3.2 Run1ga - Side

The run1ga is a 30-foot impact followed by a crush impact, with the crush plate centered above the CV flange. The run1g 30-foot impact restart file was used and the crush plate was moved during the restart phase so that its centerline was approximately above the CV flange. The 30-foot impact was from time 0.0 to 0.0085 sec. The crush plate translation to center it above the CV flange was from time 0.0085 sec to 0.0086 sec. The run1ga crush occurred from 0.0086 sec to 0.027 sec. Therefore, the 30-foot impact results for this run would be the Section 3.1, 30-foot results for run1g, and the crush results for run 1ga (offset crush) are presented in this section.

Figure 3.2.1 shows the configuration of the model after the crush plate was moved above the CV flange (time = 0.0086 sec). Figure 3.2.2 shows the model configuration after the run1ga crush impact. Figure 3.2.3 through Figure 3.2.6 show enlarged views in the lid and bottom regions of the package assembly.

Figure 3.2.7 shows that the maximum strain in the CV body for the run1ga crush impact is 0.0348 in/in. The effective plastic strain in the CV lid is 0.0002 in/in and is shown in Figure 3.2.8. The CV nut ring remains elastic for the crush impact of run1ga.

The maximum effective plastic strain in the drum angle is shown in Figure 3.2.9 to be 0.1058 in/in. The maximum effective plastic strain in the drum is 0.3818 in/in and occurs in the top drum roll near the crush plate (Figure 3.2.10).

Figure 3.2.11 gives the maximum effective plastic strain in the lid to be 1.1345 in/in. This is a relatively high strain level and the maximum occurs near the stud hole at the 90° position (initially along Y axis). Another high region of strain is near the upper stud nearest the crush plate. The solid elements (used for contact bearing on the studs) around the stud holes show effective plastic strain maximum of 0.8745 in/in. The membrane effective plastic strain in the shell elements is a maximum of 0.8057 in/in and is highly localized near the stud hole at the 90° position. Some tearing of the lid could occur in the lid hole at the 90° position and at the lid hole nearest the crush plate (180°).

Figure 3.2.12 shows the effective plastic strain levels in the drum studs. The maximum is shown to be 0.5207 in/in and occurs in the stud at the 90° position. From Figure 3.2.12 it is seen that the elevated strain occurs near the outer extreme of the stud, and that the through thickness strain levels between 0.3170 and 0.3802 in/in exist.

A study of the timing of the elevated effective plastic strain levels in the lid and the drum studs shows that the lid reaches failure magnitudes before the studs. At the stud hole in the drum lid nearest the crush plate (180°), the bending strain crosses the 0.57 in/in

strain at about 0.0122 seconds in the crush impact. The membrane strain in the lid elements at 180° reaches a maximum of .5295 in/in. The stud at 180° does not experience elevated strain levels (final maximum in this stud is 0.17 in/in). So at the 180° position, only the lid experiences relatively high levels of effective plastic strain.

At the 90° position in the lid, the membrane effective plastic strain exceeds the 0.57 in/in level near 0.0164 seconds in the crush impact. The surface maximum effective plastic strain exceeds 0.57 in/in at about 0.0161 seconds, slightly ahead of the membrane. At time 0.0164 seconds, the effective plastic strain levels in the stud at 90° is about 0.35 in/in maximum, with the through thickness levels between 0.104 in/in to 0.136 in/in. Therefore, at the 90° position, the lid reaches the failure level of 0.57 in/in before the stud.

From this timing data, it is shown that the lid would reach failure levels in bending and membrane before the stud effective plastic strain levels become relatively high. Therefore, it would be expected that the lid would locally tear before the bolting reached elevated effective plastic strain levels, thus possibly reducing the loadings on the studs. Due to the extent of the relatively high levels of effective plastic strain in the drum lid, it would be expected that any lid tearing would be localized and that the large washers would restrain the drum lid.

The effective plastic strain contour patterns for the other components are not shown in figures. The maximum effective plastic strain in the drum bottom is 0.2444 in/in; in the liner it is 0.2853 in/in; in the lid stiffener it is 0.1116 in/in; in the drum stud nuts it is 0.0103 in/in; in the drum stud washers it is 0.1685 in/in and in the plug liner it is 0.2181 in/in.

The kinetic energy time history for the crush plate impact is shown in Figure 3.2.13. The X velocity time history is shown in Figure 3.2.14.

The lid separation time history is shown in Figure 3.2.15 (nodes defined in Figure 3.1.30). From Figure 3.2.15 it is seen that the spike separation of just under 0.004 inches can occur with a final nominal separation of less than 0.002 inches expected.

The kaolite thickness time histories for the nodes defined in Figure 3.1.32 are given in Figure 3.2.16 for run1ga. The drum diameter time histories are given in Figures 3.2.17 and 3.2.18. The nodes defining this response are shown in Figure 3.1.34. As shown in Figure 3.2.17, the bottom head and the bottom drum roll remain at, or near 30-foot impact diameters for the crush impact. This response is expected as qualitatively shown in Figure 3.2.2. The response in the Y-direction is shown in Figure 3.2.18.

Figure 3.2.19 shows the diameter time history for various locations along the liner length. Figure 3.1.37 and Table 3.1.3 define the locations at which the diameters are obtained.

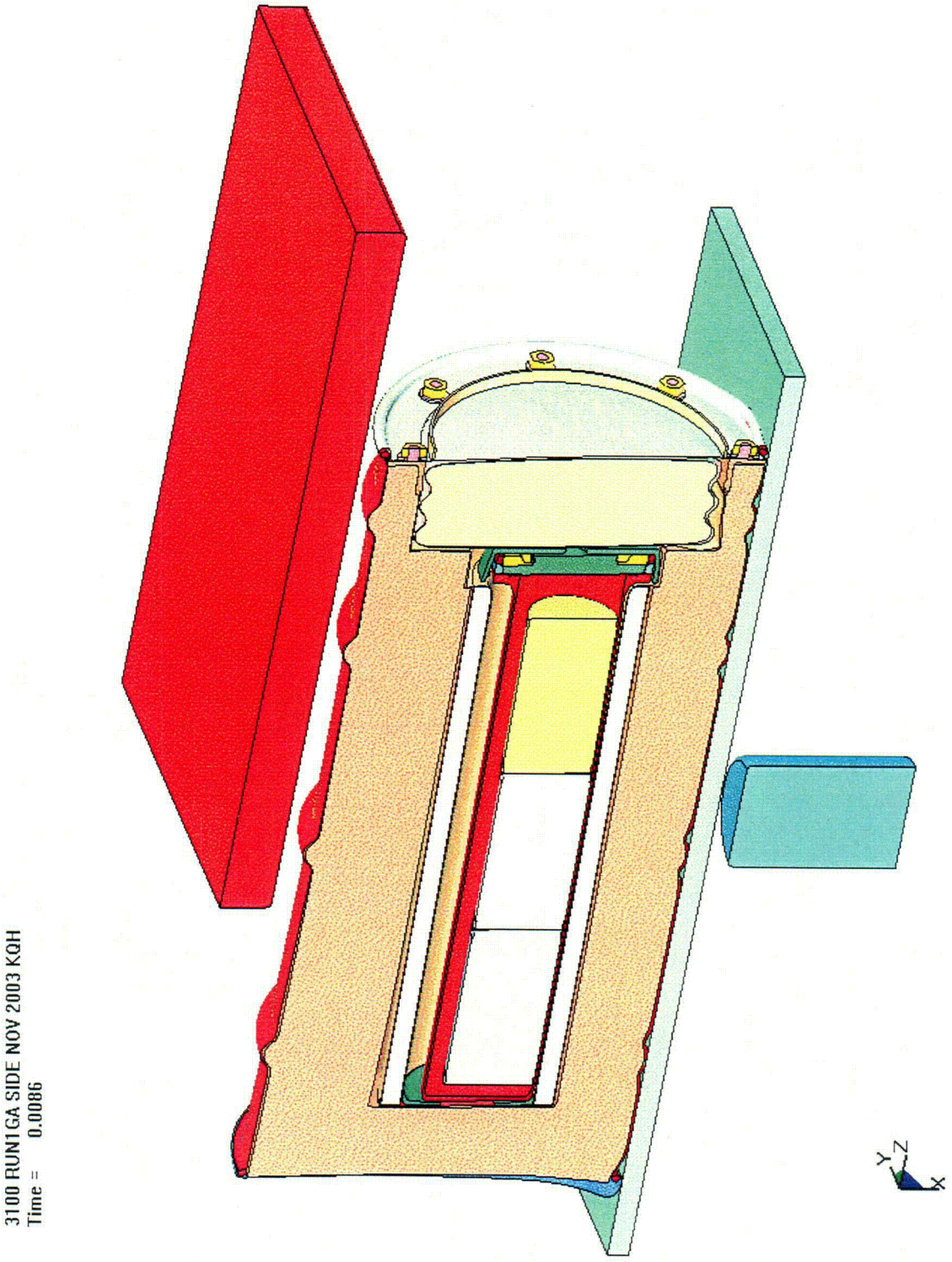

Figure 3.2.1 - Run1ga, Crush Impact, Initial Configuration for the Crush Impact

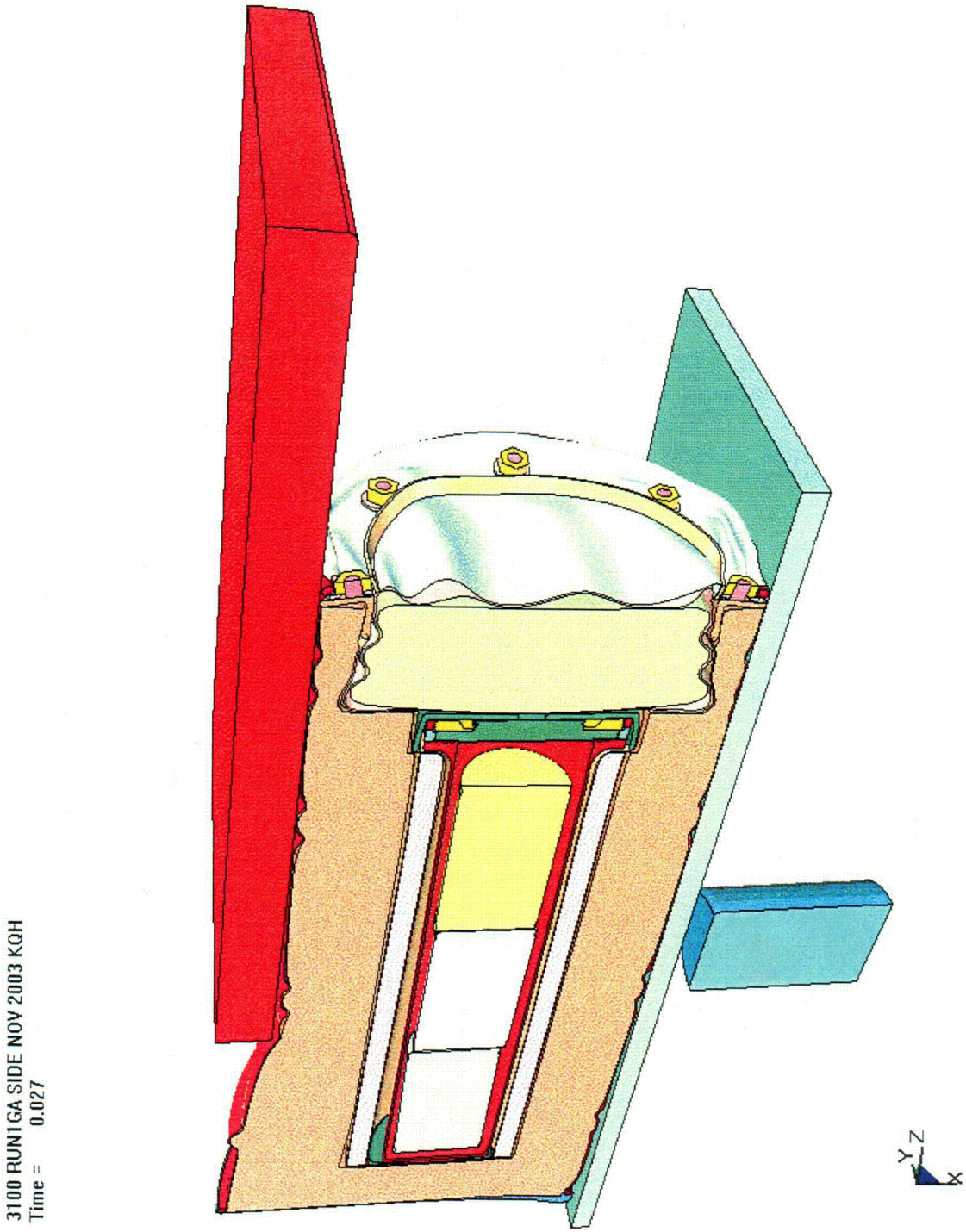

Figure 3.2.2 - Run1ga, Crush Impact, Configuration of the ES-3100 After the Crush Impact

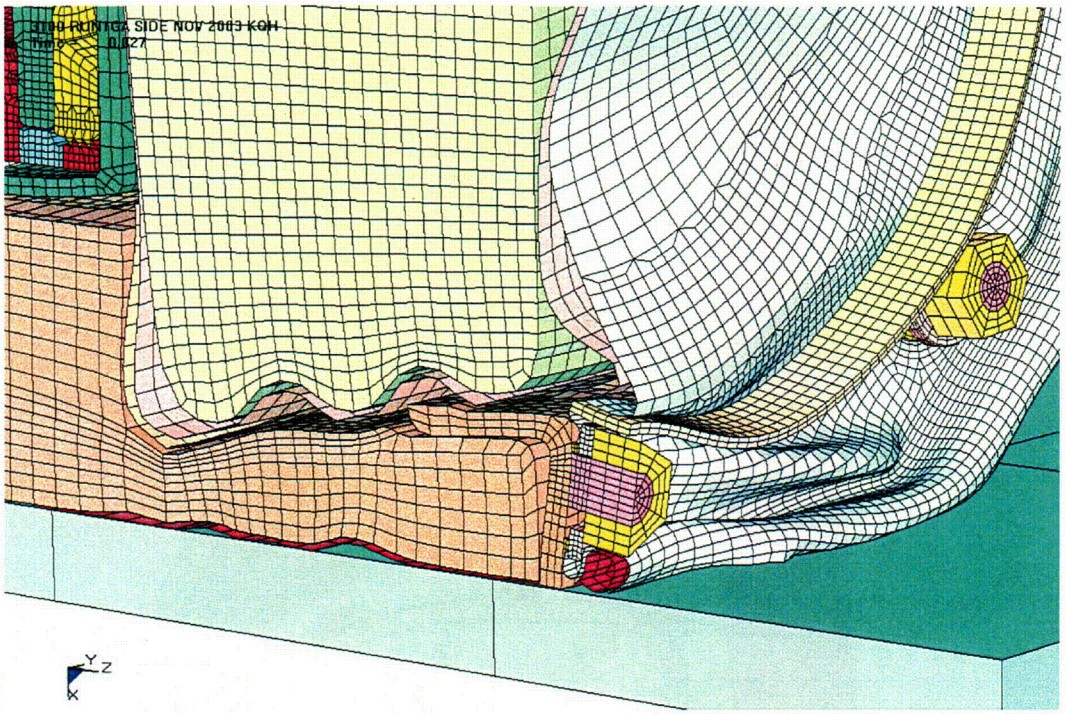

Figure 3.2.3 - Run1ga, Crush Impact, Configuration of the Lid Region Near the Rigid Plane

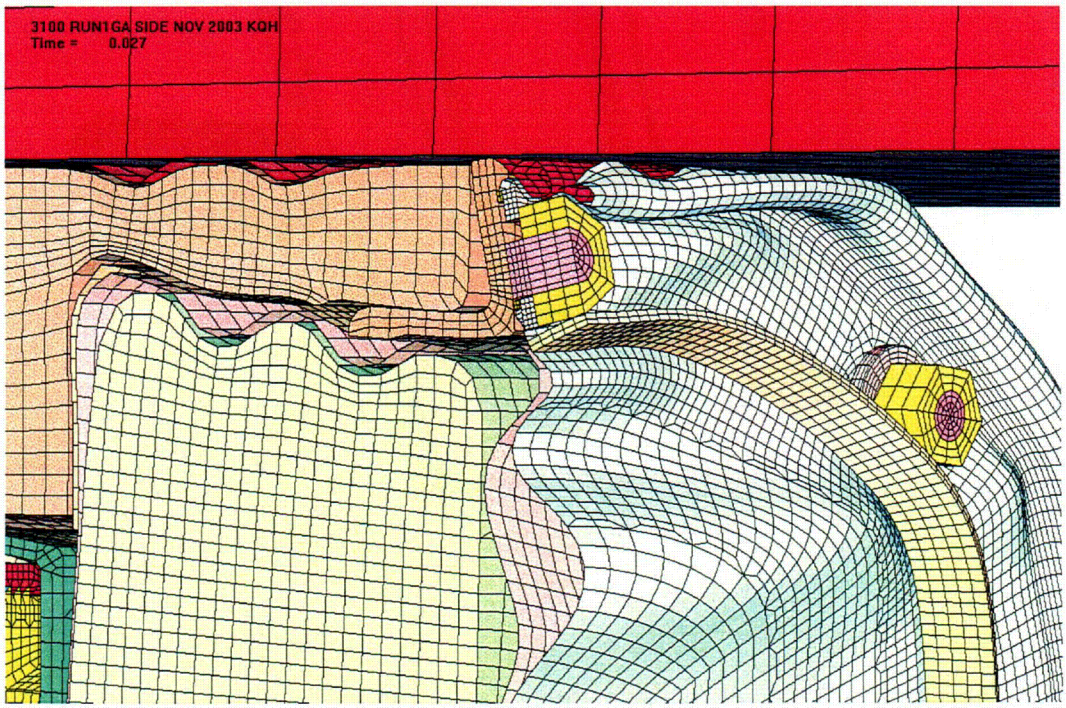

Figure 3.2.4 - Run1ga, Crush Impact, Configuration of the Lid Region Near the Crush Plate

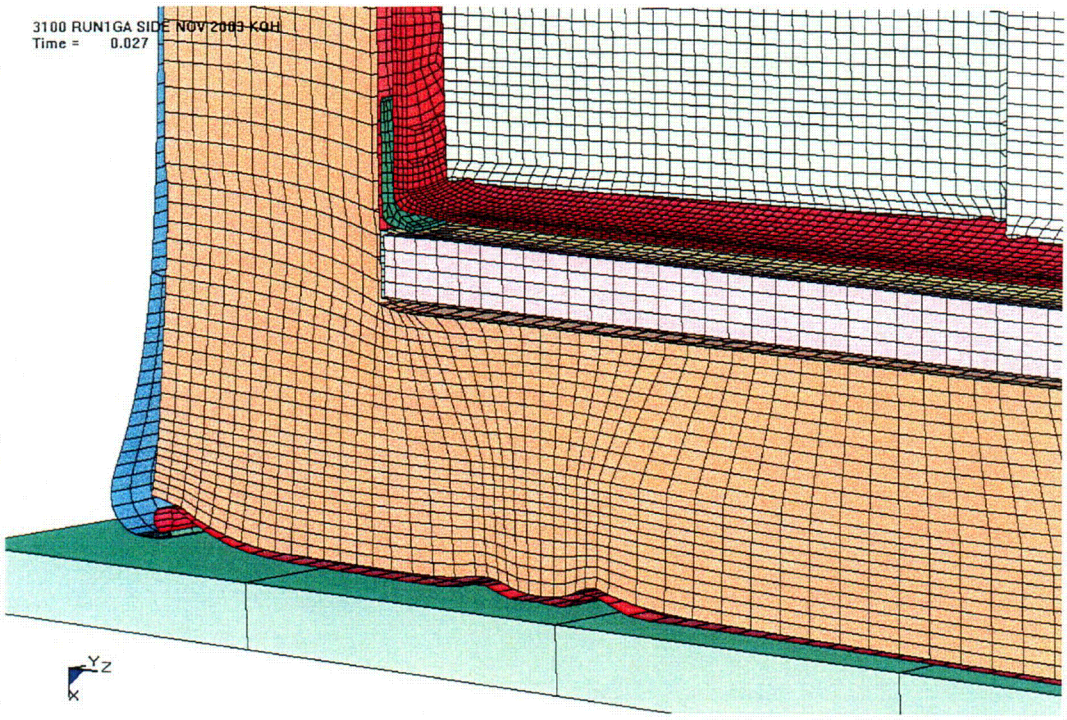

Figure 3.2.5 - Run1ga, Crush Impact, Configuration of the Bottom Near the Rigid Plate

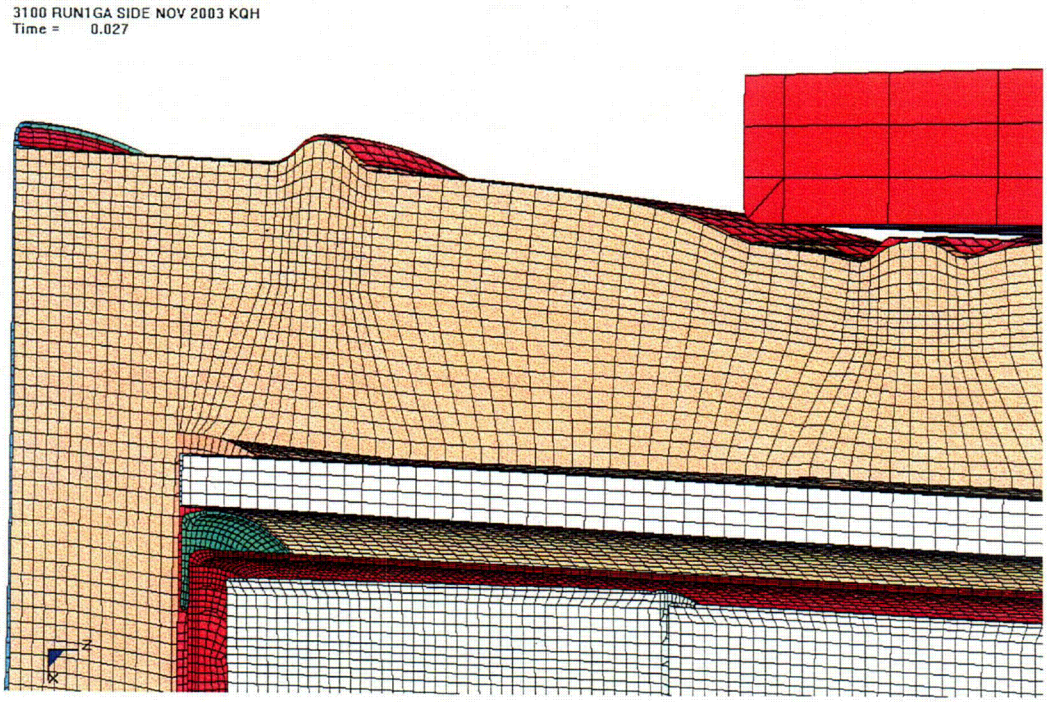

Figure 3.2.6 - Run1ga, Crush Impact, Configuration of the Bottom Near the Crush Plate

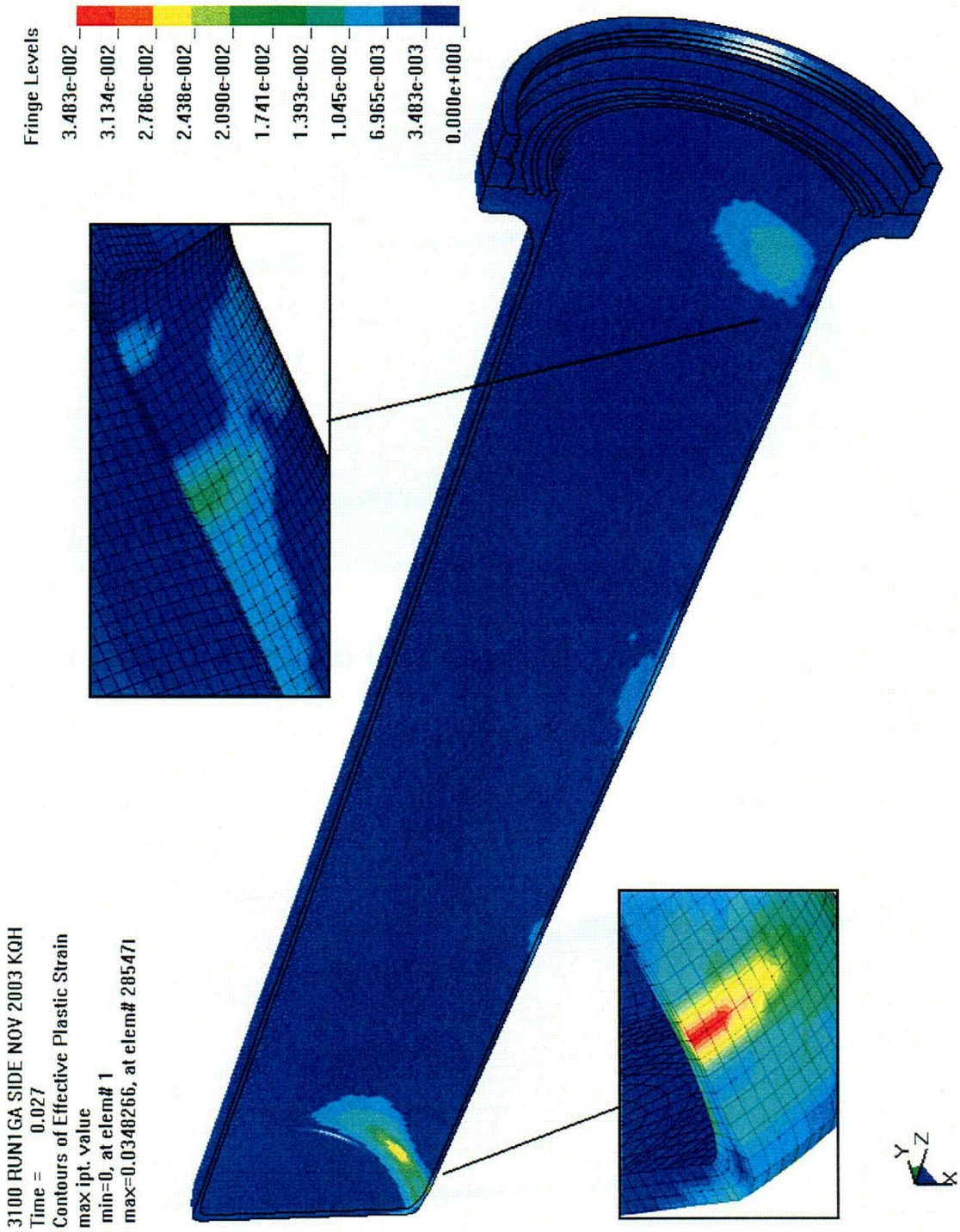

Figure 3.2.7 - Run1ga, Crush Impact, Effective Plastic Strain in the CV Body

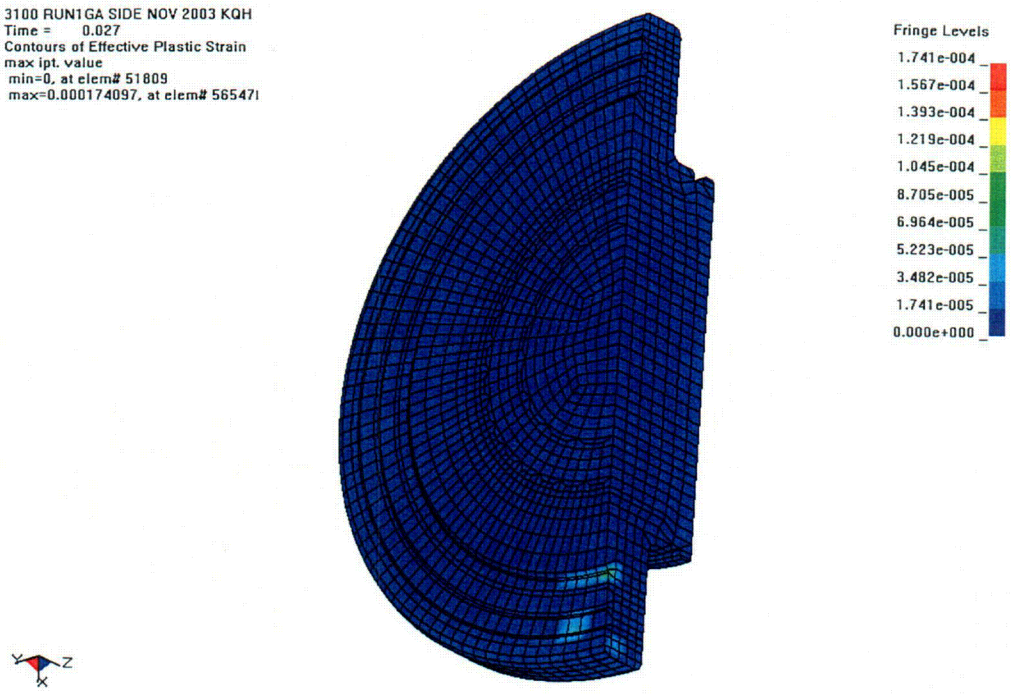

Figure 3.2.8 - Run1ga, Crush Impact, Effective Plastic Strain in the CV Lid

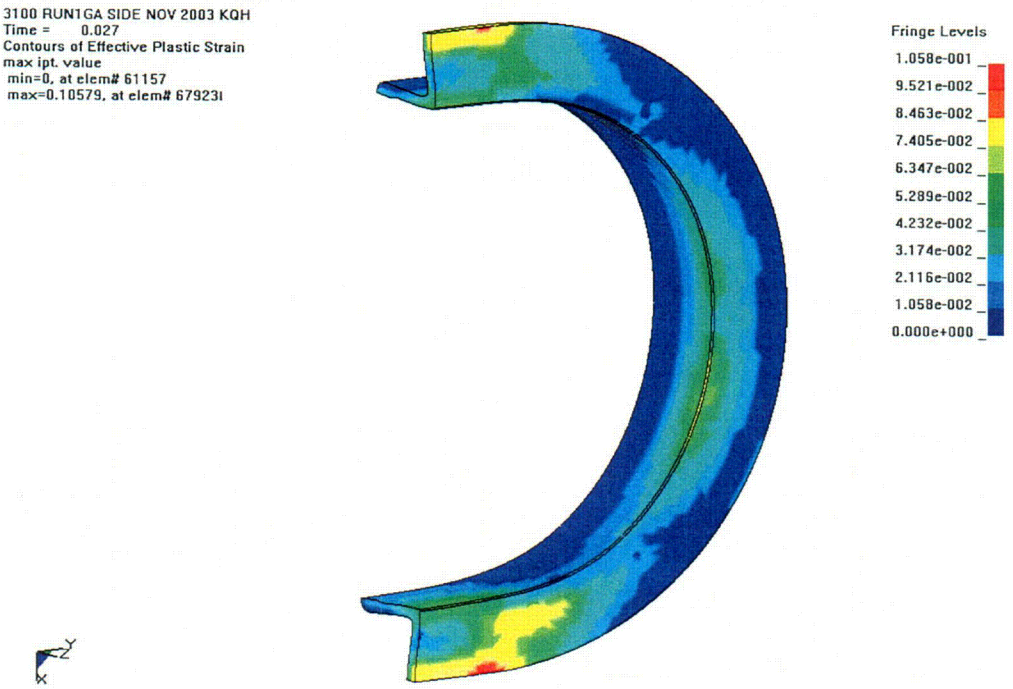

Figure 3.2.9 - Run1ga, Crush Impact, Effective Plastic Strain in the Drum Angle

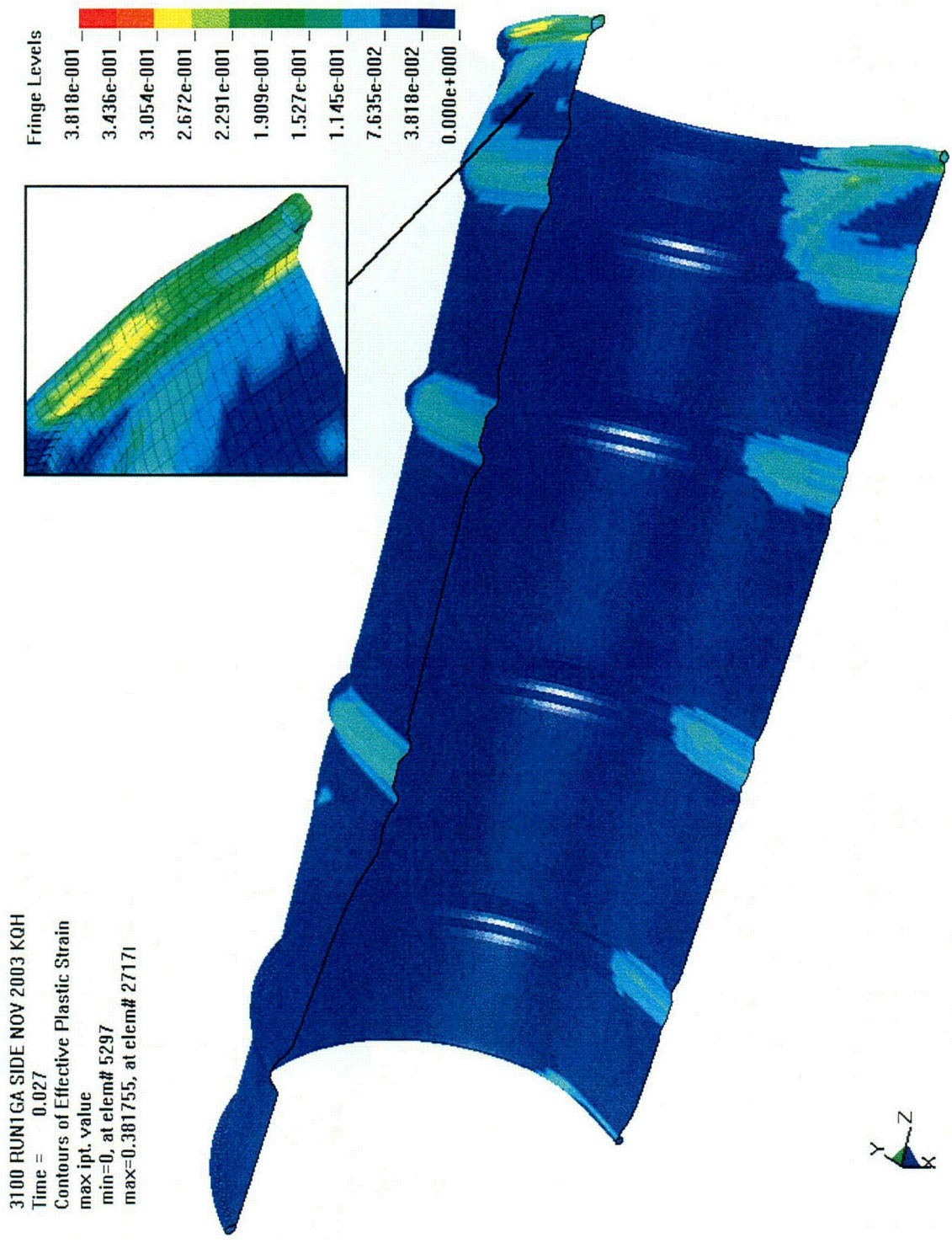

Figure 3.2.10 - Run1ga, Crush Impact, Effective Plastic Strain in the Drum

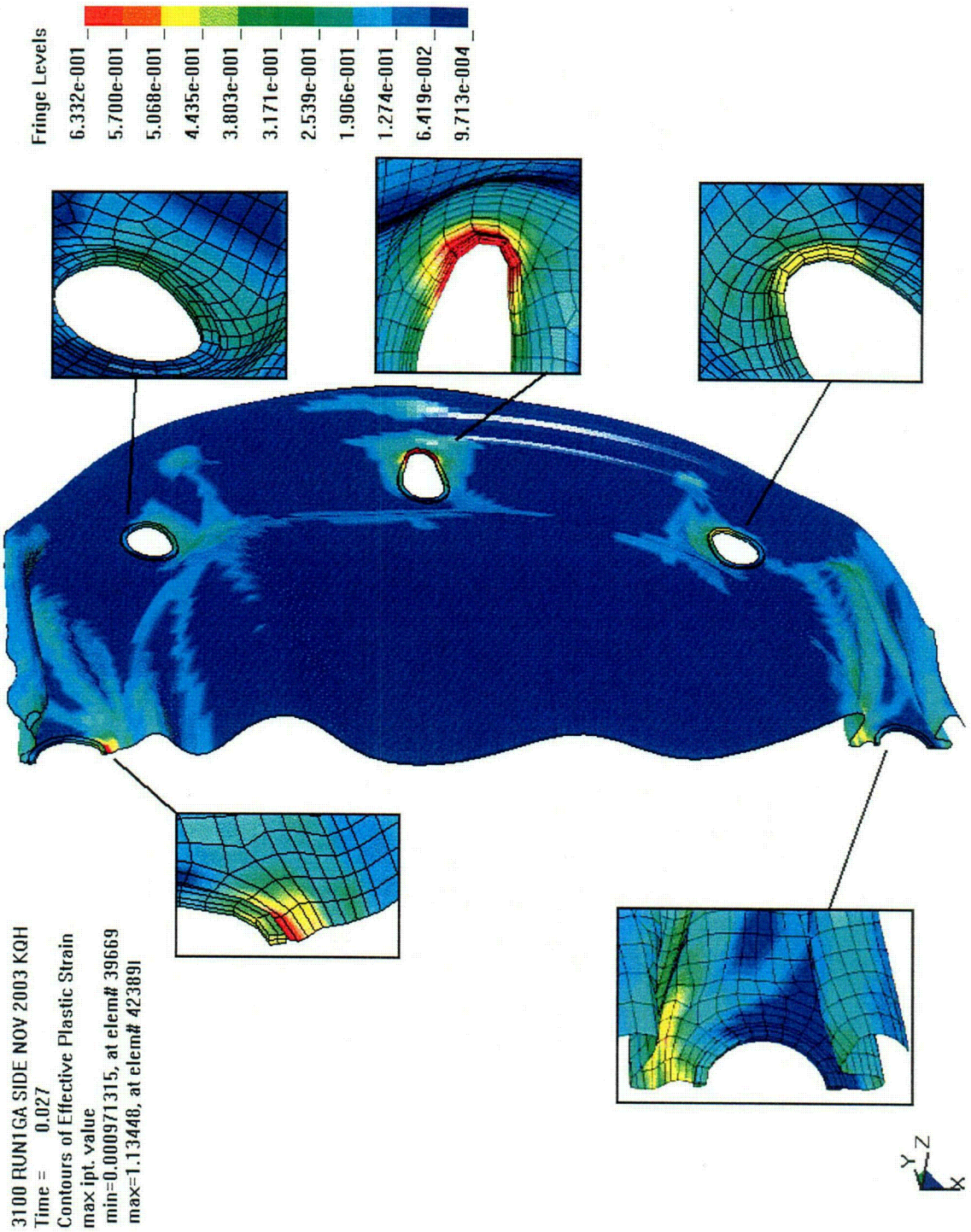

Figure 3.2.11 - Run1ga, Crush Impact, Effective Plastic Strain in the Lid

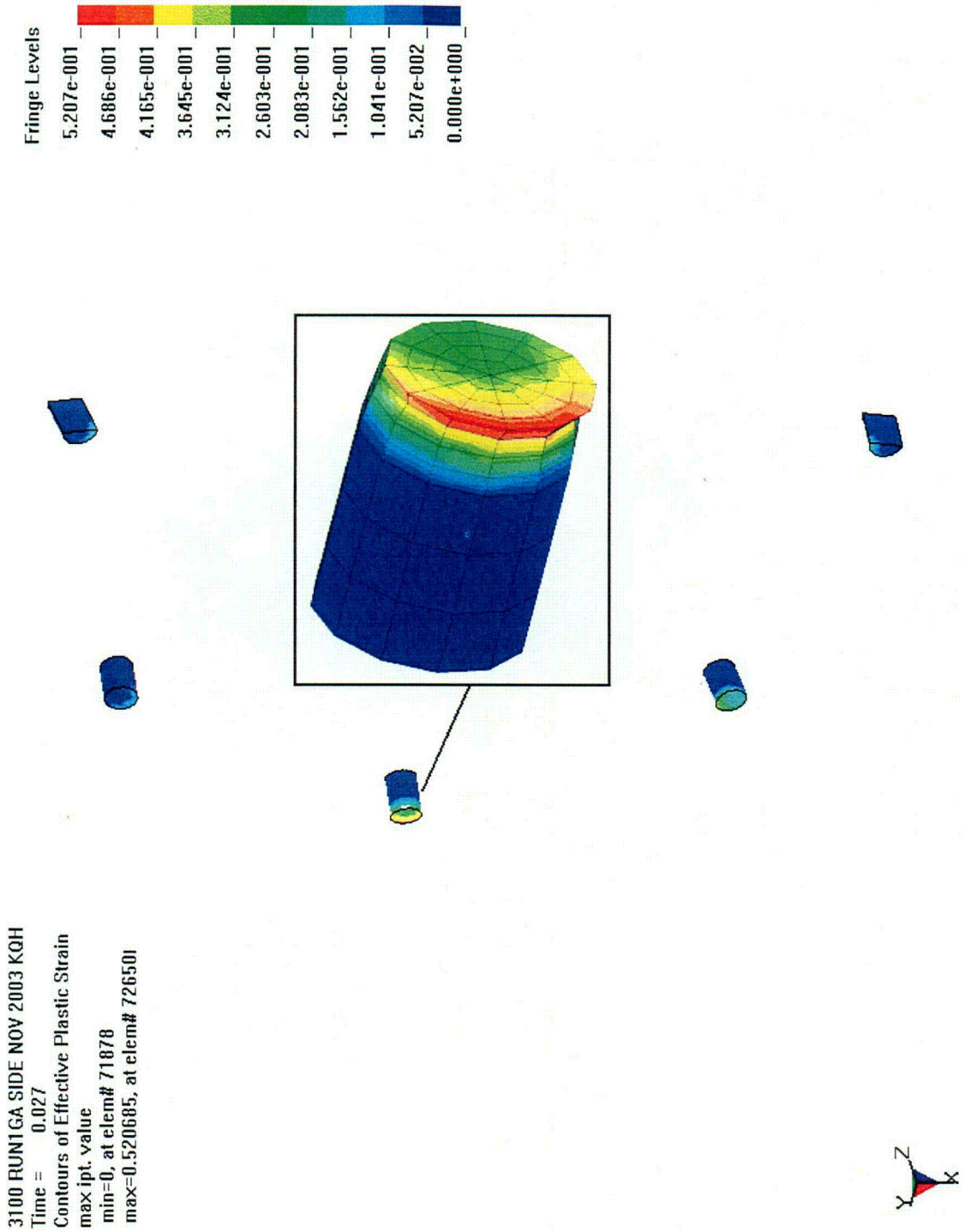

Figure 3.2.12 - Run1ga, Crush Impact, Effective Plastic Strain in the Drum Studs

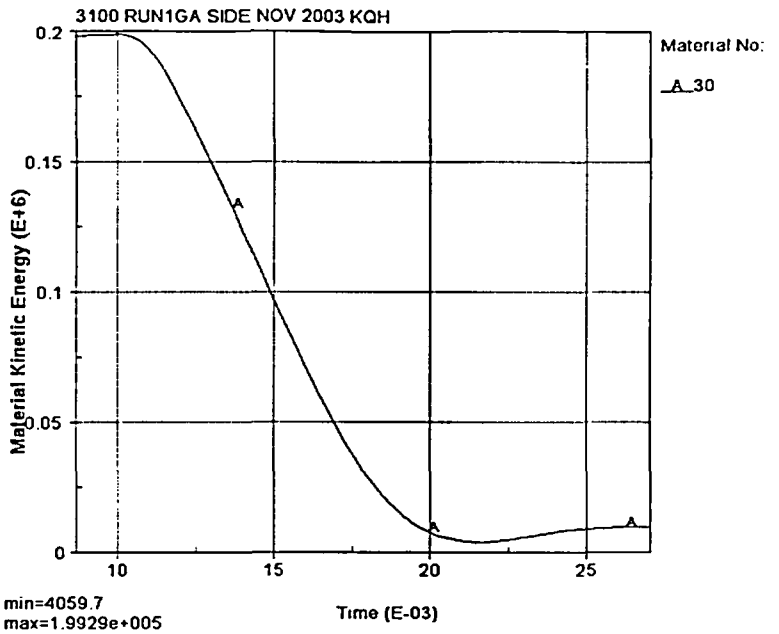

Figure 3.2.13 - Run1ga, Crush Impact, Kinetic Energy Time History

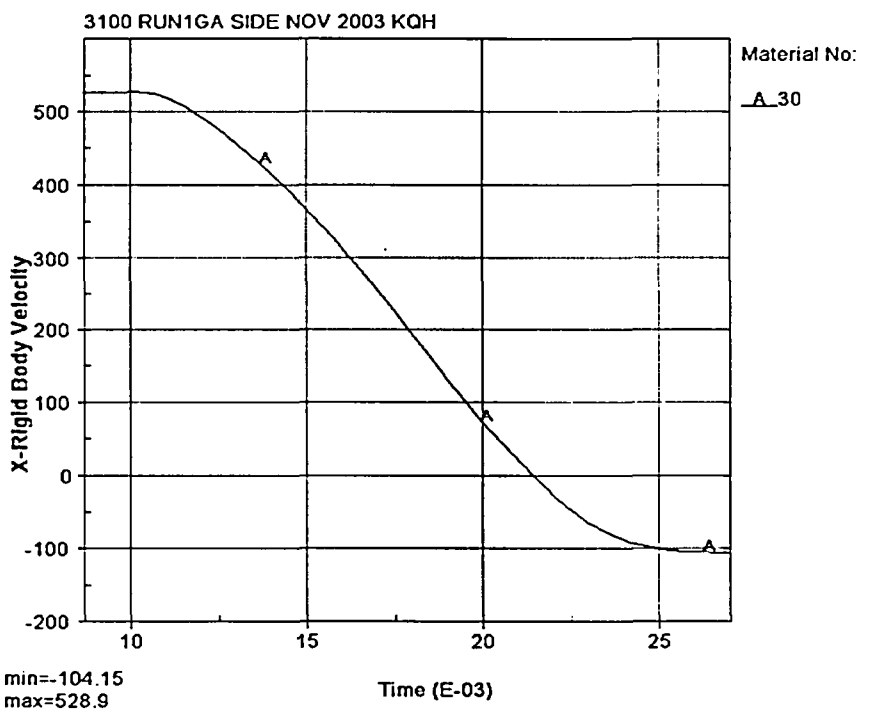

Figure 3.2.14 - Run1ga, Crush Impact, X Velocity Time History

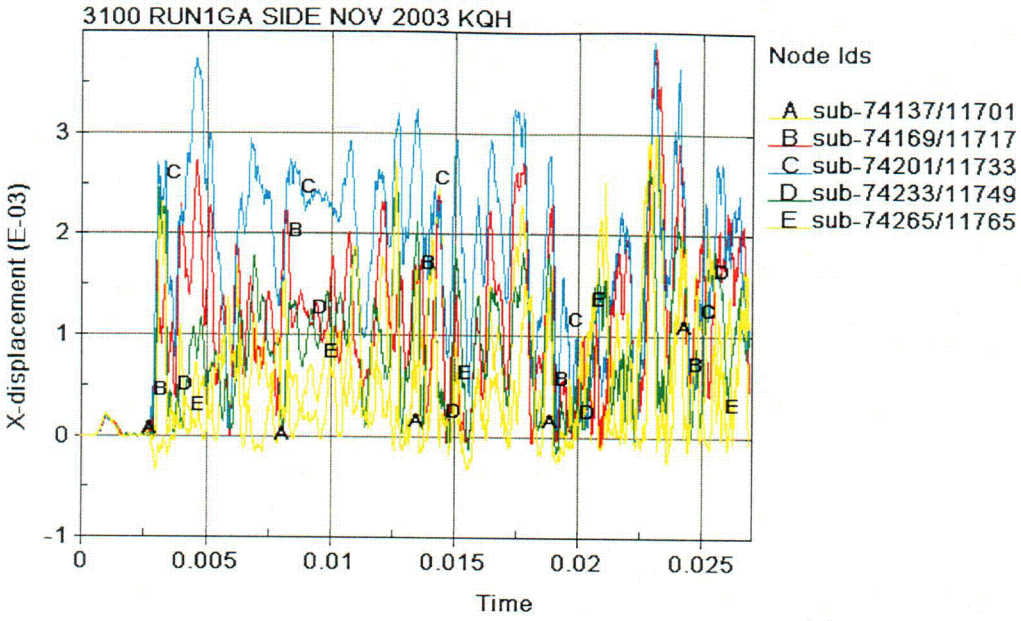

Figure 3.2.15 - Run1ga, Lid Separation Time History

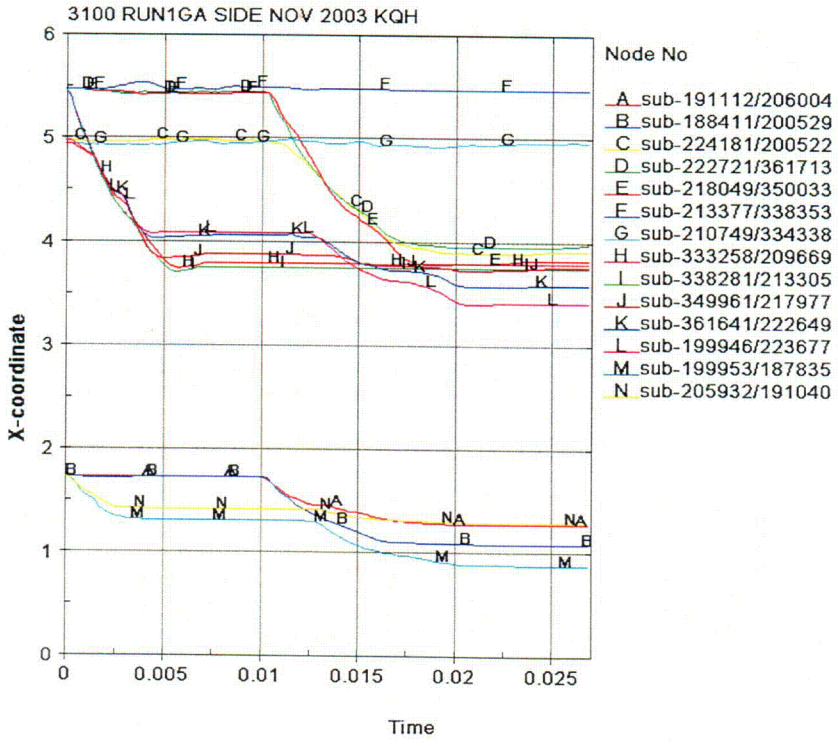

Figure 3.2.16 - Run1ga, Drum Kaolite Thickness Time Histories

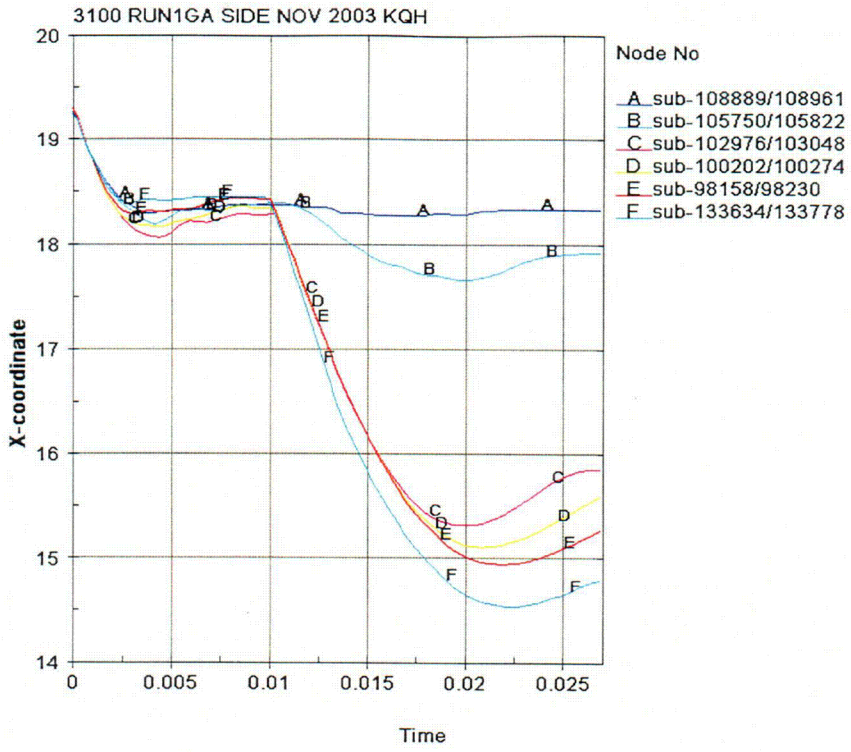

Figure 3.2.17 - Run1ga, Drum Dimension Time History in the X-Direction

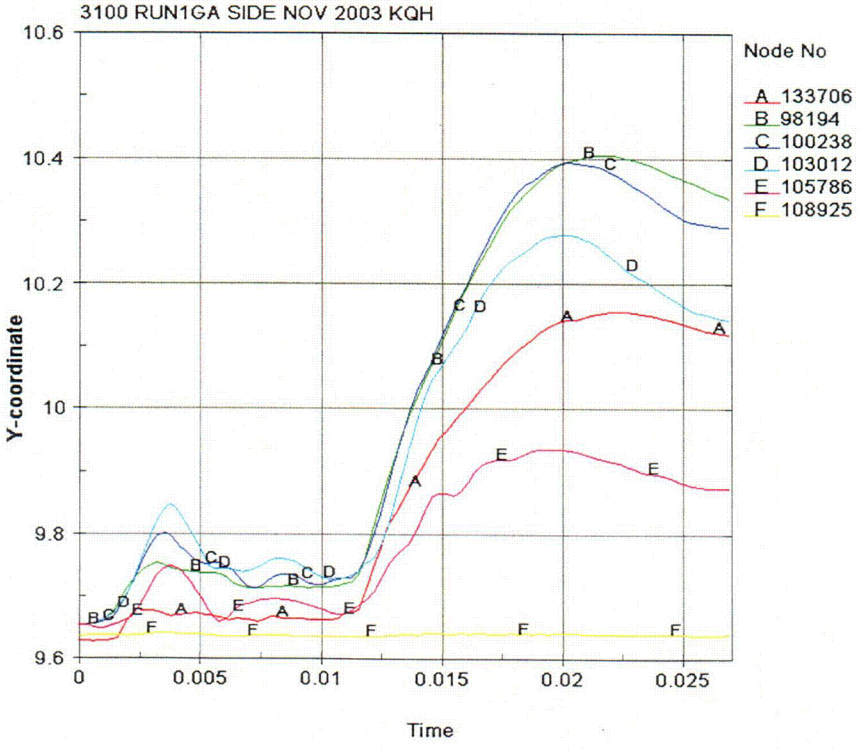

Figure 3.2.18 - Run1ga, Drum Dimension Time History in the Y-Direction

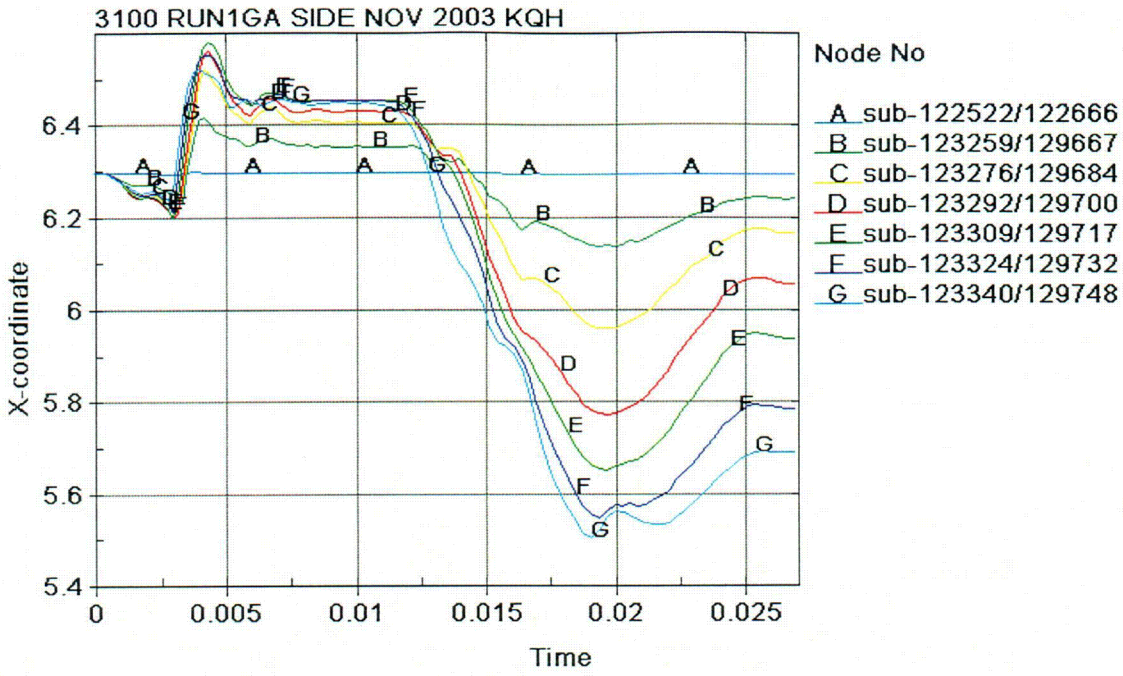

Figure 3.2.19 - Run1ga, Liner Diameter Time History

3.3 Run1hl - Side

Run1hl is the lower bounding kaolite run (100°F). It is basically the run1g model, but with kaolite properties of section 2.3.5.2. It is a run with a 4-foot impact (time = 0 to 0.01 seconds), followed by a 30-foot impact (0.01 to 0.02 seconds), followed by a 30-foot crush impact (0.02 to 0.04 seconds), finally followed by a 40-inch punch impact (0.04 to 0.055 seconds). The initial configuration of run1hl is similar to Figure 3.1.1. The configuration after the 4-foot impact is shown in Figure 3.3.1. Figure 3.3.2 and 3.3.3 show the configuration at the extremes of the package.

The CV body undergoes plastic deformation in the 4-foot impact. The effective plastic strain in the CV body is shown in Figure 3.3.4 to have a maximum of 0.0263 in/in. The elevated plastic strain levels are near the CV bottom head. The CV lid and nut ring remain elastic during the 4-foot impact. The plastic strain in other components for the 4-foot impact are given in Table 3.3.1.

Table 3.3.1 - Run1hl, 4-Foot Impact, Effective Plastic Strain Levels in Some Components

Component	Effective Plastic Strain, in/in
Angle	0.0054
Drum	0.1561
Drum Bottom Head	0.0991
Liner	0.0537
Lid	0.1320
Lid Stiffener	0.0001
Lid Studs	0.0000
Lid Stud Nuts	0.0000
Lid Stud Washers	0.0011
Plug Liner	0.0022

Figure 3.3.5 shows the final configuration for the run1hl 30-foot impact. Figures 3.3.6 and 3.3.7 show the configurations for the package extremes.

The maximum effective plastic strain due to the 30-foot impact in the CV body is 0.0287 in/in as shown in Figure 3.3.8. The maximum effective plastic strain in the drum lid

is shown to be 0.5180 in/in in Figure 3.3.9. The maximum lid strain is a surface strain at the stud hole nearest the rigid surface (0°). The membrane effective plastic strain component is 0.4026 in/in in the localized region near the stud hole. Effective plastic strain levels in other components for the 30-foot impact are given in Table 3.3.2.

Table 3.3.2 - Run1hl, 30-Foot Impact, Effective Plastic Strain Levels in Some Components

Component	Effective Plastic Strain, in/in
CV Lid	0.0001
CV Nut Ring	0.0000
Angle	0.0777
Drum	0.2250
Drum Bottom Head	0.2125
Liner	0.1800
Lid Stiffener	0.0118
Lid Studs	0.1098
Lid Stud Nuts	0.0000
Lid Stud Washers	0.0225
Plug Liner	0.0956

The final configuration for the crush impact is shown in Figure 3.3.10. The configuration at the package extremes are shown in Figure 3.3.11. The maximum effective plastic strain in the CV body is 0.0287 in/in as shown in Figure 3.3.12. The maximum effective plastic strain in the drum for the crush impact is 0.5309 in/in (surface strain). The maximum in the drum occurs near the angle on the crush plate side of the drum as shown in Figure 3.3.13. The maximum membrane effective plastic strain at this location is 0.3616 in/in.

The maximum effective plastic strain in the lid is 1.2969 in/in (surface strain) and occurs just below the upper stud hole (hole nearest the crush plate, 180°) as shown in Figure 3.3.14. The maximum membrane effective plastic strain in this region of the lid is 0.8995 in/in. A time line investigation during the crush impact shows that the lid exceeds 0.57 in/in strain in bending at about 0.0228 seconds at the 180° stud hole. The crush impact started at about 0.0200 seconds, so the lid reaches failure level near the start of the crush impact. The membrane levels in the lid reach 0.57 in/in at about 0.0236 seconds.

The elevated effective plastic strain levels in the lid are localized in the region just inboard of the upper stud.

The effective plastic strain in the drum studs is 0.4159 in/in and occurs in the upper stud at the bearing of the lid onto the stud (180°). The elevated strains in the stud are localized on the inner surface. Effective plastic strain levels throughout the thickness of the stud are generally 0.25 in/in or less.

Considering the strain levels in the lid and the studs, some tearing in the lid at the 180° stud hole would be expected. But the tearing would be localized to the stud hole due to the extent of the strain patterns. Failure of the stud to restrain the lid due to this tearing is not expected. The lid stiffener would limit any tearing from the stud at 180° and the large washer would be expected to restrain the lid.

The effective plastic strain in other components due to the crush impact are listed in Table 3.3.3.

Table 3.3.3 - Run1hl, Crush Impact, Effective Plastic Strain Levels in Some Components

Component	Effective Plastic Strain, in/in
CV Lid	0.0003
CV Nut Ring	0.0000
Angle	0.1178
Drum Bottom Head	0.3342
Liner	0.2637
Lid Stiffener	0.0530
Lid Stud Nuts	0.0007
Lid Stud Washers	0.0832
Plug Liner	0.1255

The final configuration after the punch impact is shown in Figure 3.3.16. The effective plastic strain level in the CV body is shown in Figure 3.3.6. The maximum strain is 0.0299 in/in and is located near the bottom head. The effective plastic strain level in the drum after the punch impact remains at 0.5309 in/in as shown in Figure 3.3.18. The maximum effective plastic strain in the other package components for the punch impact are listed in Table 3.3.4.

Table 3.3.4 - Run1hl, Punch Impact, Effective Plastic Strain Levels in Some Components	
Component	Effective Plastic Strain, in/in
CV Lid	0.0006
CV Nut Ring	0.0000
Angle	0.1178
Drum Bottom Head	0.3345
Liner	0.2637
Lid	1.2971
Lid Stiffener	0.0530
Lid Studs	0.4221
Lid Stud Nuts	0.0007
Lid Stud Washers	0.0844
Plug Liner	0.1255

Figure 3.3.19 shows the lid separation time history for all the impacts. The CV lid separation shows a maximum spike separation of about 0.006 inches occurs during the punch. The spike is a response to the rebounding impact of the CV/weights. An average value of .003 in or less is demonstrated in the response when the solution is stopped.

Figure 3.3.20 shows the time history for the kaolite thicknesses. The nodal locations for nodes shown in Figure 3.3.20 are shown in Figure 3.1.32.

Figure 3.3.21 shows the diameter changes in the drum in the model X direction.
Figure 3.3.22 shows the radial changes in the Y direction (normal to the impact directions). The nodes are defined in Figure 3.1.34.

Figure 3.3.23 shows the liner diameter time history. The node pair locations are shown in Figure 3.1.37 and Table 3.1.3.

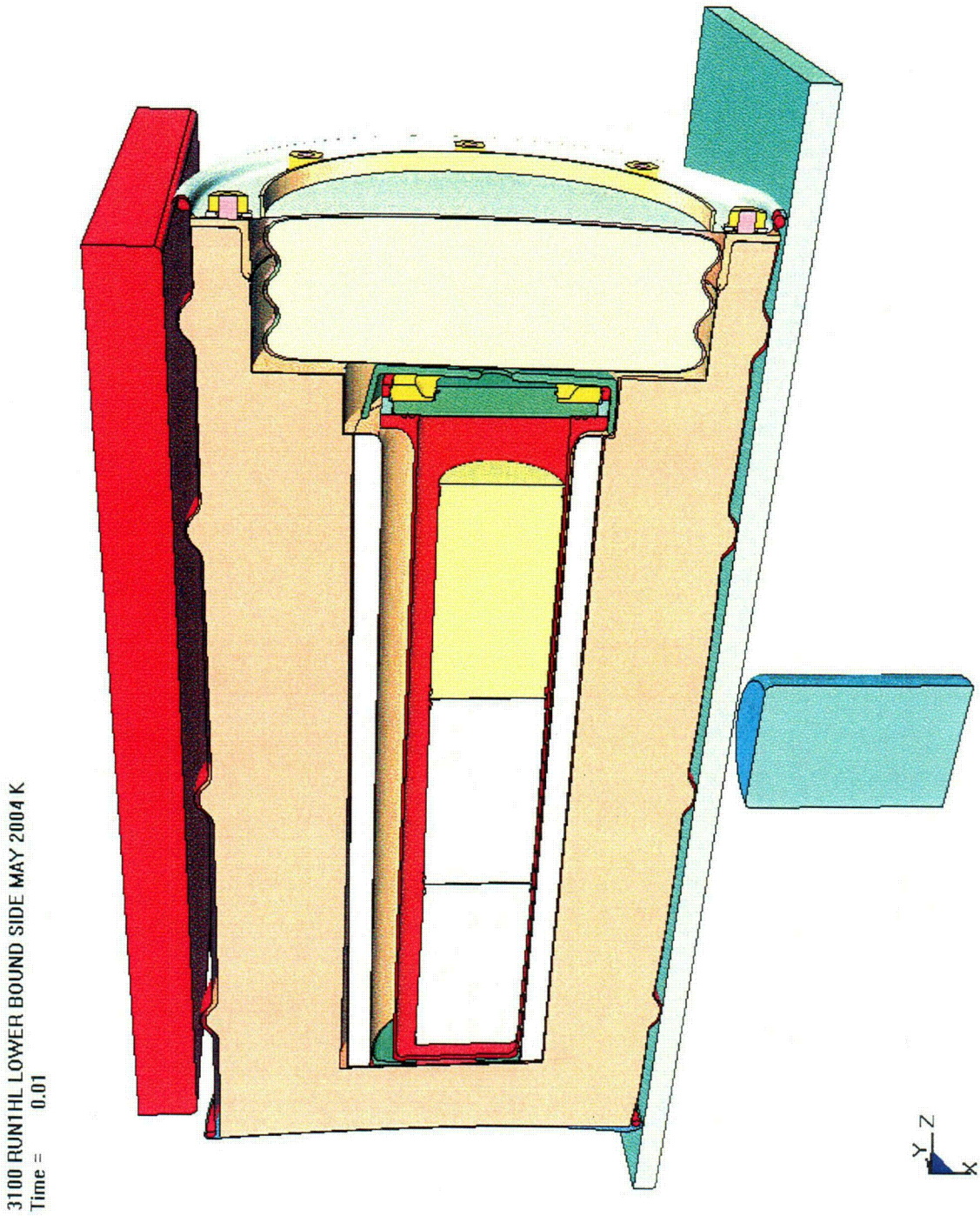

Figure 3.3.1 - Run1hl, 4-Foot Impact, Final Configuration

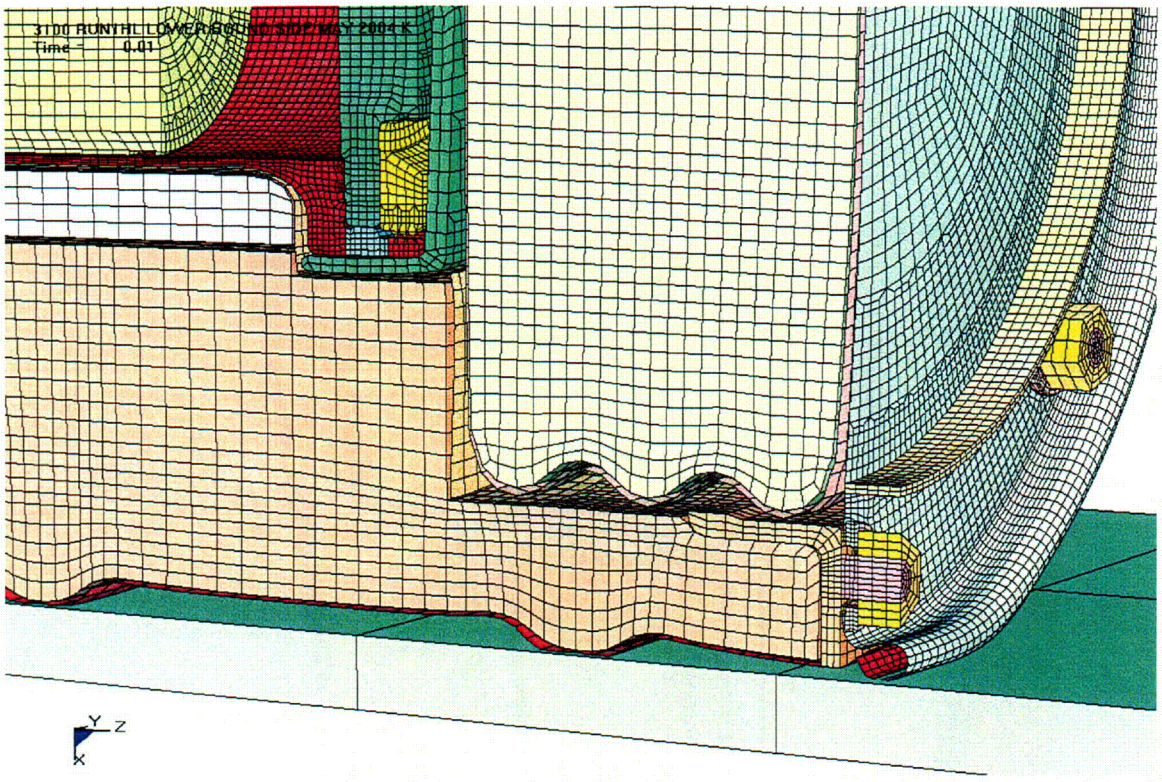

Figure 3.3.2 - Run1hl, 4-Foot Impact, Configuration in the Lid

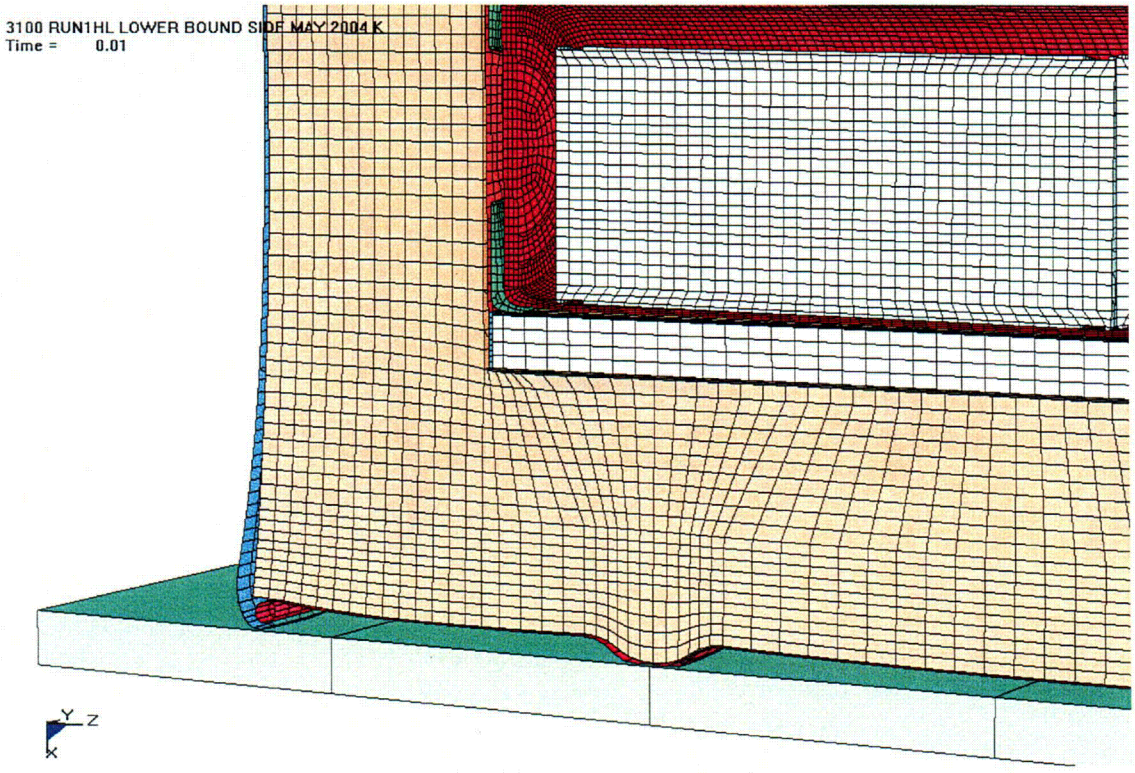

Figure 3.3.3 - Run1hl, 4-Foot Impact, Configuration in the Bottom

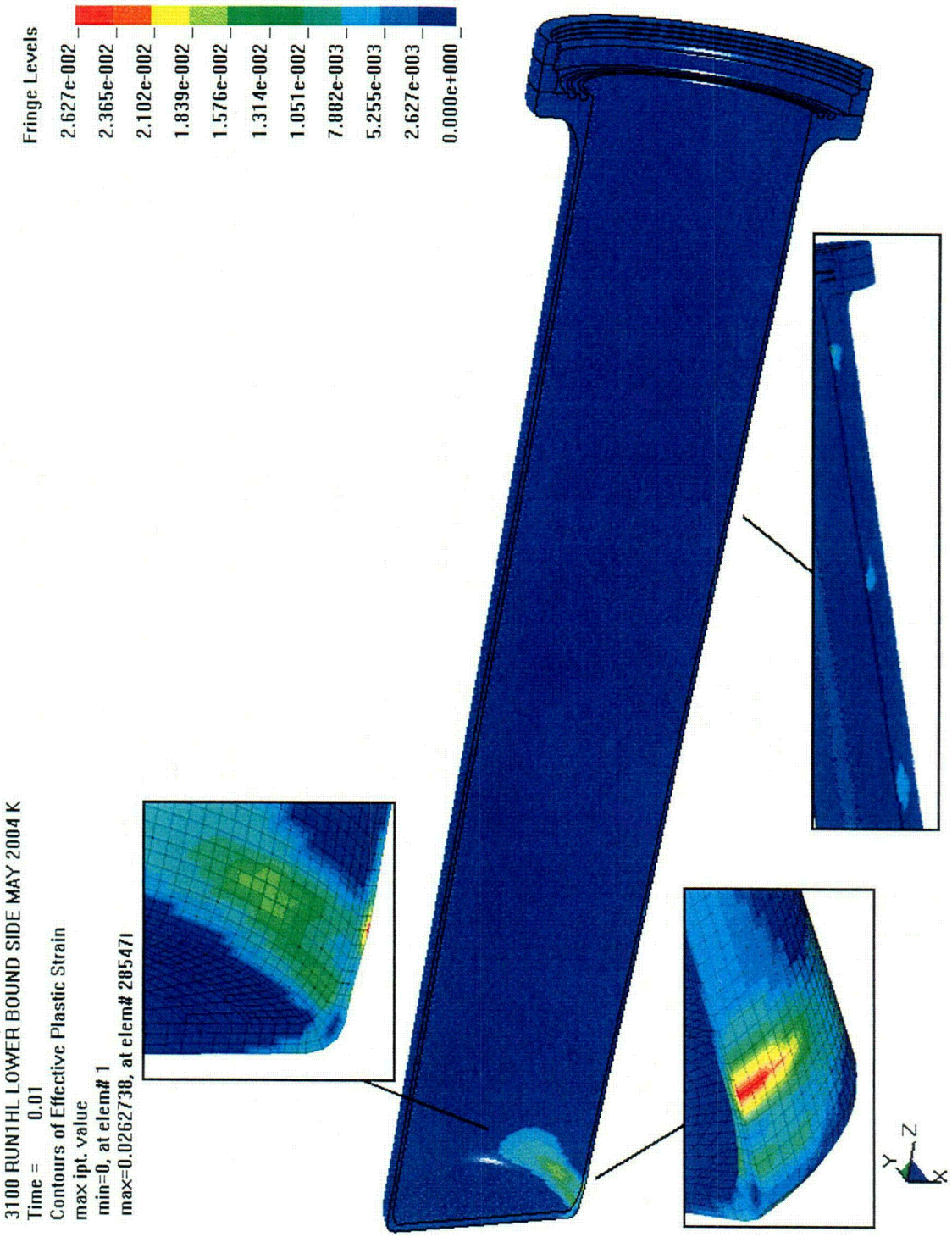

Figure 3.3.4 - Run1hl, 4-Foot Impact, Effective Plastic Strain in the CV Body

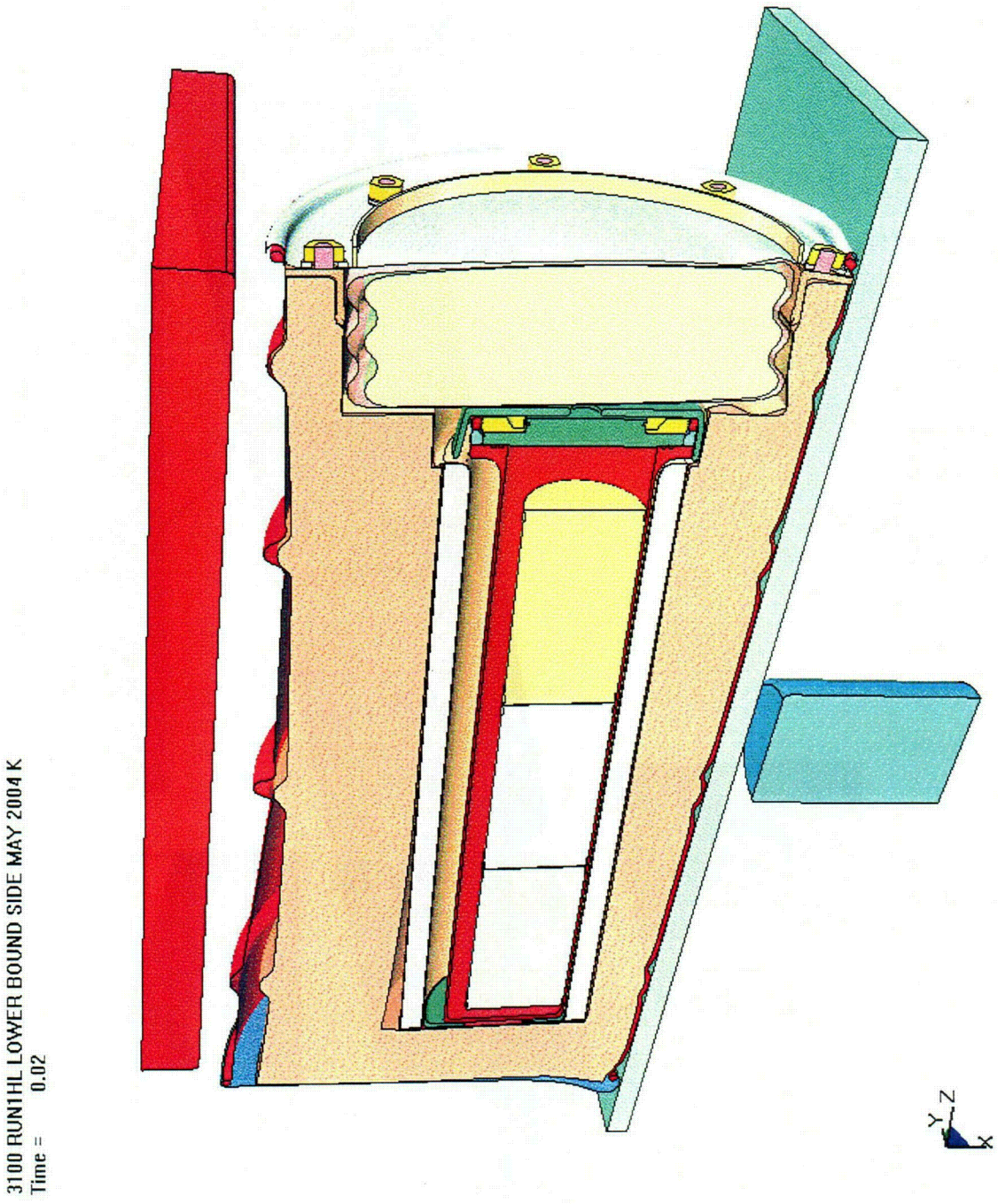

Figure 3.3.5 - Run1hl, 30-Foot Impact, Final Configuration

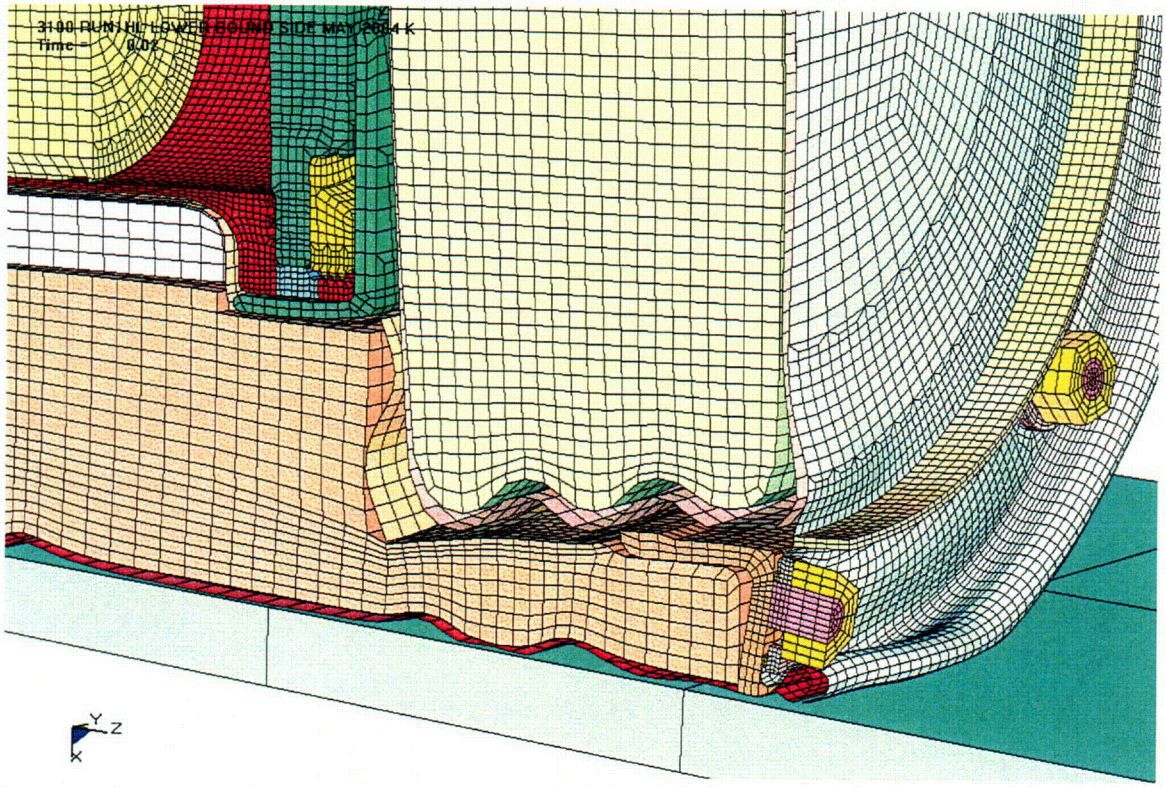

Figure 3.3.6 - Run1hl, 30-Foot Impact, Configuration of the Lid

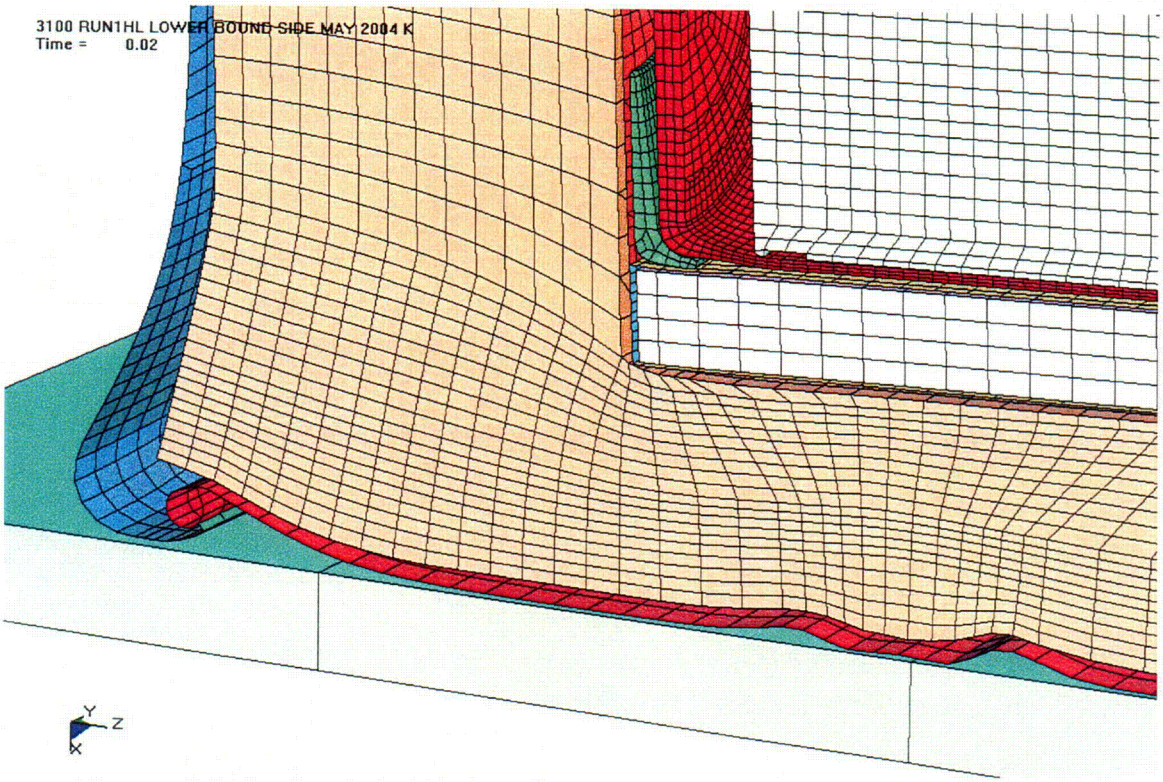

Figure 3.3.7 - Run1hl, 30-Foot Impact, Configuration of the Bottom

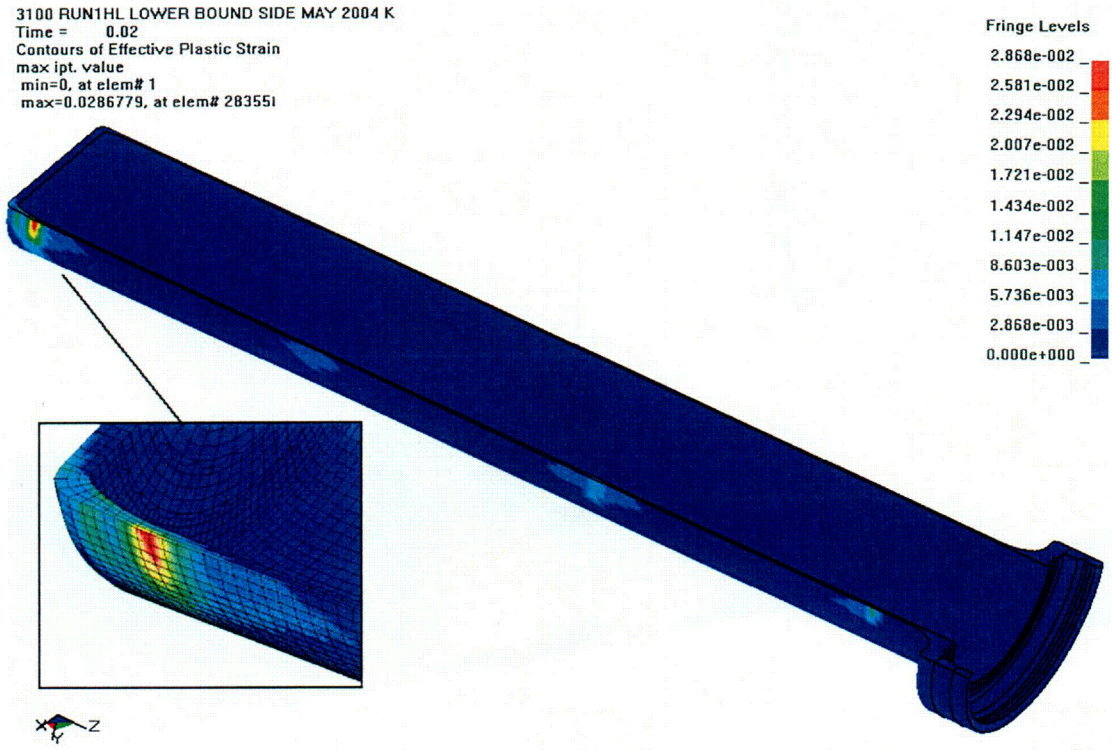

Figure 3.3.8 - Run1hl, 30-Foot Impact, Effective Plastic Strain in the CV

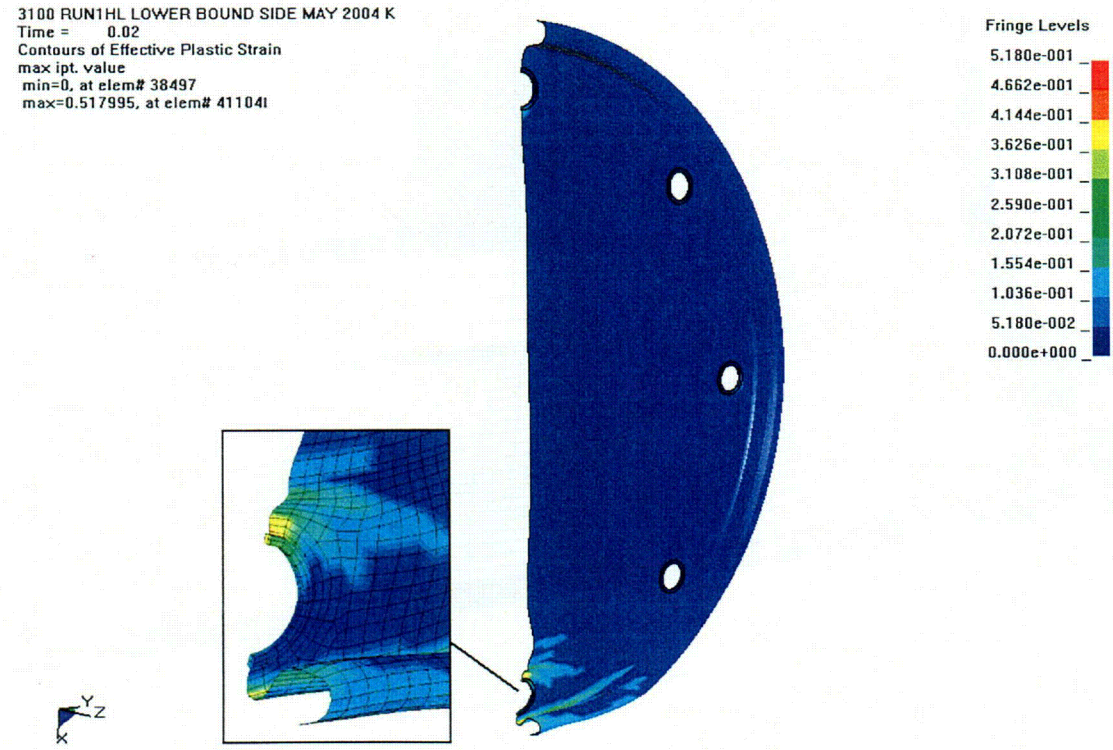

Figure 3.3.9 - Run1hl, 30-Foot Impact, Effective Plastic Strain in the Lid

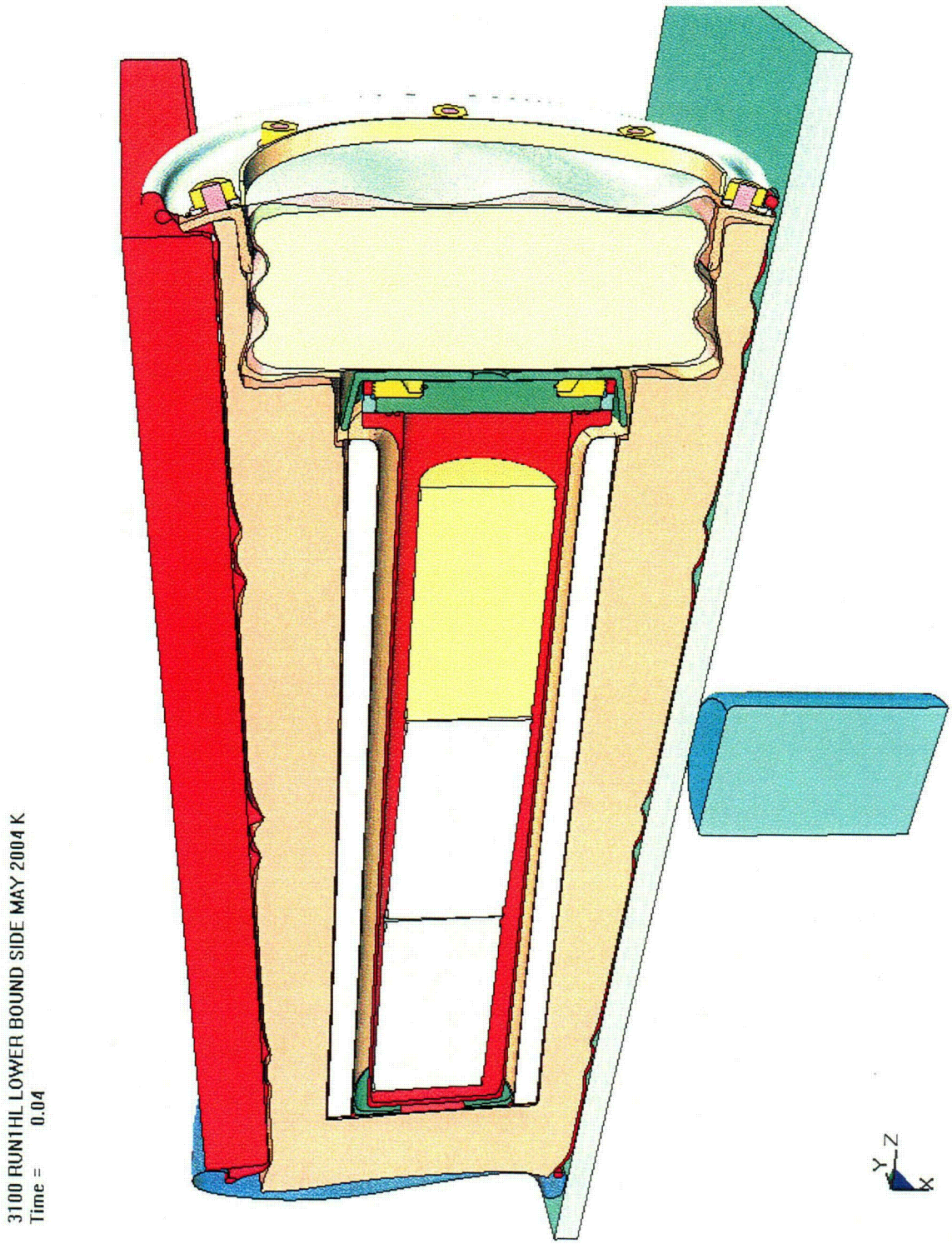

Figure 3.3.10 - Run1hl, Crush Impact, Final Configuration

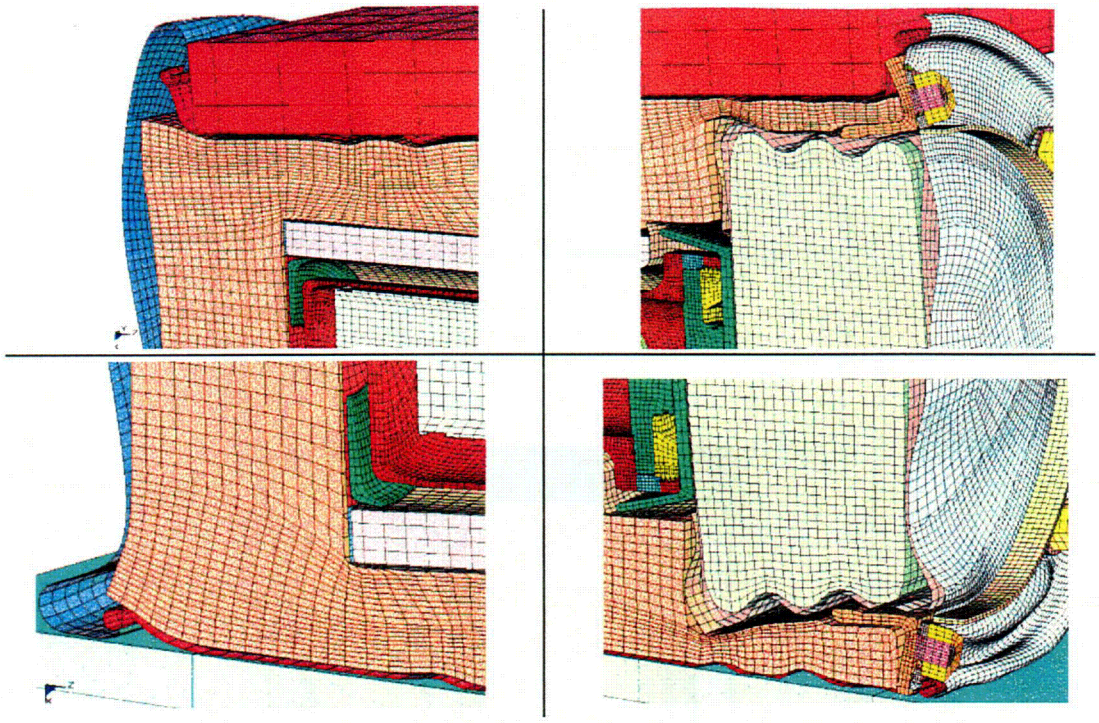

Figure 3.3.11 - Run1hl, Crush Impact, Configuration at the Package Corners

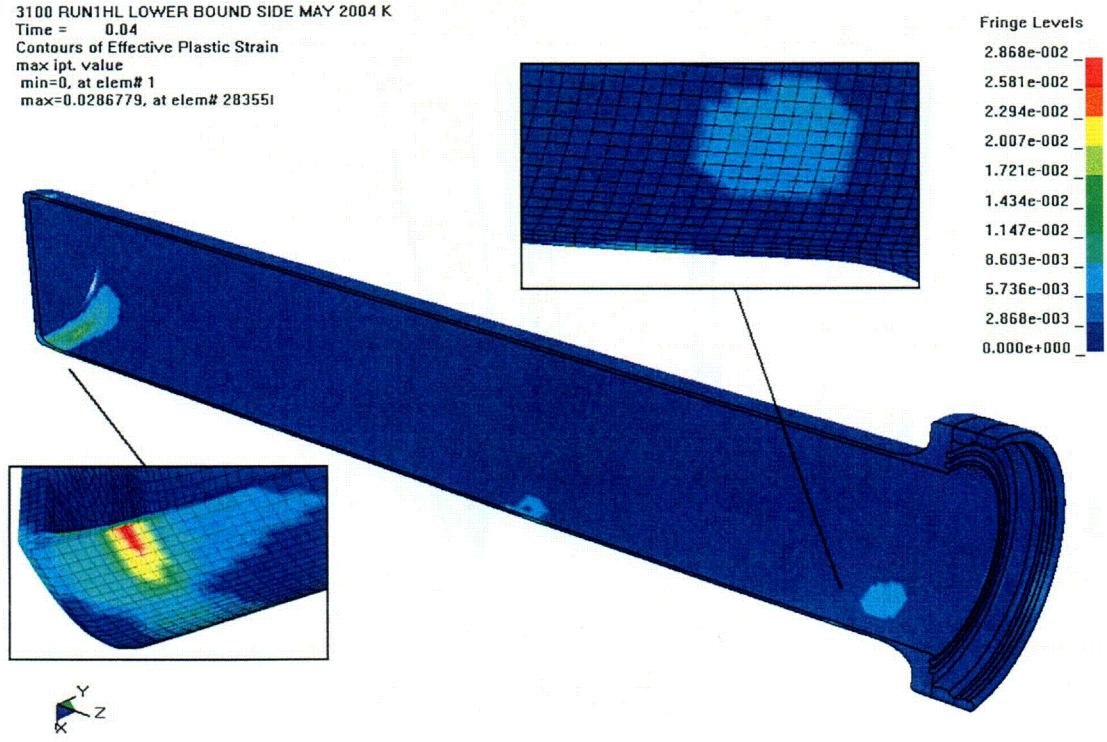

Figure 3.3.12 - Run1hl, Crush Impact, Effective Plastic Strain in the CV Body

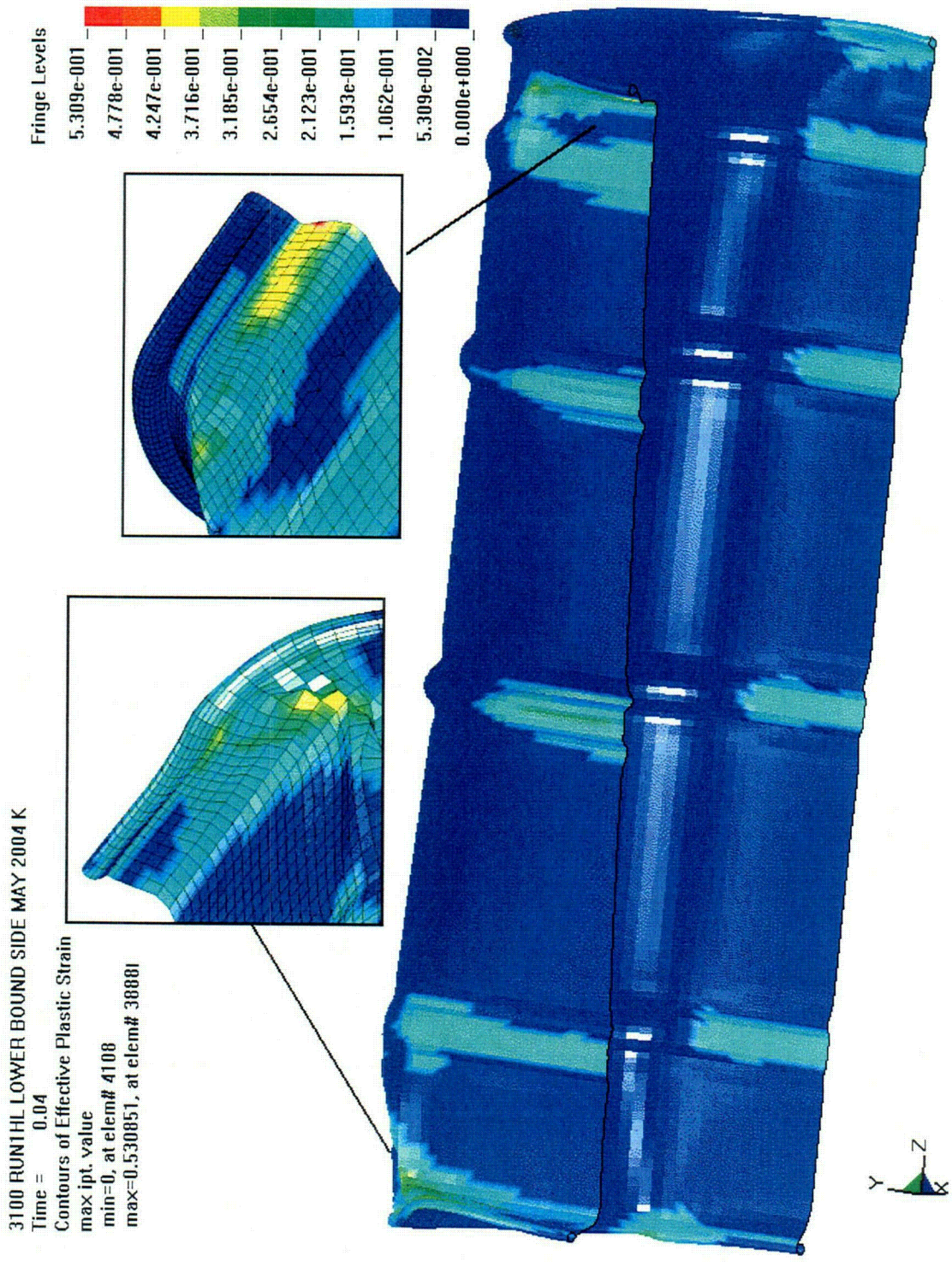

Figure 3.3.13 - Run1hl, Crush Impact, Effective Plastic Strain in the Drum

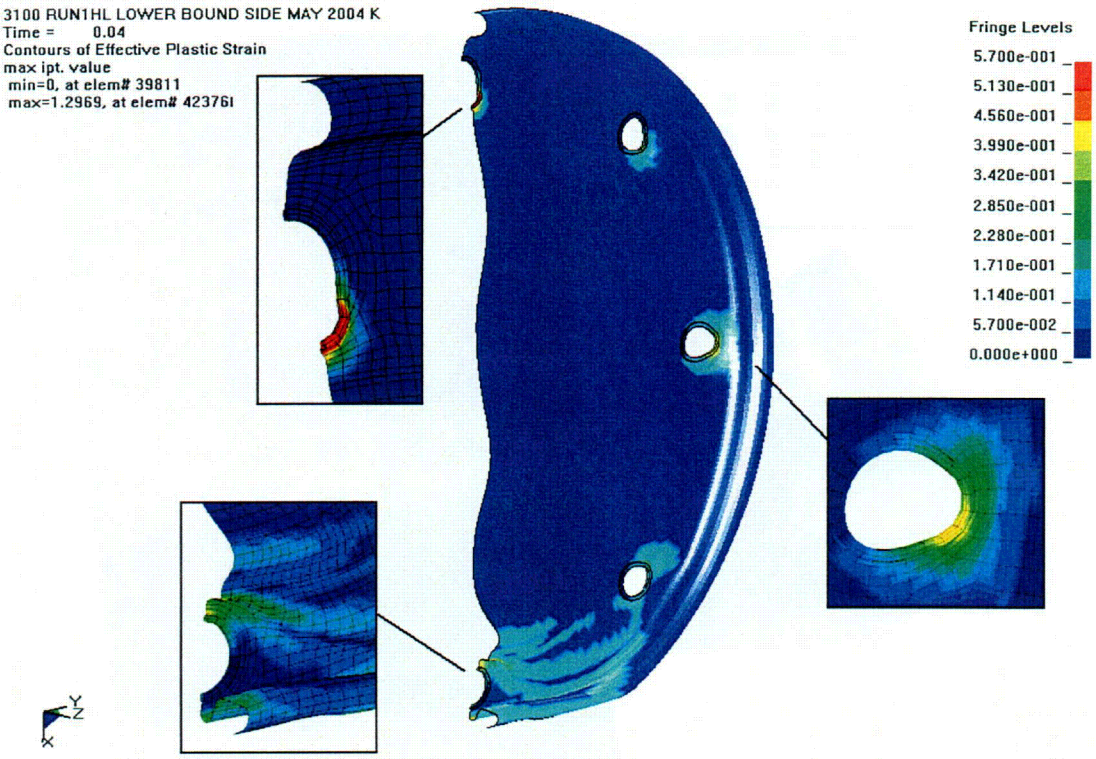

Figure 3.3.14 - Run1hl, Crush Impact, Effective Plastic Strain in the Lid

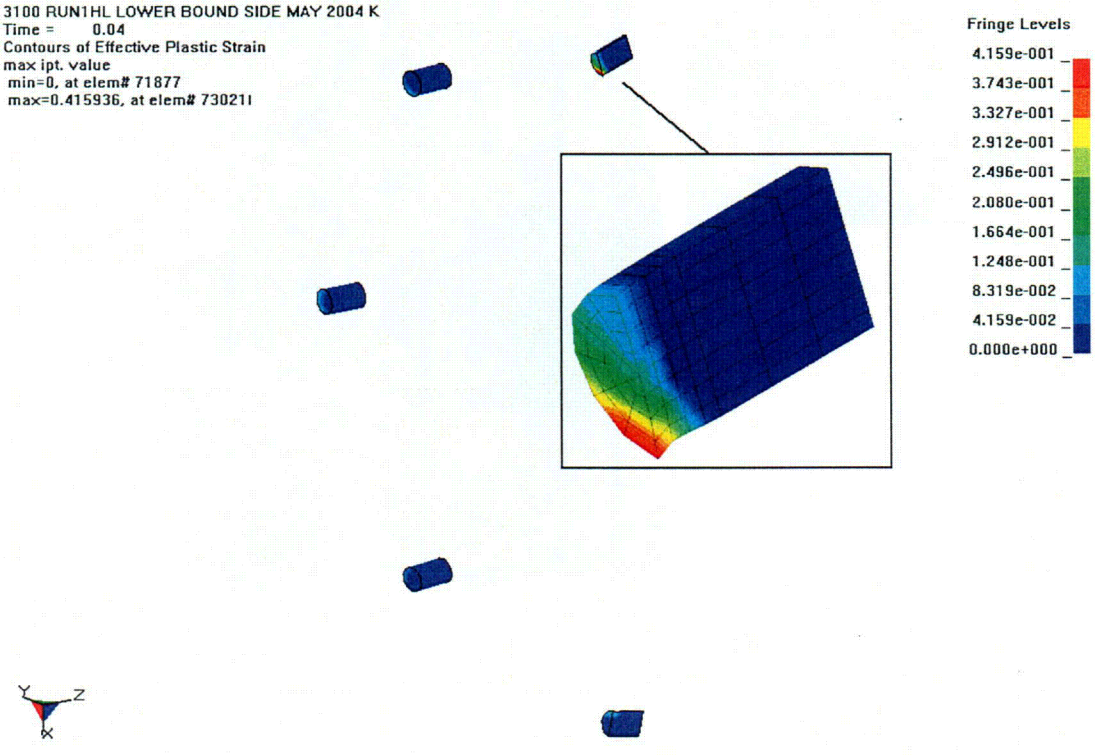

Figure 3.3.15 - Run1hl, Crush Impact, Effective Plastic Strain in the Studs

C82

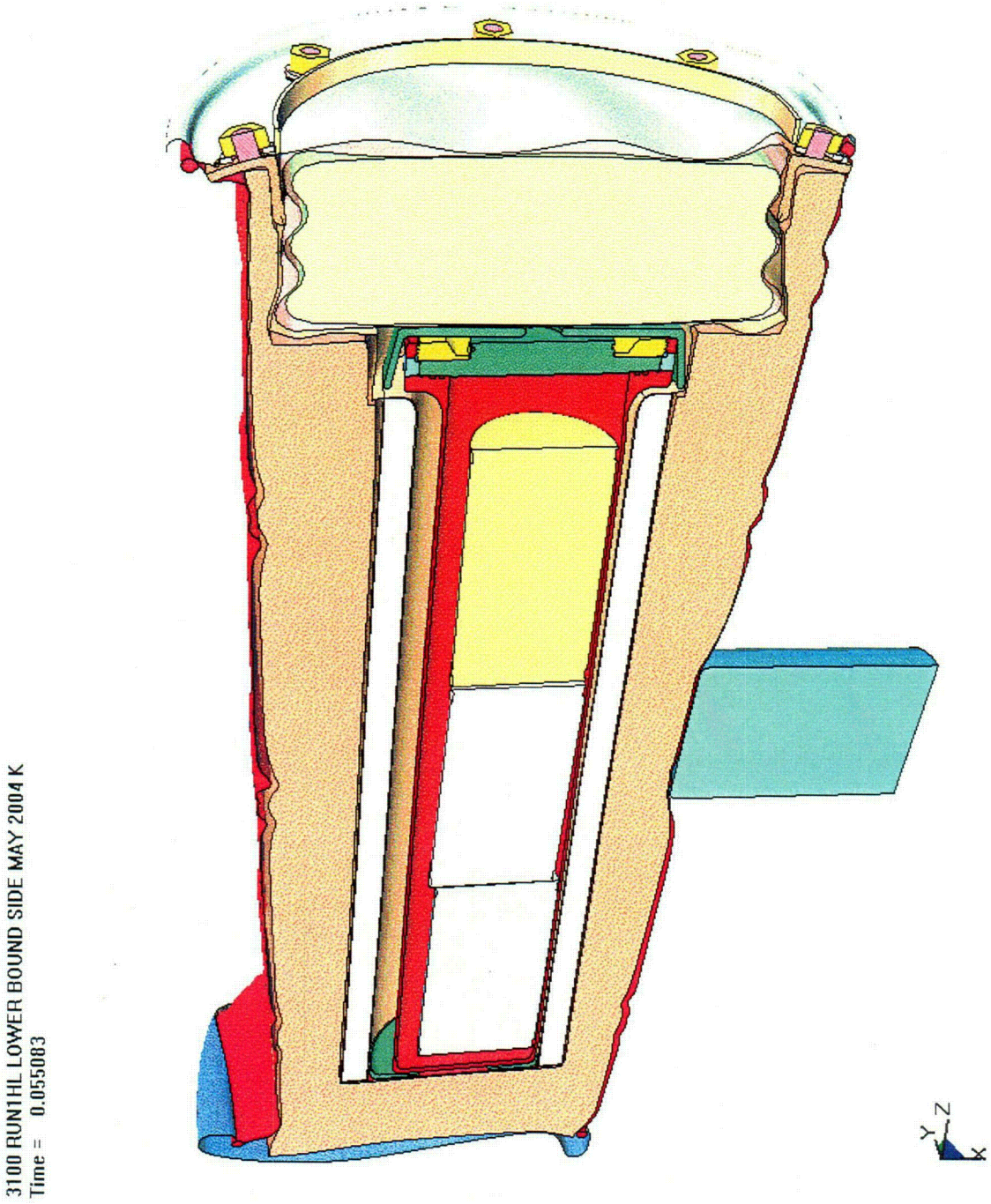

Figure 3.3.16 - Run1hl, Punch Impact, Final Configuration

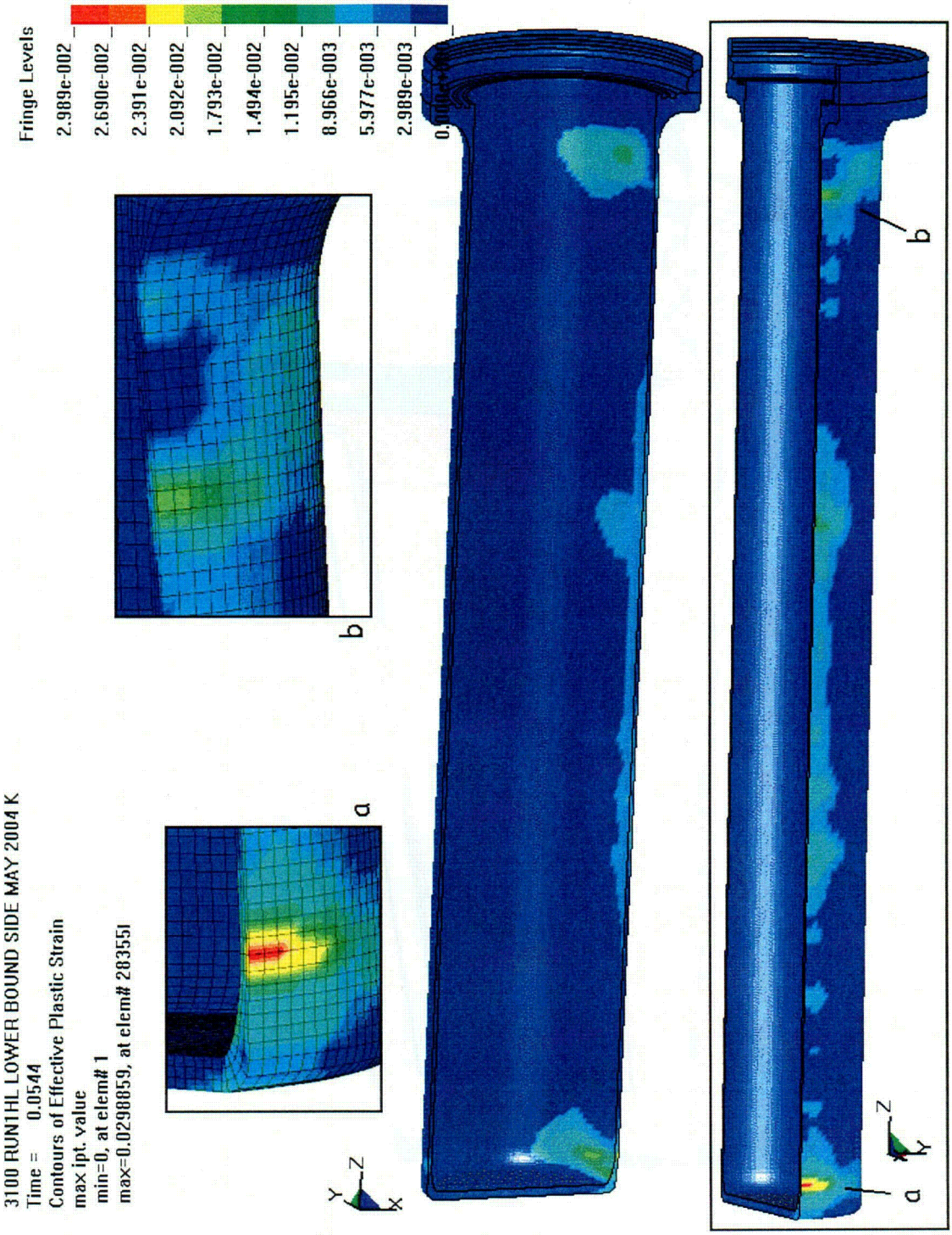

Figure 3.3.17 - Run1hl, Punch Impact, CV Effective Plastic Strain

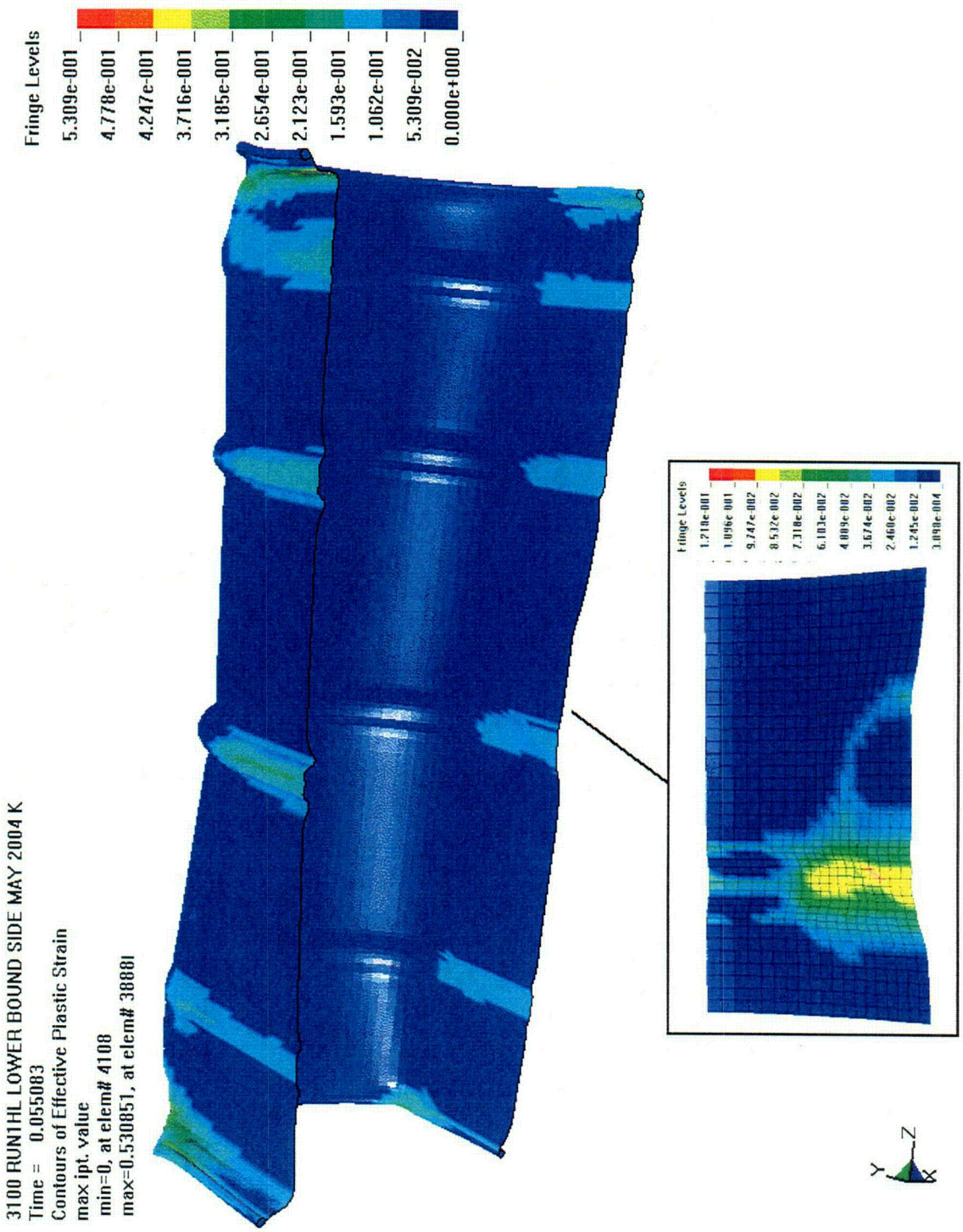

Figure 3.3.18 - Run1hl, Punch Impact, Effective Plastic Strain in the Drum

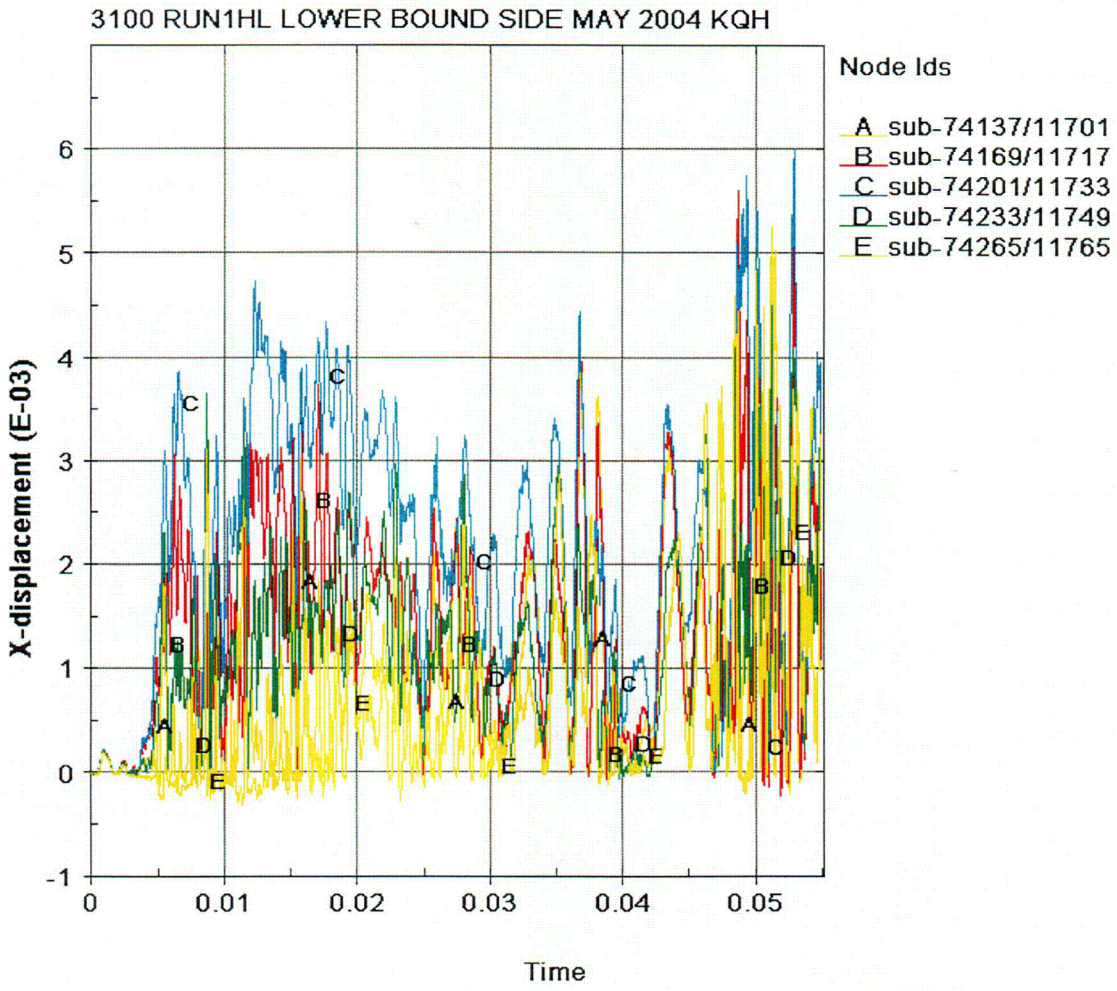

Figure 3.3.19 - Run1hl, CV Lid Separation Time History

C85

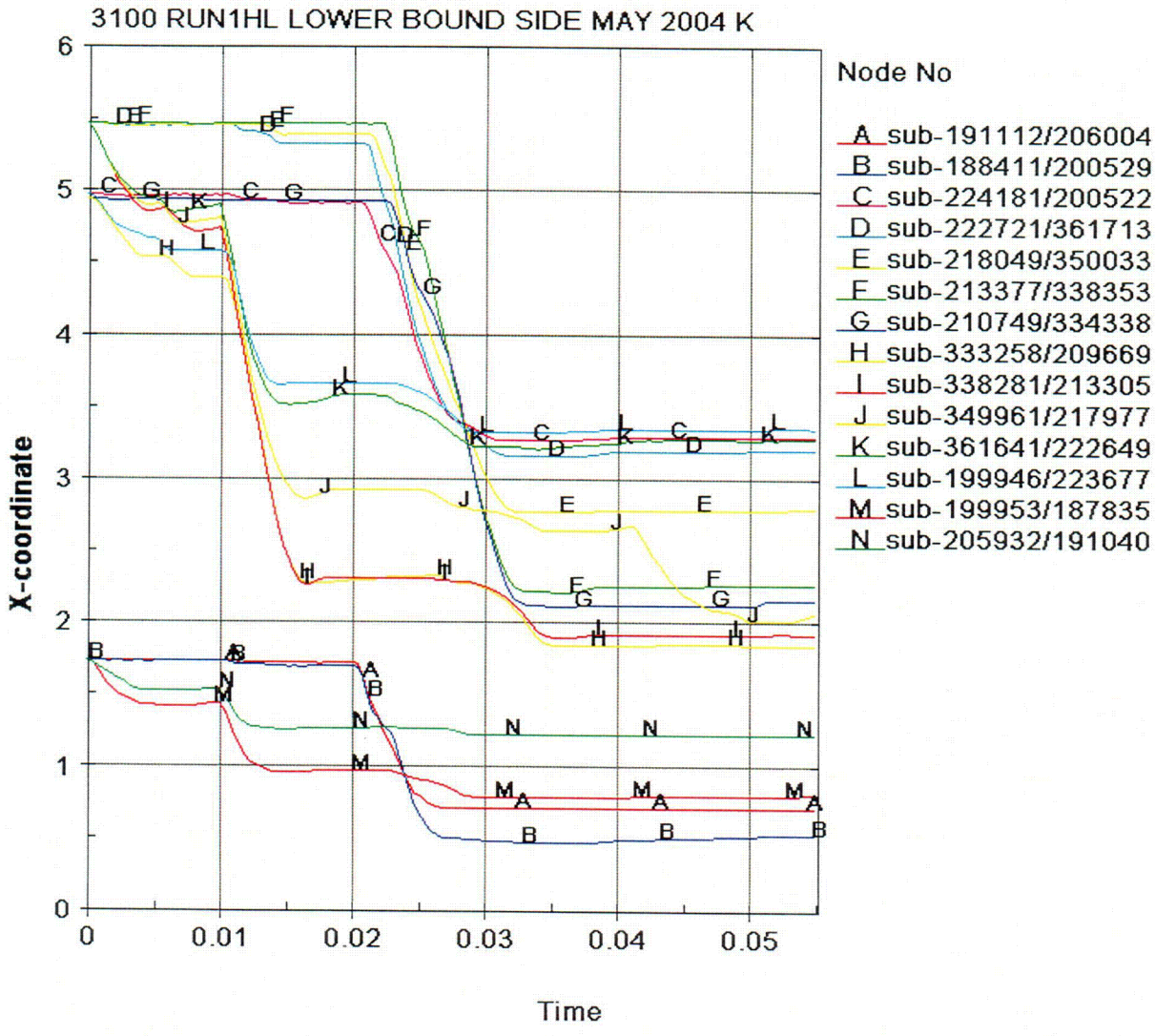

Figure 3.3.20- Run1hl, Kaolite Thickness Time History

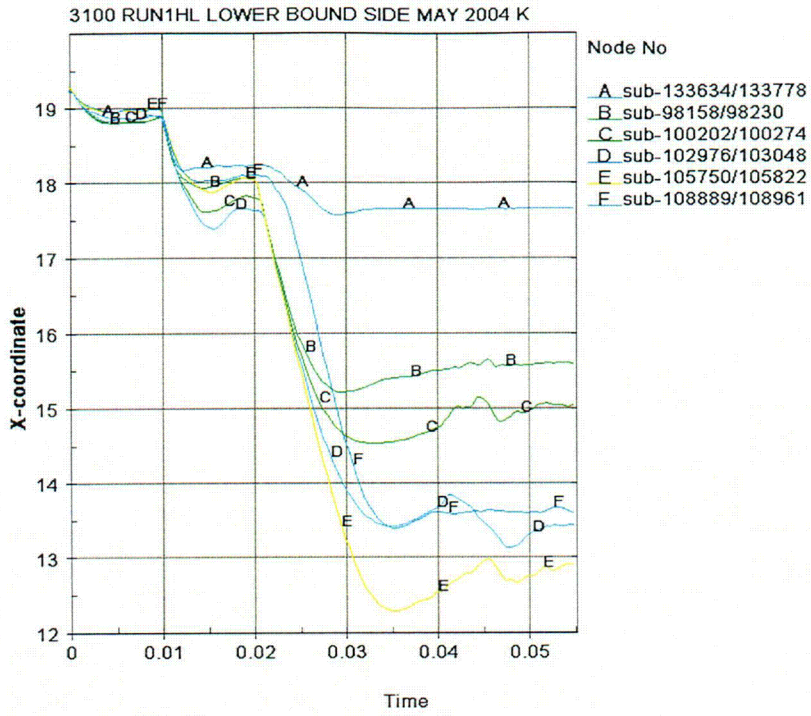

Figure 3.3.21 - Run1hl, Drum Dimension Time History in the X-Direction

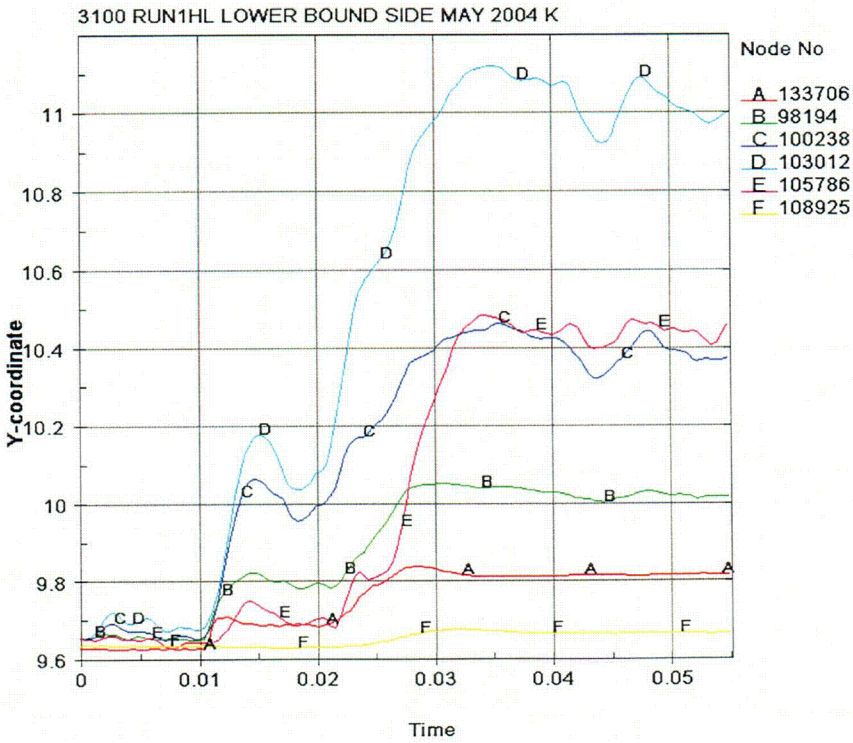

Figure 3.3.22- Run1hl, Drum Dimension Time History in the Y-Direction

C87

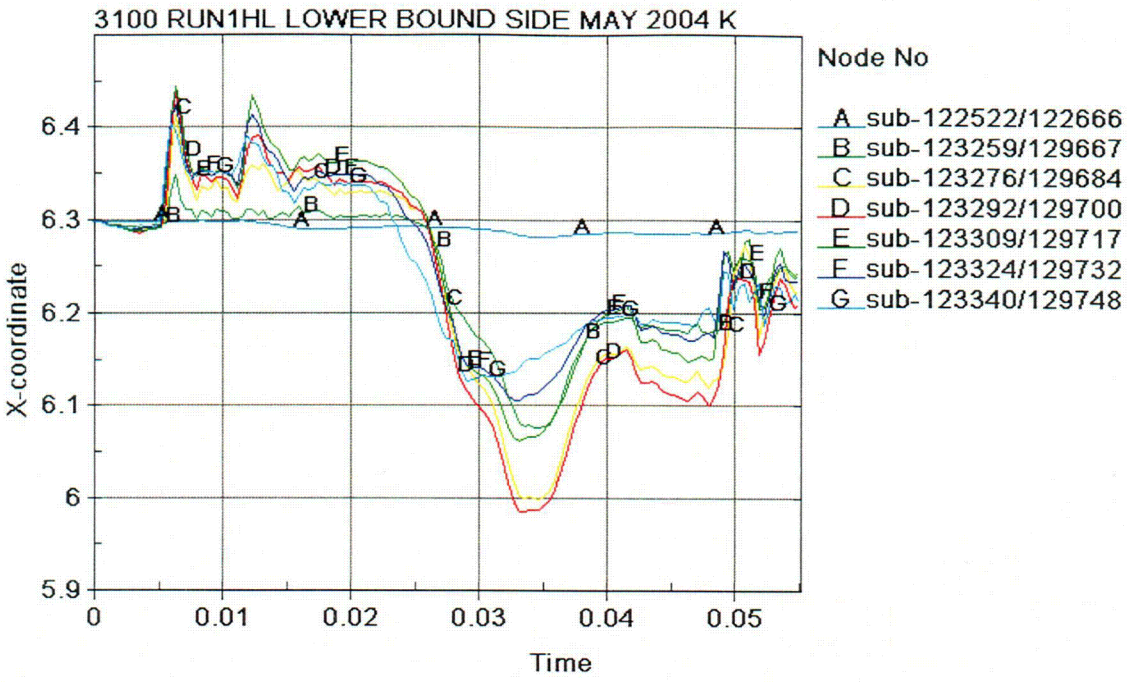

Figure 3.3.23 - Run1hl, Liner Diameter Time History

3.4 Run1hh - Side

Run1hh is the upper bounding kaolite run(-40°). It is basically the run1g model, but with the upper bound kaolite properties of section 2.3.5.3. It is a run with a 4-foot impact (time = 0 to 0.01 seconds), followed by a 30-foot impact (0.01 to 0.0188 seconds), followed by a 30-foot crush impact (0.0188 to 0.04 seconds), finally followed by a 40-inch punch impact (0.04 to 0.052 seconds).

The final configuration for the 4-foot impact is shown in Figure 3.4.1. Figures 3.4.2 and 3.4.3 show the configuration at the corners of the shipping package. The effective plastic strain in the CV body for the 4-foot impact is shown in Figure 3.4.4. The maximum effective plastic strain is shown to be 0.0298 in/in near the bottom head. The effective plastic strain in other package components for the 4-foot impact are listed in Table 3.4.1.

Table 3.4.1 - Run1hh, 4-Foot Impact, Effective Plastic Strain Levels in Some Components

Component	Effective Plastic Strain, in/in
CV Lid	0.0000
CV Nut Ring	0.0000
Angle	0.0059
Drum	0.1170
Drum Bottom Head	0.1215
Liner	0.0598
Lid	0.0860
Lid Stiffener	0.0000
Lid Studs	0.0000
Lid Stud Nuts	0.0000
Lid Stud Washers	0.0310
Plug Liner	0.0046

The final configuration for the 30-foot impact is shown in Figure 3.4.5. Figures 3.4.6 and 3.4.7 show the configuration at the corners of the package. The maximum effective plastic strain for the 30-foot impact in the CV Body is 0.0386 in/in near the bottom head. The maximum effective plastic strain in the drum lid is 0.4073 in/in near the rigid plane.

The effective plastic strain in other components for the 30-foot impact are given in Table 3.4.2.

Table 3.4.2 - Run1hh, 30-Foot Impact, Effective Plastic Strain Levels in Some Components	
Component	Effective Plastic Strain, in/in
CV Lid	0.0000
CV Nut Ring	0.0000
Angle	0.0622
Drum	0.2259
Drum Bottom Head	0.2528
Liner	0.0970
Lid Stiffener	0.0069
Lid Studs	0.1226
Lid Stud Nuts	0.0000
Lid Stud Washers	0.0951
Plug Liner	0.0995

The final configuration for the crush impact is shown in Figure 3.4.10. The configuration at the extremes of the package are shown in Figure 3.4.11. The maximum effective plastic strain for the crush impact in the CV body is 0.0462 in/in, on the crush plate side near the lid end of the top inner weight as shown in Figure 3.4.12. The maximum effective plastic strain in the drum is 0.2623 in/in near the angle and the rigid plane (Figure 3.4.13). The maximum effective plastic strain in the drum lid is 0.6411 in/in (surface strain), Figure 3.4.14. The maximum occurs at the lid hole for the stud closest to the crush plate(180°). The membrane effective plastic strain is 0.4922 in/in at this location. The effective plastic strain in the studs is 0.1753 in/in as shown in Figure 3.4.15. The effective plastic strain in other components are listed in Table 3.4.3 for the crush impact.

Table 3.4.3 - Run1hh, Crush Impact, Effective Plastic Strain Levels in Some Components	
Component	Effective Plastic Strain, in/in
CV Lid	0.0004
CV Nut Ring	0.0000
Angle	0.0816
Drum Bottom Head	0.2807
Liner	0.2005
Lid Stiffener	0.0217
Lid Stud Nuts	0.0000
Lid Stud Washers	0.1034
Plug Liner	0.1258

The final configuration for the punch impact is shown in Figure 3.4.16. The maximum effective plastic strain in the CV body after the punch impact is shown to be 0.0599 in/in in Figure 3.4.17. The maximum effective plastic strain in the drum is 0.2623 in/in (surface strain) and is located near the angle at the rigid surface. The maximum effective plastic strain in elements local to the punch impact is 0.1382 in/in (surface strain) as shown in the insert in Figure 3.4.18. The maximum effective plastic strain for the lid and other package components at the end of the punch impact are listed in Table 3.4.4.

Table 3.4.4 - Run1hh, Punch Impact, Effective Plastic Strain Levels in Some Components	
Component	Effective Plastic Strain, in/in
CV Lid	0.0004
CV Nut Ring	0.0000
Angle	0.0816
Drum Bottom Head	0.2807
Liner	0.2027
Lid	0.6411
Lid Stiffener	0.0217
Lid Studs	0.1761
Lid Stud Nuts	0.0000
Lid Stud Washers	0.1034
Plug Liner	0.1258

Figure 3.4.19 shows the CV lid separation for all the impacts. A maximum spike for the lid separation of less than 0.008 inches is found. At the end of the impacts, the maximum separation is on the order of 0.006 in, with the response being oscillatory in nature. Average separation of 0.003 inches or less is shown to be expected after the successive impacts.

Figure 3.4.20 shows the drum diameter time history response to the impacts in the X direction (direction of the impacts). Figure 3.4.21 shows the Y direction radial response (normal to the impact direction). The drum nodes are defined in Figure 3.1.34.

The Figure 3.4.22 shows the kaolite thickness time history for the four impacts. Figure 3.1.32 shows the nodal locations.

Figure 3.4.23 shows the liner diameter time history along its length. The nodal pairs are defined in Figure 3.1.37 and Table 3.1.3.

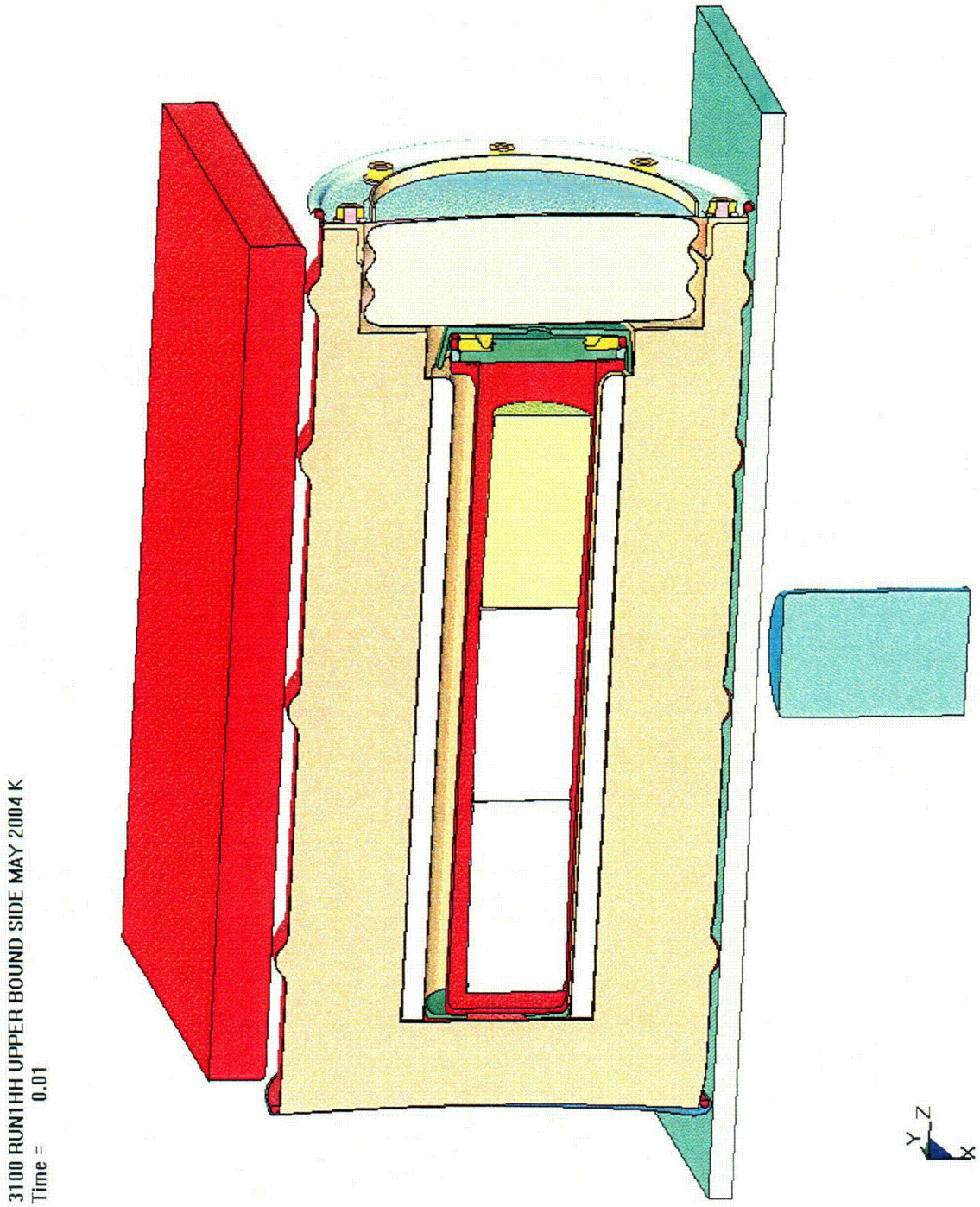

Figure 3.4.1 - Run1hh, 4-Foot Impact, Final Configuration

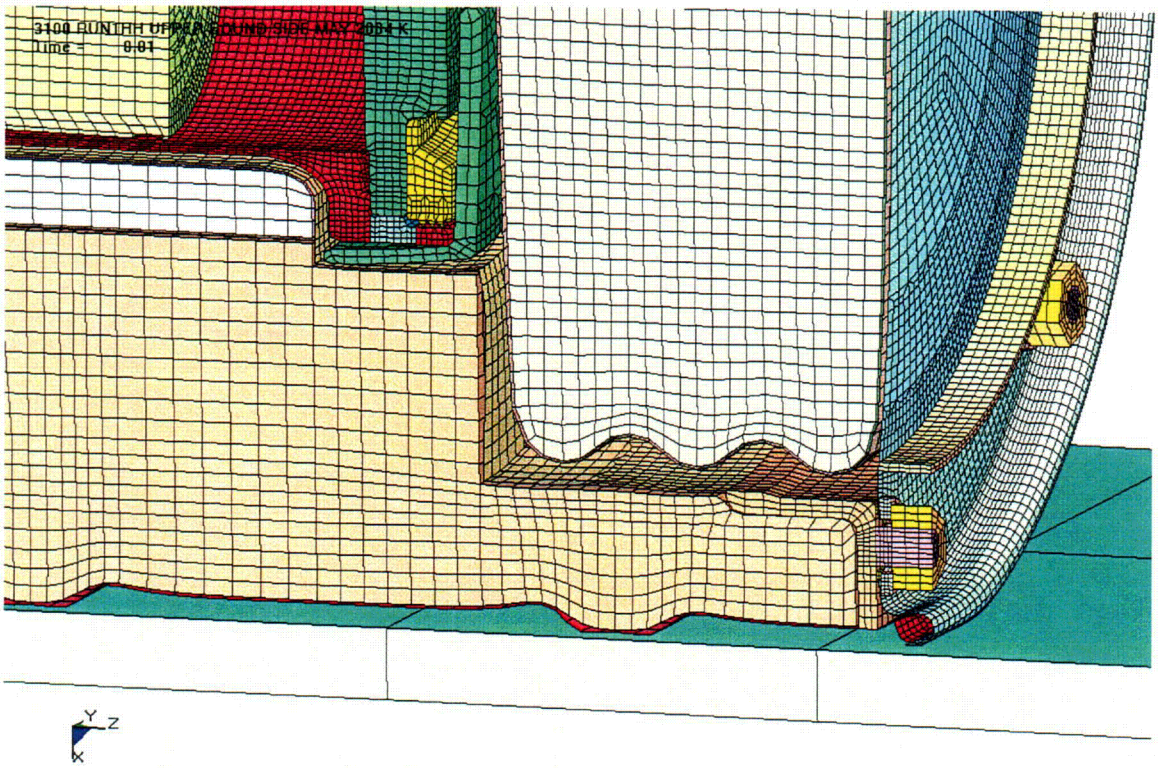

Figure 3.4.2 - Run1hh, 4-Foot Impact,

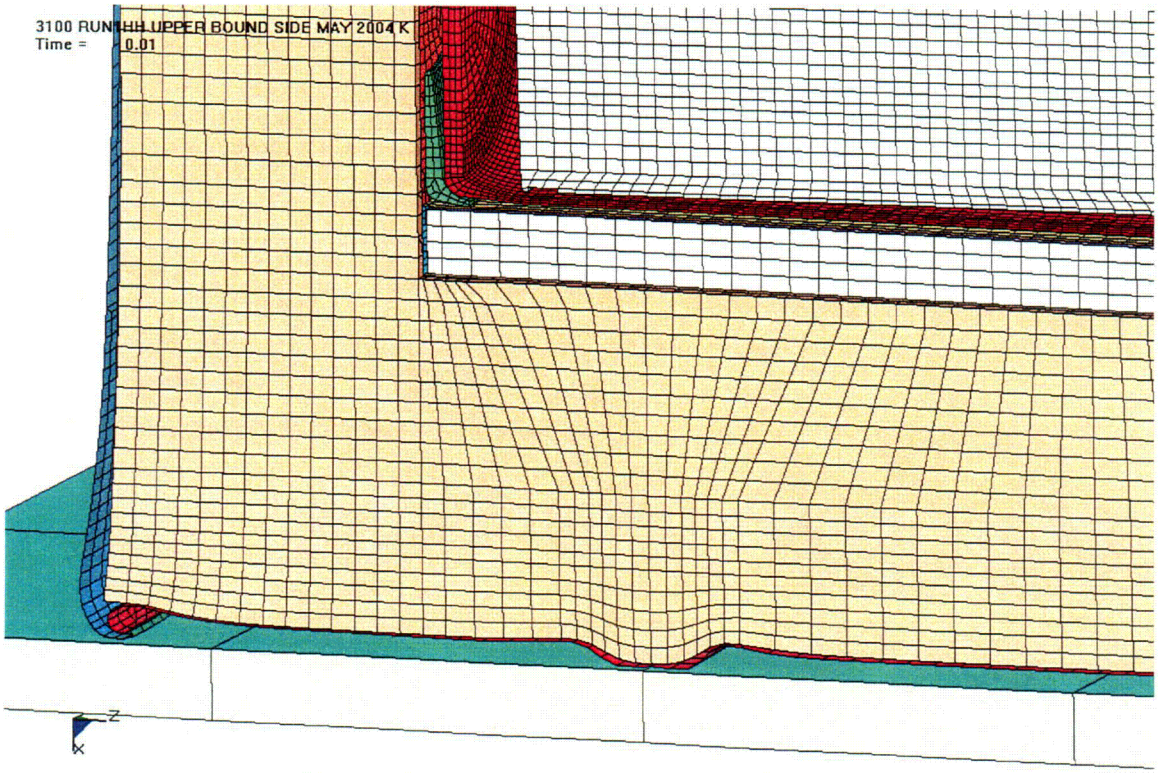

Figure 3.4.3 - Run1hh, 4-Foot Impact,

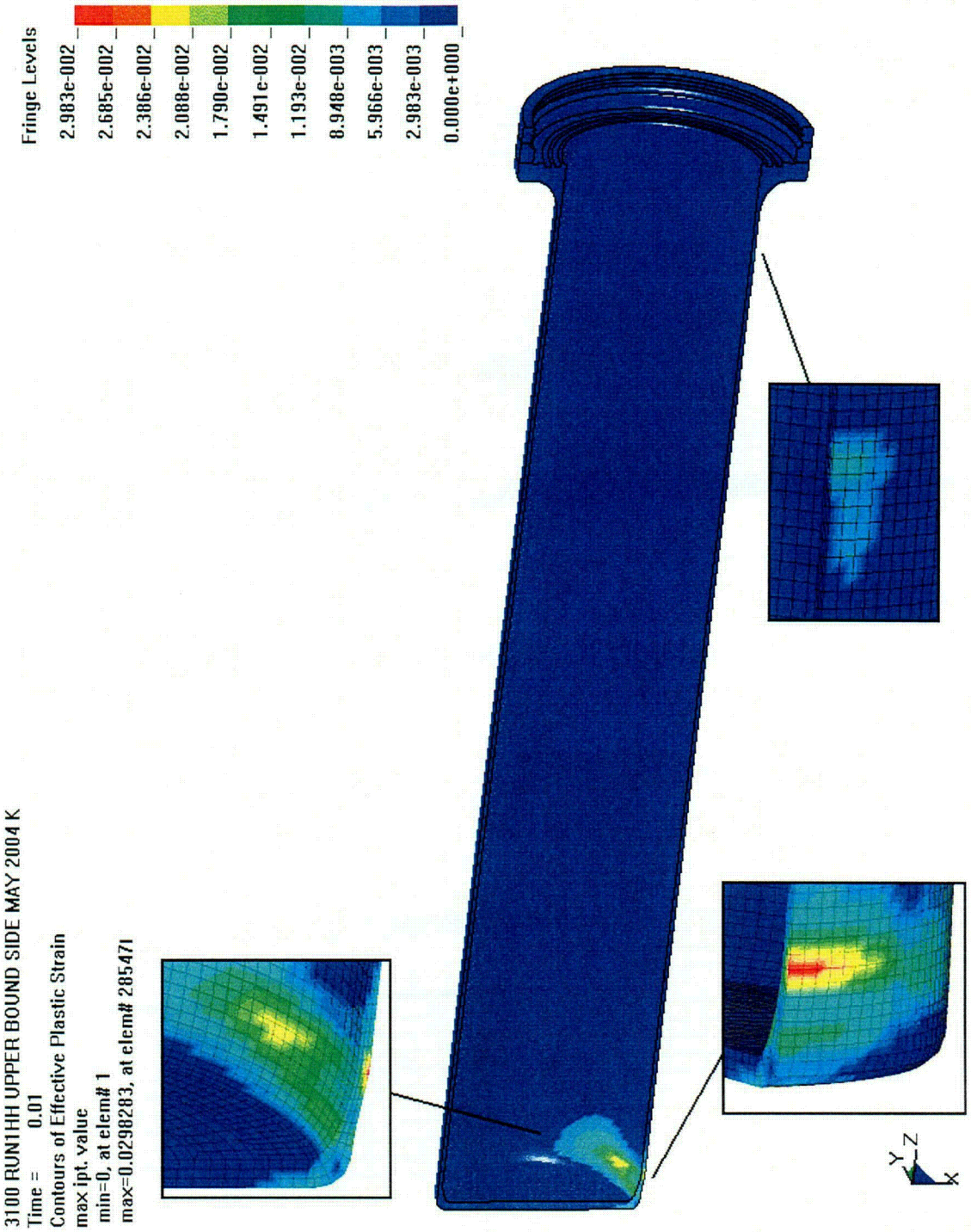

Figure 3.4.4 - Run1hh, 4-Foot Impact, Effective Plastic Strain in the CV Body

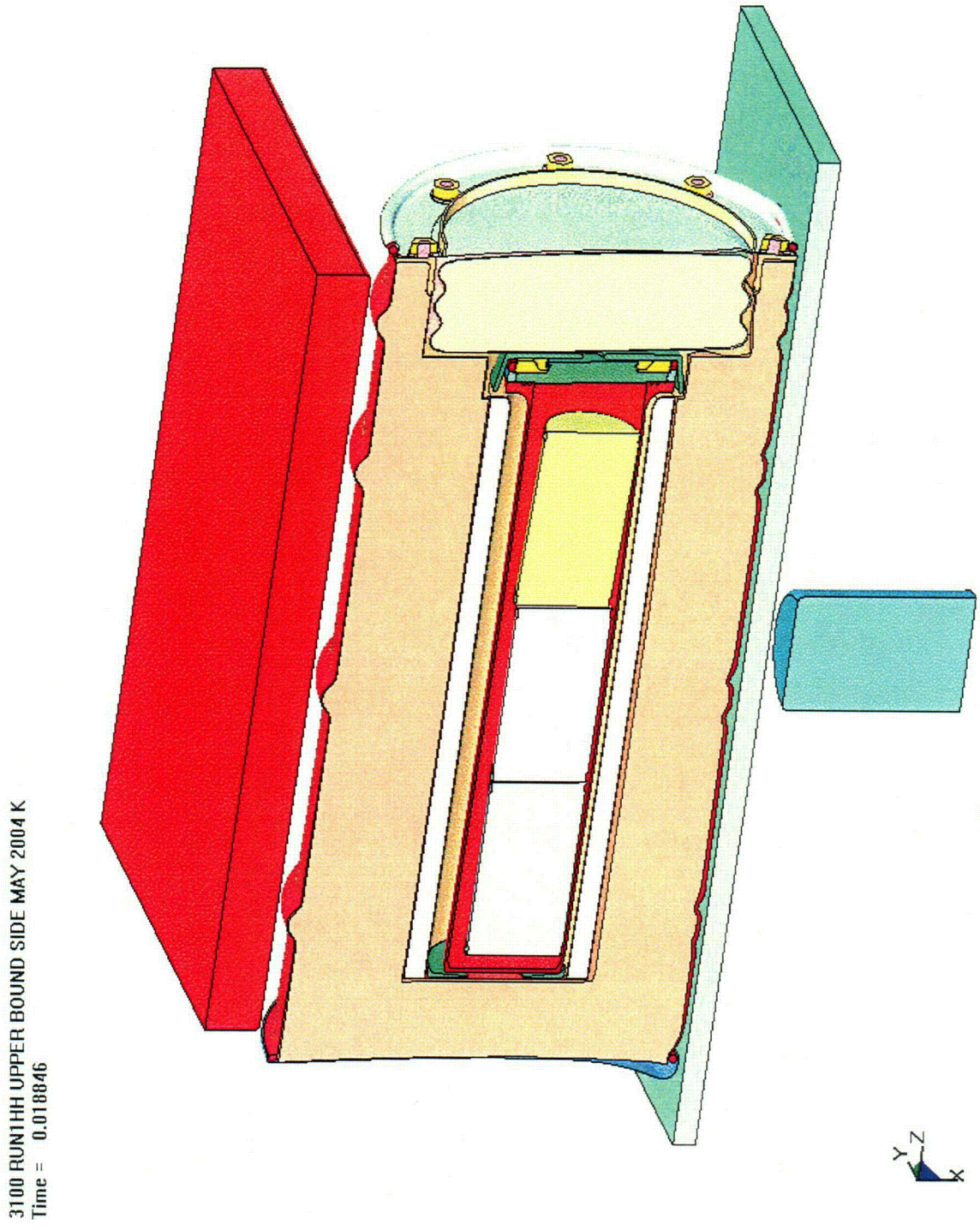

Figure 3.4.5 - Run1hh, 30-Foot Impact, Final Configuration

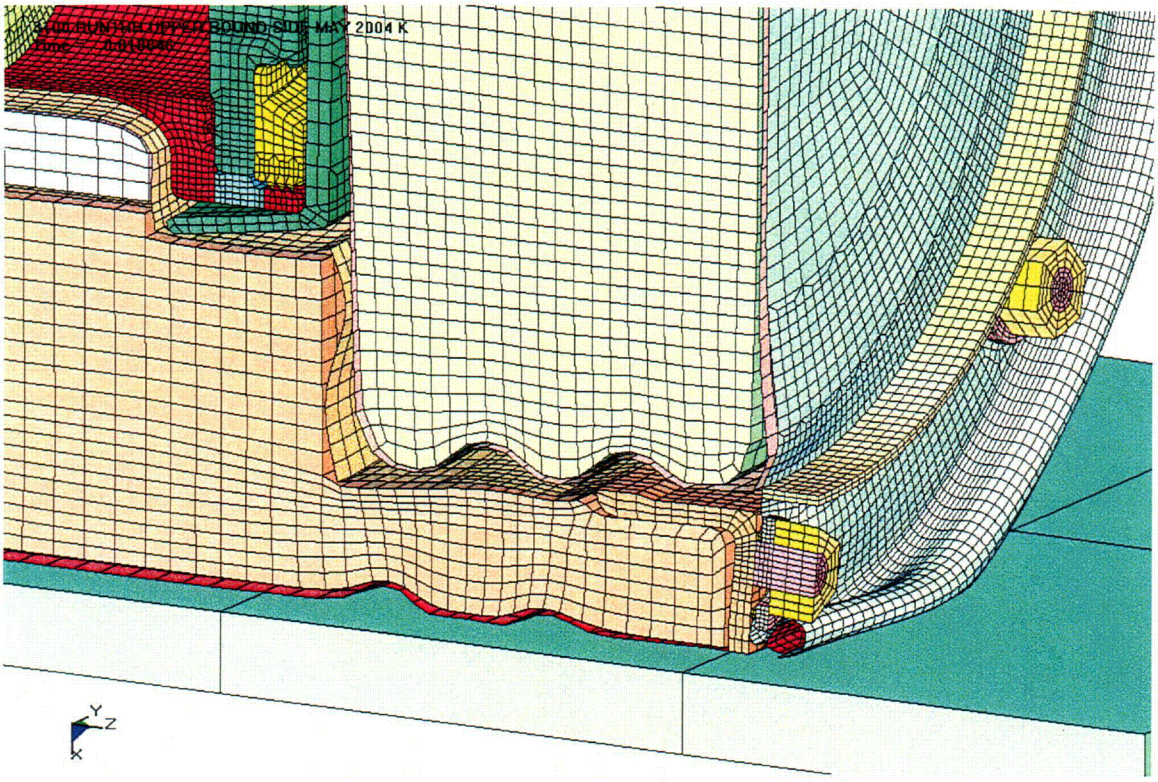

Figure 3.4.6 - Run1hh, 30-Foot Impact, Configuration in the Lid

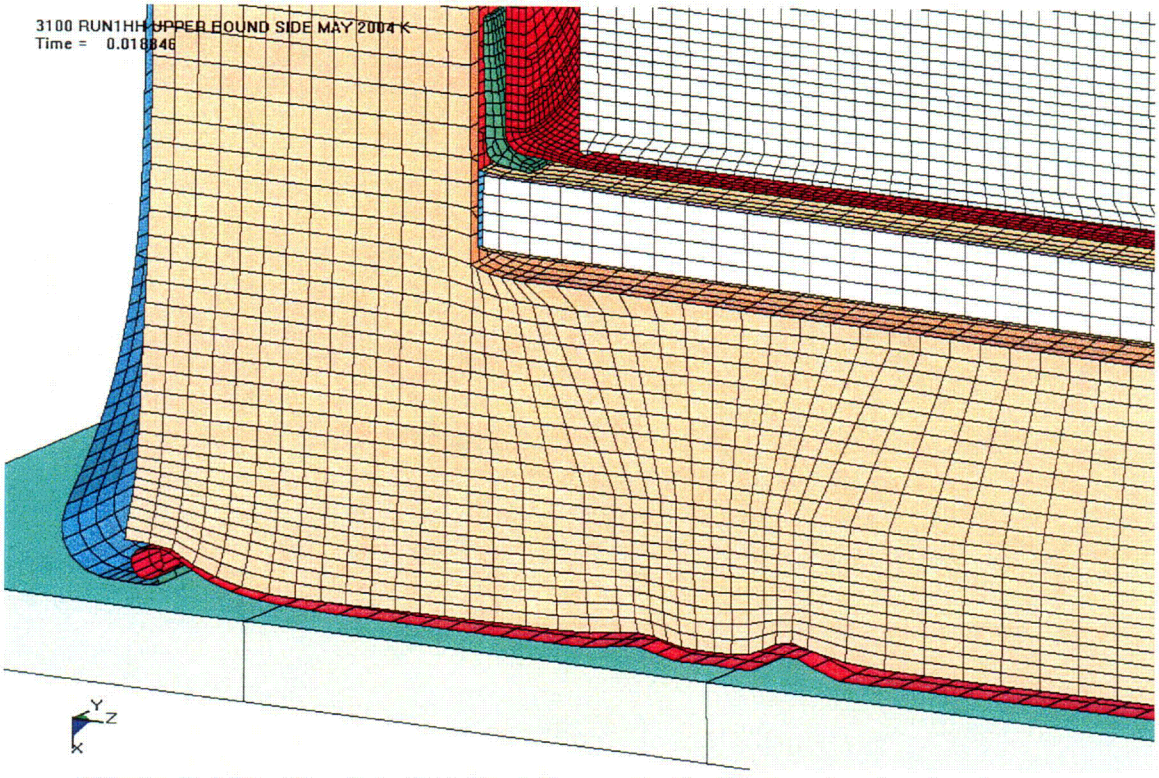

Figure 3.4.7 - Run1hh, 30-Foot Impact, Configuration in the Bottom

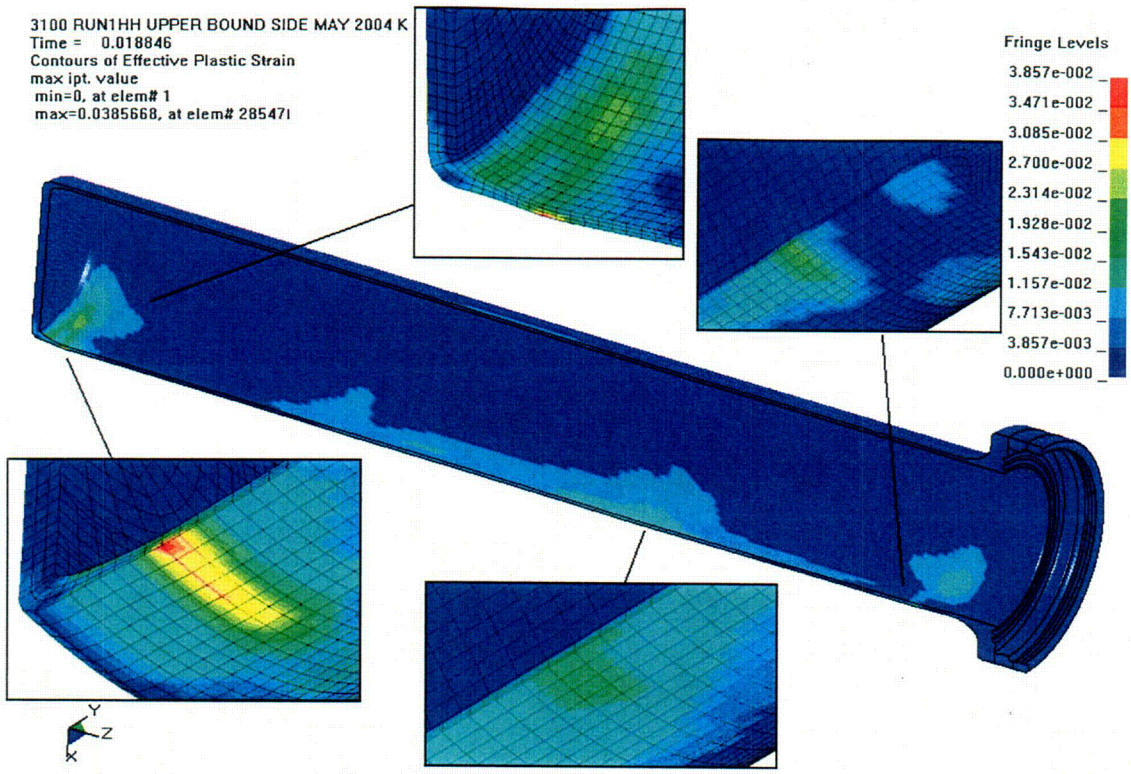

Figure 3.4.8 - Run1hh, 30-Foot Impact, Effective Plastic Strain in the CV Body

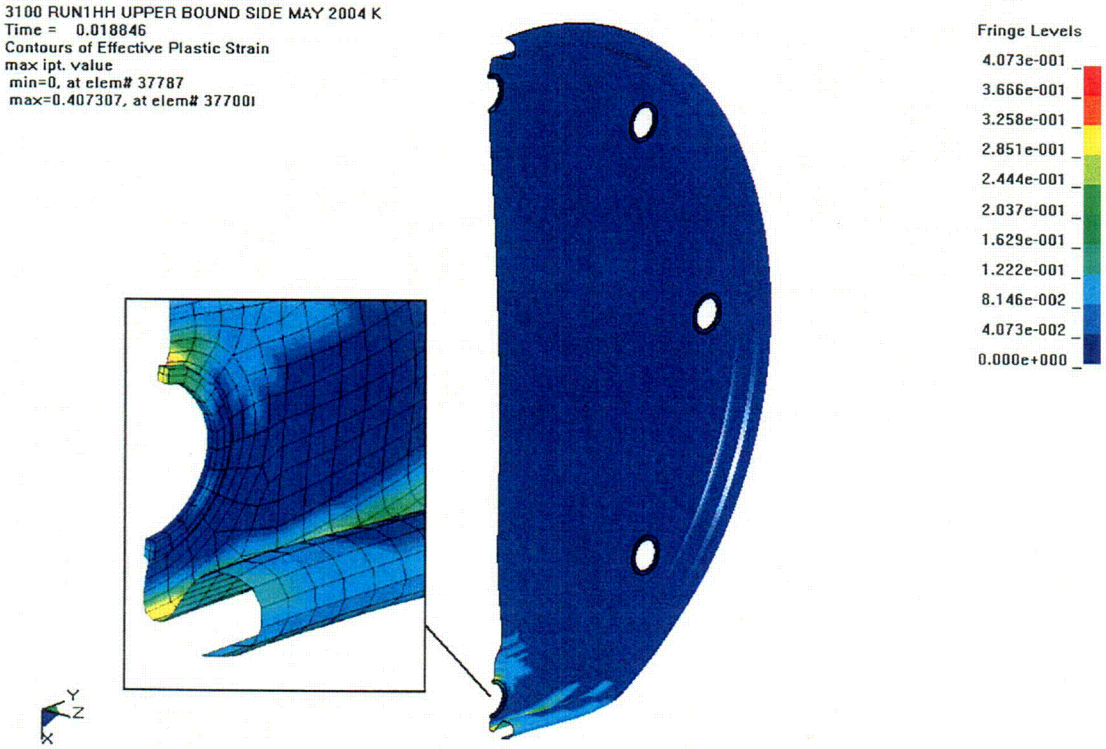

Figure 3.4.9 - Run1hh, 30-Foot Impact, Effective Plastic Strain in the Lid

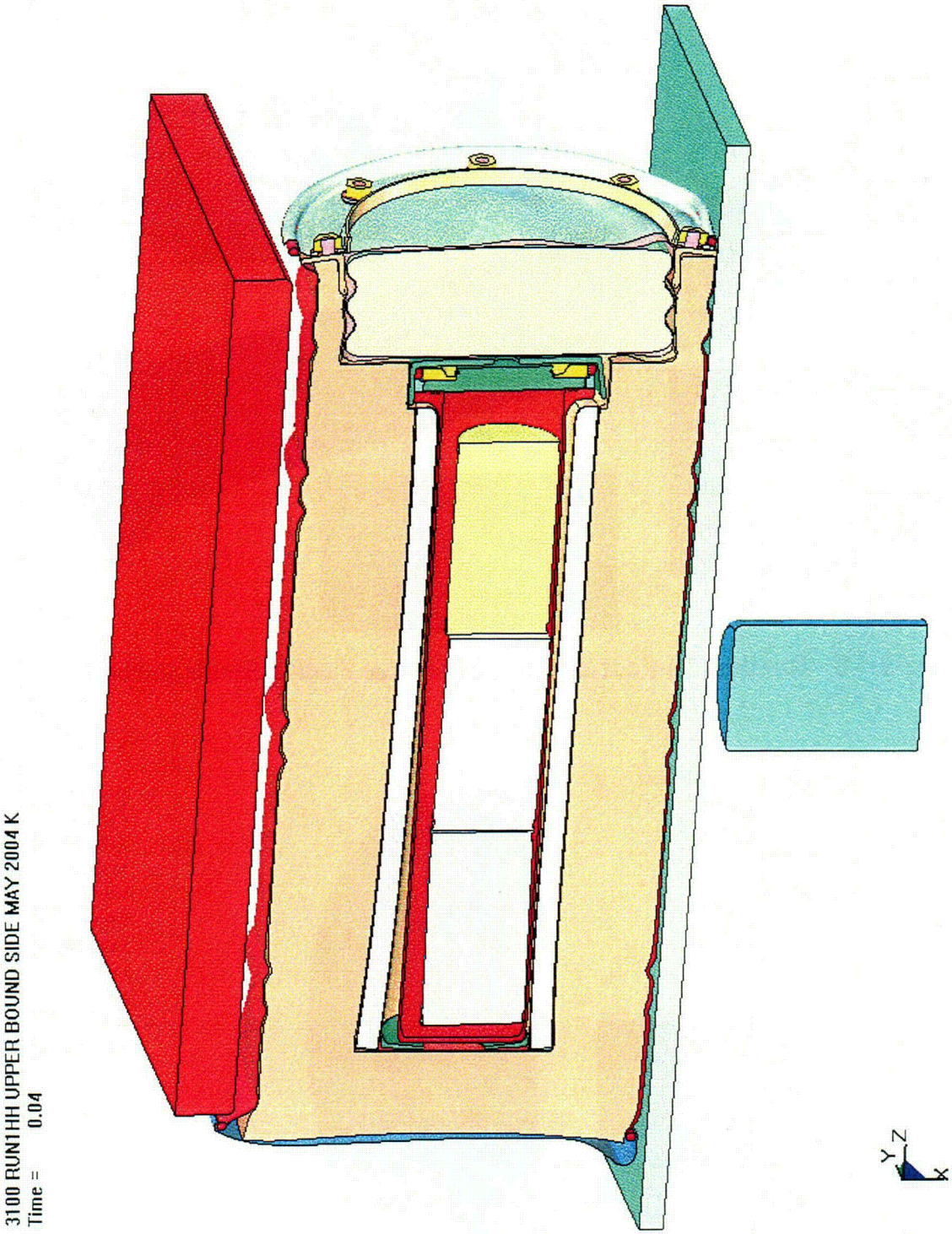

Figure 3.4.10 - Run1hh, Crush Impact, Final Configuration

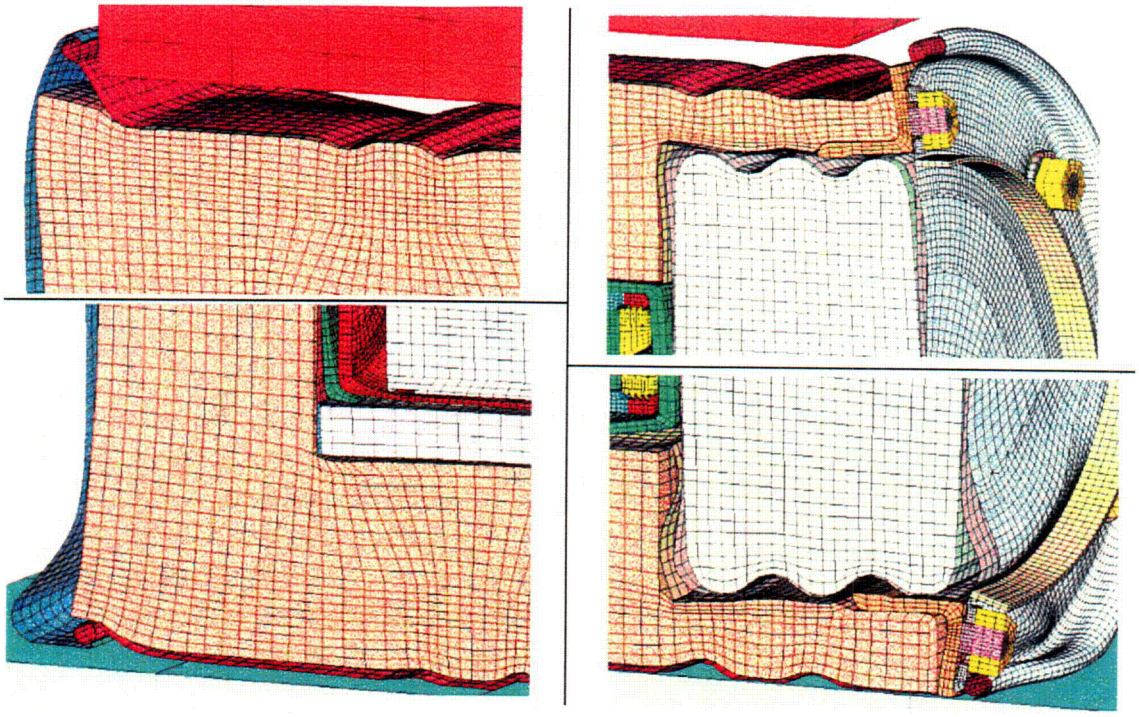

Figure 3.4.11 - Run1hh, Crush Impact, Configuration of the Package Corners

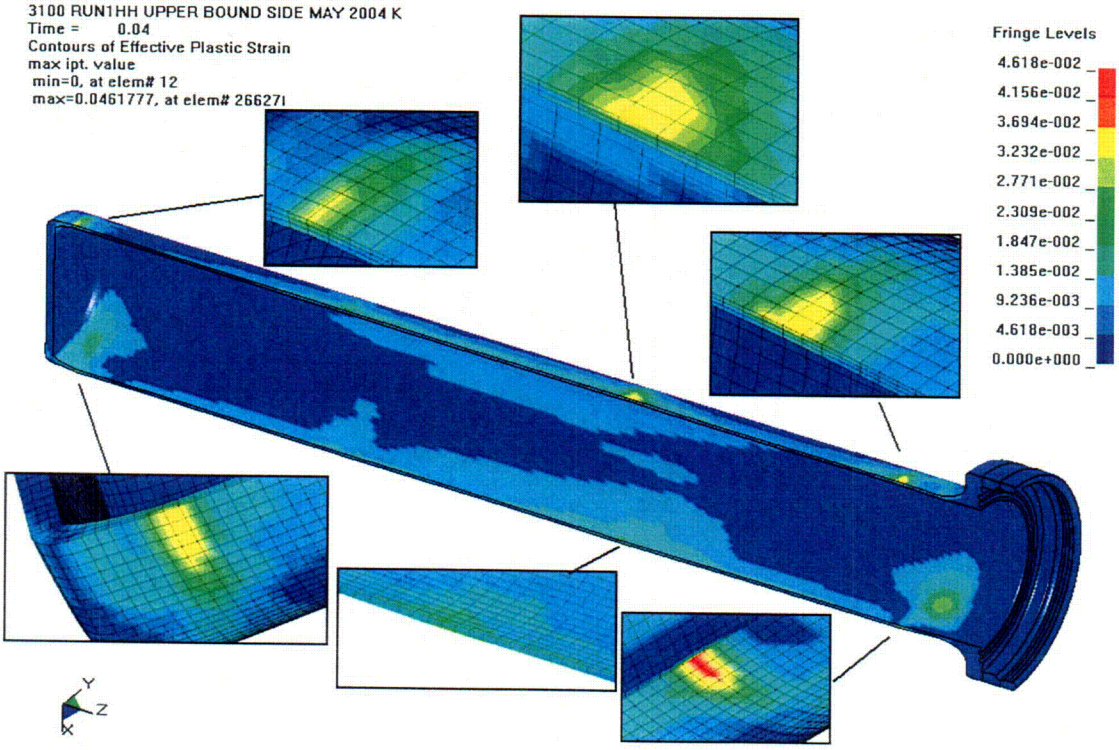

Figure 3.4.12 - Run1hh, Crush Impact, Effective Plastic Strain in the CV Body

C96

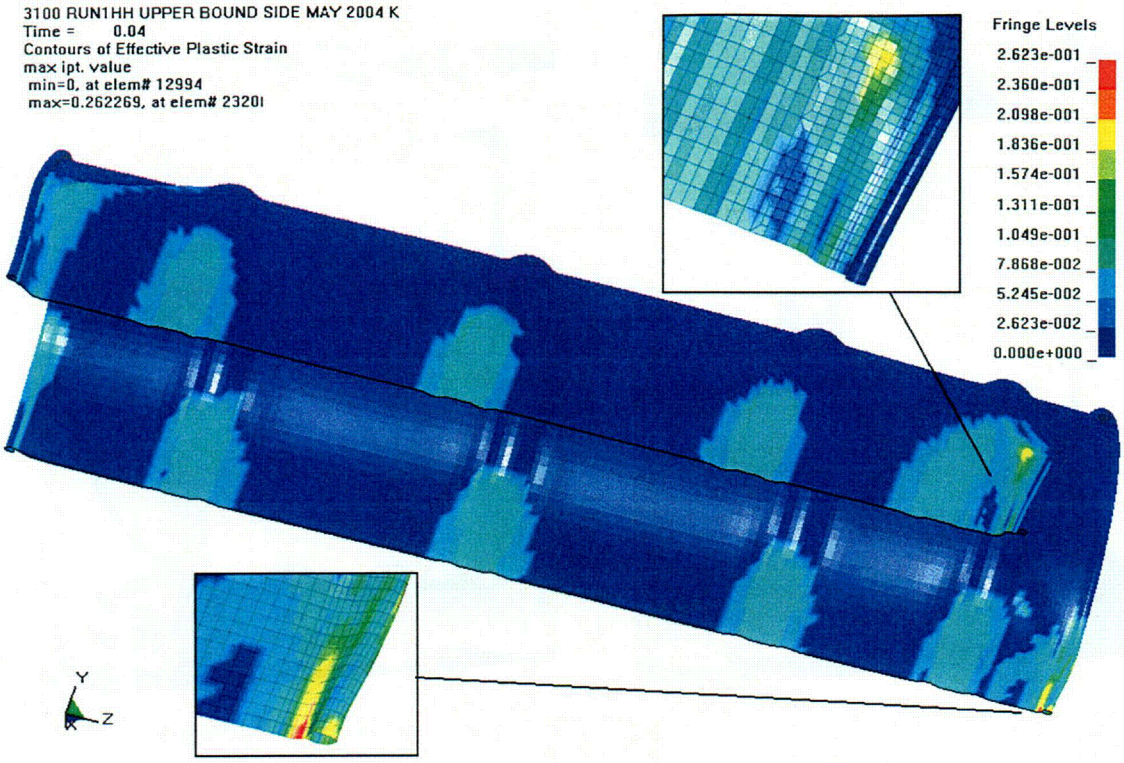

Figure 3.4.13 - Run1hh, Crush Impact, Effective Plastic Strain in the Drum

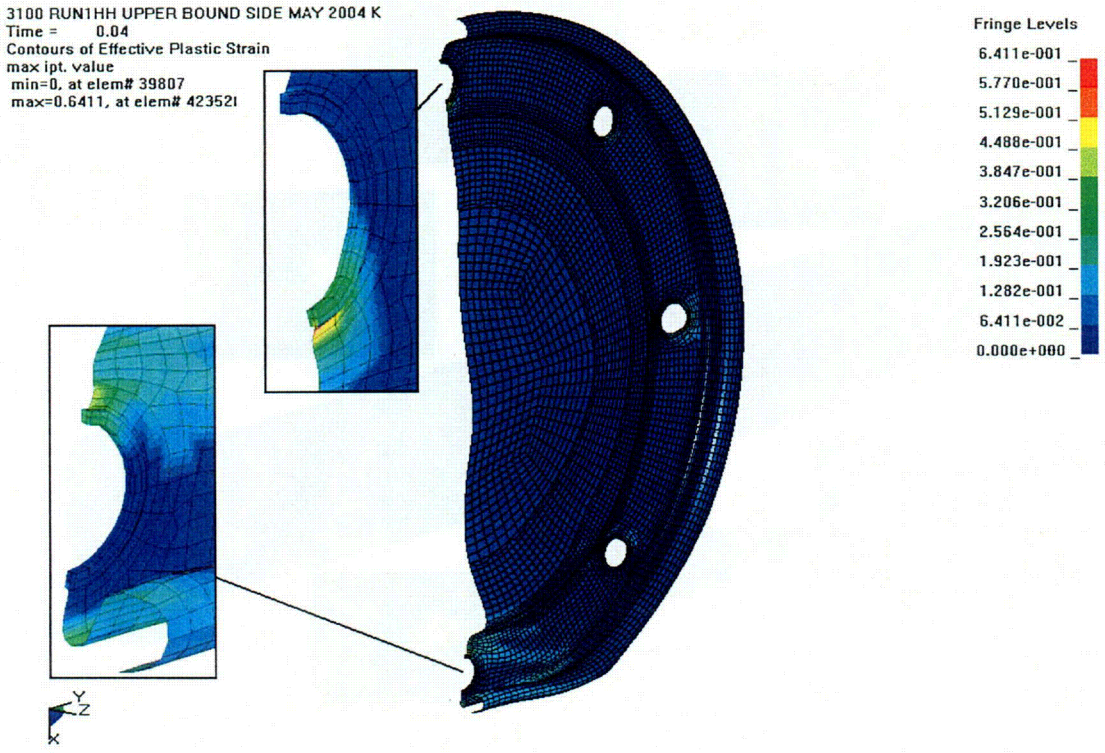

Figure 3.4.14 - Run1hh, Crush Impact, Effective Plastic Strain in the Lid

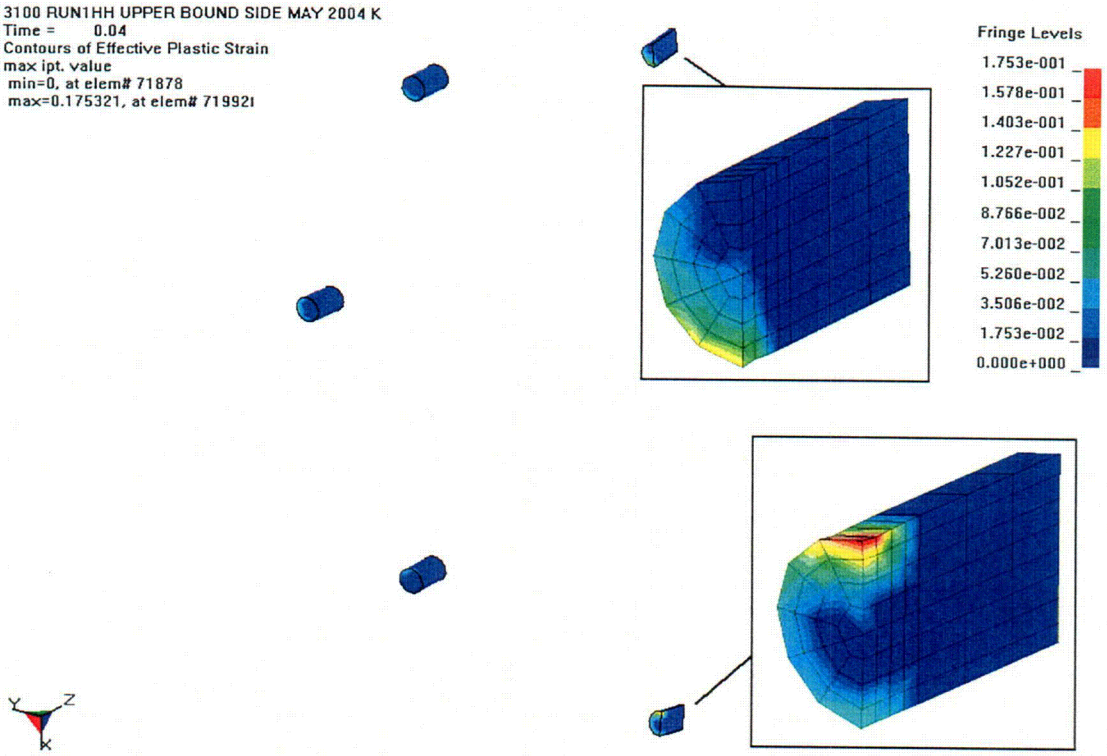

Figure 3.4.15 - Run1hh, Crush Impact, Effective Plastic Strain in the Studs

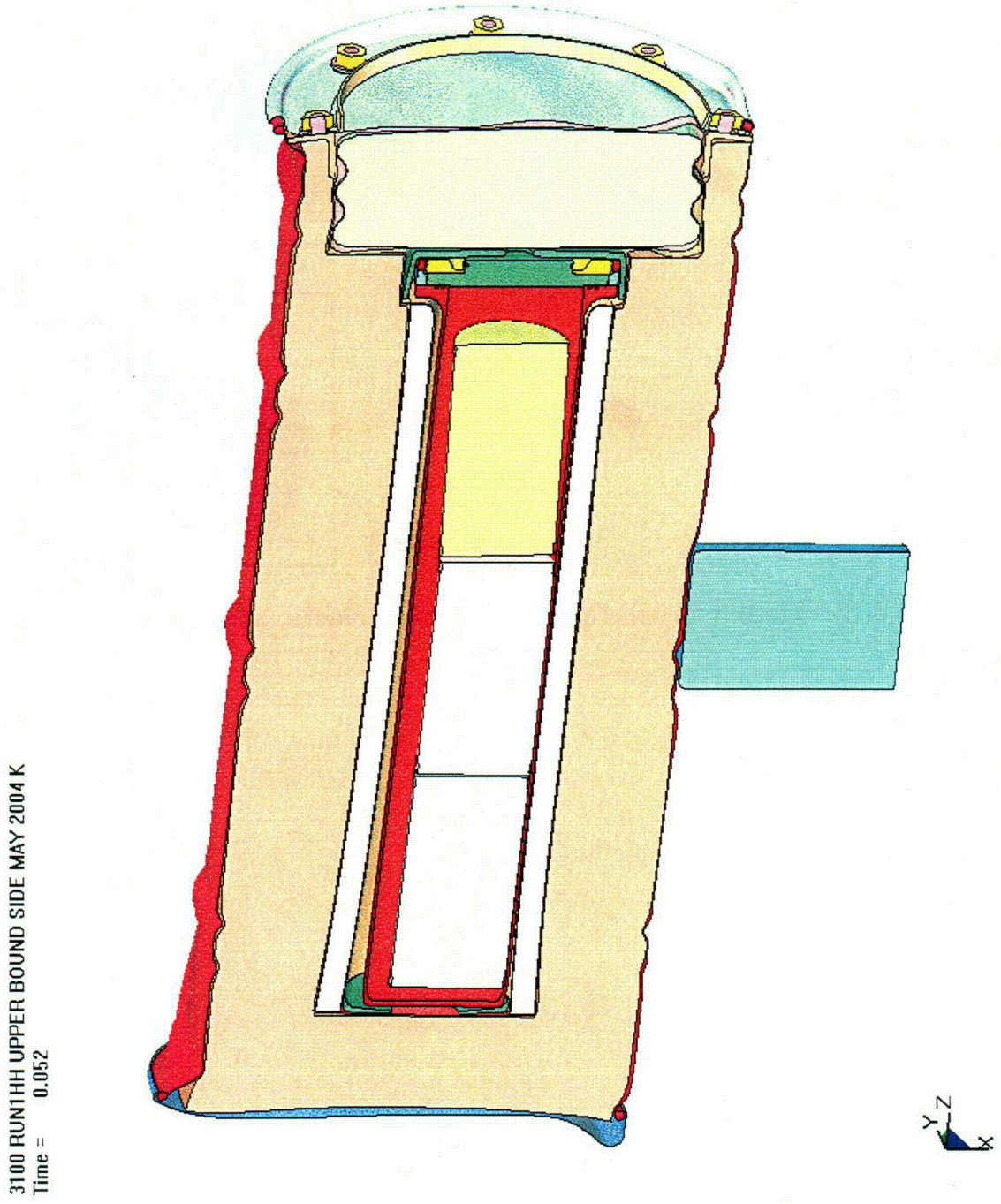

Figure 3.4.16 - Run1hh, Punch Impact, Final Configuration

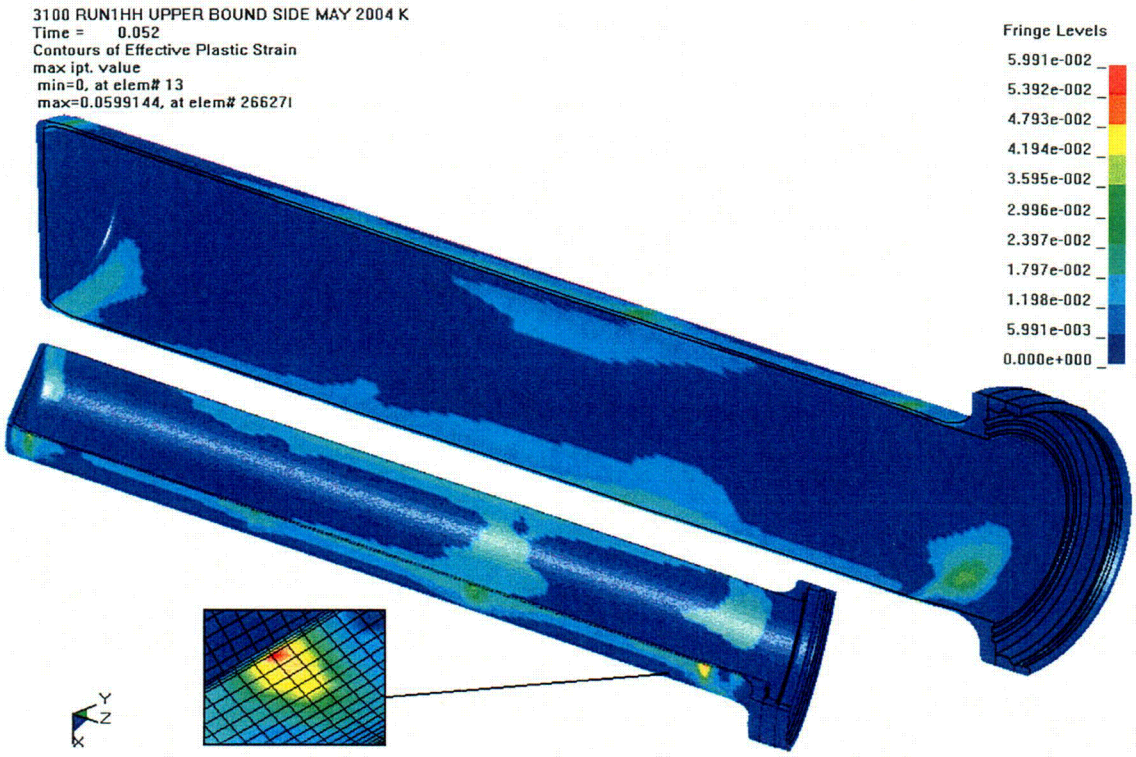

Figure 3.4.17 - Run1hh, Punch Impact, Effective Plastic Strain in the CV Body

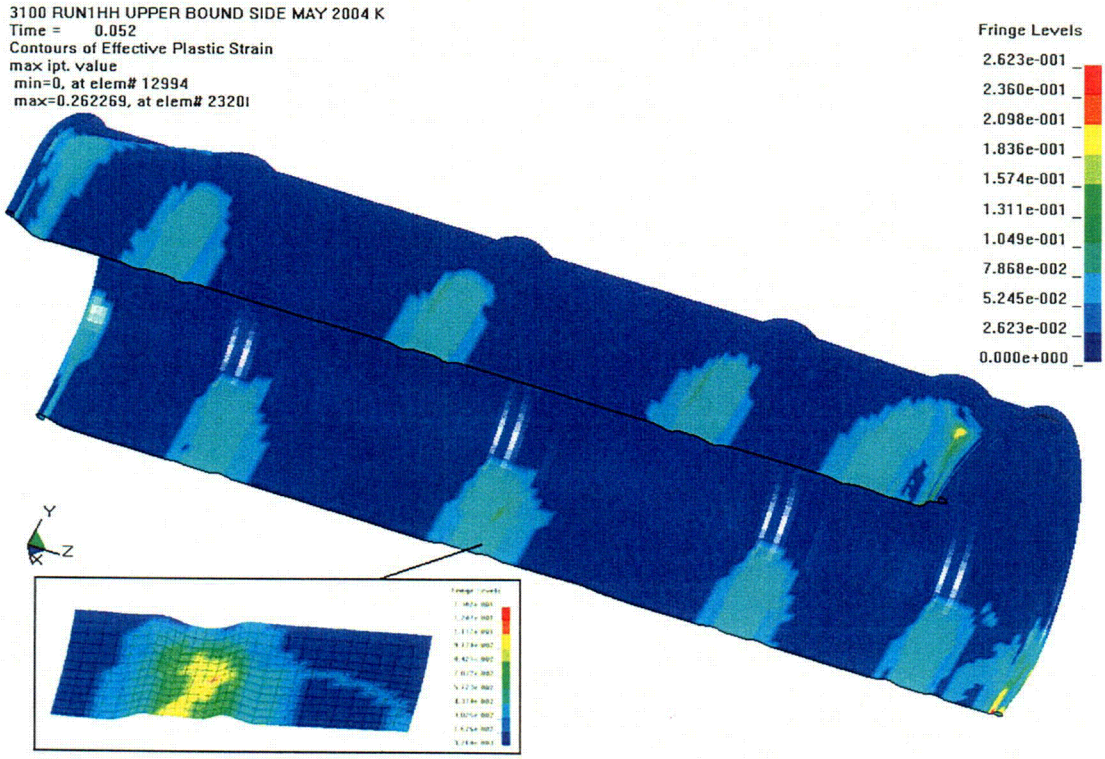

Figure 3.4.18 - Run1hh, Punch Impact, Effective Plastic Strain in the Drum

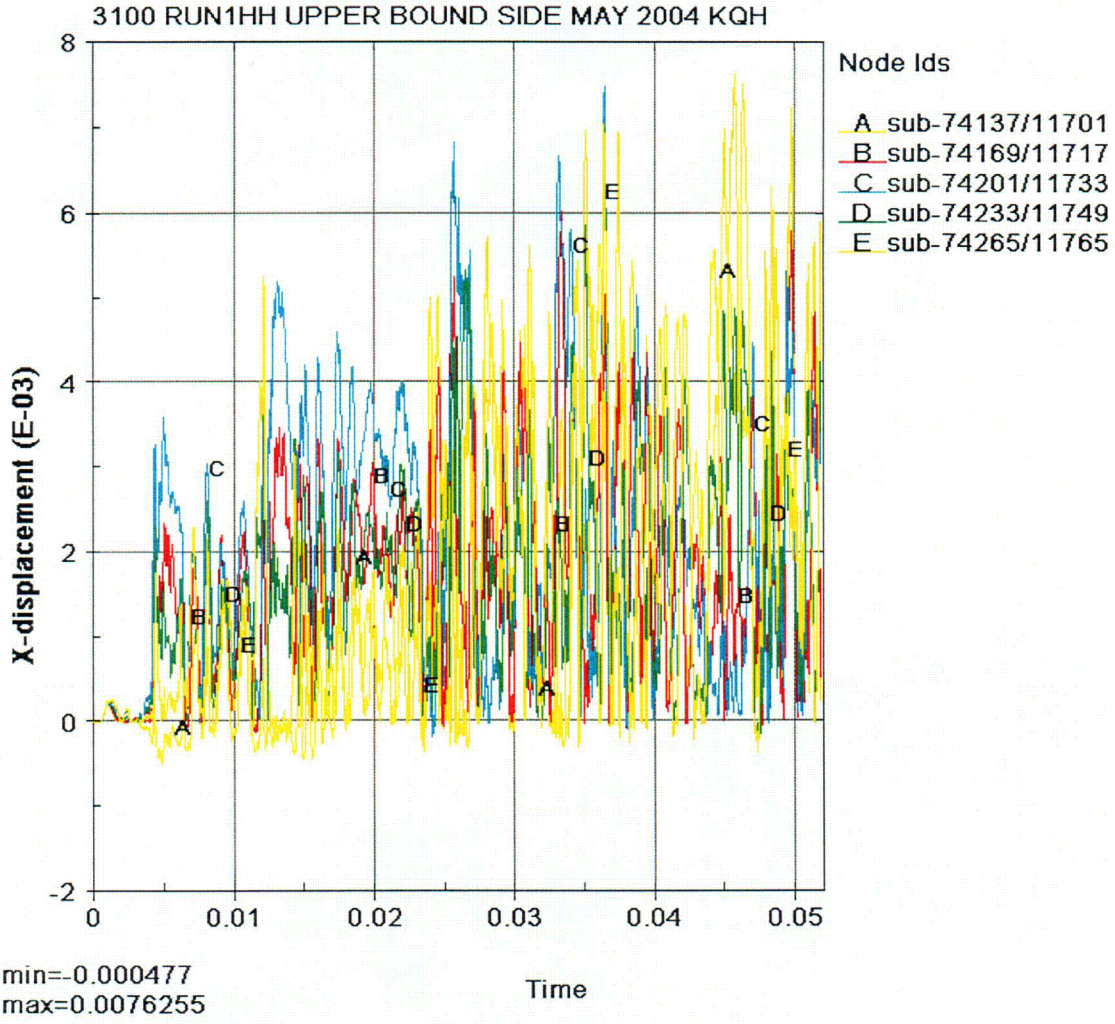

Figure 3.4.19 - Run1hh, CV Lid Separation Time History

C101

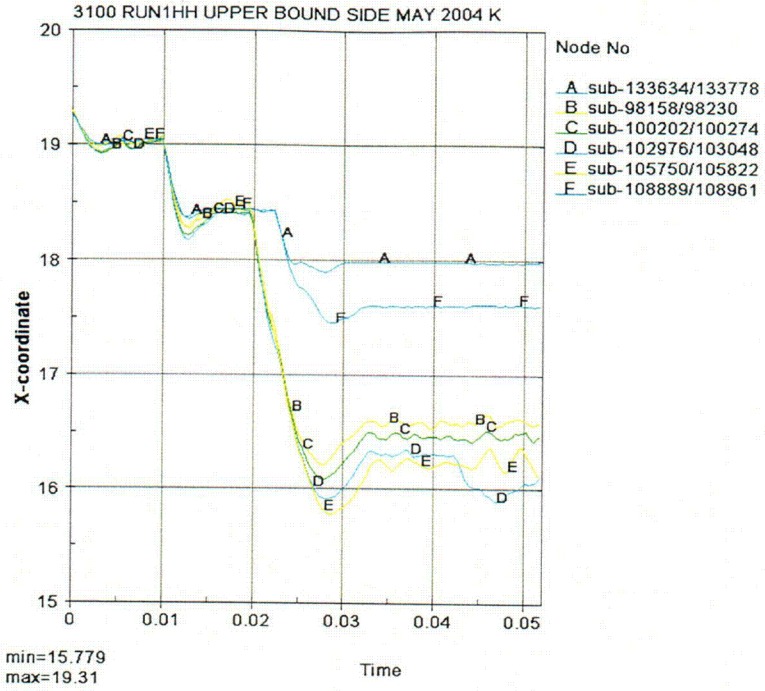

Figure 3.4.20 - Run1hh, Diameter of the Drum in the Direction of the Impacts

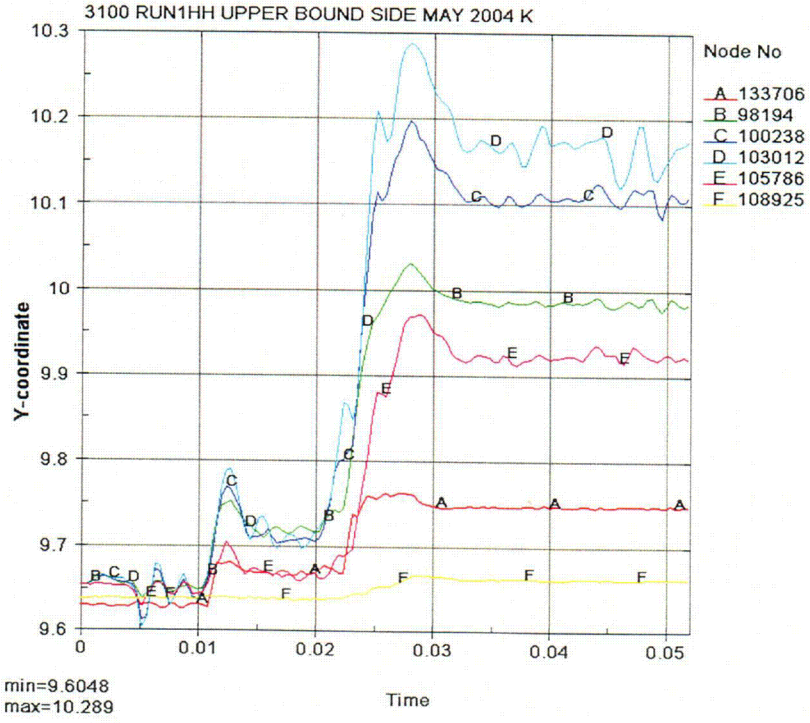

Figure 3.4.21 - Run1hh, Radius of the Drum in the Direction Normal to the Impacts

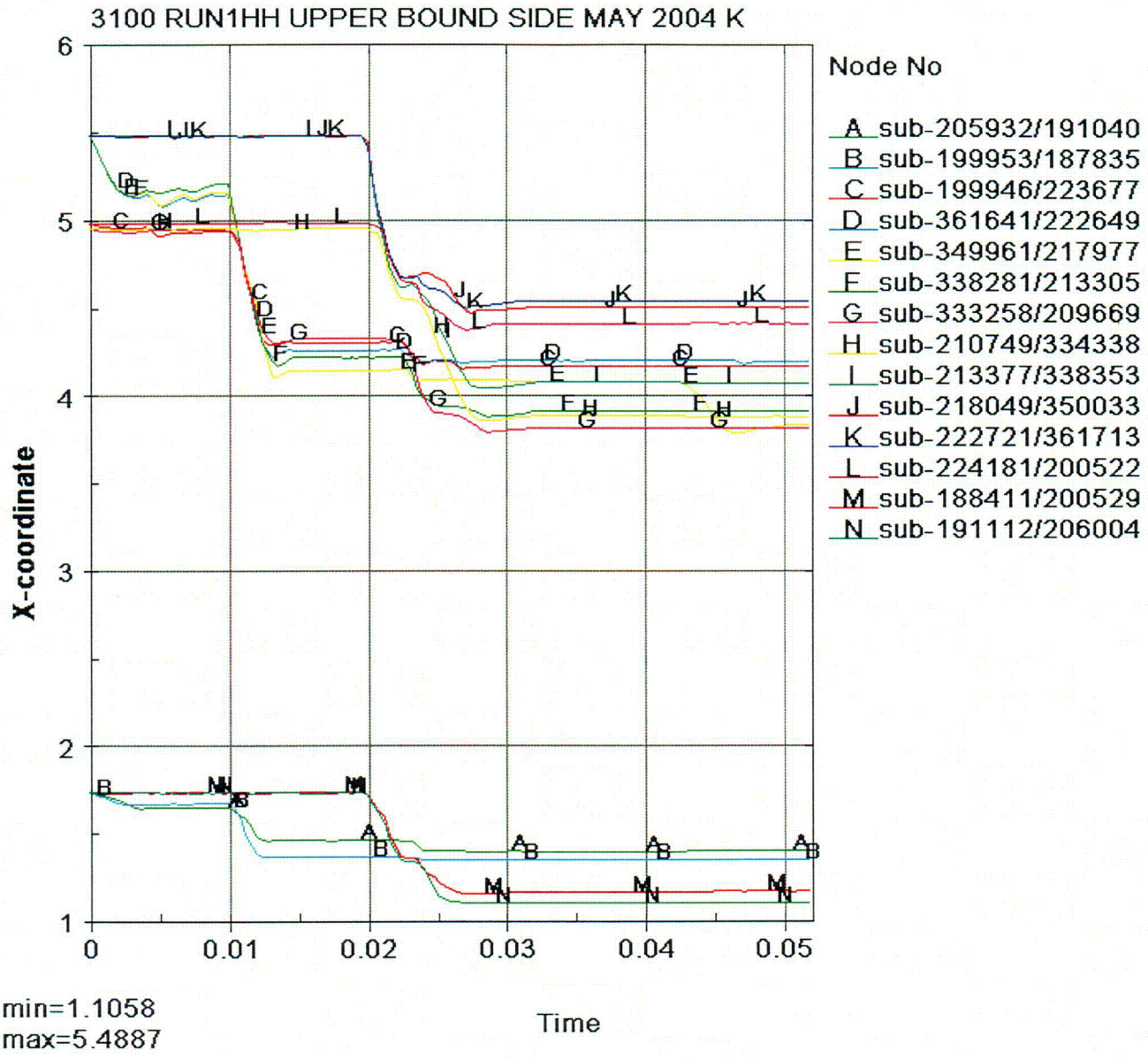

Figure 3.4.22 - Run1hh, Thickness Time History of the Drum Kaolite

C103

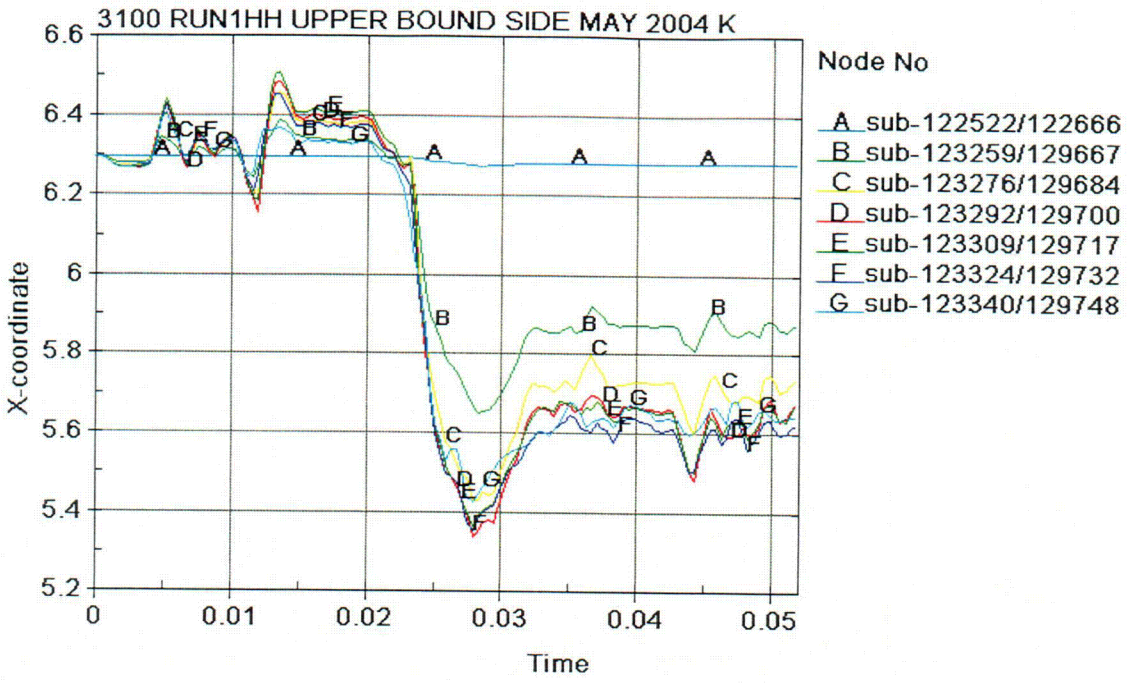

Figure 3.4.23 - Run1hh, Liner Diameter Time Histories

3.5 Run2e - Corner

Run2e is a package CG over corner impact with a 30-foot impact (time = 0 to 0.015 seconds)followed by a crush impact (0.015 to 0.05 seconds).

The configuration after the 30-foot impact is shown in Figure 3.5.1. The maximum effective plastic strain in the lid studs is in the stud at the impact with the rigid plane (0°) and is 0.5197 in/in as shown in Figure 3.5.2. It can be seen from the insert in Figure 3.5.2, that strains near the maximum exist across the thickness of the stud. Therefore, it should be noted that slight differences between the modeled length and actual length of the stud could be significant relative to possible failure of the stud. Other differences such as friction and local flexibility in the test pad armored plate (stud "digging in") could also significantly effect this stud and cause failure. The maximum effective plastic strain of other components for this impact are listed in Table 3.5.1.

Table 3.5.1 - Run2e, 30-Foot Impact, Effective Plastic Strain Levels in Some Components

Component	Effective Plastic Strain, in/in
CV Body	0.0142
CV Lid	0.0024
CV Nut Ring	0.0000
Angle	0.0393
Drum	0.3238
Drum Bottom Head	0.0000
Liner	0.3797
Lid	0.2968
Lid Stiffener	0.0271
Lid Stud Nuts	0.2252
Lid Stud Washers	0.0907
Plug Liner	0.1131

Figure 3.5.3 shows the final configuration for the crush impact. In Figure 3.5.4 the maximum effective plastic strain in the CV lid is shown to remain at 0.0024 in/in. Figure 3.5.5 shows the effective plastic strain in the liner to be a maximum of 0.5507 in/in. The maximum effective plastic strain in the drum is in the crimping as shown in Figure 3.5.6 and is a maximum of 0.3787 in/in. The maximum effective plastic strain in the drum studs

is shown to be 0.5578 in/in in Figure 3.5.7. As explained in the 30-foot impact results, slight variances in the length/configuration in this vicinity could prove significant in the test due to the relatively high level of strain through the thickness of the stud. There is a crimping of the lid and the drum roll in this local region, hence, even if the stud did shear, the lid would be held captive by the drum roll.

Table 3.5.2 - Run2e, Crush Impact, Effective Plastic Strain Levels in Some Components

Component	Effective Plastic Strain, in/in
CV Body	0.0364
CV Nut Ring	0.0000
Angle	0.0464
Drum Bottom Head	0.0731
Lid	0.3579
Lid Stiffener	0.0272
Lid Stud Nuts	0.2258
Lid Stud Washers	0.1111
Plug Liner	0.1170

The lid separation time history is given in Figure 3.5.8. A spike separation occurs in the crush impact with a maximum gap of about 0.010 inches. The run2e was extended to about 0.06 seconds so that the ringing associated with the gap at 0.05 seconds could relax. From the figure it is seen that an average value of gap would be 0.002 inches, or less due to the oscillatory nature of the gap response.

Figure 3.5.9 shows the location of the nodes used to obtain the minimum koalite thickness in the package bottom. The time history thickness is shown in Figure 3.5.10 for the bottom kaolite. A minimum thickness of about 1.8 inches is shown.

Figure 3.5.11 shows the location of the nodes used to obtain the minimum kaolite thickness in the plug. Figure 3.5.12 shows the distance time history with the minimum being about 2.8 inches.

Figure 3.5.13 shows the nodes used to obtain overall drum dimensions for the impacts. The final lengths from the bottom head to the lid are used to describe the deformations. Curve A in Figure 3.5.14 gives the length response of the crush corner to the lid. It has a

final length of about 38.2 inches. Curve B in Figure 3.5.14 gives the length response from the initial 30-foot impact corner on the rigid surface to the bottom of the drum. This length has a final value of about 38.75 inches.

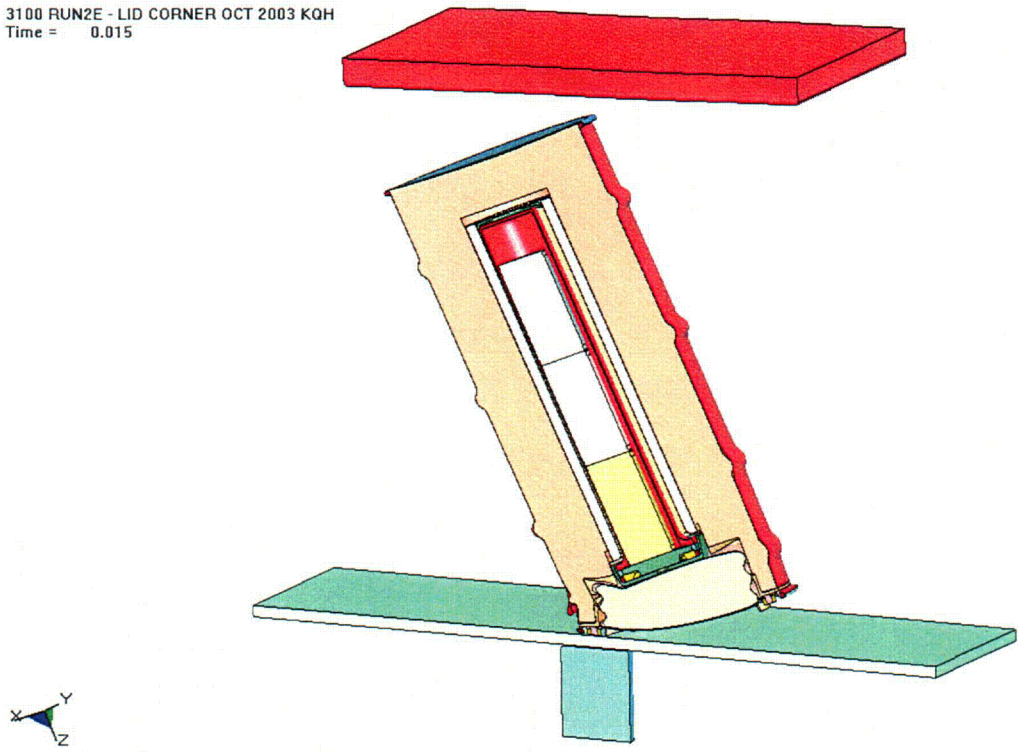

Figure 3.5.1 - Run2e, 30-Foot Impact, Final Configuration

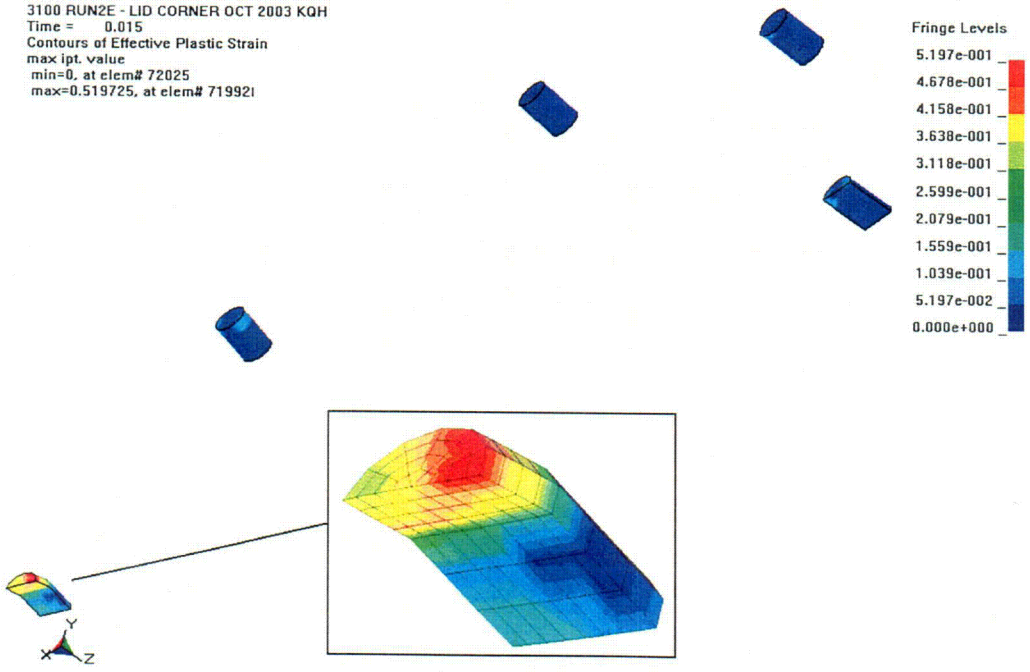

Figure 3.5.2 - Run2e, 30-Foot Impact, Effective Plastic Strain in the Drum Studs

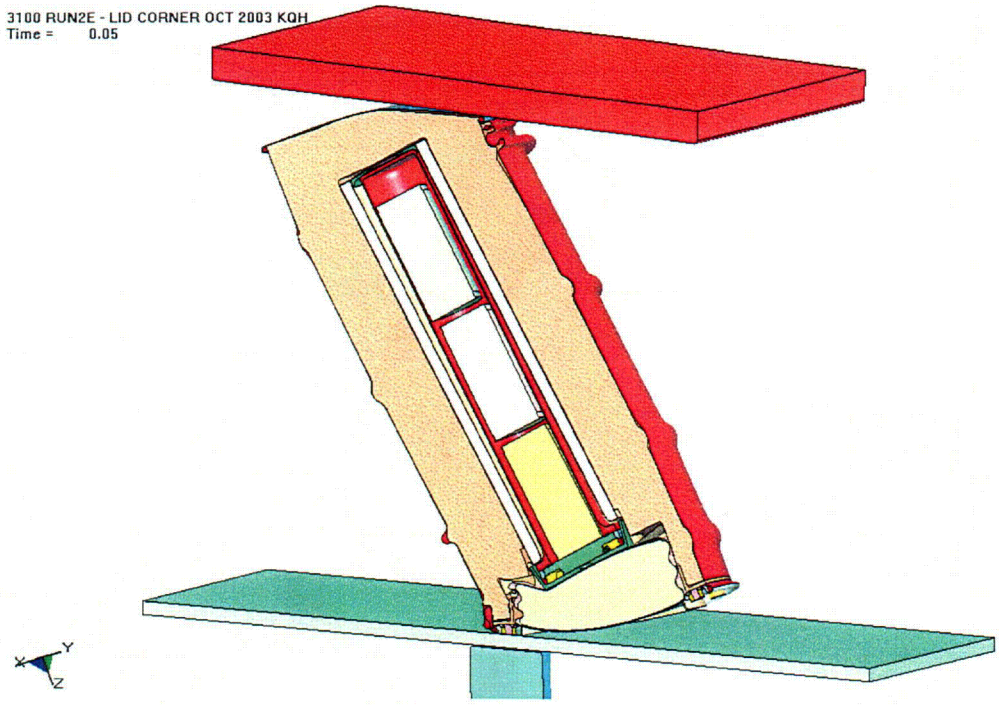

Figure 3.5.3 - Run2e, Crush Impact, Final Configuration

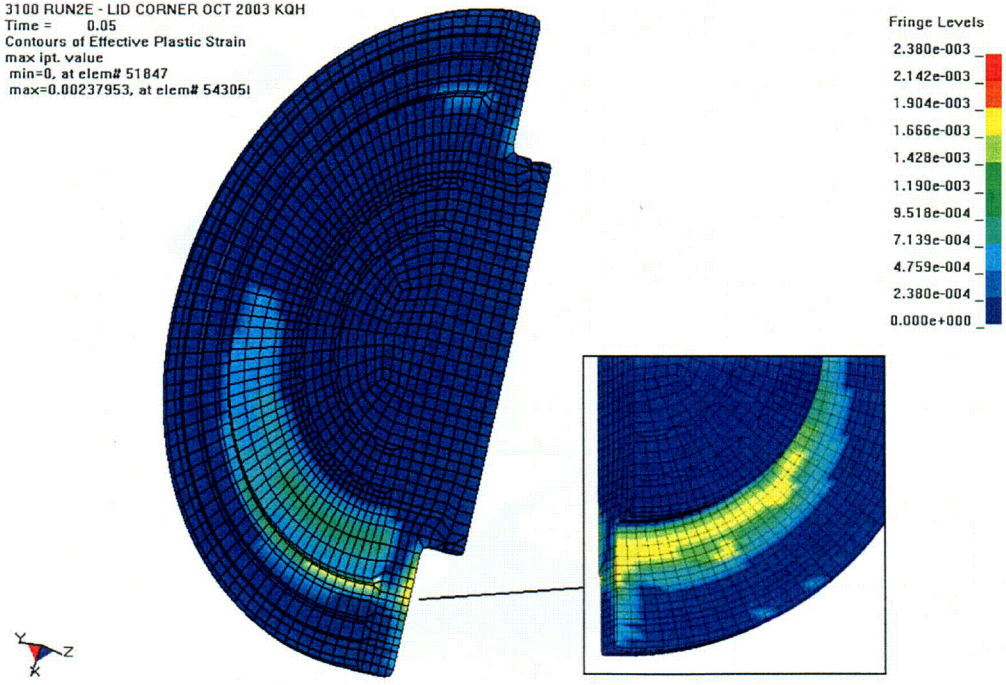

Figure 3.5.4 - Run2e, Crush Impact, Effective Plastic Strain in the CV Lid

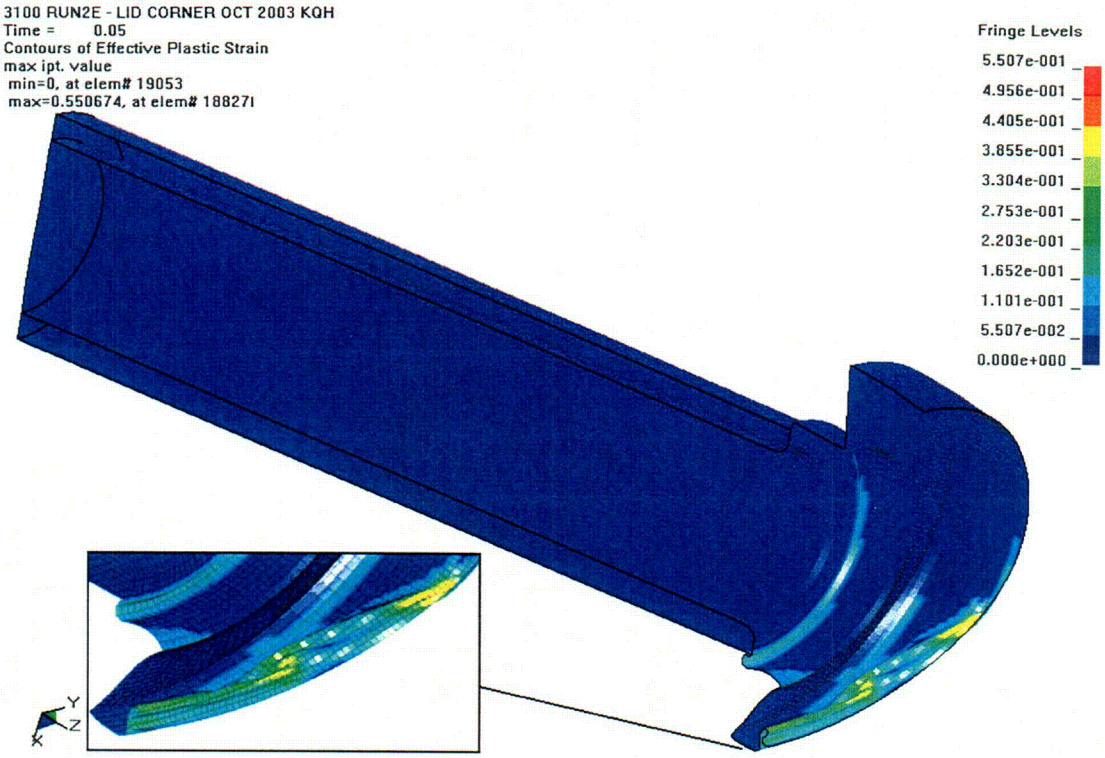

Figure 3.5.5 - Run2e, Crush Impact, Effective Plastic Strain in the Liner

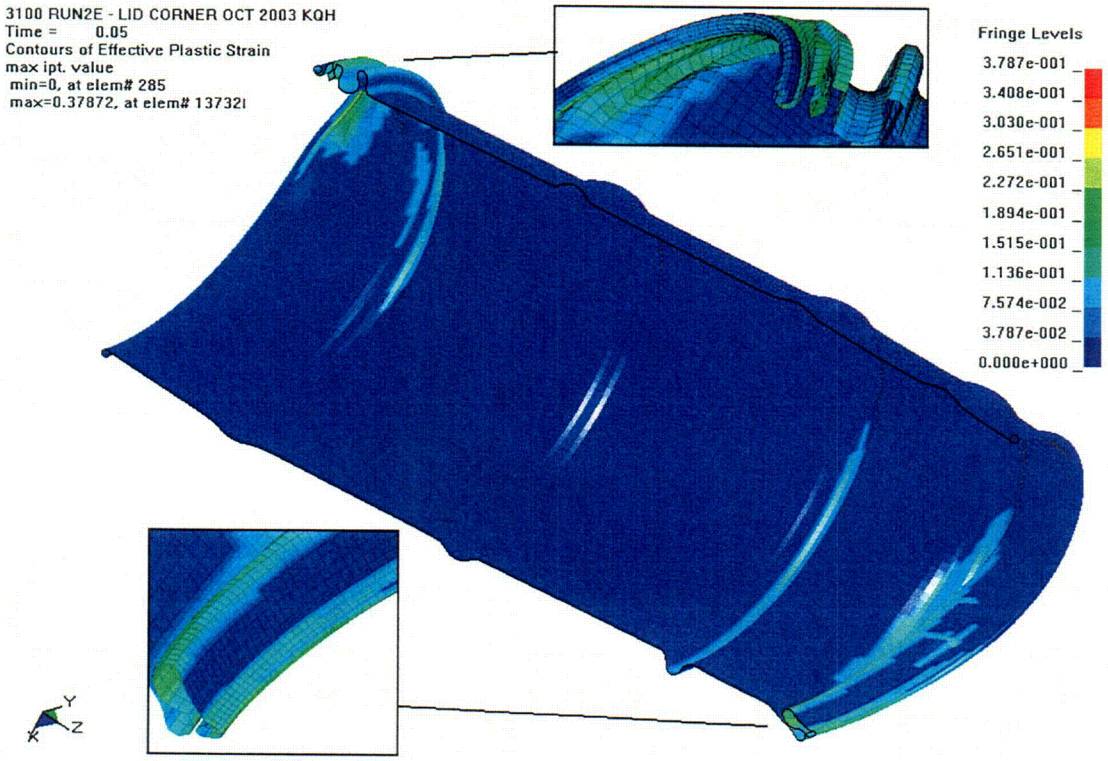

Figure 3.5.6 - Run2e, Crush Impact, Effective Plastic Strain in the Drum

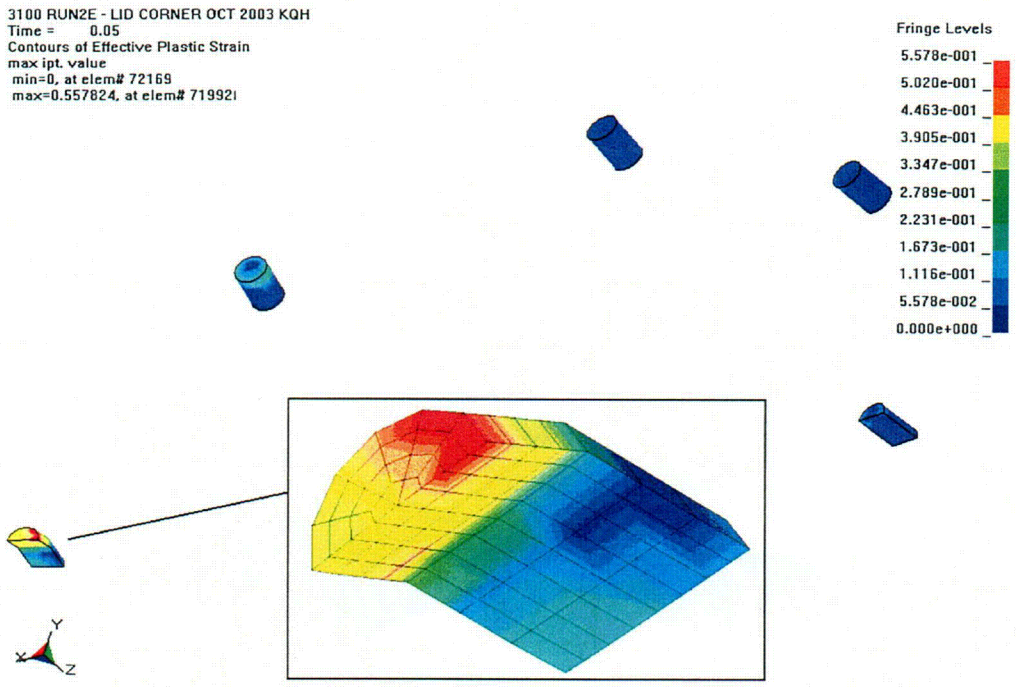

Figure 3.5.7 - Run2e, Crush Impact, Effective Plastic Strain in the Drum Studs

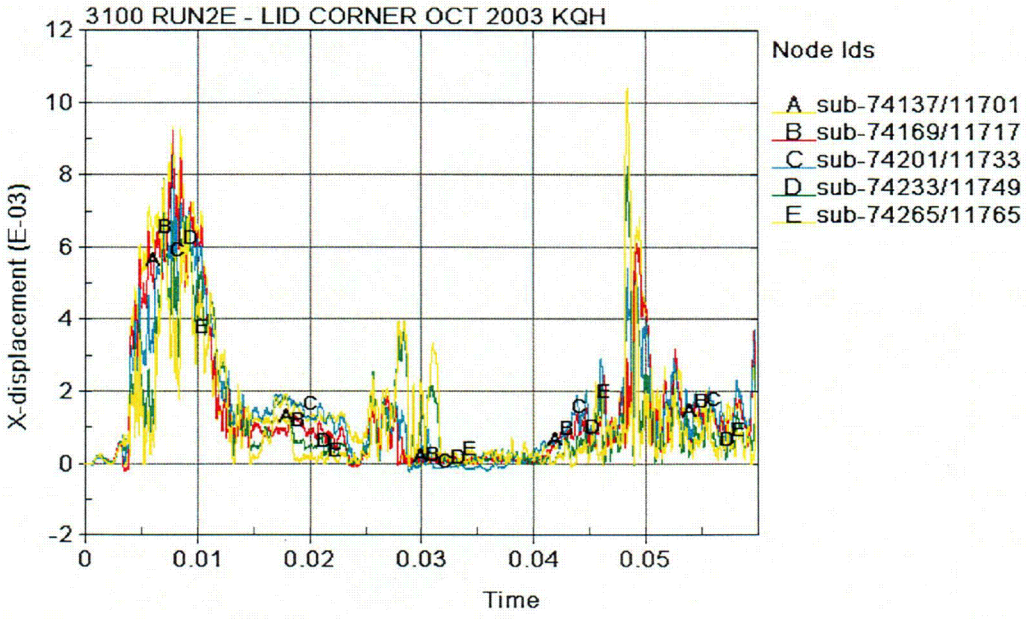

Figure 3.5.8 - Run2e, CV Lid/Body Separation Time History

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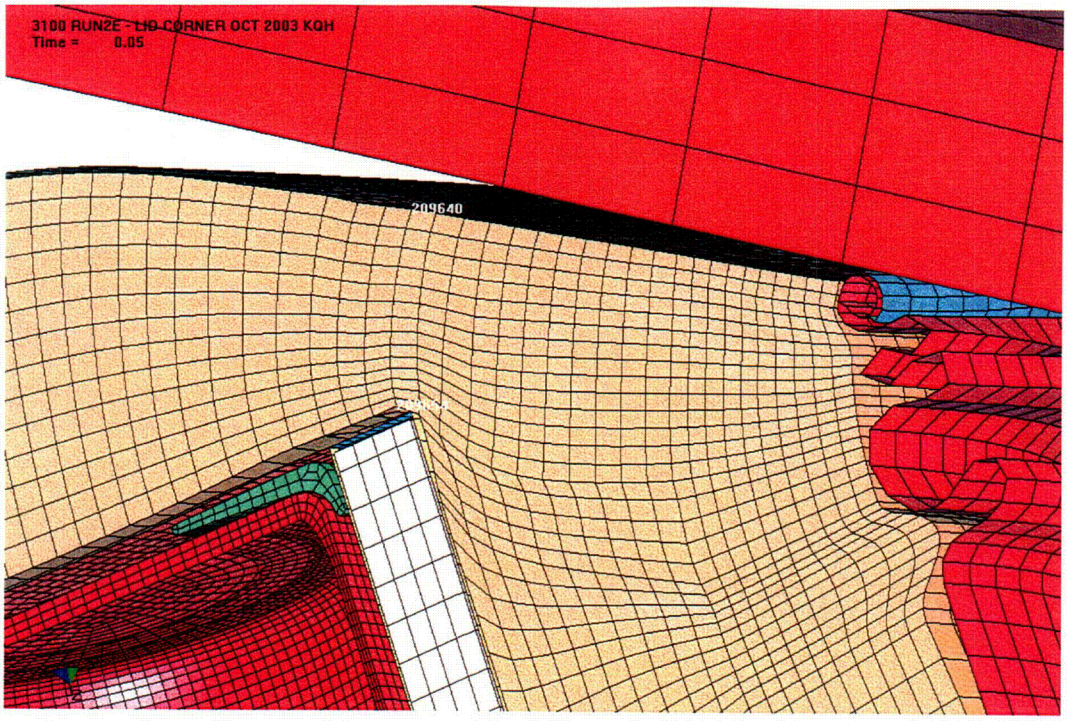

Figure 3.5.9 - Run2e, Location of Kaolite Nodes at the Bottom for Thickness Evaluation

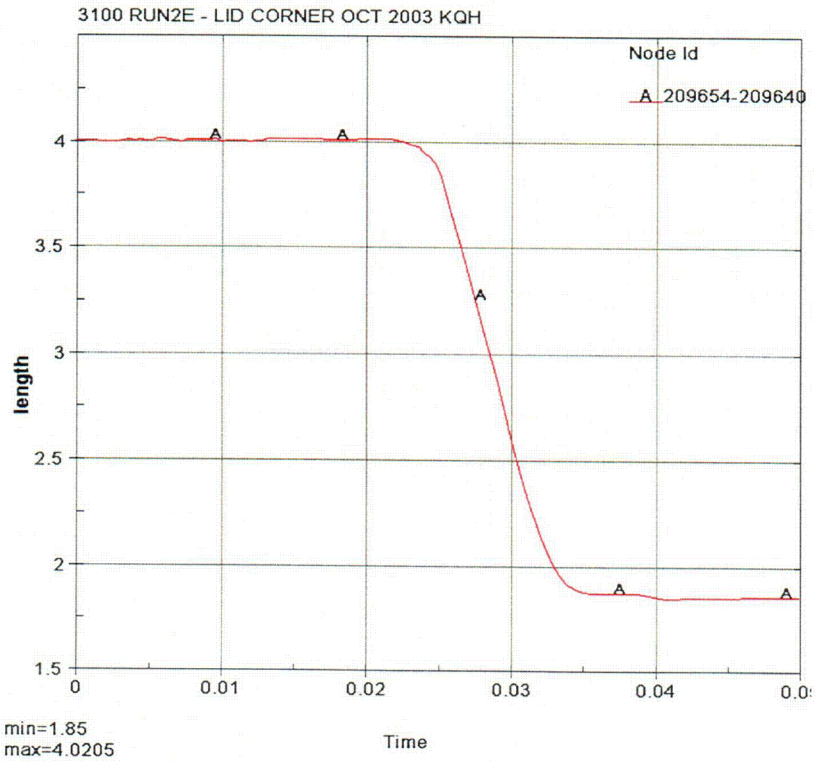

Figure 3.5.10 - Run2e, Minimum Thickness Time History for the Bottom Kaolite

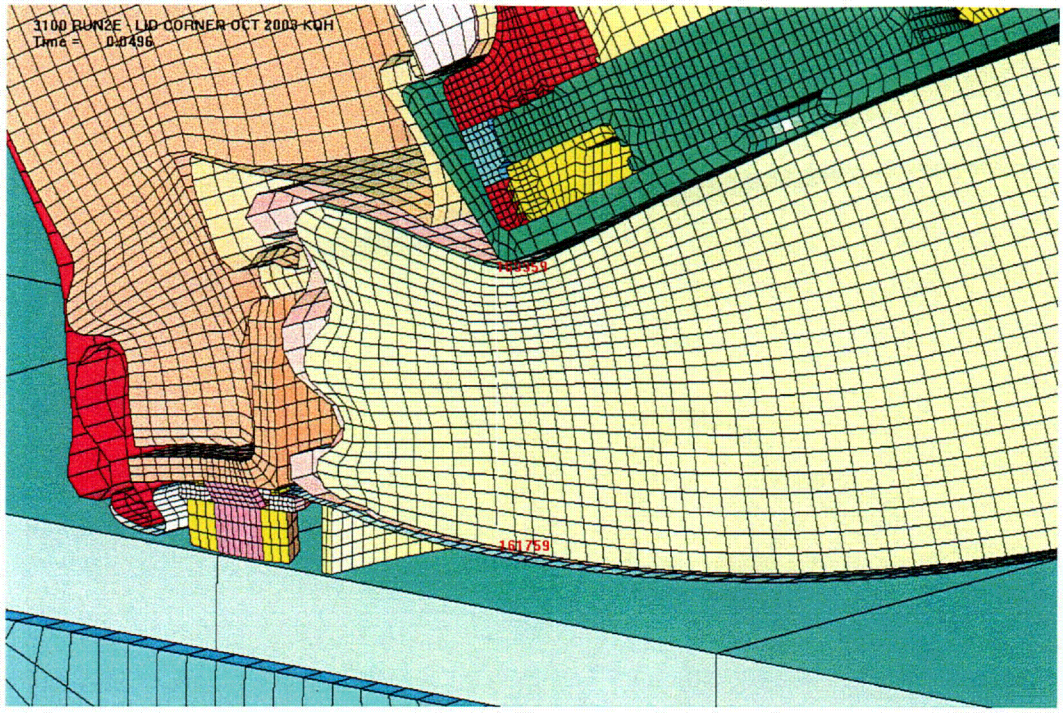

Figure 3.5.11 - Run2e, Location of Kaolite Nodes in the Plug for Thickness Evaluation

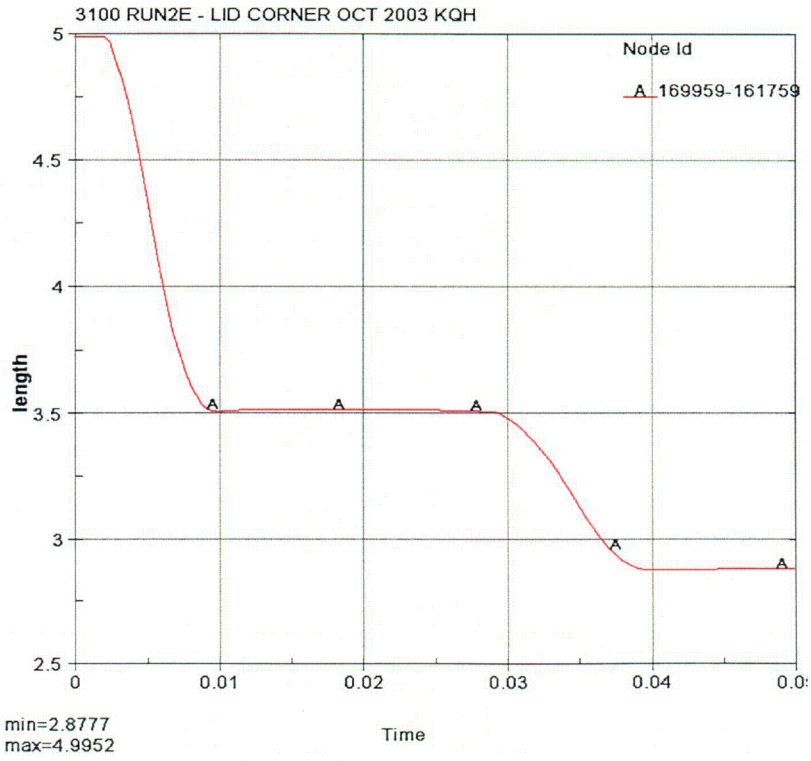

Figure 3.5.12 - Run2e, Minimum Thickness Time History for the Plug Kaolite

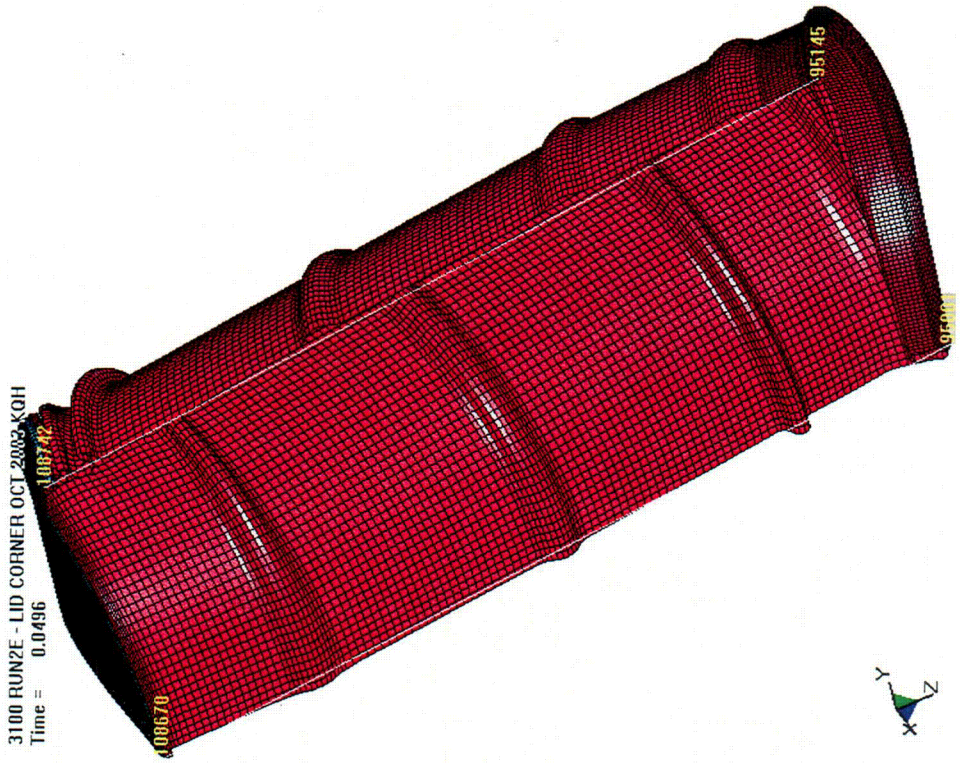

Figure 3.5.13 - Run2e, Length Dimensions in the Drum

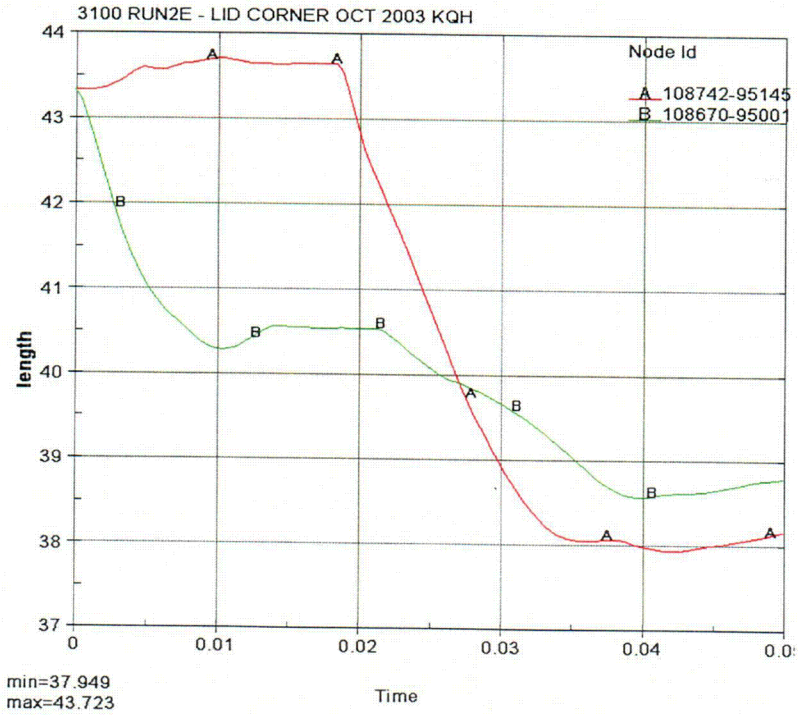

Figure 3.5.14 - Run2e, Time History of Length Dimensions in the Drum

3.6 Run3b - End

Run3b is a 30-foot lid end impact (time = 0 to 0.010 seconds) followed by a crush impact onto the package bottom (0.010 to 0.028 seconds). Figure 3.6.1 shows the final configuration for the 30-foot impact. Because of the relatively low demand placed on the components, no strain plots are presented for the 30-foot impact. Table 3.6.1 summarizes the maximum effective plastic strains in the package components.

Table 3.6.1 - Run3b, 30-Foot Impact, Effective Plastic Strain Levels in Some Components

Component	Effective Plastic Strain, in/in
CV Body	0.0012
CV Lid	0.0031
CV Nut Ring	0.0000
Angle	0.0287
Drum	0.0565
Drum Bottom Head	0.0024
Liner	0.1665
Lid	0.1094
Lid Stiffener	0.0068
Lid Studs	0.0962
Lid Stud Nuts	0.0162
Lid Stud Washers	0.0510
Plug Liner	0.0636

Figure 3.6.2 shows the final configuration for the 30-foot impact and the successive crush impact. Figure 3.6.3 shows that the maximum effective plastic strain in the CV body is 0.0053 in/in. The maximum occurs in the bearing of the body flange onto the lid (at the O-ring seals). The magnitude of effective plastic strain is questioned due to the fact that the elevated strains occur at single nodes and are not symmetric (see the insert in Figure 3.6.3). The maximum effective plastic strain in the bottom region of the CV body is found to be 0.0035 in/in and does exhibit a symmetric characteristic as is shown in Figure 3.6.3.

The CV lid effective plastic strain fringes are shown from both sides in a split image in Figure 3.6.4. The maximum effective plastic strain in the lid is shown to be 0.0034 in/in in the figure. The other components are summarized in Table 3.6.2.

Table 3.6.2 - Run3b, Crush Impact, Effective Plastic Strain Levels in Some Components

Component	Effective Plastic Strain, in/in
CV Nut Ring	0.0000
Angle	0.0304
Drum	0.1258
Drum Bottom Head	0.0312
Liner	0.3585
Lid	0.1415
Lid Stiffener	0.0098
Lid Studs	0.1541
Lid Stud Nuts	0.0170
Lid Stud Washers	0.0510
Plug Liner	0.0944

The CV lid separation time history is shown in Figure 3.6.5. The response during the 30-foot impact is a spike separation of about 0.012 inches, which relaxes to a maximum value of 0.003 inches for the remainder of the 30-foot impact. During the crush impact it is seen that separation is spikes to a maximum of about 0.004 inches, but the average remains at about 0.002 inches or less at the end of the impact.

Figure 3.6.6 shows the nodes chosen to obtain the drum height and kaolite thickness time history data. Figure 3.6.7 shows the drum height time history. From the figure it is seen that the overall height would be approximately 39 inches. Figure 3.6.8 shows the thickness time histories in the kaolite for the plug and the bottom. The curve A in the figure is for the bottom kaolite thickness, and it reaches about 2.2 inches as a final value. Curve B, is for the plug and it reaches about 3.4 inches for the final kaolite thickness.

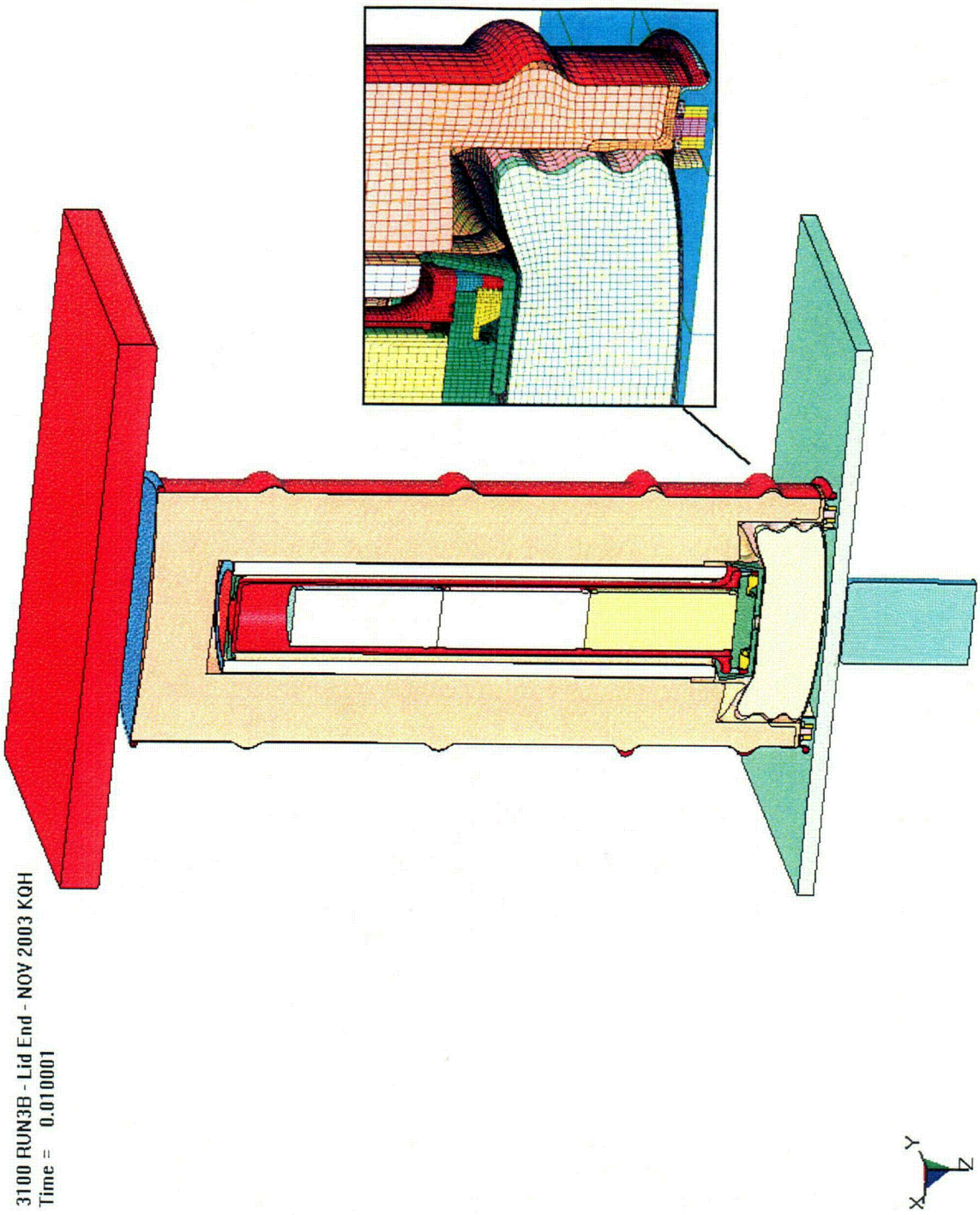

Figure 3.6.1 - Run3b, Configuration After the 30-Foot Impact

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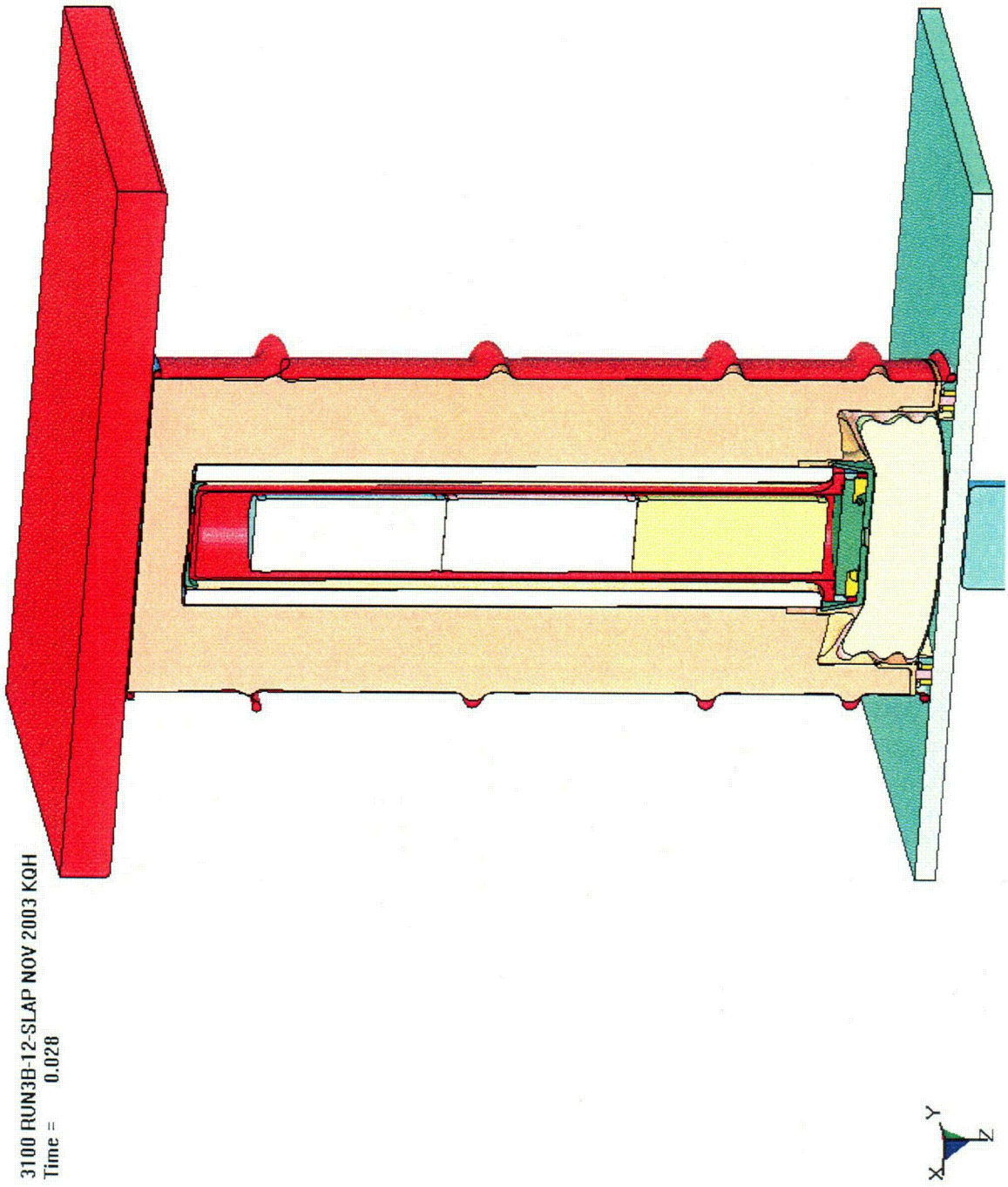

Figure 3.6.2 - Run3b, Crush Impact, Final Configuration

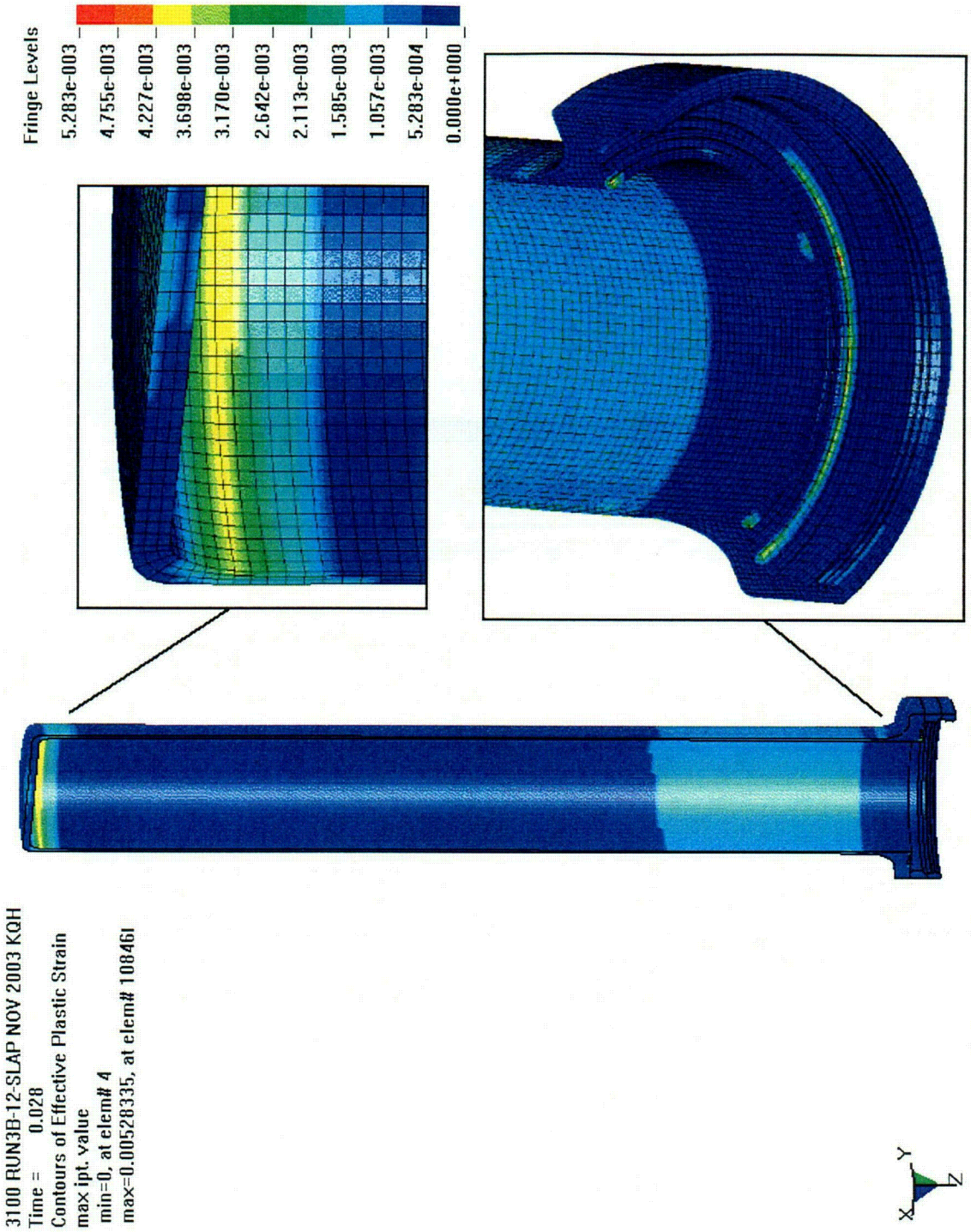

Figure 3.6.3 - Run3b, Crush Impact, Effective Plastic Strain in the CV Body

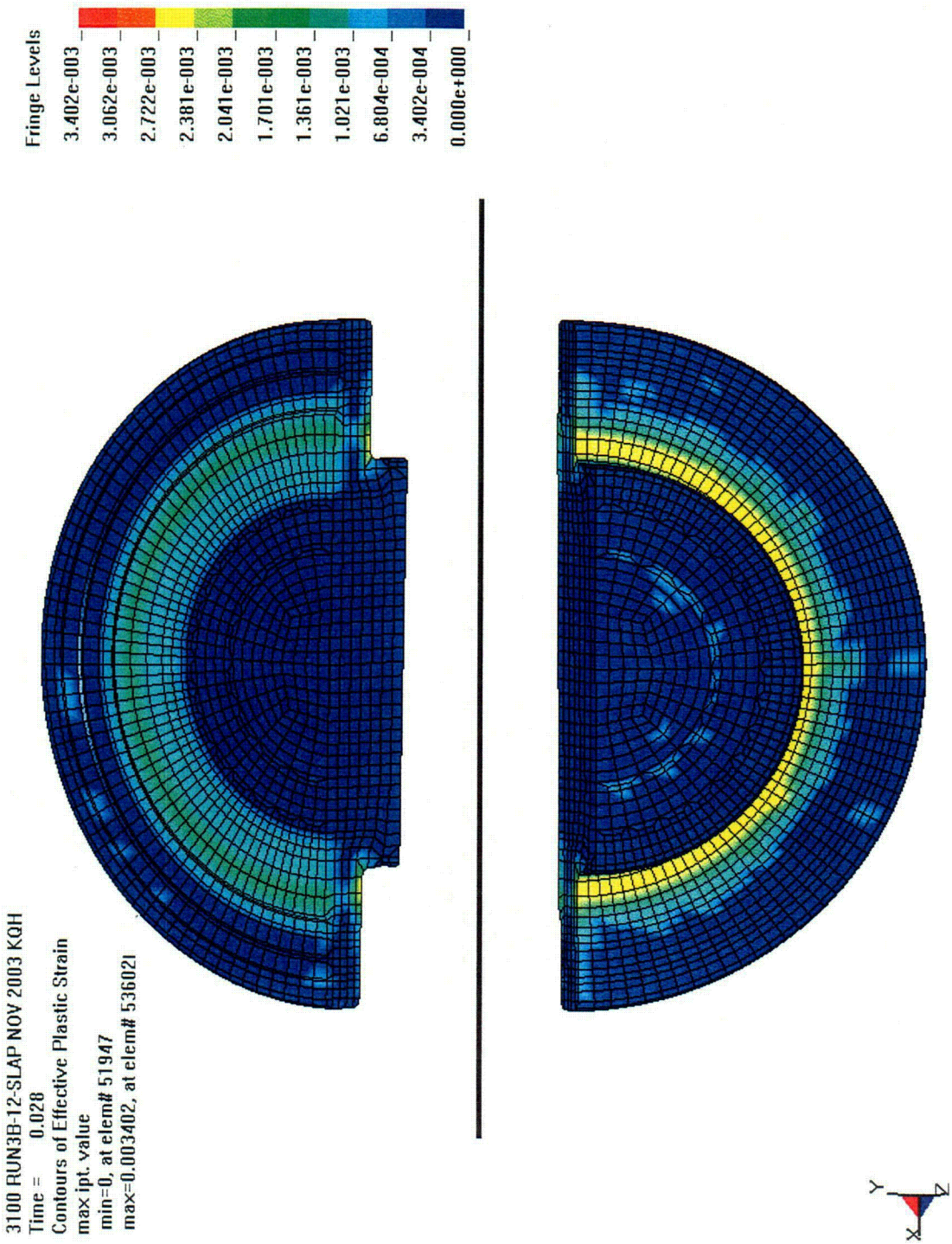

Figure 3.6.4 - Run3b, Crush Impact, Effective Plastic Strain in the CV Lid

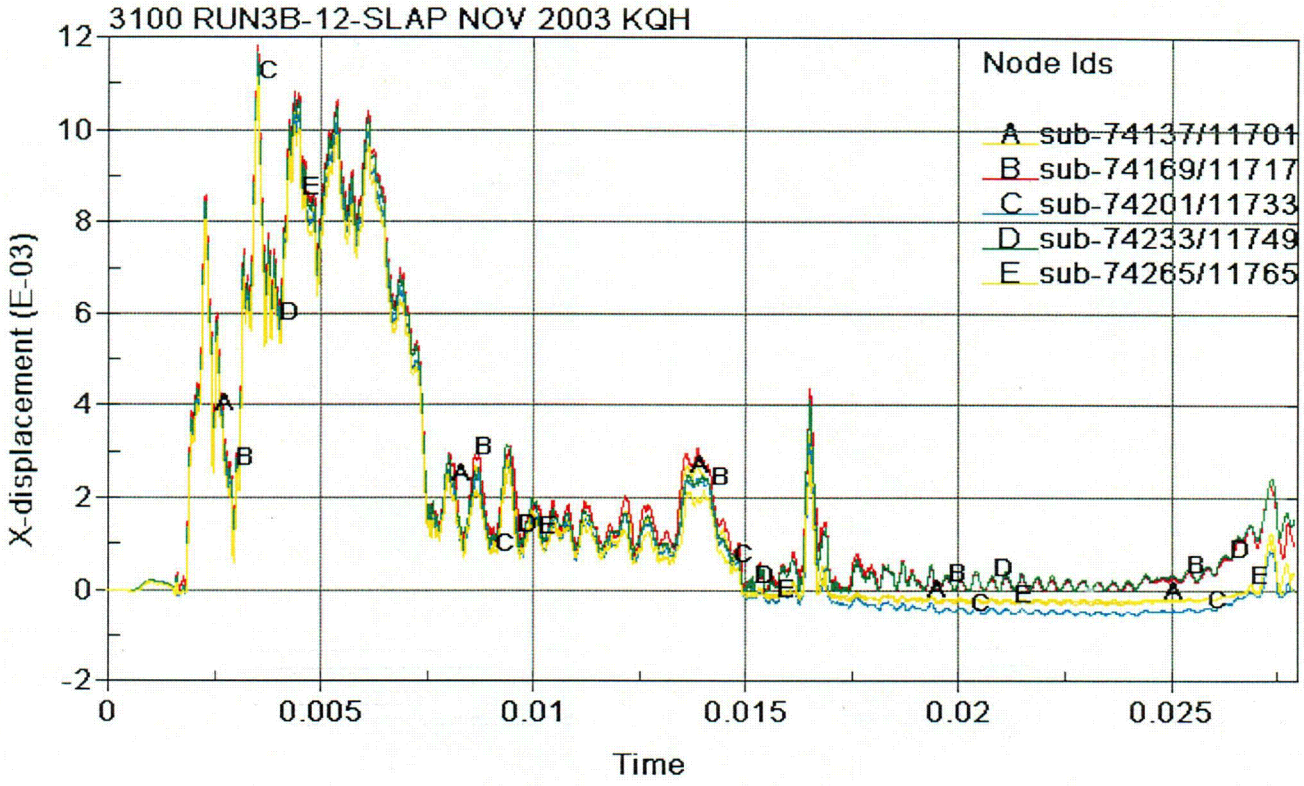

Figure 3.6.5 - Run3b, CV Lid Separation Time History

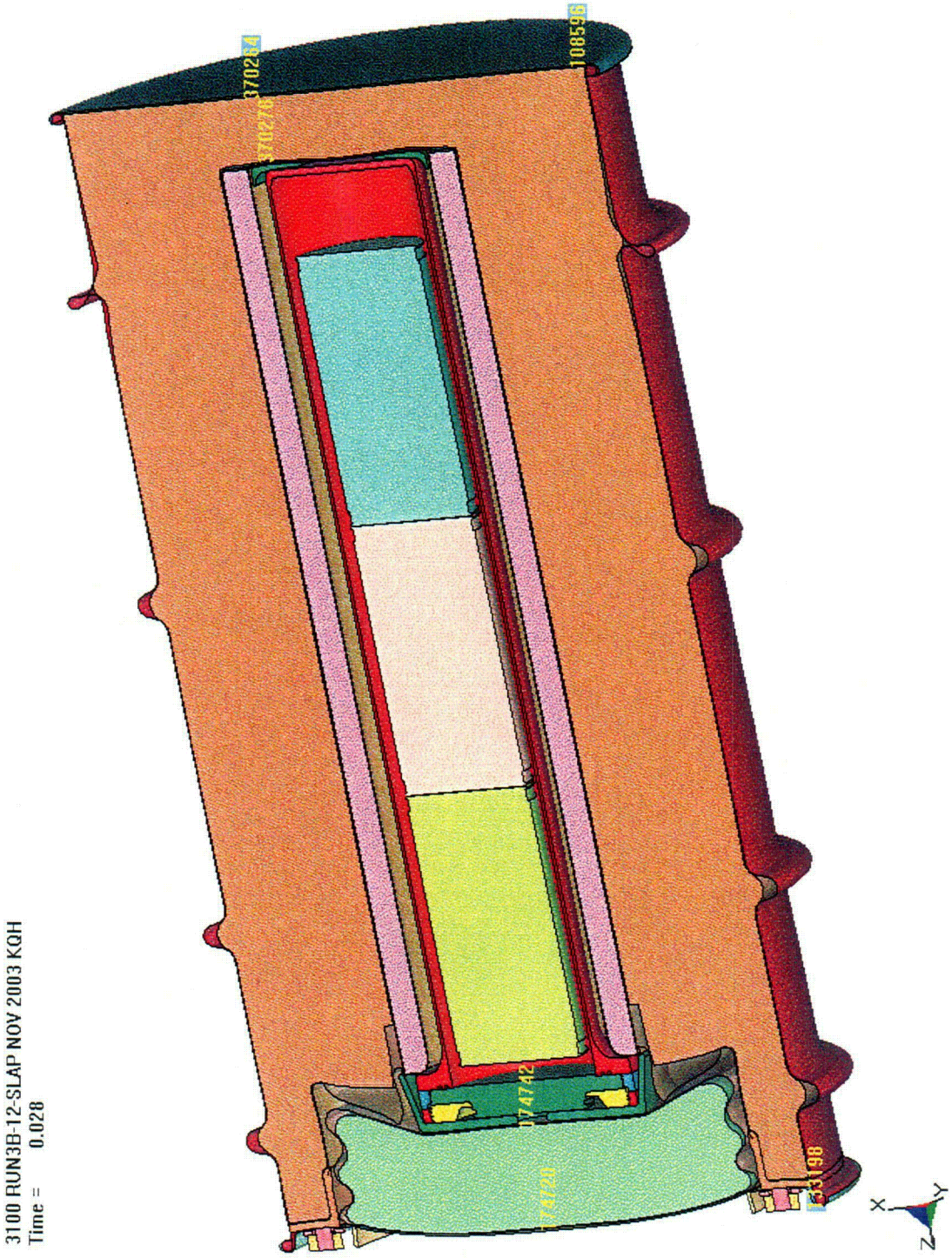

Figure 3.6.6 - Run3b, Nodes Chosen for Displacement Time Histories

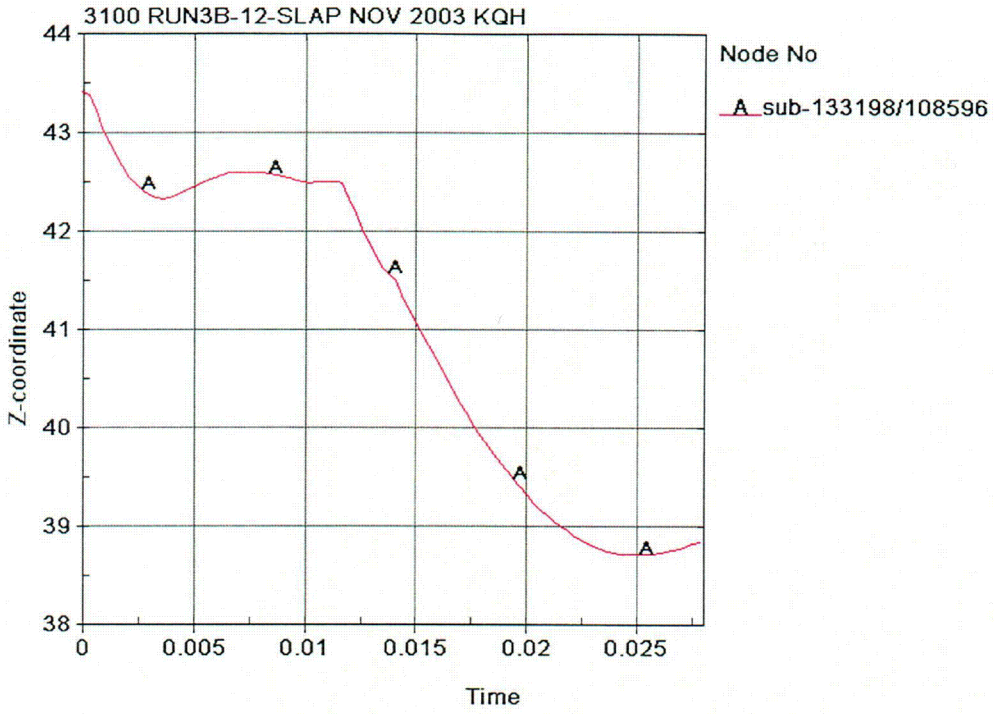

Figure 3.6.7 - Run3b, Drum Height Time History

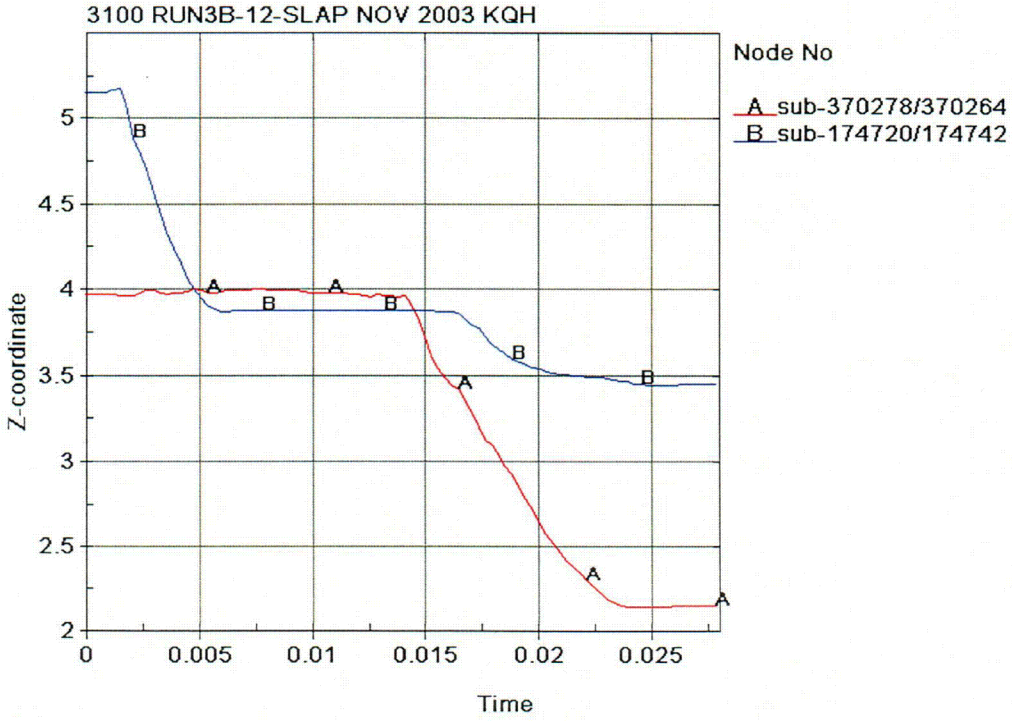

Figure 3.6.8 - Run3b, Kaolite Thickness Time History

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