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Analysis of an Instrumented Projectile

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Analysis of an Instrumented Projectile

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Abstract

A preliminary analysis of the M831E1 instrumented heat round was performed using the DYNA3D finite element code. The purpose of this initial analysis was to estimate the magnitude of the vertical and horizontal accelerations of an M831E1 during launch. The analysis results indicate that during a normal (firings that are not hot) launch the vertical accelerations will be in the range of ± 800g's and the horizontal accelerations are of order ± 500 g's. The acceleration estimates are taken at the same location as the instrumentation package's accelerometers. These initial estimates are undoubtedly low in as much as the recoil of the gun system was not included in this analysis. However, it is planned to include gun recoil and a more concise structural modeling of the instrumentation package at a later date. Experience with kinetic energy projectiles of the same caliber have shown that gun recoil and tube shape contribute equally to the dynamic path of the bullet. Therefore, it is postulated that not more than a doubling of the observed accelerations will occur when both of these attributes are included in the analysis.

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1. Analysis

A finite element model of an M830E1 experimental heat round was assembled inside an M256 120-mm gun tube using the PATRAN pre- and post-processing software. The total model consisted of 18 primary parts, and each piece was discretized into a series of eight noded solid brick elements. The final model contained 15,834 solid elements, with 21,642 nodes and over 120,000 degrees of freedom. The model was analyzed using the DYNA3D finite element program on an SGI Indigo II workstation with an approximate run time of 12 hr.

2. Model

The model consists of two primary parts, the bullet and the gun tube. A model of the bullet is positioned inside a model of the gun tube with sliding interfaces between their surfaces. The aft ramp of the bullet is loaded with a pressure that is calculated using the interior ballistic code XKTC-Nova. The bullet rides the gun tube along the obturator and the front bore rider. Sliding interfaces provide the contact algorithm between the gun tube and bullet allowing the bullet to accelerate down the inside of the gun tube while forcing the bullet to follow the tube's nonstraight profile. The profile from gun tube no. 4087 was chosen for this simulation. Additional movement is typically transmitted to the bullet via the gun recoil system during a firing. However, for this initial analysis, the gun system was not included. In subsequent analyses, it is intended that the full gun recoil model will be included. A three-dimensional depiction of the gun and bullet models is shown in Figure 1.

3. Bullet Model

The bullet model was broken into six primary parts: sabot, projectile housing, tail flair and fins, instrumentation package, obturator, and a wind screen. A brief description of each is given here.

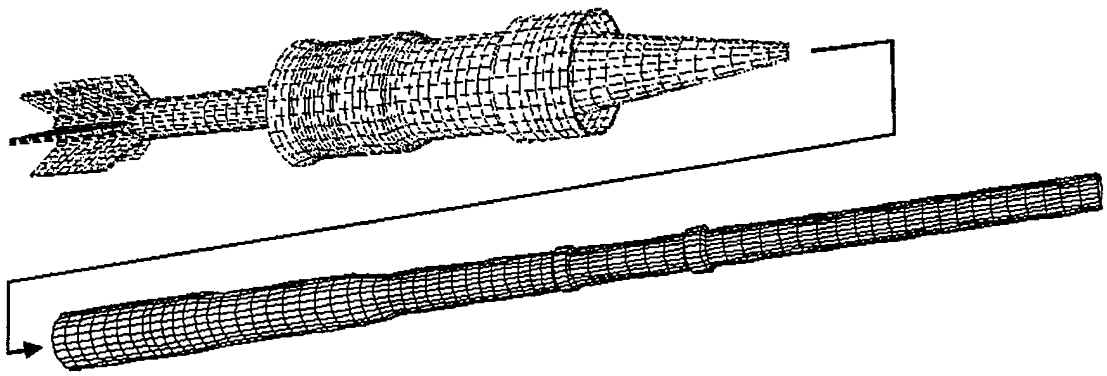


Figure 1. Gun Tube and Bullet Discretization.

3.1 Sabot. The aluminum sabot consists of three individual petals, each spanning 120° and attaching to the projectile housing via a series of interlocking threads. The approximation for the attachment is accomplished using a smeared interface region of elements consisting of an average of the sabot's material properties and the projectile housing material (Figure 2).*

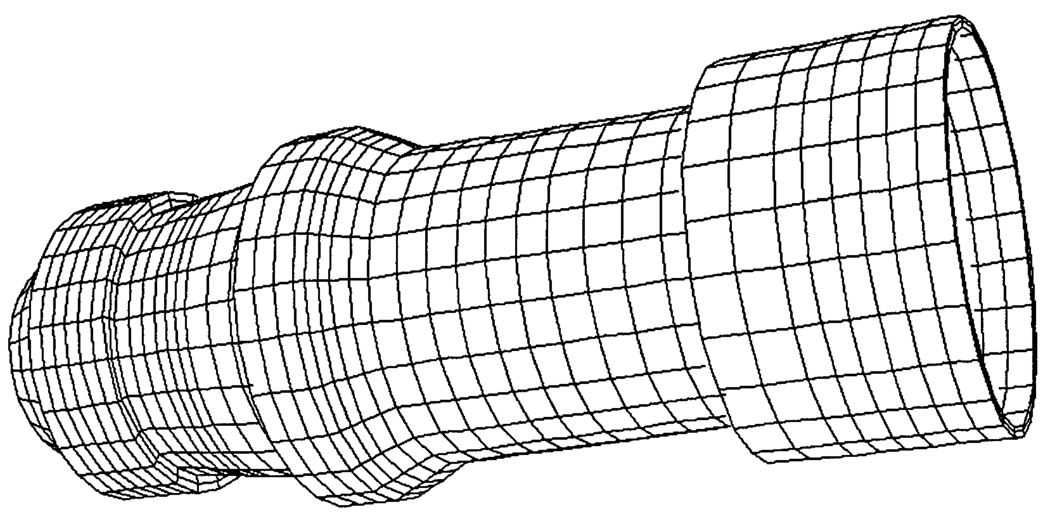


Figure 2. Sabot Model.

* This is a standard procedure for approximating the threaded region between a sabot and a long rod penetrator for kinetic energy projectiles. The technique was originally validated by Dr. Rabern of the Los Alamos National Laboratories.

3.2 Projectile Housing. The projectile housing is a steel body that will support the instrument package and is connected to the sabot petals through the smeared interface region (Figure 3).

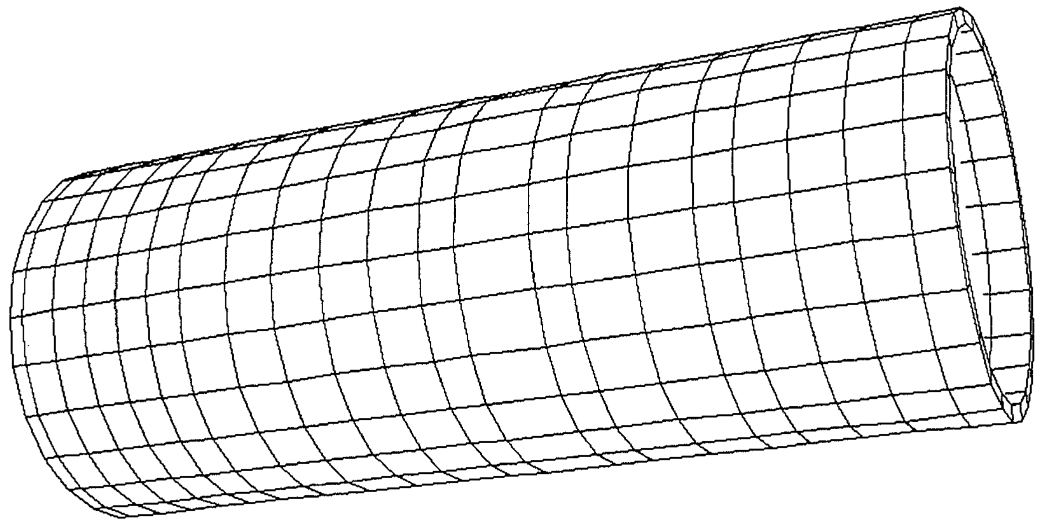


Figure 3. Main Projectile Housing.

3.3 Tail. The tail consists of an aluminum tail section that connects to the steel body rigidly and a set of aluminum fins that attach to this aluminum tail section (Figure 4).

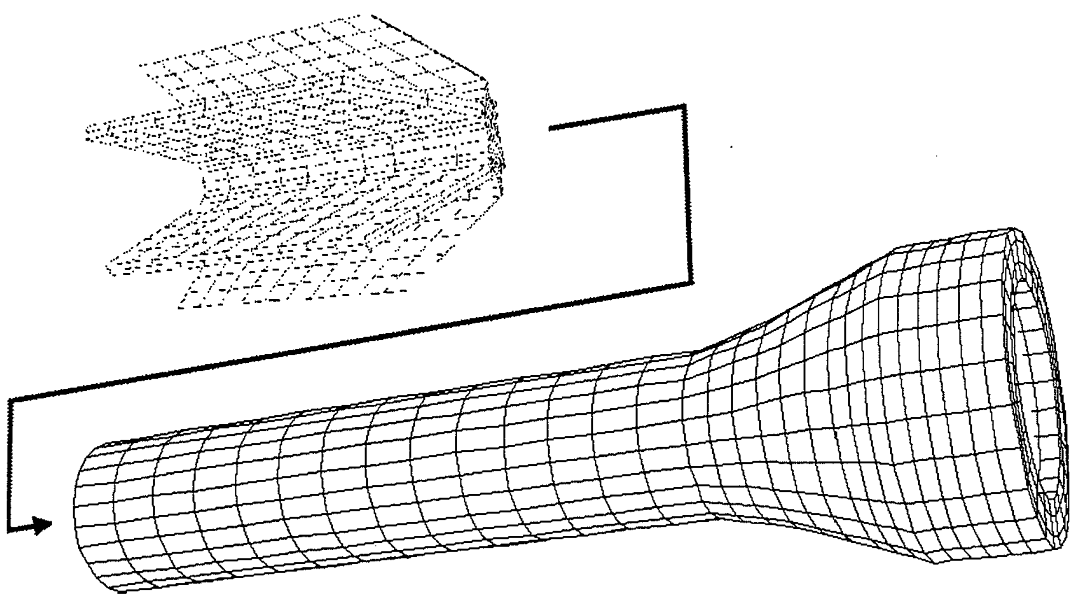


Figure 4. Tail Section and Fins.

3.4 Instrumentation Package. The instrumentation package has a body, shown in green, with five primary components separated by aluminum barriers (red) and further supported by aluminum rings (blue). The instrumentation packages are: The accelerometer, power supply, signal condenser, mux, and transmitter. The antenna on the front of the package is not modeled discretely but is included as part of the housing (Figure 5).

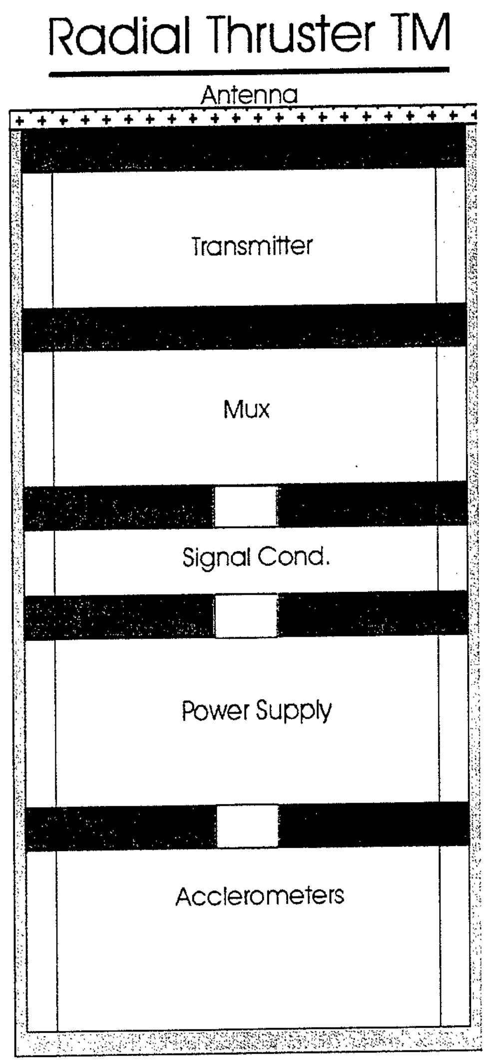


Figure 5. Telemetry Package.

3.5 Obturator. The obturator is made of a nylon-type material (Zytel 101) and is rigidly attached to the sabot petals (Figure 6).

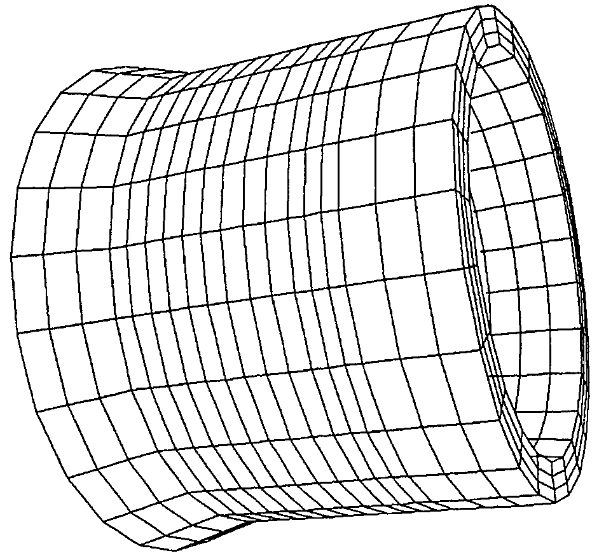


Figure 6. Obturator.

3.6 Wind Screen. The wind screen consists of an aluminum two-piece nose cap and several filler plugs used in the forward section to fill the air space (Figure 7).

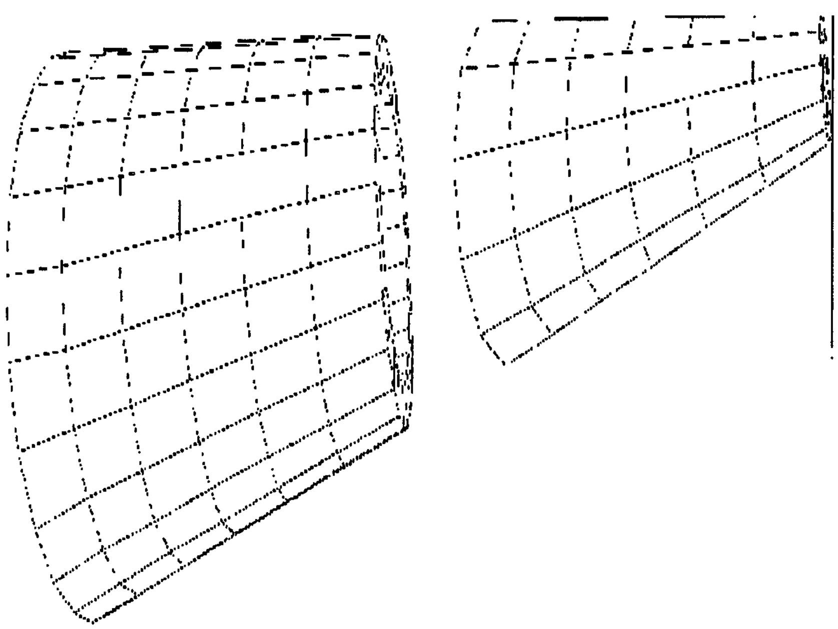


Figure 7. Nose Cap and Base.

4. Gun Tube Model

Gun tube no. 4087 was used due to its unusual shape. It is believed that differences in tube shape have an effect on the center of impact fall of shot variance typically seen between two different tanks. This particular tube was chosen in as much as it fell outside what is normally observed in tube shapes. This was done to give the projectile a more energetic, or bumpy, ride inbore, thereby helping to compensate for the lack of the gun recoil model. The vertical deviations from straightness for tube shape no. 4087 are shown in Figure 8.

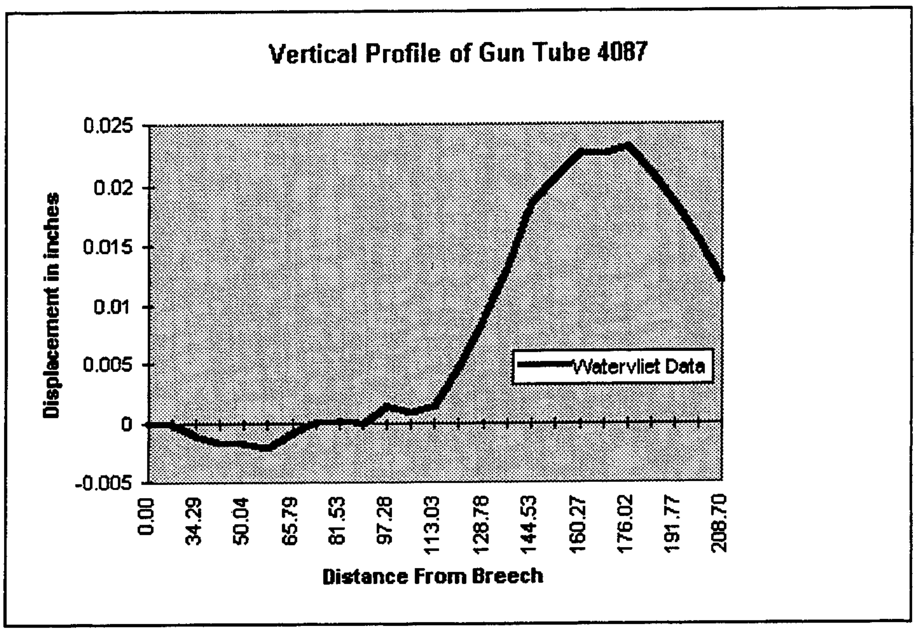
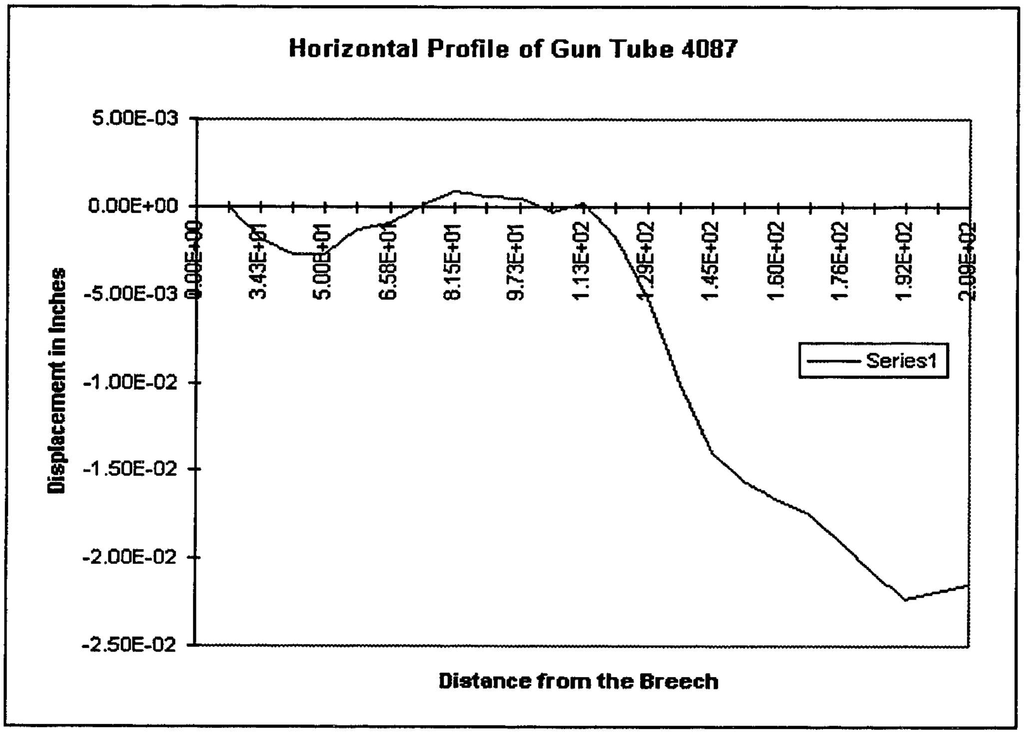


Figure 8. Vertical Tube Shape.

5. Results

The DYNA3D post-processing package TAURUS allows displacements, velocities, and accelerations to be computed at specific locations on the model or averaged over an area. For this application, the accelerations were averaged for the material used to represent the accelerometer package within the instrumentation package. Figure 9 shows the vertical acceleration, and Figure 10 shows the horizontal accelerations for the accelerometers.



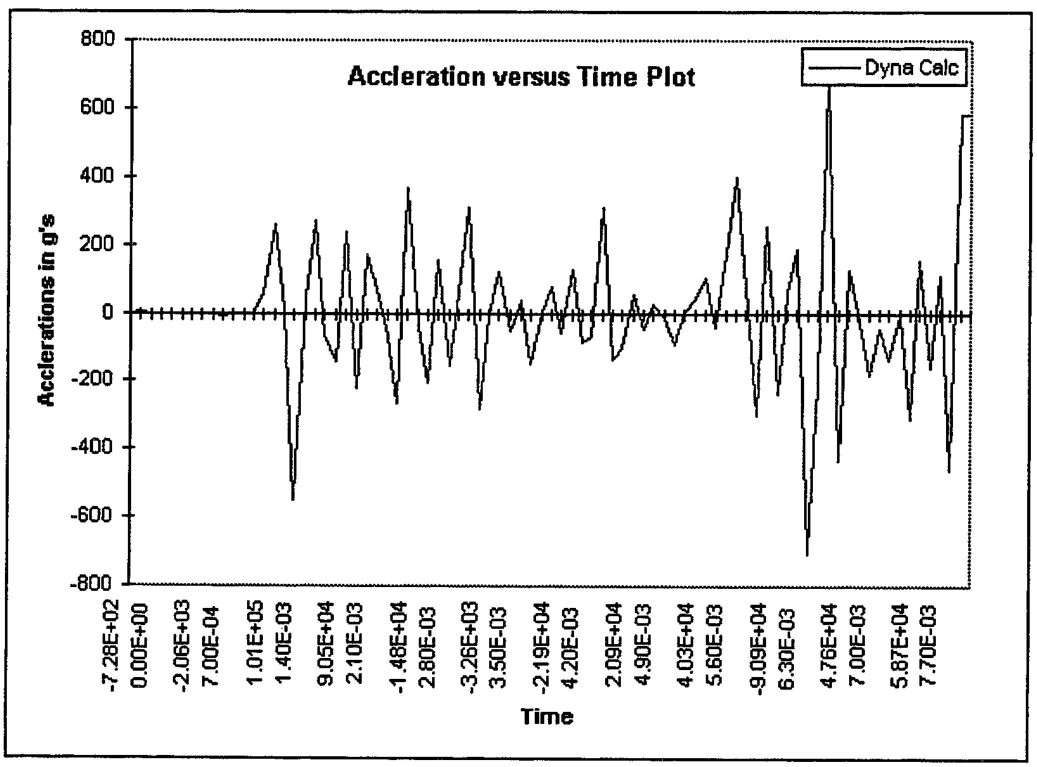


Figure 9. Vertical Accelerations at Accelerometer Package.

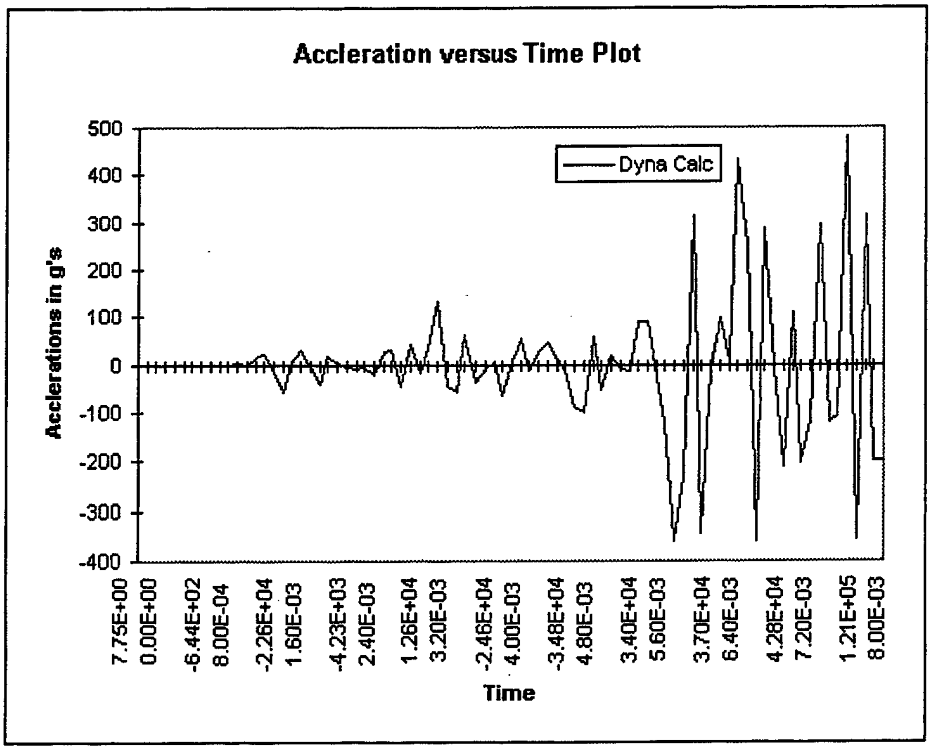


Figure 10. Horizontal Accelerations at Accelerometer Package.

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13. ABSTRACT *(Maximum 200 words)*

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