACEMENT ACROSS BOLT	-0.12243E-02
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.13391E+05
TOTAL BOLT SHEAR FORCE	0.56953E+04

4.5.3.2.3.6 Output, Hypothetical Accident Conditions of Transport, 30-Ft. Side Drop, -40°C (-40°F) Ambient – Model AOS-100

```
30-FT DROP - Side  AOS-100, -40F Ambient



*************** INPUT DATA ****************

NUMBER OF BOLTS .....................(NB)          14
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.14064E+02
LID DIAMETER AT GASKET  .............(DLG) 0.12172E+02
NOMINAL BOLT DIAMETER ...............(DB) 0.87500E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.11040E+02
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.16590E+02
THICKNESS OF LID ....................(TL) 0.15100E+01
THICKNESS OF LID FLANGE .............(TLF) 0.19400E+01
THICKNESS OF CASK WALL ..............(TC) 0.28050E+01
BOLT LENGTH .........................(BL) 0.10600E+01
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.29000E-01

YOUNG'S MODULUS FOR LID .............(EL) 0.28300E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.28300E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.28300E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.28900E+08
POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.86000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.70000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.86000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.28000E+03
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.28000E+03
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL) 0.15000E+02
TEMPERATURE CHG ACROSS BOLT .......(TEMPB) 0.15000E+02
TEMPERATURE CHG ACROSS WALL .......(TEMPC) 0.15000E+02
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO) 0.16000E+02
TEMPERATURE AT INSIDE OF LID .....(TEMPLI) 0.16000E+02

WEIGHT OF CASK CONTENTS .............(WC) 0.78600E+03
WEIGHT OF CASK LID ..................(WL) 0.96000E+02
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.00000E+00
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.24000E+03
DYNAMIC LOAD FACTOR ................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
```

```
AXIAL VIBRATION ACCELERATION ........(AVA) 0.00000E+00
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.00000E+00
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.60000E+04
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.54000E+00

Sm STRESS ............................(SM) 0.10000E+03
Sy STRESS ............................(SY) 0.15000E+03
Su STRESS ............................(SU) 0.18500E+03
CODE EVALUATION TYPE..................(CET)           2

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.15000E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)           9
```

```
******** BOLT LOADS & STRESSES *********
```

```
BOLT FORCES DUE TO PRESSURE, TABLE 4.3
--------------------------------------------------
AXIAL LOAD DUE TO PRESSURE.........    0.22026E+04
SHEAR LOAD DUE TO PRESSURE.........    0.45227E+04
EDGE LOAD DUE TO PRESSURE..........    0.93174E+03
EDGE MOMENT DUE TO PRESSURE........    0.16380E+04
```

```
BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4
--------------------------------------------------
AXIAL LOAD DUE TO TEMPERATURE......    0.41708E+03
SHEAR LOAD DUE TO TEMPERATURE......    0.00000E+00
EDGE LOAD DUE TO TEMPERATURE.......    0.00000E+00
EDGE MOMENT DUE TEMPERATURE........    0.00000E+00
```

```
BOLT FORCES DUE TO IMPACT, TABLE 4.5
--------------------------------------------------
AXIAL LOAD DUE TO IMPACT...........    0.00000E+00
SHEAR LOAD DUE TO IMPACT...........    0.16457E+04
EDGE LOAD DUE TO IMPACT............    0.00000E+00
EDGE MOMENT DUE IMPACT.............    0.00000E+00
```

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.00000E+00
SHEAR LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE MOMENT DUE VIBRATION.....	0.00000E+00

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.45714E+05
AXIAL LOAD DUE TO GASKET SEATING....	0.81942E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.78172E+03
TORQUE DUE TO PRELOAD.....	0.30000E+04
TORQUE DUE TO GASKET	0.53774E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.49116E+05
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.46131E+05
AXIAL LOAD LESS TEMP & PRELOAD.....	0.29843E+04
TOTAL EDGE LOAD.....	0.93174E+03
TOTAL EDGE MOMENT.....	0.16380E+04

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	-0.29717E+05
BENDING MOMENT DUE TO PRYING.....	0.61831E+03

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.16414E+05
TOTAL BOLT SHEAR LOAD.....	0.61685E+04
TOTAL BOLT BENDING MOMENT.....	0.22563E+04
TOTAL BOLT TORSIONAL MOMENT.....	0.30000E+04

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.86535E+05
TOTAL BOLT DIRECT STRESS (-MC/I) ...	-0.15436E+05
AVE BOLT DIRECT STRESS	0.35549E+05
TOTAL BOLT SHEAR STRESS	0.33895E+05
AVE BOLT SHEAR STRESS	0.16948E+05

CODE EVALUAT. FOR ACCIDENT COND, TABLE 6.3

ALLOWABLE TENSILE STRESS (Sa)	0.12950E+06
ALLOWABLE SHEAR STRESS (Ta)	0.77700E+05
Rt (AVE AXIAL STRESS/Sa)	0.27451E+00
Rs (AVE SHEAR_STRESS/Ta)	0.21812E+00
Rtý+Rsý	0.12293E+00

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.13430E+05
DISPLACEMENT ACROSS BOLT	-0.10668E-02
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.12087E+05
TOTAL BOLT SHEAR FORCE	0.61685E+04

4.5.3.2.3.7 Output, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, 38°C (100°F) Ambient – Model AOS-100

```
30-FT DROP - @ 45 DEG CORNER AOS-100, 100F AMBIENT



*************** INPUT DATA ****************

NUMBER OF BOLTS .....................(NB)          14
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.14064E+02
LID DIAMETER AT GASKET  .............(DLG) 0.12172E+02
NOMINAL BOLT DIAMETER ...............(DB) 0.87500E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.11040E+02
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.16590E+02
THICKNESS OF LID ....................(TL) 0.15100E+01
THICKNESS OF LID FLANGE .............(TLF) 0.19400E+01
THICKNESS OF CASK WALL ..............(TC) 0.28050E+01
BOLT LENGTH .........................(BL) 0.10600E+01
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.29000E-01

YOUNG'S MODULUS FOR LID .............(EL) 0.27100E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.27100E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.27100E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.27900E+08
POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.91000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.73000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.91000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.28000E+03
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.28000E+03
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL) 0.22300E+03
TEMPERATURE CHG ACROSS BOLT .......(TEMPB) 0.22300E+03
TEMPERATURE CHG ACROSS WALL .......(TEMPC) 0.22300E+03
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO) 0.22400E+03
TEMPERATURE AT INSIDE OF LID .....(TEMPLI) 0.22400E+03

WEIGHT OF CASK CONTENTS .............(WC) 0.78600E+03
WEIGHT OF CASK LID ..................(WL) 0.96000E+02
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.45000E+02
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.88000E+02
DYNAMIC LOAD FACTOR .................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
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AXIAL VIBRATION ACCELERATION ........(AVA) 0.00000E+00
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.00000E+00
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.60000E+04
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.54000E+00

Sm STRESS ............................(SM) 0.94000E+02
Sy STRESS ............................(SY) 0.14100E+03
Su STRESS ............................(SU) 0.17400E+03
CODE EVALUATION TYPE..................(CET)           2

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.14100E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)           9



******** BOLT LOADS & STRESSES *********


BOLT FORCES DUE TO PRESSURE, TABLE 4.3
-------------------------------------------------
AXIAL LOAD DUE TO PRESSURE.........    0.22026E+04
SHEAR LOAD DUE TO PRESSURE.........    0.45227E+04
EDGE LOAD DUE TO PRESSURE..........    0.93174E+03
EDGE MOMENT DUE TO PRESSURE........    0.16380E+04


BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4
-------------------------------------------------
AXIAL LOAD DUE TO TEMPERATURE.......    0.67342E+04
SHEAR LOAD DUE TO TEMPERATURE.......    0.00000E+00
EDGE LOAD DUE TO TEMPERATURE........    0.00000E+00
EDGE MOMENT DUE TEMPERATURE.........    0.00000E+00


BOLT FORCES DUE TO IMPACT, TABLE 4.5
-------------------------------------------------
AXIAL LOAD DUE TO IMPACT............    0.60410E+04
SHEAR LOAD DUE TO IMPACT............    0.42669E+03
EDGE LOAD DUE TO IMPACT.............    0.19142E+04
EDGE MOMENT DUE IMPACT..............    0.33651E+04
```

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.00000E+00
SHEAR LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE MOMENT DUE VIBRATION.....	0.00000E+00

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.45714E+05
AXIAL LOAD DUE TO GASKET SEATING....	0.81942E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.78172E+03
TORQUE DUE TO PRELOAD.....	0.30000E+04
TORQUE DUE TO GASKET	0.53774E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.61474E+05
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.52449E+05
AXIAL LOAD LESS TEMP & PRELOAD.....	0.90253E+04
TOTAL EDGE LOAD.....	0.28459E+04
TOTAL EDGE MOMENT.....	0.50031E+04

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	-0.23581E+05
BENDING MOMENT DUE TO PRYING.....	0.19021E+04

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.28867E+05
TOTAL BOLT SHEAR LOAD.....	0.49494E+04
TOTAL BOLT BENDING MOMENT.....	0.69052E+04
TOTAL BOLT TORSIONAL MOMENT.....	0.30000E+04

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.21855E+06
TOTAL BOLT DIRECT STRESS (-MC/I) ...	-0.93517E+05
AVE BOLT DIRECT STRESS	0.62519E+05
TOTAL BOLT SHEAR STRESS	0.33895E+05
AVE BOLT SHEAR STRESS	0.16948E+05

CODE EVALUAT. FOR ACCIDENT COND, TABLE 6.3

ALLOWABLE TENSILE STRESS (Sa)	0.12180E+06
ALLOWABLE SHEAR STRESS (Ta)	0.73080E+05
Rt (AVE AXIAL STRESS/Sa)	0.51329E+00
Rs (AVE SHEAR_STRESS/Ta)	0.23191E+00
Rtý+Rsý	0.31725E+00

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.19842E+05
DISPLACEMENT ACROSS BOLT	-0.16326E-02
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.17858E+05
TOTAL BOLT SHEAR FORCE	0.49494E+04

4.5.3.2.3.8 Output, Hypothetical Accident Conditions of Transport, 30-Ft. Cg/Corner Drop, -40°C (-40°F) Ambient – Model AOS-100

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30-FT DROP - @ 45 DEG CORNER AOS-100, -40F AMBIENT



*************** INPUT DATA ****************

NUMBER OF BOLTS .....................(NB)          14
LID DIAMETER AT BOLT CIRCLE .........(DLB) 0.14064E+02
LID DIAMETER AT GASKET  .............(DLG) 0.12172E+02
NOMINAL BOLT DIAMETER ...............(DB) 0.87500E+00
LID DIAMETER AT INNER EDGE ..........(DLI) 0.11040E+02
LID DIAMETER AT OUTER EDGE ..........(DLO) 0.16590E+02
THICKNESS OF LID ....................(TL) 0.15100E+01
THICKNESS OF LID FLANGE .............(TLF) 0.19400E+01
THICKNESS OF CASK WALL ..............(TC) 0.28050E+01
BOLT LENGTH .........................(BL) 0.10600E+01
BOLT MOMENT OF INERTIA / CIR ........(XIB) 0.29000E-01

YOUNG'S MODULUS FOR LID .............(EL) 0.28300E+08
YOUNG'S MODULUS FOR LID FLANGE ......(ELF) 0.28300E+08
YOUNG'S MODULUS FOR CASK ............(EC) 0.28300E+08
YOUNG'S MODULUS FOR BOLT ............(EB) 0.28900E+08
POISSON'S RATIO FOR LID .............(XNUL) 0.30000E+00
POISSON'S RATIO FOR CASK ............(XNUC) 0.30000E+00
LID THERMAL EXPANSION COEFF ..........(AL) 0.86000E-05
BOLT THERMAL EXPANSION COEFF .........(AB) 0.70000E-05
WALL THERMAL EXPANSION COEFF .........(AC) 0.86000E-05
FLANGE COEFFICIENT OF FRICTION ......(FCF) 0.90000E+00

INSIDE PRESSURE AT LID ..............(PLI) 0.28000E+03
OUTSIDE PRESSURE AT LID .............(PLO) 0.15000E+02
INSIDE PRESSURE AT CASK WALL ........(PCI) 0.28000E+03
OUTSIDE PRESSURE AT CASK WALL .......(PCO) 0.15000E+02

TEMPERATURE CHG ACROSS LID ........(TEMPL) 0.15000E+02
TEMPERATURE CHG ACROSS BOLT .......(TEMPB) 0.15000E+02
TEMPERATURE CHG ACROSS WALL .......(TEMPC) 0.15000E+02
TEMPERATURE AT OUTSIDE OF LID ....(TEMPLO) 0.16000E+02
TEMPERATURE AT INSIDE OF LID .....(TEMPLI) 0.16000E+02

WEIGHT OF CASK CONTENTS .............(WC) 0.78600E+03
WEIGHT OF CASK LID ..................(WL) 0.96000E+02
DROP ANGLE OF IMPACT, deg .......(XI_DROP) 0.45000E+02
CG/CORNER IMPACT ACCEL, g ..........(ACCI) 0.12400E+03
DYNAMIC LOAD FACTOR .................(DYLF) 0.11500E+01

PUNCTURE LOAD .....................(PUNC) 0.00000E+00
PUNCTURE ANGLE OF IMPACT, deg ...(XI_PUNC) 0.45000E+02
```

```
AXIAL VIBRATION ACCELERATION ........(AVA) 0.00000E+00
TRANSVERSE VIBRATION ACCELERATION ...(AVT) 0.00000E+00
VIBRATION TRANSMISSIBILITY FACTOR ...(VTR) 0.10000E+01

PRELOAD TORQUE .......................(Q) 0.60000E+04
NUT FACTOR FOR PRELOAD TORQUE ........(QK) 0.15000E+00
GASKET SEATING WIDTH .................(GB) 0.10000E+01
GASKET SEATING STRESS ................(GY) 0.30000E+04
GASKET FACTOR ........................(GM) 0.54000E+00

Sm STRESS ............................(SM) 0.10000E+03
Sy STRESS ............................(SY) 0.15000E+03
Su STRESS ............................(SU) 0.18500E+03
CODE EVALUATION TYPE..................(CET)           2

OPERATING FATGIGUE STRESS (ksi) .....(FSO) 0.15000E+03
VIBRATION FATIGUE STRESS (ksi) ......(FSV) 0.13000E+02
NUMBER OF BOLT THREADS / INCH .......(NTI)           9
```

```
******** BOLT LOADS & STRESSES *********
```

```
BOLT FORCES DUE TO PRESSURE, TABLE 4.3
--------------------------------------------------
AXIAL LOAD DUE TO PRESSURE.........    0.22026E+04
SHEAR LOAD DUE TO PRESSURE.........    0.45227E+04
EDGE LOAD DUE TO PRESSURE..........    0.93174E+03
EDGE MOMENT DUE TO PRESSURE........    0.16380E+04
```

```
BOLT FORCES DUE TO TEMPERATURE, TABLE 4.4
--------------------------------------------------
AXIAL LOAD DUE TO TEMPERATURE.......    0.41708E+03
SHEAR LOAD DUE TO TEMPERATURE.......    0.00000E+00
EDGE LOAD DUE TO TEMPERATURE........    0.00000E+00
EDGE MOMENT DUE TEMPERATURE.........    0.00000E+00
```

```
BOLT FORCES DUE TO IMPACT, TABLE 4.5
--------------------------------------------------
AXIAL LOAD DUE TO IMPACT............    0.85124E+04
SHEAR LOAD DUE TO IMPACT............    0.60124E+03
EDGE LOAD DUE TO IMPACT.............    0.26972E+04
EDGE MOMENT DUE IMPACT..............    0.47417E+04
```

BOLT FORCES DUE TO PUNCTURE, TABLE 4.7

AXIAL LOAD DUE TO PUNCTURE.....	0.00000E+00
SHEAR LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE LOAD DUE TO PUNCTURE.....	0.00000E+00
EDGE MOMENT DUE PUNCTURE.....	0.00000E+00

BOLT FORCES DUE TO VIBRATION, TABLE 4.8

AXIAL LOAD DUE TO VIBRATION.....	0.00000E+00
SHEAR LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE LOAD DUE TO VIBRATION.....	0.00000E+00
EDGE MOMENT DUE VIBRATION.....	0.00000E+00

BOLT FORCES DUE TO PRELOAD, TABLE 4.1, 4.2

AXIAL LOAD DUE TO PRELOAD.....	0.45714E+05
AXIAL LOAD DUE TO GASKET SEATING....	0.81942E+04
AXIAL LOAD DUE TO GASKET OPERATION..	0.78172E+03
TORQUE DUE TO PRELOAD.....	0.30000E+04
TORQUE DUE TO GASKET	0.53774E+03

TOTAL NON-PRYING BOLT FORCES, TABLE 4.9

TOTAL NON-PRYING AXIAL LOAD.....	0.57628E+05
TEMP & PRELOAD NON-PRYING AXIAL LD..	0.46131E+05
AXIAL LOAD LESS TEMP & PRELOAD.....	0.11497E+05
TOTAL EDGE LOAD.....	0.36290E+04
TOTAL EDGE MOMENT.....	0.63797E+04

PRYING ACTION FORCES, TABLE 2.1 & 2.2

AXIAL LOAD DUE TO PRYING.....	-0.14241E+05
BENDING MOMENT DUE TO PRYING.....	0.24082E+04

TOTAL BOLT FORCES

TOTAL BOLT AXIAL LOAD.....	0.31890E+05
TOTAL BOLT SHEAR LOAD.....	0.51240E+04
TOTAL BOLT BENDING MOMENT.....	0.87880E+04
TOTAL BOLT TORSIONAL MOMENT.....	0.30000E+04

TOTAL BOLT STRESSES

TOTAL BOLT DIRECT STRESS (+MC/I) ...	0.26765E+06
TOTAL BOLT DIRECT STRESS (-MC/I) ...	-0.12951E+06
AVE BOLT DIRECT STRESS	0.69066E+05
TOTAL BOLT SHEAR STRESS	0.33895E+05
AVE BOLT SHEAR STRESS	0.16948E+05

CODE EVALUAT. FOR ACCIDENT COND, TABLE 6.3

ALLOWABLE TENSILE STRESS (Sa)	0.12950E+06
ALLOWABLE SHEAR STRESS (Ta)	0.77700E+05
Rt (AVE AXIAL STRESS/Sa)	0.53333E+00
Rs (AVE SHEAR_STRESS/Ta)	0.21812E+00
Rtý+Rsý	0.33201E+00

FLANGE SEPARATION EVALUATION

BOLT CLAMPING FORCE	-0.20393E+05
DISPLACEMENT ACROSS BOLT	-0.16200E-02
ALLOWABLE FLANGE SEPARATION	0.30000E-02
FLANGE FRICTION FORCE	-0.18354E+05
TOTAL BOLT SHEAR FORCE	0.51240E+04

4.6 REFERENCES

[4.1] U.S. Nuclear Regulatory Commission (NRC), *Title 10, Code of Federal Regulations, Part 71 (10 CFR 71)*, "Packaging and Transportation of Radioactive Material."

[4.2] U.S. Department of Transportation (DOT), *Title 49, Code of Federal Regulations, Part 173 (49 CFR 173)*, "Shippers – General Requirements for Shipments and Packagings."

[4.3] *International Atomic Energy Agency (IAEA) Safety Standards Series No. TS-R-1* (*IAEA TS-R-1*), "Regulations for the Safe Transport of Radioactive Material," 1996 Ed. (as amended 2003).

[4.4] American National Standards Institute, *ANSI N14.5-2014*, "Radioactive Materials – Leakage Tests on Packages for Shipment," June 19, 2014.

[4.5] American Society of Mechanical Engineers, *ASME Boiler and Pressure Vessel Code*, Section III, Division 3, 2004, No Addenda.

[4.6] Mok, G. C., L. E. Fischer, and S. T. Hsu, *NUREG/CR-6007*, *Stress Analysis of Closure Bolts for Shipping Casks*, Lawrence Livermore National Laboratory and Kaiser Engineering, Prepared for U.S. Nuclear Regulatory Commission, April, 1992.

[4.7] *Machinery's Handbook*, "Fasteners" Section, Industrial Press, 26th Ed., 1988.

[4.8] Alcoa Fastening Systems, *Keenserts Inserts and Studs*, Technical Information and Product Data Sheets, November 9, 2006, accessed July 3, 2011, http://alcoafastener.thomasnet.com/item/keenserts-reg-inserts-general-purpose-inserts/heavy-duty-insert/knh1409j?&plpver=10&origin=keyword&by=prod&filter=0.